CMD 25-H9.REF8 CNSC Staff Submission

Reference Package 8 for CMD 25-H9 CNSC Staff Submission on Denison Mines Licence Application to Prepare Site and Construct the Wheeler River Project

Classification	Unclassified
Type of CMD	References
CMD Number	CMD 25-H9.REF8
Original CMD	CMD 25-H9
Public hearing date	08 December 2025
PDF e-DOC #	7605583
Summary	This document contains documents related to the Environmental Assessment process, as posted to the Canadian Impact Assessment Registry, to be placed on the Record for the proceeding.
Actions required	There are no actions requested of the Commission. This CMD is in support of the actions and recommendations set out in CNSC staff CMD 25-H9.

CMD 25-H9.REF8 Soumission par le personnel de la CCSN

Références liées 8 au CMD 25-H9 Soumission par le personnel de la CCSN la demande de Denison Mines visant à prépare le site du projet de Wheeler River et à entamer les activités de construction

Classification	Choisir un niveau de classification
Type de CMD	Références
Numéro de CMD	CMD 25-H9.REF8
CMD Original	CMD 25-H9
Date de l'audience	08 décembre 2025
Numéro e-Doc du PDF	7605583
Résumé	Ce document contient des documents liés au processus d'évaluation environnementale, tels que publiés dans le Registre canadien d'évaluation d'impact, à verser au dossier de l'instance.
Mesures requises	Aucune mesure n'est requise de la Commission. Le présent CMD appuie les mesures et les recommandations énoncées dans le CMD CMD 25-H9 du personnel de la CCSN.

Canadian Nuclear Safety Commission | Commission canadienne de sûreté nucléaire

Canada

CMD 25-H9.REF8

Reference Package 8 for CMD 25-H9 CNSC Staff Submission on Denison Mines Licence Application to Prepare Site and Construct the Wheeler River Project

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Denison Mines

Wheeler River Project

Final Environmental Impact Statement

November 2024

Powering
PEOPLE, PARTNERSHIPS AND PASSION.

Appendix 9-B

Denison Mines Corporation
Wheeler River Project

Terrestrial Environment
Wildlife and Vegetation Baseline Inventory

January 2020 Update

OMNIA ECOLOGICAL SERVICES

OMNIA
ECOLOGICAL SERVICES

Denison Mines Corporation
Wheeler River Project

Terrestrial Environment
Wildlife and Vegetation Baseline Inventory
-2019 DRAFT REPORT UPDATE-

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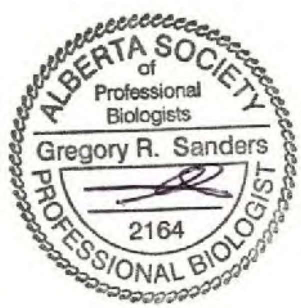


January 2020

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1.0 INTRODUCTION

1.1 Study Background and Objectives

Omnia Ecological Services (Omnia) was retained by Denison Mines Corporation (Denison) in September 2016 to collect terrestrial (wildlife and vegetation resources) baseline data in support of the proposed development of the Wheeler River Project. The terrestrial baseline data was originally collected to support future pre-feasibility studies, technical assessments, project layout and environmental effects assessments related to the development of the Gryphon and Phoenix uranium deposits and associated infrastructure. However, in 2019 the focus was narrowed to the Phoenix development only.

The objectives of the terrestrial baseline surveys were to:

- Characterize the existing terrestrial environment in the Project Area
- Inform pre-feasibility engineering design work
- Inform environmental effects and technical assessments
- Establish a framework to facilitate future environmental effects monitoring
- Support the development of project specific mitigation strategies

This report documents and summarizes baseline ecological land classification, baseline anthropogenic disturbance, wildlife elements including: avian, terrestrial, semi-aquatic furbearers and amphibians, and baseline chemistry of soil, vegetation, and small mammals obtained during field programs completed from 2016 to 2019. In addition, local Indigenous land user information has been collected to inform and supplemental baseline field surveys where possible.

1.2 Study Area

The Denison Wheeler River Project is located along the eastern edge of the Athabasca Basin in northern Saskatchewan and is located approximately 35 km north-northeast of the Key Lake mill and 35 km southwest of the McArthur River uranium mine. The terrestrial baseline surveys were stratified into two nested study areas, a Local Study Area (LSA) and a Regional Study Area (RSA). The original study areas were based on both the Gryphon and Phoenix developments; in 2019 both the LSA and RSA were adjusted to focus on the Phoenix development only. The LSA was 48 km^2 and sized to account for direct effects of the Phoenix project as well as a sensory buffer (1.7 km) for the proposed mine access road options and mine site(s) development. The RSA was 400 km^2 and was designed to capture potential cumulative effects of the project on a subregion (including species with large home ranges), and included areas with potential to be affected directly or indirectly as well as suitable reference areas. The RSA was also used to provide context to support future impacts assessments on valued ecosystems components (Figure 1.2-1).

1.3 Ecological Setting

Ecoregion

The LSA and RSA fall entirely within the Athabasca Plain Ecoregion. The Athabasca Plain Ecoregion occurs in the northeastern portion of the Boreal Shield Ecozone in Saskatchewan, extending south from Lake Athabasca to Cree Lake and as far west as the Alberta border (Acton *et al*. 1998).

Landforms and Soils

The extent and type of vegetation in this area is greatly influenced by landform type. Topography is more subdued (low relief) in this ecoregion than elsewhere in the Canadian Shield, due to flat-lying sandstone bedrock and almost continuous cover of sandy glacial deposits. Distinctive landscape features of this ecoregion include large areas of kame and kettle topography with sandy-till moraines and areas of active sand dunes. Numerous lakes occur, while rivers are generally small and uncommon. Glaciation has left a lasting imprint on this area which is reflected in thin soils and irregular relief. Surficial materials are mainly composed of an undulating to strongly rolling discontinuous drift plain. Eskers and drumlins are common terrain features. Sandy and gravelly Podzols, Brunisols, and Luvisols occur on till materials, while sand and sandy loam Brunisols have developed on glaciofluvial deposits. Organic soils, Cryosols, and Mesisols are characteristic of lowland depressions. Discontinuous permafrost may also be present in the area (Acton *et al*. 1998).

Regional Vegetation

Stands of jack pine with a ground cover of lichen occupy the dry sandy sites. Mixed stands of jack pine and black spruce occupy moist sites such as topographic lows. White spruce, aspen, and balsam poplar are rare but can occur. Open jack pine (*Pinus banksiana*) forests with a thin cover of lichen are common and dominate the uplands but black spruce (*Picea mariana*) forests can also occur. Blueberry (*Vaccinium myrtilloides*) is the most prevalent ground cover species in the uplands. Black spruce, and to a lesser extent tamarack, are the dominant forest types in poorly drained lowland situations including bog and fen areas. Labrador tea (*Rhododendron groenlandicum*) is the most common ground cover plant in low sites. Areas of birch (*Betula papyrifera*) and willow (*Salix spp.*) do occur but these are generally limited to riparian areas along streams and rivers. Fire is common across the region resulting in extensive areas which are at various stages of regeneration (Acton *et al*. 1998).

Regional Wildlife

Vertebrate wildlife species known, expected or with the potential to occur within the Denison Wheeler River project area are presented in Appendix 1. The list of species with potential to occur within the Denison Wheeler Project area was developed using information from previous studies in the area (Rio Tinto 2014, Cameco 2013), regional and provincial references (SKCDC 2019b, Smith 1996 and Banfield 1974), field data collected in support of this project and the author's experience. All species observed during field investigations were denoted in Appendix 1 and all provincial and federal sensitive or at-risk species designations included (SKCDC 2019b, GOC 2019, SkMOE 2017.)

2.0 BASELINE FIELD INVESTIGATIONS

2.1 Anthropogenic, Fire and Predictive Ecosite Mapping

Anthropogenic, fire and predictive Ecosite mapping was created/compiled and refined for the Denison Wheeler River LSA and RSA.

The objectives of this mapping were to:

- Provide an Ecosite map (and supply by type) for characterizing the study areas and to support analysis of terrestrial wildlife-Ecosite affiliations
- Provide baseline anthropogenic disturbance mapping for the Wheeler River Project area
- Provide baseline vegetation cover/fire mapping to support project planning
- Provide baseline vegetation cover mapping for monitoring and/or assessment of impacts

2.1.1 Anthropogenic Mapping

Methods

To develop baseline anthropogenic mapping for the LSA and RSA a two-step procedure was used. First, the Environment and Climate Change Canada (ECCC) national level anthropogenic mapping was downloaded and clipped to the study area boundaries (ECCC 2015). Second, to improve the resolution and ensure completeness, all visually discernible anthropogenic features in the Denison Wheeler Project area were digitized at a scale 1:5,000. To support this process and enhance the final product, a combination of 2018 project specific ortho-photography, Landsat Imagery (2018) and Map Info Microsoft Bing Imagery (2018) were used to visually identify anthropogenic features. Industrial Clearings (polygons) were hand drawn based on imagery, and all linear features were digitized as lines and buffered to create polygons as per the widths detailed below:

- Cutline: 1.75 m
- Right-of-way (ROW): 2.5 m
- Trail: 4 m
- Rough Road: 5.5 m
- Road: 10 m
- Transmission ROW: 40 m
- McArthur-Key Haul Road: 40-60 m

The digitized features were layered according to the following priority (where the layers overlapped, the above layer stamped out the layer below):

1. Industrial Clearing
2. McArthur-Key Haul Road
3. Transmission ROW

4. Road
5. Rough road
6. Trail
7. Cutline
8. ROW

Results

The results of the anthropogenic mapping for the LSA and RSA are displayed in Figure 2.1-1. Using the refined anthropogenic map product (unbuffered), the total amount of anthropogenic disturbance was 2.0 km^2 (0.04%) in the LSA and 6.1 km^2 (0.02%) in the RSA (Table 2.1-1). Industrial Clearings, Roads, and Cutlines were the most common anthropogenic disturbance types in the LSA.

Per the ECCC (2015) mapping, the density of unbuffered linear feature disturbances is 1.04 km per km^2 in the LSA and 0.42 km per km^2 in the RSA (Table 2.1-2). A comparison of the refined anthropogenic mapping versus the unbuffered EC (2012) linear feature data set found the refined LSA map had a linear feature density 7.8 times higher than the ECCC (2015) data set. Comparatively, the refined RSA anthropogenic map had a linear feature density that was 9.5 times greater than ECCC (2015). As noted above, refined anthropogenic mapping indicated seven linear feature types in the Denison Wheeler Project area, while the ECCC (2015) data set detected three types (road, cutline and transmission line). This difference was as a result of the approach and scale (1:30,000) of the mapping completed by ECCC (2015).

The results of the updated and improved anthropogenic footprint including 500m buffer were compared to the buffered ECCC (2015) anthropogenic data set (Table 2.1-3). The refined anthropogenic map for the LSA resulted in total linear disturbance of 47.4 km^2 (99.1%), versus the ECCC (2015) dataset including 32.8 km^2 (69.1%) linear disturbance. For the RSA the refined anthropogenic footprint was 331.4 km^2 (82.8%) compared to 129.3 km^2 (32.3%) using the ECCC (2015) dataset.

2.1.2 Fire Mapping

Methods

Historical fire data (mapping) was obtained from the Saskatchewan Ministry of Environment (SkMOE), Wildfire Management Branch (Jones 2019). The fire data spans from 1945 to 2018 and is provided as a shapefile. The data was downloaded, clipped and overlaid onto the Denison Wheeler Project area. The mapped fire polygons include water bodies therefore; the hydrological layer developed by NRCAN (2017) was used to exclude water polygons. The resulting imagery was then queried to analyze fire history for the LSA and RSA. The data is presented as percent burned area as a function of the study areas and percent burn of the terrestrial study areas.

The coarse level of fire polygon mapping does not account for residual patches (unburned areas) within the larger fire polygon, typically this results in an over estimation of total hectares burned (Kansas et al. 2016). The interpreted Ecosite mapping (Section 2.1.3) delineates residual patches and therefore provides a more accurate delineation of burned areas within the LSA and RSA.

Results

A total of 7 fires have occurred in the Denison Wheeler Project CRSA since 1945. The age of these fires ranges from recent (2008) to 46 years (Table 2.1-4). The historical fires that have occurred within the RSA are displayed in Figure 2.1-2.

Fires in the LSA:

- Two fires occurred within the LSA during the last 40 years (Table 2.1-4, Figure 2.1-2).
- The two fires covered 19.4 km^2, which equates to 40.9% of the LSA (including water) and 45.0% of the terrestrial area only.

Fires in the RSA:

- Six fires have occurred in the RSA historically. Five of these fires have occurred within the last 40 years (Table 2.1-4, Figure 2.1-2).
- These five fires covered 223.4 km^2, which equates to 55.9% of the RSA (70.6% of the terrestrial area only).

2.1.3 Ecosite Mapping

2.1.3.1 Predictive Ecosite Map (PEM)

Methods

Predictive Ecosite Mapping (PEM) was obtained from the Saskatchewan Technical Branch to support the creation of an Ecosite map for the study area. To further refine and assess mapping accuracy, a ground truth component was included in the baseline field studies.

A total of 2,352 field sampling/ground truthing sites were used, where Ecosite delineation was completed. The sampling sites provided the supporting data for expanding, refining and accuracy assessment of the PEM for the LSA and RSA.

Field sampling/ground truthing sites included data from:

- Ungulate pellet group/browse availability survey: 1,596 locations
- Small mammal trapping program: 389 locations
- Vegetation/Ecosite characterization survey: 154 locations
- Songbird survey: 101 locations
- Linear feature regeneration assessment program: 46 locations
- Ground control points: 56 locations
- Soil/lichen program: 10 locations

Approximately half of the locations from the ungulate pellet group/browse availability survey (n=723) were used for the map accuracy assessment. The remaining locations were set aside to support Ecosite mapping in the event that the PEM was found to have insufficient accuracy. The ground control points were overlain onto the mapped Ecosites to assess accuracy of the predictive Ecosite map.

Results

Predictive Ecosite map accuracy was 28.4% or 205 of 723 correct ground control points. The main reason for this inaccuracy is that McLaughlan *et al*. (2010) did not describe forest types under 40 years of age in their Ecosite classification system. Since 70.6% of the RSA is mapped as having burned within the last 40 years (see Section 2.1.2), the majority of the study area was covered by regenerating forests that are not described by the McLaughlan *et al*. (2010). The PEM was therefore not suitable on its own to map the Ecosites in the LSA and RSA.

2.1.3.2 Interpreted Ecosite Map

Methods

To create a refined Ecosite map to accurately outline the current Ecosites (including regenerating stages) in the LSA and RSA, a combination of the existing PEM and alternative sources including Landsat Imagery (2018), Bing and Google Earth Imagery (2017-2018) were utilized. Visual interpretation was guided by field data not used for the accuracy assessment. The resulting Ecosite map was completed at a 1:20,000 scale.

The regenerating land cover types less than 40 years old, which did not match any of the Ecosites described by McLaughlan *et al*. (2010), were categorized based on vegetation height and therefore broadly on stand age, following methods outlined by Skatter *et al*. (2017). The categories were grouped as low shrub (< 1m tall, approximately 5–20 years of age), tall shrub (1–5m tall, approximately 20–40 years of age), and treed (> 5 m tall, approximately 30–50 years of age). The categories were further divided into two vegetation types (bog and coniferous) based on moisture regime (upland versus lowland).

Results

The accuracy of the resulting Ecosite map, taking into consideration the newly created regenerating forest "Ecosite types" was 70.7%, and included 23 different land cover classifications (Figure 2.1-3). The most abundant land cover types in the RSA were RF2-C (regenerating coniferous forest) (26.2%), BS3 (jack pine / blueberry / lichen) (25.8%), and water bodies (20.9%). These three land cover types accounted for 72.9% of the RSA. The most abundant land cover types in the LSA were RF2-C (regenerating coniferous forest) (38.4%) and BS3 (jack pine / blueberry / lichen) (33.8%), accounting for 72.2% of the LSA (Table 2.1-5).

The Ecosite map outlined several areas of unburned residual patches that were mapped as burned in the fire map provided by SkMOE (Figure 2.1-2). Findings from other studies in the region have documented this as well. Kansas *et al*. (2016) studied the potential for residual fire patches to occur in the Saskatchewan Boreal Shield and documented that 25% of the area within mapped fire polygons was unburned (excluding water, which accounted for 8% of the area). Residual patches therefore can make up a considerable amount of the landscape within this region. Notwithstanding, refined project specific mapping demonstrates that that 43.4% of the LSA and 37.6% of the RSA has burned within the last 40 years.

2.2 Ecosite Characterization, Plant Structural Diversity, and Species Richness Assessment

The purpose of the detailed vegetation and wildlife habitat characterization field surveys was to describe and quantify the ecological and botanical conditions within recurring mapped Ecosite types and regeneration forests. By sub-sampling sites representative of each mapped Ecosite type and regeneration stage, information was obtained to describe, evaluate and map the relative ecological importance and integrity of landscapes in the study area. The data collected at sampling sites also allowed for an evaluation of structural and compositional diversity and species richness components. Data on wildlife habitat included information regarding downed woody debris, standing dead tree (snag) frequency, diameter and decay class, and hiding cover (horizontal foliar diversity).

Structural diversity is a measure of the manner in which species are arranged vertically into categories within an ecosystem (Kimmins 1997). Vegetation structure is therefore based on size and physical features (e.g. trees, tall shrubs, forbs, etc.) rather than taxonomy. The structural complexity of an ecological community is positively correlated with the diversity of animal life (Meffe *et al.* 1997). This is especially true for vertebrate wildlife species that require unique and variable reproductive, forage, and cover opportunities or "niches" for survival and reproduction. Areas with high structural diversity also tend to provide greater amounts of hiding cover.

The number of species present and their relative abundance are measures of species diversity and richness (Kimmins 1997). A fundamental principle of conservation biology is to protect sites that support high levels of local "species richness" (the number of organisms present in an area) (Noss 1990; Council on Environmental Quality 1993). Ecosystems that support a high level of diversity of plant species tend to be structurally diverse and productive (Meffe *et al*. 1997) and these areas in turn support a wide variety and abundance of insect and animal forms.

2.2.1 Methods

Data Collection for Ecosites and Regeneration Forests

In order to describe and classify the vegetation cover types, data for five main vegetation components and four structural components were collected:

<u>Vegetation components:</u>

1) Woody plants
2) Graminoids
3) Forbs
4) Bryophytes
5) Lichens

<u>Structural components:</u>

1) Standing dead trees (Snags)
2) Course woody debris (CWD)
3) The percent cover of bare soil, rock, and open water
4) Foliar and horizontal hiding cover

Woody plants were segregated by tree and shrub layer. These were further divided into the following five sub-layers:

A) Trees were defined as *all* woody plants greater than 5 m tall. Within the tree layer, three sub-layers were recognized:

A1) Super canopy - included the tallest trees of the main canopy, which may be veterans of one or more fires, or the tallest trees of the same age class as the main canopy (usually a minor portion of the stand composition).

A2) Main tree canopy (co-dominant trees) - the main layer of tree cover, composed of trees whose crowns form the upper layer of foliage; typically the major portion of the stand composition.

A3) Sub-canopy trees - included trees greater than 5 m high that do not reach the main canopy. These may form a distinct secondary canopy and were often a mixture of trees of various heights younger than those in the main canopy, or they were suppressed trees of the same age.

To be defined as a multi-layer tree stand, tree layers had to differ by 2 m before being defined as a separate layer.

B) The shrub layer included all woody plants less than 5 m tall. Established tree species regeneration less than 5 m in height was considered part of the shrub layer. Two sub-layers were recognized:

B1) Tall shrub layer - included all woody plants 1-5 m tall, including shrubs and advanced tree regeneration and trees in poorly growing stands where the canopy was less than 5 m high.

B2) Low shrub layer - included all woody plants less than 1 m height. This layer included dwarfed or immature specimens of species normally considered in tall shrub or tree layers (Figure 2.2-1).

Graminoids (Gr) were defined as grasses and grass like species such as sedges and rushes. Forbs (Fo) were defined as herbaceous flowering plants that were not graminoids. Bryophytes (Br) include mosses and liverworts, whereas lichens (Li) were limited to terrestrial lichen species.

Snags were defined as standing dead trees greater than 10 cm diameter at breast height (DBH), and 2 meter in height. These were categorized into species and stages of decay based on criteria developed by Lee *et al.* (1995) (Figure 2.2-2). Course woody debris comprised any deadfall greater than 10 cm in diameter.

Each vegetation/wildlife habitat plot sampling site consisted of a main plot (30 m x 20 m); five 1 x 1 m sub-plots; and five 20 x 50 cm sub plots (Figure 2.2-3), see Skatter *et al.* 2014 and Charlebois *et al*. 2015 for details. A 30 m tape was laid out to establish the start and end points of the sample site. The main plots comprised a 10 m band on either side of the 30 m transect. The 1 x 1 m sub-plots were placed at 5 m intervals along the sampling transect, and the 20 x 50 cm sub-plots were placed within the 1 x 1 m sub-plots. UTM locations for the start and end points of the 30 m transect were recorded, and a photograph was taken of each sampling site.

Data for tree layers and the tall shrub layer, as well as snag info were collected in the main 30 m x 20 m plots. Each tree layer was assigned its own species composition, percentage canopy closure, median height, and DBH. Tree core samples were taken to determine the age of representative trees for each layer. The percentage canopy closure and median height of tall shrub species within the 30 x 20 m main plot were measured. The number and decay class (Lee *et al.* 1995) of CWD intercepts along the 30 m tape were recorded. In each of the 1 x 1 m sub-plots the percent covers of each low shrub, forb and graminoid species were recorded. In the 20 x 50 cm sub-plots percent covers of bryophyte and lichen species as well as bare soil, rocks and open water were estimated. Plant species that could not be identified in the field were collected, pressed, and provided to a plant taxonomist for identification. The level of hiding cover afforded by vegetation within each vegetation cover type was measured using methods developed by Nudds (1977). A canvas cloth with ten alternating 25 x 30 cm bands of white and red paint at heights of from ground level to 2.5 m was held up and viewed in four cardinal directions at a distance of 15 m from the plot centre (Figure 2.2-4). The percentage of each of the ten bands that was hidden by vegetation was estimated to the nearest 10%.

Data Presentation for Ecosites and Regeneration Stages

A detailed description of each of the Ecosite types sampled is provided in the form of a two-page fact sheet. The first fact sheet contains information about species composition and vegetation layers. The second sheet provides information about structural attributes and ratings as well as biodiversity information and Ecosite supply. An example of each of the two fact sheets is provided in Figure 2.2-5 and Figure 2.2-6. Instructions on how to read the fact sheets are provided below.

An identification banner at the top of each fact sheet provides the Ecosite code [1] and the Ecosite name followed by the number of sampling plots completed [2] (Figure 2.2-5). The codes and names follow McLaughlan *et al.* (2010). For habitats that did not match any of the Ecosites described in McLaughlan *et al.* (2010), a two letter and one number code was assigned. These were predominantly the post fire regenerating stages. These would in most cases be classified as BS3(jack pine/blueberry/lichen) or BS2 (lichen/felsenmeer- bedrock), however as McLaughlan *et al* (2010) do not describe forests younger than 40 years, there are a high portion of areas that would be excluded because there are large areas of young forest in the project area. By describing each regeneration stage, these younger forests and their attributes will be described in detail.

The name of the Ecosite conveys information about the ecology of the unit, as the species and soil conditions used to name the site are diagnostic of the Ecosite (McLaughlan *et al.* 2010). A sample photograph [3] taken from one of the plots for each Ecosite provides a pictorial representation of the site. A short text description [4] of the Ecosite is provided under the Ecosite Description heading. This description is usually taken directly from McLaughlan *et al.* 2010, with additional study area specific comments where applicable.

A bar graph [5] is used to depict the mean percent cover of each vegetation layer. The Species and Vegetation Layer Info section [6] provides the average, minimum, and maximum number of plant and lichen species per sample plot. Detailed botanical and structural information for each vegetation layer in the Ecosite is provided in two separate tables. The first table provides information (total number of species observed; average crown closure; mean tree height; mean diameter at breast height (DBH); species composition; year of origin) for each tree layer (A1, A2, and A3).

The second table provides botanical and structural information for all remaining vegetation layers, including: total number of species observed; characteristic species; and, average percentage cover.

On the second fact sheet the Structural Attributes and Relative Rating table [7] provides information about snags (mean number per plot; mean snag diameter; mean snag height; and mean snag decay class); course woody debris (CWD) (mean frequency per plot; mean diameter; and mean decay class); and mean percent cover of litter, bare soil, bare rock and open water (Figure 2.2-6). A bar graph [8] is displayed to show the vertical distribution of hiding cover for the Ecosite. Each bar represents the average hiding cover for each 25 cm layer. The overall average hiding cover (for all vertical layers) per Ecosite is presented at the top of the graph.

Section [9] of the second fact sheet page provides information about structural diversity (value), species richness (average number of species per plot), and unique and rare species occurrences (total numbers observed per Ecosite). A rating for each of these values is provided in a separate column.

Section 10 (Ecosite Supply) shows the relative proportion of LSA and RSA occupied by the Ecosite. Section 11 (Ecological Interpretations) is taken primarily from McLaughlan *et al*. (2010). It provides a written description of how the site may respond to disturbances such as fire, harvesting, etc. It may also include a predicted successional trajectory of the Ecosite.

Plant Structural Diversity and Species Richness Assessments

A structural diversity index value was calculated for each sampled Ecosite using a Shannon-Wiener coefficient. This calculation took into account the number of vegetation layers present in each plot as well as the percent cover of each layer. Due to similarity in height, bryophytes and lichens were considered as one layer. A mean value for each Ecosite was calculated. The higher the number of cover and evenness of vegetation layers present, the higher the structural diversity value.

To estimate and rank the relative plant and lichen species diversity among the different Ecosite types in the Wheeler River LSA, two species richness measures were used. The two measures of diversity are based on plant and lichen species data collected during the field survey in the LSA. The first measure, total species richness of Ecosite types, was developed by dividing the total number of plant species found in sampling plots by the number of plots completed per Ecosite. A second diversity metric was a count of the number of plant species that were unique to each Ecosite type. It was assumed that unequal sample size did not affect the probability of finding unique species. Both types of measures were ranked-ordered by Ecosite and rated from Low to High.

2.2.2 Results

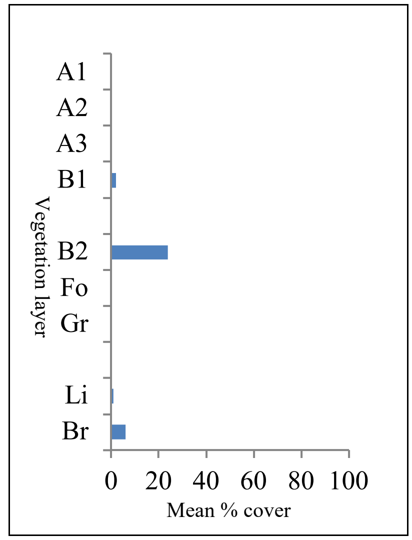
Vegetation and wildlife habitat characterization field surveys were completed between July 7 and July 16, 2017. Sample site locations were widely distributed throughout the study area (Figure 2.2-7), with a focus on the LSA. A total of 194 species and/or genus of spp. were recorded during the vegetation field survey. A list of all plant and lichen species is provided in Appendix 2.

A total of 78 vegetation/wildlife habitat sampling plots were completed in the Wheeler River Project area. From two to five sample plot sites were completed in each Ecosite. Based on species composition and structural attributes, a total of 20 distinct Ecosite types or regeneration forest types were identified:

Code	Type
RF3	Regenerating forest - low shrub dominated
RF2	Regenerating forest - tall shrub dominated
RF1	Regenerating forest - tree dominated
BS3	Jack pine/blueberry/lichen
BS4	Jack pine - black spruce/feathermoss
BS7	Black spruce/blueberry/lichen
BS9	Black spruce - jack pine/feathermoss
BS16	Black spruce/balsam poplar/river alder swamp
BS17	Black spruce treed bog
BS18	Labrador tea shrubby bog
BS19	Graminoid bog
BS20	Open bog
BS21	Tamarack treed fen
BS22	Leatherleaf shrubby poor fen
BS23	Willow shrubby rich fen
BS24	Graminoid fen
BS25	Open fen
BS26	Rush sandy shore
BS27	Sedge rocky shore
DL1	Disturbed lands - vegetated

Plot sampling was not completed for Waterbody (LK) and Disturbed lands – non vegetated (DL2), hence no Ecosite Fact Sheets were developed. Fact sheets for each of the remaining 20 Ecosite types are provided below.

RF3 **Regenerating forest – low shrub dominated** (n=4)



Ecosite Description

The RF3 regeneration stage is a pioneer stage following forest fires, and is therefore low shrub dominated. Blueberry and jack pine are the most common low shrub species, although cranberry is found in some plots. There are scattered tall shrubs as well, including black spruce and jack pine. The ground is characterized by a high percentage cover of bare soil and litter. Forbs, graminoids, mosses and lichens are virtually absent. The average age of this stage is 12 years in the study area.

Species and Vegetation Layer Info

Average number plant and lichen species per plot (min, max): 6 (3, 11)

Tree Layer Info:

Tree Layer	Total # Species	Crown Closure	Mean Height	Mean DBH	Species Composition	Year of Origin
A1 (n=0):						
A2 (n=0):						
A3 (n=0):						

Lower Vegetation Layer info:

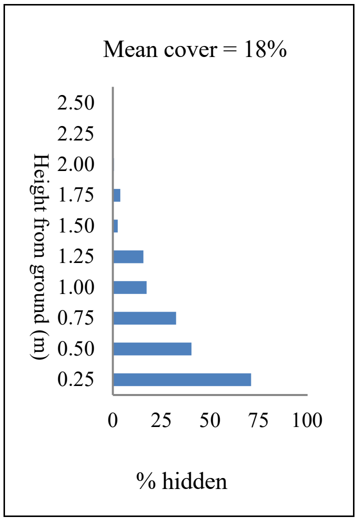
Vegetation Layer	Total # Species	Percentage Cover	Species Composition*
B1	2	2%	Pinuban10
B2	2	24%	Vaccmyr5 Pinuban5
Forb			
Graminoid			
Lichen	9	1%	Cladcor3 Cladmit2 Claddef1 Cladfim1 Cladsp.1 Parmamb1 Vulppin1
Bryophyte	1	6%	Polyjun10

*Only including species that constitute 10% or more by composition.

RF3 **Regenerating forest – low shrub dominated** (n=4)

Structural Attributes and Relative Rating

Structural Component	Attribute	Value	Rating
Snags	Mean # of snags/plot	0.8	Moderate
	Mean snag diameter (cm)	11.2	
	Mean snag height (m)	3.4	
	Mean snag decay Class	3.0	
Course Woody Debris	Mean frequency of CWD	0.5	Low
	Mean CWD diameter (cm)	10	
	Mean CWD decay class	3.0	
Mean Percent Ground Cover	Litter Cover	42.6	High
	Litter Depth (cm)	0.6	Low
	Bare Soil	49.8	High
	Bare Rock	0.0	Low
	Open Water	0.0	Low

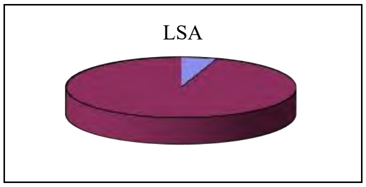


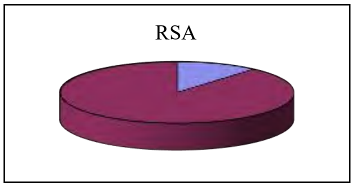
Structural Diversity, Species Richness, and Unique and Rare Species Occurrence Evaluation

Attribute	Value	Rating
Structural diversity	0.7	Low
Species richness	6	Low
Unique species	0	Low
Provincially listed species	0	Low
Unique species observed: None		
Provincially listed species observed: None		

Ecosite Supply

Areas occupied by the RF3 ecosite comprised 237.1 ha (5%) of the LSA and 4536.9 ha (11.3%) of the RSA.

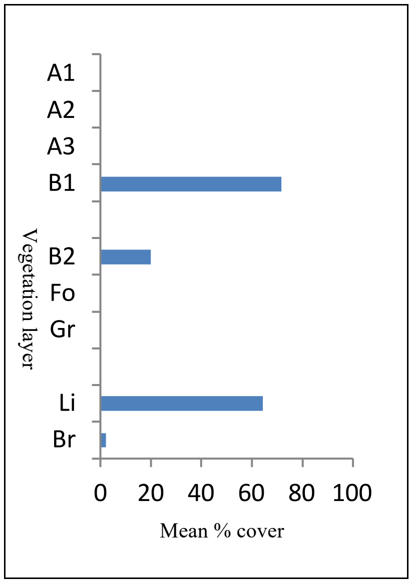




Ecological Interpretation

This is a commonly encountered ecosite in the study area. They are associated with the hills of eskers and drumlins as well as level plains. RF3 ecosites are poor in plant and lichen species diversity. The RF3 ecosite is a pioneer stage following forest fires, and will succeed towards RF2 in absence of fire.

RF2 **Regenerating forest – tall shrub dominated** (n=4)



Ecosite Description

This regeneration stage is usually dominated by a thick cover of tall jack pine shrubs. Some areas have residual patches of trees within. The low shrub layer is dominated by blueberry. The dominant ground cover is reindeer lichen. The average age of this phase is 36 years in the study area.

Species and Vegetation Layer Info

Average number plant and lichen species per plot (min, max): 15 (10, 21)

Tree Layer Info:

Tree Layer	Total # Species	Crown Closure	Mean Height	Mean DBH	Species Composition	Year of Origin
A1 (n=1):	1	<1%	6.0 m	5.0 cm	Pj10	1988
A2 (n=0):						
A3 (n=0):						

Lower Vegetation Layer info:

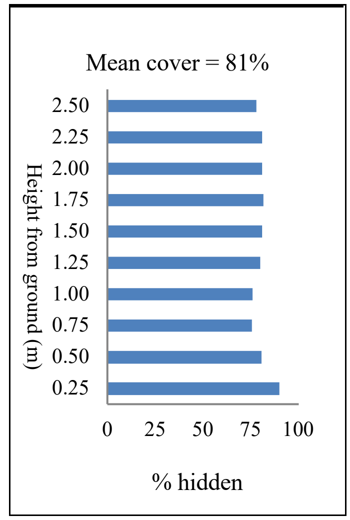
Vegetation Layer	Total # Species	Percentage Cover	Species Composition*
B1	3	72%	Pinuban10
B2	8	20%	Vaccmyr7 Ledugro1 Chamcal1
Forb	2	<1%	Corncan8 Lycoann2
Graminoid			
Lichen	16	65%	Cladmit9
Bryophyte	5	2%	Pleusch5 Polyjun4 Polypil1

*Only including species that constitute 10% or more by composition.

RF2 **Regenerating forest – tall shrub dominated** (n=4)

Structural Attributes and Relative Rating

Structural Component	Attribute	Value	Rating
Snags	Mean # of snags/plot	0.0	Low
	Mean snag diameter (cm)		
	Mean snag height (m)		
	Mean snag decay Class		
Course Woody Debris	Mean frequency of CWD	0.3	Low
	Mean CWD diameter (cm)	11.0	
	Mean CWD decay class	3.0	
Mean Percent Ground Cover	Litter Cover	33.0	High
	Litter Depth (cm)	1.1	Moderate
	Bare Soil	1.3	Low
	Bare Rock	0.0	Low
	Open Water	0.0	Low

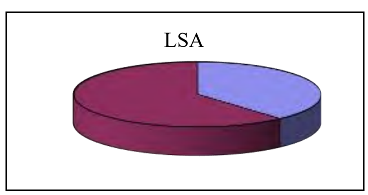


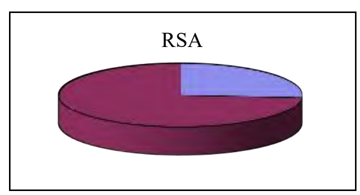
Structural Diversity, Species Richness, and Unique and Rare Species Occurrence Evaluation

Attribute	**Value**	**Rating**
Structural diversity	1.0	Low
Species richness	15	Moderate
Unique species	1	Low
Provincially listed species	0	Low
Unique species observed: Wooden soldiers (*Cladonia botrytes*)		
Provincially listed species observed: None		

Ecosite Supply

Areas occupied by the RF2 ecosite comprised 1822.5 ha (38.4%) of the LSA and 10480.5 ha (26.2%) of the RSA. It is the most common ecosite in the area.

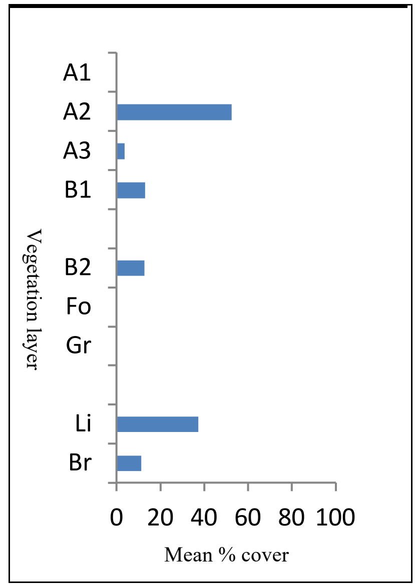




Ecological Interpretation

RF2 ecosites are relatively poor in vascular species diversity. However, lichen diversity is relatively high. They closely resemble the RF1 ecosite but are generally younger. As the case is for RF3, this is a commonly encountered ecosite on the Boreal Shield. They are associated with the hills of eskers and drumlins as well as level plains. The RF2 ecosite succeeds the RF3 ecosite, and will continue to succeed towards RF1 in absence of fire.

RF1 **Regenerating forest – tree dominated** (n=4)



Ecosite Description

RF1 rgeneration stage is usually jack pine dominated. Blueberry and bog cranberry shrubs can be found beneath the tree canopy, along with jack pine and the occasional black spruce and Labrador tea. Bryophytes are sporadically distributed and the dominant ground cover is reindeer lichen. This phase is on average 40 years old in the study area.

Species and Vegetation Layer Info

Average number plant and lichen species per plot (min, max): 16 (13, 18)

Tree Layer Info:

Tree Layer	Total # Species	Crown Closure	Mean Height	Mean DBH	Species Composition	Year of Origin
A1 (n=0):						
A2 (n=6):	2	53%	7.2 m	7.6 cm	Pj10	1980
A3 (n=1):	1	4%	5.8 m	5.7 cm	Pj10	1987

Lower Vegetation Layer info:

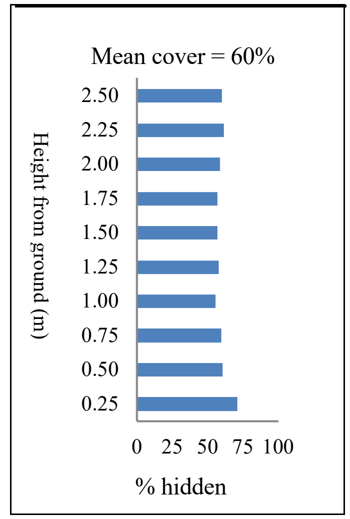
Vegetation Layer	Total # Species	Percentage Cover	Species Composition*
B1	3	13%	Pinuban6 Alnucri3 Picemar1
B2	3	13%	Vaccmyr8 Vaccvit1 Ledugro1
Forb			
Graminoid			
Lichen	20	37%	Cladmit9
Bryophyte	7	11%	Pleusch9

*Only including species that constitute 10% or more by composition.

RF1 **Regenerating forest – tree dominated** (n=4)

Structural Attributes and Relative Rating

Structural Component	Attribute	Value	Rating
Snags	Mean # of snags/plot	0.0	Low
	Mean snag diameter (cm)		
	Mean snag height (m)		
	Mean snag decay Class		
Course Woody Debris	Mean frequency of CWD	1.8	High
	Mean CWD diameter (cm)	11.5	
	Mean CWD decay class	5.7	
Mean Percent Ground Cover	Litter Cover	50.4	High
	Litter Depth (cm)	1.1	Moderate
	Bare Soil	0.0	Low
	Bare Rock	0.0	Low
	Open Water	0.0	Low

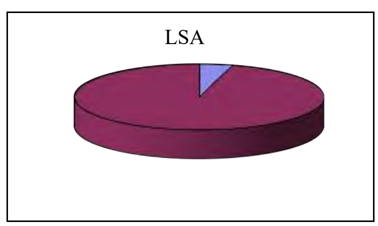


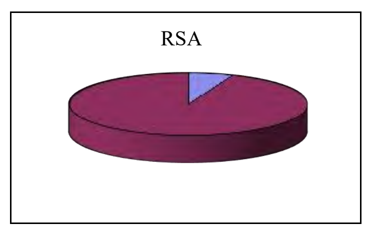
Structural Diversity, Species Richness, and Unique and Rare Species Occurrence Evaluation

Attribute	Value	Rating
Structural diversity	1.3	Moderate
Species richness	16	Moderate
Unique species	0	Low
Provincially listed species	0	Low
Unique species observed: None		
Provincially listed species observed: None		

Ecosite Supply

Areas occupied by RF1 comprised 199.3 ha (4.2%) of the LSA and 2401.8 ha (6.0%) of the RSA.

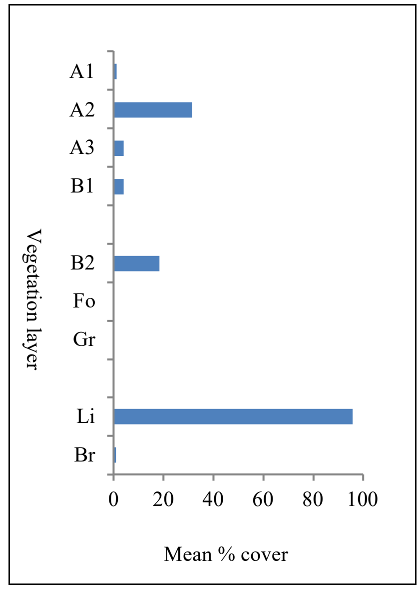




Ecological Interpretation

RF1 ecosites have a moderate structural diversity and high species richness. They closely resemble the RF2 ecosite but RF1 sites have a greater structural diversity and canopy closure. RF1 can be considered to be in a more advanced successional stage than RF2, and will (if wild fires are absent) succeed towards a BS3 or BS7 over time.

BS3 **Jack pine/blueberry/lichen: Moderately fresh sand** (n=4)



Ecosite Description

BS3 is dominated by jack pine in the overstory. The vascular plant understory is relatively sparse but includes Labrador tea, blueberry, and bog cranberry. Herbs are virtually absent. The forest floor is covered with reindeer lichen. Lichen species diversity is high. The age for this ecosite ranges from approximately 80 years old in the study area.

Species and Vegetation Layer Info

Average number plant and lichen species per plot (min, max): 17 (15, 19)

Tree Layer Info:

Tree Layer	Total # Species	Crown Closure	Mean Height	Mean DBH	Species Composition	Year of Origin
A1 (n=0):						
A2 (n=5):	1	27%	9.2 m	13.4 cm	Pj10	1938
A3 (n=6):	2	2%	7.2 m	9.0 cm	Pj9 Sb1	1962

Lower Vegetation Layer info:

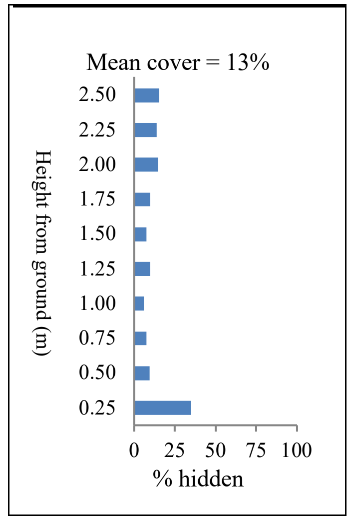
Vegetation Layer	Total # Species	Percentage Cover	Species Composition*
B1	2	4%	Pinuban10
B2	6	18%	Vaccmyr7 Vaccvit2 Ledugro1
Forb			
Graminoid			
Lichen	20	96%	Cladmit6 Cladunc2 Cladste1
Bryophyte	5	1%	Polypil6 Pholnut2 Polyjun1 Dicrpol1

*Only including species that constitute 10% or more by composition.

BS3 Jack pine/blueberry/lichen: Moderately fresh sand (n=4)

Structural Attributes and Relative Rating

Structural Component	Attribute	Value	Rating
Snags	Mean # of snags/plot	0.3	Low
	Mean snag diameter (cm)	10.1	
	Mean snag height (m)	0.9	
	Mean snag decay Class	5.0	
Course Woody Debris	Mean frequency of CWD	0.8	Moderate
	Mean CWD diameter (cm)	11.5	
	Mean CWD decay class	3.0	
Mean Percent Ground Cover	Litter Cover	25.5	Moderate
	Litter Depth (cm)	0.9	Moderate
	Bare Soil	1.8	Low
	Bare Rock	0.0	Low
	Open Water	0.0	Low



Structural Diversity, Species Richness, and Unique and Rare Species Occurrence Evaluation

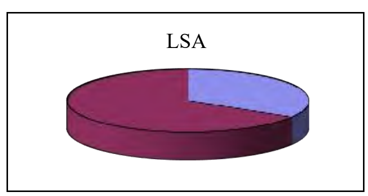
Attribute	**Value**	**Rating**
Structural diversity	1.0	Moderate
Species richness	17	Moderate
Unique species	3	Moderate
Provincially listed species	0	Low

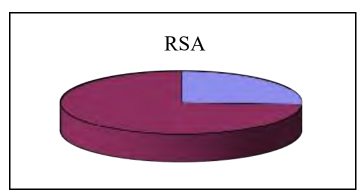
Unique species observed:
Pholia moss (*Pholia nutans*), Shingled Cladonia (*Cladonia scabriuscula*), Common bearberry (*Arctostaphylos uva-ursi*)

Provincially listed species observed:
None

Ecosite Supply

Areas occupied by Jack pine /blueberry /lichen forests comprised 1605.8 ha (33.8%) of the LSA and 10330.5 ha (25.8%) of the RSA.

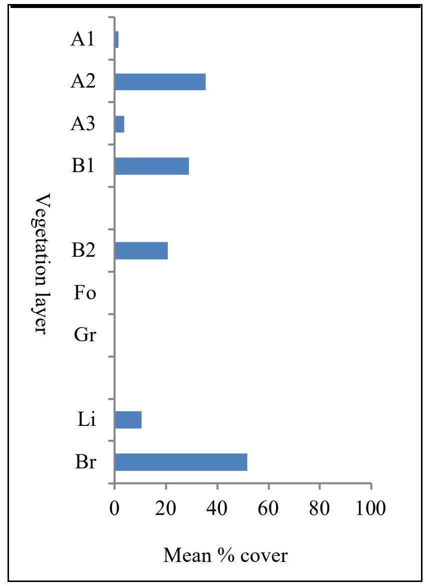




Ecological Interpretation

BS3 ecosites are relatively dry and occur in almost every topographic position and with every slope class. They are associated with the hills of eskers and drumlins as well as level plains. Following disturbance, these ecosites will usually return to being pine dominated, provided an adequate cone crop existed prior to disturbance. When compared to BS4 ecosites these ecosites tend to be drier, have less understory, and more open canopy. In the absence of disturbance, these ecosites may transition toward the BS7 ecosite condition.

BS4 **Jack pine – black spruce/feathermoss: Moderately dry sand** (n=4)



Ecosite Description

BS4 ecosite types are dominated by jack pine and black spruce in the overstory. Some of the sites encountered, however, may be pure jack pine. The understory of BS4 ecosite consists mainly of ericaceous shrubs, jack pine, green alder and black spruce. The forest floor is predominantly a mixture of litter as well as Schreber's moss and some reindeer lichen. The moisture regime of BS4 ecosites tends toward being relatively fresh and soils tend to be sandy loams and loamy sands. The age of this ecosite is approximately 55 years old.

Species and Vegetation Layer Info

Average number plant and lichen species per plot (min, max): 17 (14, 23)

Tree Layer Info:

Tree Layer	Total # Species	Crown Closure	Mean Height	Mean DBH	Species Composition	Year of Origin
A1 (n=3):	2	2%	9.9 m	11.0 cm	Sb8 Pj2	1955
A2 (n=6):	2	36%	8.6 m	10.4 cm	Pj9 Sb1	1962
A3 (n=3):	2	4%	6.5 m	7.3 cm	Pj10	1963

Lower Vegetation Layer info:

Vegetation Layer	Total # Species	Percentage Cover	Species Composition*
B1	4	29%	Pinuban8 Picemar1 Alnucri1
B2	5	20%	Ledugro5 Vaccmyr3 Vaccvit1
Forb	1	<1%	Lycoann10
Graminoid			
Lichen	14	11%	Cladmit6 Cladgra1 Peltneo1
Bryophyte	10	52%	Pleusch9

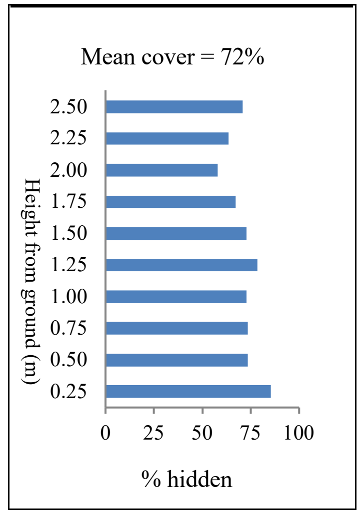
*Only including species that constitute 10% or more by composition.

BS4

Jack pine – black spruce/feathermoss: Moderately dry sand (n=4)

Structural Attributes and Relative Rating

Structural Component	Attribute	Value	Rating
Snags	Mean # of snags/plot	0.3	Low
	Mean snag diameter (cm)	15.1	
	Mean snag height (m)	5.5	
	Mean snag decay Class	2.0	
Course Woody Debris	Mean frequency of CWD	0.5	Low
	Mean CWD diameter (cm)	13.1	
	Mean CWD decay class	4.0	
Mean Percent Ground Cover	Litter Cover	40.4	High
	Litter Depth (cm)	2.2	Moderate
	Bare Soil	0.1	Low
	Bare Rock	0.0	Low
	Open Water	0.0	Low

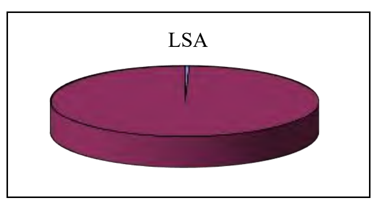


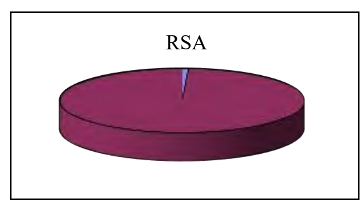
Structural Diversity, Species Richness, and Unique and Rare Species Occurrence Evaluation

Attribute	**Value**	**Rating**
Structural diversity	1.4	High
Species richness	17	Moderate
Unique species	1	Low
Provincially listed species	0	Low
Unique species observed: Carpet pelt (*Peltigera neopolydactyla*)		
Provincially listed species observed: None		

Ecosite Supply

Areas occupied by Jack pine-black spruce/feather moss comprised 22.8 ha (0.5%) of the LSA and 331.3 ha (0.8%) of the RSA.

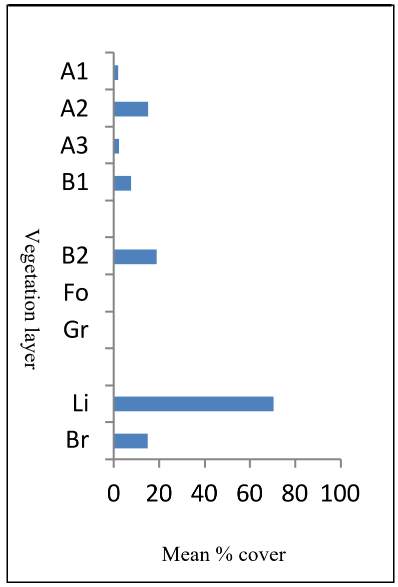




Ecological Interpretation

BS4 ecosites relatively are commonly encountered in the study area. While similar in overstory to BS3, they are moister, have a greater proportion of black spruce, are associated with a greater diversity of vascular plants, and have more of a closed canopy. Following fire, these sites will usually return to being pine and pine/spruce dominated. In the absence of disturbance these sites may transition toward the BS9 ecosite condition.

BS7 Black spruce/blueberry/lichen: Moderately dry sand (n=5)



Ecosite Description

BS7 is usually black spruce dominated and may be mixed with subdominant jack pine. A cover of ericaceous shrubs can be found beneath the tree canopy along with black spruce advanced. Forbs and graminoids are absent, and the dominant ground cover is reindeer lichen. These sandy sites are usually associated with upper and mid-slope topography on islands and peninsulas where wild fires are rare. The average age of this ecosite type is 90 years in the study area.

Species and Vegetation Layer Info

Average number plant and lichen species per plot (min, max): 20 (14, 25)

Tree Layer Info:

Tree Layer	Total # Species	Crown Closure	Mean Height	Mean DBH	Species Composition	Year of Origin
A1 (n=6):	2	2%	12.4 m	17.9 cm	Sb7 Pj3	1917
A2 (n=10):	2	15%	8.6 m	11.4 cm	Sb7 Pj3	1928
A3 (n=3):	1	2%	5.9 m	5.9 cm	Sb10	1974

Lower Vegetation Layer info:

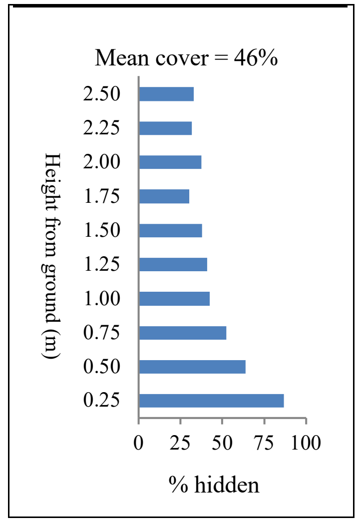
Vegetation Layer	Total # Species	Percentage Cover	Species Composition*
B1	6	8%	Picemar7 Pinuban2 Salibeb1 Alnucri1
B2	6	19%	Vaccmyr5 Ledugro3 Vaccvit2
Forb			
Graminoid			
Lichen	27	71%	Cladmit7 Cladste2 Cladran1
Bryophyte	8	15%	Pleusch8 Ptilcil1 Dicrpol1

*Only including species that constitute 10% or more by composition.

BS7 Black spruce/blueberry/lichen: Moderately dry sand (n=5)

Structural Attributes and Relative Rating

Structural Component	Attribute	Value	Rating
Snags	Mean # of snags/plot	0.6	Low
	Mean snag diameter (cm)	11.2	
	Mean snag height (m)	2.8	
	Mean snag decay Class	4.7	
Course Woody Debris	Mean frequency of CWD	2.4	High
	Mean CWD diameter (cm)	13.0	
	Mean CWD decay class	3.6	
Mean Percent Ground Cover	Litter Cover	10.7	Moderate
	Litter Depth (cm)	0.6	Low
	Bare Soil	0.0	Low
	Bare Rock	0.0	Low
	Open Water	0.0	Low



Structural Diversity, Species Richness, and Unique and Rare Species Occurrence Evaluation

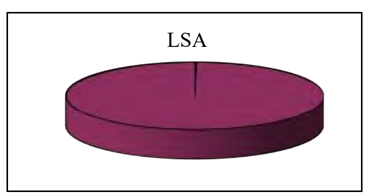
Attribute	Value	Rating
Structural diversity	1.1	Moderate
Species richness	20	High
Unique species	4	Moderate
Provincially listed species	0	Low

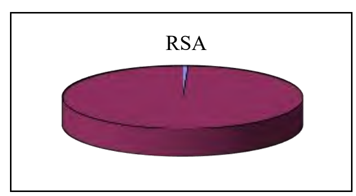
Unique species observed:
Greater sulphur-cup (Cladonia sulfurina), Common freckle pelt (Peltigera aphthosa), Dusty Gristle (Ramalina pollinaria), Blanket-leaf Willow (Salix silicicola)

Provincially listed species observed:
None

Ecosite Supply

Areas occupied by black spruce/ lichen forests comprised 9.6 ha (0.2%) of the LSA and 279.8 ha (0.7%) of the RSA.

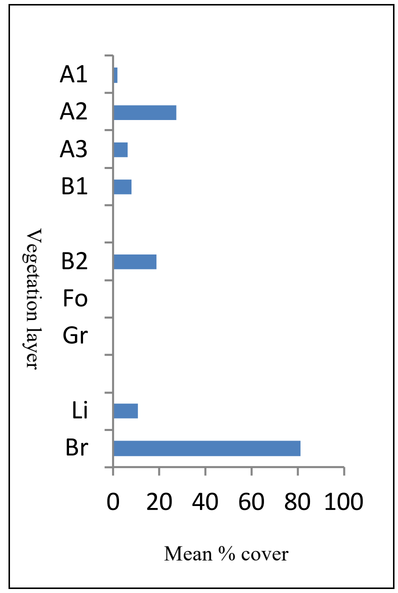




Ecological Interpretation

BS7 ecosites are relatively poor in vascular species diversity, but high in lichen species diversity. They closely resemble the BS3 ecosite but are spruce dominated and have slightly less canopy closure. Given the dry condition and lack of vascular species, these ecosites may return to their former condition following disturbance. BS7 can be considered to be in a climax condition. The low ground cover, relatively open canopy, and presence of black spruce in the understory are features that would tend to perpetuate the ecosite in the absence of disturbance.

BS9 **Black spruce – jack pine/feathermoss: Moderately dry sand** (n=4)



Ecosite Description

BS9 ecosite canopies are predominantly pure black spruce. These ecosites tend to have high stem density and closed canopy conditions. Ericaceous shrub cover is relatively high. One of the distinguishing features of this ecosite is the nearly continuous carpet of Schreber's moss. These sandy sites are usually associated with lower slope topography adjacent to lakes on islands and peninsulas where wild fires are rare. The average age of this ecosite in the study area is 70 years old.

Species and Vegetation Layer Info

Average number plant and lichen species per plot (min, max): 15 (10, 19)

Tree Layer Info:

Tree Layer	Total # Species	Crown Closure	Mean Height	Mean DBH	Species Composition	Year of Origin
A1 (n=2):	1	2%	10.3 m	14.2 cm	Sb10	1941
A2 (n=8):	2	28%	7.9 m	9.7 cm	Sb7 Pj3	1947
A3 (n=4):	2	6%	5.9 m	7.2 cm	Sb6 Pj4	1955

Lower Vegetation Layer info:

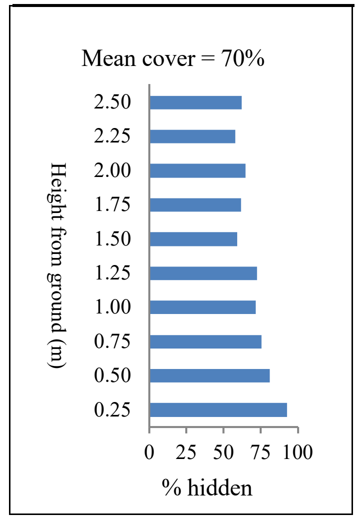
Vegetation Layer	Total # Species	Percentage Cover	Species Composition*
B1	4	8%	Picemar6 Pinuban3 Alnucri1
B2	6	19%	Ledugro6 Vaccvit2 Vaccmyr2
Forb			
Graminoid			
Lichen	13	11%	Cladmit7 Cladste1
Bryophyte	7	81%	Pleusch9

*Only including species that constitute 10% or more by composition.

BS9 **Black spruce – jack pine/feathermoss** (n=4)

Structural Attributes and Relative Rating

Structural Component	Attribute	Value	Rating
Snags	Mean # of snags/plot	1.0	Moderate
	Mean snag diameter (cm)	11.6	
	Mean snag height (m)	5.8	
	Mean snag decay Class	2.0	
Course Woody Debris	Mean frequency of CWD	0.3	Low
	Mean CWD diameter (cm)	10.0	
	Mean CWD decay class	5.0	
Mean Percent Ground Cover	Litter Cover	8.0	Low
	Litter Depth (cm)	0.9	Moderate
	Bare Soil	0.0	Low
	Bare Rock	0.0	Low
	Open Water	0.0	Low

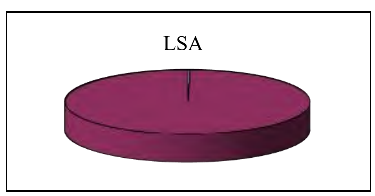


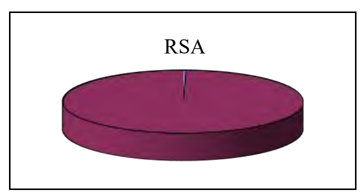
Structural Diversity, Species Richness, and Unique and Rare Species Occurrence Evaluation

Attribute	Value	Rating
Structural diversity	1.2	Moderate
Species richness	15	Moderate
Unique species	0	Low
Provincially listed species	0	Low
Unique species observed: None		
Provincially listed species observed: None		

Ecosite Supply

Areas occupied by black spruce-jack pine/feathermoss forests comprised 15.1 ha (0.3%) of the LSA and 147.8 ha (0.4%) of the RSA.

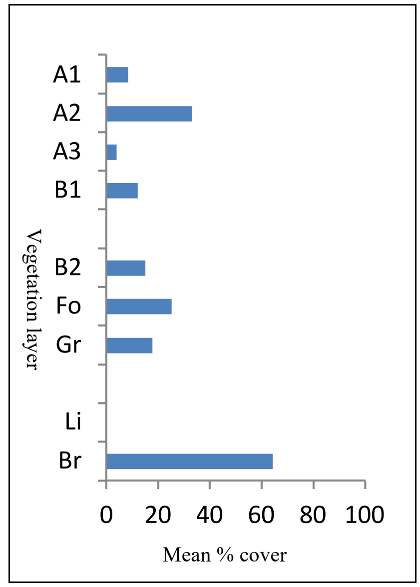




Ecological Interpretation

Although there is no herbaceous layer indicated for this ecosite, herbaceous diversity is relatively high. This is because the ecosite provides a range of microsite conditions that give refuge to a variety of herbaceous species that are not common enough to have a constancy value of > 40%. The lack of hardwood species and the occurrence of black spruce in the understory will likely lead to the perpetuation of this ecosite following fire or other disturbance.

BS16 **Black spruce/balsam poplar/river alder swamp: Very moist mesic organic** (n=3)



Ecosite Description

BS16 ecosites can, in the study area, occur with nearly pure birch overstories, both of which may have scattered black spruce present. Willows, birch and current species are common in the understory, as are a variety of herbaceous plants. In the ground layer feather moss is also frequently encountered. The average age of this ecosite is 55 years old.

Species and Vegetation Layer Info

Average number plant and lichen species per plot (min, max): 32 (28, 34)

Tree Layer Info:

Tree Layer	Total # Species	Crown Closure	Mean Height	Mean DBH	Species Composition	Year of Origin
A1 (n=4):	3	8%	10.9 m	13.7 cm	Sb4 Lt4 Bw2	1951
A2 (n=6):	3	33%	11.0 m	13.1 cm	Sb6 Bw3 Lt1	1962
A3 (n=3):	2	4%	9.1 m	13.3 cm	Sb8 Pb2	1957

Lower Vegetation Layer info:

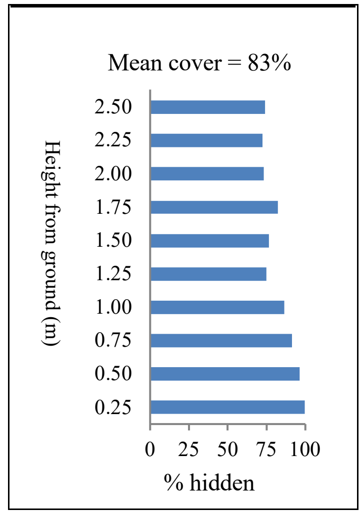
Vegetation Layer	Total # Species	Percentage Cover	Species Composition*
B1	8	12%	Betuocc3 Picemar3 Batupap2 Salidis1 Salisp.1
B2	15	15%	Myrigal5 Ribetri2 Rubuaca1 Rubuida1 Ledugro1
Forb	21	25%	Corncan3 Aralnud2 Violren2 Mentarv1 Potepal1
Graminoid	6	18%	Caredis6 Calacan3 Careutr1
Lichen			
Bryophyte	13	65%	Sphasqu2 Spharip2 Plagell2 Callgig1 Aulapal1 Ptilpul1

*Only including species that constitute 10% or more by composition.

BS16 **Black spruce/balsam poplar/river alder swamp: Very moist mesic organic** (n=3)

Structural Attributes and Relative Rating

Structural Component	Attribute	Value	Rating
Snags	Mean # of snags/plot	2.0	High
	Mean snag diameter (cm)	18.6	
	Mean snag height (m)	5.4	
	Mean snag decay Class	3.3	
Course Woody Debris	Mean frequency of CWD	2.3	High
	Mean CWD diameter (cm)	12.8	
	Mean CWD decay class	5.1	
Mean Percent Ground Cover	Litter Cover	33.7	High
	Litter Depth (cm)	6.8	High
	Bare Soil	0.0	Low
	Bare Rock	0.0	Low
	Open Water	0.0	Low



Structural Diversity, Species Richness, and Unique and Rare Species Occurrence Evaluation

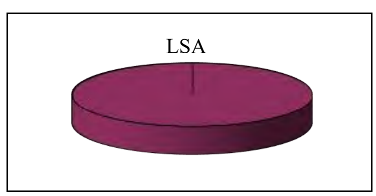
Attribute	Value	Rating
Structural diversity	1.8	High
Species richness	31	High
Unique species	15	High
Provincially listed species	0	Low

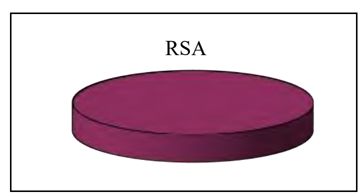
Unique species observed: Drepanocladus moss (*Drepanocladus aduncus*), Peat moss (*Sphagnum riparium*), Floating Hook Moss (*Warnstorfia fluitans*), Wild sarsaparilla (*Aralia nudicaulis*), Bulb-bearing water hemlock (*Cicuta bulbifera*), Water horsetail (*Equisetum fluviatile*), Threepetal bedstraw (*Galium trifidum*), Lapland buttercup (*Ranunculus lapponicus*), Running raspberry (*Rubus pubescens*), Starflower (*Trientalis borealis*), Hookspur violet (*Viola adunca*), Twinflower (*Linnea borealis*), Skunk currant (*Ribes glandulosum*), Wild red currant *(Ribes triste*), Raspberry *(Rubus idaeus*)

Provincially listed species observed: None

Ecosite Supply

No areas with the black spruce/balsam poplar/river alder swamp ecosite were located in the LSA, however 8.7 ha (<0.1%) were located in the RSA.

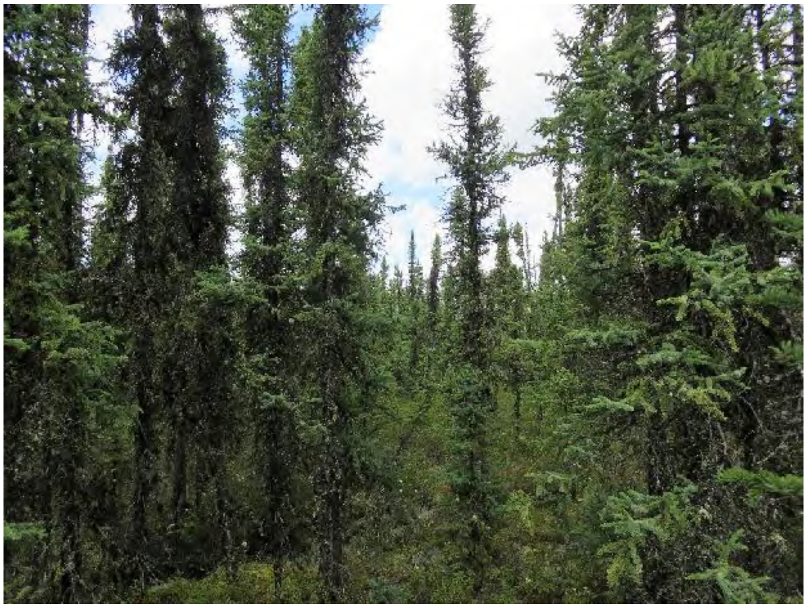


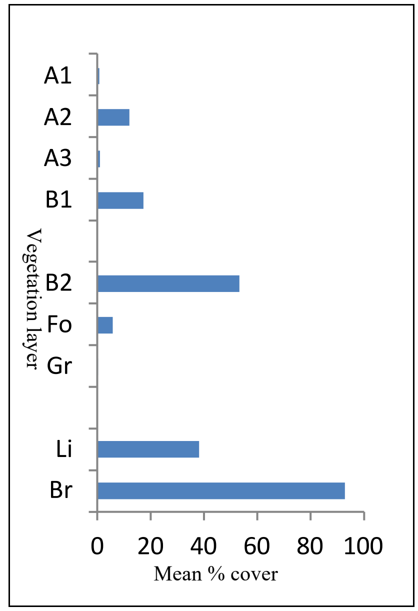


Ecological Interpretation

BS16 is uncommon in the study area. They are associated with transition positions on the landscape between wetlands and uplands, i.e. riparian areas. It is common for these sites to have abundant flowing water. Due to their position and adequate drainage, they are among the richest ecosites in the study area, both in terms of number of species, structural diversity, and number of unique species. They also have high amounts of litter and course woody debris contributing to increased number of micro habitats for numerous vertebrate and invertebrate species. SA16 is relatively stable and may return to their former composition following disturbance or stay in that condition in the absence of disturbance.

BS17 Black spruce treed bog: Very moist mesic organic (n=4)





Ecosite Description

BS17 ecosites have a somewhat open canopy of black spruce an average age of 90 years old. The understory is largely ericaceous shrub (mostly Labrador tea) and the ground cover is dominated by several peat moss species.

Species and Vegetation Layer Info

Average number plant and lichen species per plot (min, max): 20 (17, 23)

Tree Layer Info:

Tree Layer	Total # Species	Crown Closure	Mean Height	Mean DBH	Species Composition	Year of Origin
A1 (n=2):	1	<1%	9.2 m	11.8 cm	Sb10	1914
A2 (n=6):	1	12%	7.0 m	8.6 cm	Sb10	1926
A3 (n=1):	1	1	6.8 m	8.0 cm	Sb10	1903

Lower Vegetation Layer info:

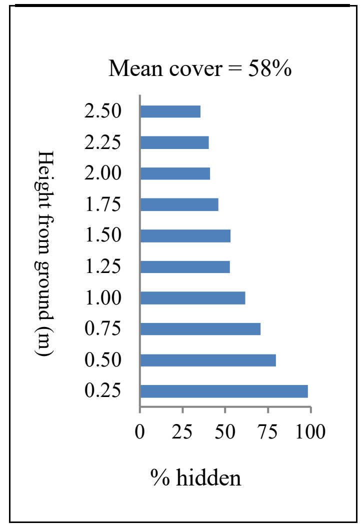
Vegetation Layer	Total # Species	Percentage Cover	Species Composition*
B1	1	18%	Picemar10
B2	13	54%	Ledugro5 Chamcal3 Ledupal1 Vaccvit1
Forb	4	6%	Rubucha9
Graminoid	1	<1%	Eriovag10
Lichen	9	38%	Cladmit9 Cladran1
Bryophyte	9	93%	Sphafus6 Sphaang2 Pleusch2

*Only including species that constitute 10% or more by composition.

BS17 Black spruce treed bog: Very moist mesic organic (n=4)

Structural Attributes and Relative Rating

Structural Component	Attribute	Value	Rating
Snags	Mean # of snags/plot	0.0	Low
	Mean snag diameter (cm)		
	Mean snag height (m)		
	Mean snag decay Class		
Course Woody Debris	Mean frequency of CWD	0.0	Low
	Mean CWD diameter (cm)		
	Mean CWD decay class		
Mean Percent Ground Cover	Litter Cover	14.0	Moderate
	Litter Depth (cm)	0.7	Low
	Bare Soil	0.0	Low
	Bare Rock	0.0	Low
	Open Water	0.0	Low



Structural Diversity, Species Richness, and Unique and Rare Species Occurrence Evaluation

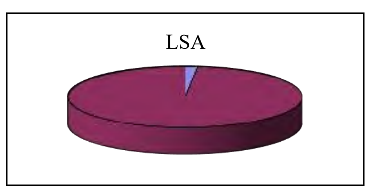
Attribute	Value	Rating
Structural diversity	1.2	Moderate
Species richness	19	Moderate
Unique species	3	Moderate
Provincially listed species	0	Low

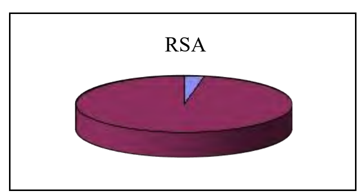
Unique species observed:
Woodland horsetail (*Equisetum sylvaticum*), Split-peg lichen (*Cladonia cariosa*), Creeping-Snowberry (*Gaultheria hispidula*)

Provincially listed species observed:
None

Ecosite Supply

Areas occupied by black spruce treed bog comprised 82.1 ha (1.7%) of the LSA and 1152.1 ha (2.9%) of the RSA.

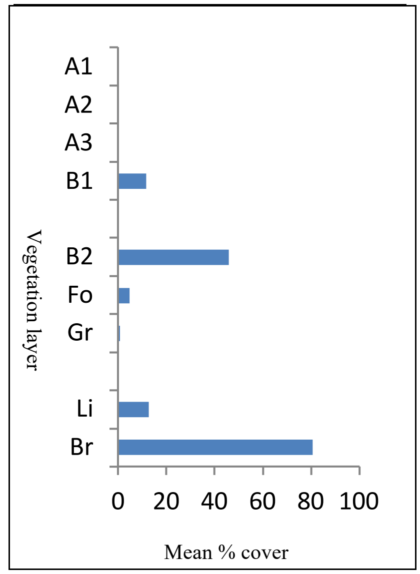




Ecological Interpretation

BS17 is common in the study area. The black spruce on these sites usually represents all ages as the *Sphagnum* moss on the site encourages vegetative reproduction by branch layering. Despite the wet conditions, black spruce can remain free from rot for long periods. In the absence of disturbance these sites will likely remain as a treed bog. Following disturbance these sites may more closely resemble BS18 or BS20.

BS18 **Labrador tea shrubby bog: Moderately wet mesic organic** (n=4)



Ecosite Description

BS18 is dominated by ericaceous shrubs, notably leatherleaf and Labrador tea. Occasionally black spruce trees may occur. Aside from the expected absence of trees, shrubby bogs tend to be very similar to treed bogs (BS17).

Species and Vegetation Layer Info

Average number plant and lichen species per plot (min, max): 19 (15, 26)

Tree Vegetation Layer Info:

Tree Layer	Total # Species	Crown Closure	Mean Height	Mean DBH	Species Composition	Year of Origin
A1 (n=1):	1	<1%	5.8 m	7.9 cm	Sb10	1903
A2 (n=2):	1	<1%	5.2 m	5.9 cm	Sb10	1974
A3 (n=1):						

Lower Layer info:

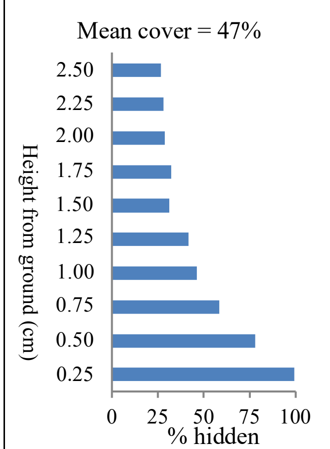
Vegetation Layer	Total # Species	Percentage Cover	Species Composition*
B1	3	12%	Picemar10
B2	10	46%	Chamcal4 Ledugro3 Ledupal2 Kalmpol1
Forb	6	5%	Rubucha7 Smiltri2
Graminoid	4	<1%	Eriovag5 Careaqu3 Careoli1 Carepau1
Lichen	11	13%	Cladmit6 Cladran3
Bryophyte	8	81%	Sphafus9

*Only including species that constitute 10% or more by composition.

BS18 Labrador tea shrubby bog: Moderately wet mesic organic (n=4)

Structural Attributes and Relative Rating

Structural Component	Attribute	Value	Rating
Snags	Mean # of snags/plot	0.0	Low
	Mean snag diameter (cm)		
	Mean snag height (m)		
	Mean snag decay Class		
Course Woody Debris	Mean frequency of CWD	0.0	Low
	Mean CWD diameter (cm)		
	Mean CWD decay class		
Mean Percent Ground Cover	Litter Cover	6.1	Low
	Litter Depth (cm)	0.6	Low
	Bare Soil	0.0	Low
	Bare Rock	0.0	Low
	Open Water	0.0	Low



Structural Diversity, Species Richness, and Unique and Rare Species Occurrence Evaluation

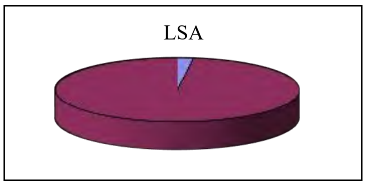
Attribute	Value	Rating
Structural diversity	1.0	Moderate
Species richness	19	Moderate
Unique species	1	Low
Provincially listed species	0	Low

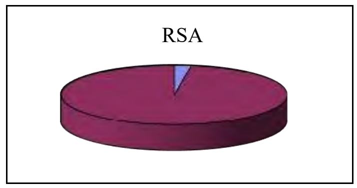
Unique species observed:
Woodland horsetail (*Equisetum pretense*)

Provincially listed species observed:
None

Ecosite Supply

Areas occupied by Labrador tea shrubby bog comprised 101.0 ha (2.1%) of the LSA and 963.4 ha (2.4%) of the RSA.

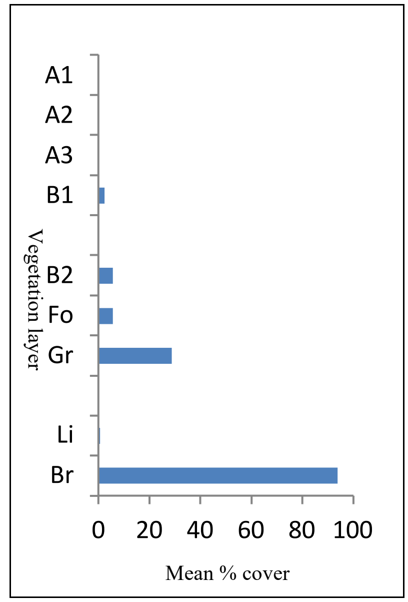




Ecological Interpretation

BS18 ecosites are commonly encountered in the study area. Like the other forms of bogs, most of the moisture they receive is the result of precipitation. Shrubby bogs, unlike treed bogs, are more likely to be found on level sites. Since the water table associated with shrubby bogs is usually below the site surface, they are also susceptible to disturbance from fire. Fires with a long enough duration or intensity may kill shrub species and the bog may transition into an open (BS20) or graminoid dominated (BS19) condition.

BS19 **Graminoid bog: Very wet humic organic** (n=4)



Ecosite Description

BS19 ecosites are dominated by sedges and other graminoids in association with peat moss species. They typically lack any substantial tree or shrub cover.

Species and Vegetation Layer Info

Average number plant and lichen species per plot (min, max): 15 (13, 17)

Tree Layer Info:

Tree Layer	Total # Species	Crown Closure	Mean Height	Mean DBH	Species Composition	Year of Origin
A1 (n=0):						
A2 (n=0):						
A3 (n=0):						

Lower Vegetation Layer info:

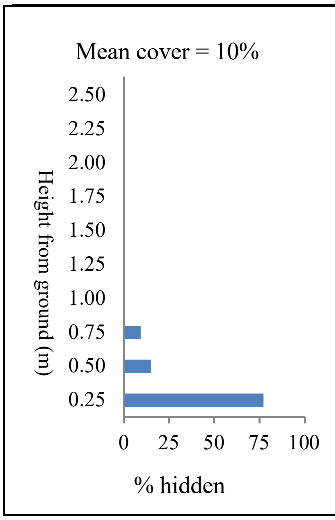
Vegetation Layer	Total # Species	Percentage Cover	Species Composition*
B1	2	2%	Picemar6 Larilar4
B2	6	6%	Andrpol5 Chamcal1 Kalmpol1 Oxycmic1
Forb	5	6%	Schepal6 Smiltri4
Graminoid	9	29%	Careoli3 Eriovag2 Careutr1 Careliv1 Caremag1 Juncbuf1
Lichen	1	<1%	Cladmit10
Bryophyte	7	94%	Sphafus5 Sphaang2 Sphagir1 Sphamaj1 Pleusch1

*Only including species that constitute 10% or more by composition.

BS19 Graminoid bog: Very wet humic organic (n=4)

Structural Attributes and Relative Rating

Structural Component	Attribute	Value	Rating
Snags	Mean # of snags/plot	0.0	Low
	Mean snag diameter (cm)		
	Mean snag height (m)		
	Mean snag decay Class		
Course Woody Debris	Mean frequency of CWD	0.0	Low
	Mean CWD diameter (cm)		
	Mean CWD decay class		
Mean Percent Ground Cover	Litter Cover	0.5	Low
	Litter Depth (cm)	0.3	Low
	Bare Soil	0.0	Low
	Bare Rock	0.0	Low
	Open Water	0.0	Low



Structural Diversity, Species Richness, and Unique and Rare Species Occurrence Evaluation

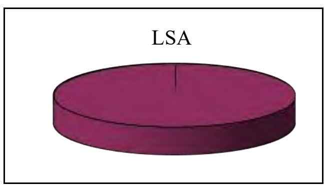
Attribute	**Value**	**Rating**
Structural diversity	0.9	Low
Species richness	15	Moderate
Unique species	1	Low
Provincially listed species	1	Low

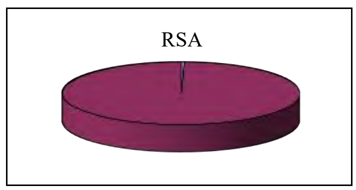
Unique species observed:
Short-tail Rush (*Juncus brevicaudatus*)

Provincially listed species observed:
Angle-leaved sundew (*Drosera anglica*)

Ecosite Supply

Areas occupied by a combination of BS19 and BS24 comprised 11.1 ha (0.2%) of the LSA and 171.2 ha (0.4%) of the RSA

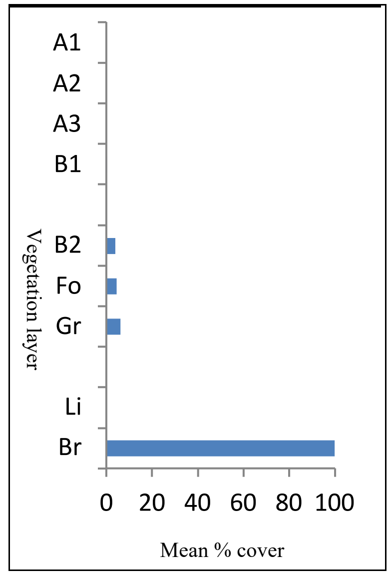




Ecological Interpretation

Graminoid bogs are infrequently encountered in the study area. While similar to graminoid fens (BS24) they lack fen species and standing water is not readily seen. Following disturbance by either fire or prolonged flooding, these sites will typically return to their former condition. However, they may revert to an open bog condition until the grasses become reestablished.

BS20 Open bog: Moderately wet fibric organic (n=4)



Ecosite Description

BS20 ecosites are dominated by peat moss species and have low cover values of shrubs and graminoids and forbs. Trees are completely lacking.

Species and Vegetation Layer Info

Average number plant and lichen species per plot (min, max): 12 (10, 15)

Tree Layer Info:

Tree Layer	Total # Species	Crown Closure	Mean Height	Mean DBH	Species Composition	Year of Origin
A1 (n=0):						
A2 (n=0):						
A3 (n=0):						

Lower Vegetation Layer info:

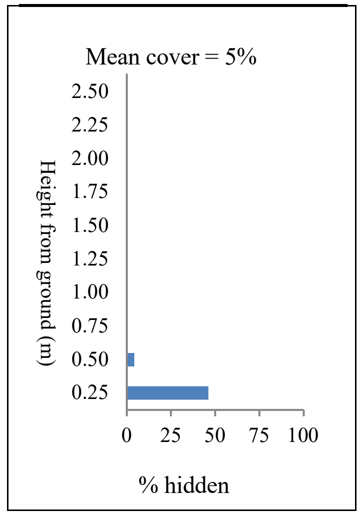
Vegetation Layer	Total # Species	Percentage Cover	Species Composition*
B1	1	<1%	Picemar10
B2	5	4%	Andrpol5 Chamcal3 Oxycmic2
Forb	5	4%	Schepal6 Drosrot2 Smiltri1
Graminoid	6	6%	Eriovag3 Juncbuf2 Eleoqui2 Carelim2 Caremag1
Lichen			
Bryophyte	3	100%	Sphafus5 Sphamaj4 Sphamag1

*Only including species that constitute 10% or more by composition.

BS20 Open bog: Moderately wet fibric organic (n=4)

Structural Attributes and Relative Rating

Structural Component	Attribute	Value	Rating
Snags	Mean # of snags/plot	0.0	Low
	Mean snag diameter (cm)		
	Mean snag height (m)		
	Mean snag decay Class		
Course Woody Debris	Mean frequency of CWD	0.0	Low
	Mean CWD diameter (cm)		
	Mean CWD decay class		
Mean Percent Ground Cover	Litter Cover	0.0	Low
	Litter Depth (cm)	0.0	Low
	Bare Soil	0.0	Low
	Bare Rock	0.0	Low
	Open Water	0.0	Low



Structural Diversity, Species Richness, and Unique and Rare Species Occurrence Evaluation

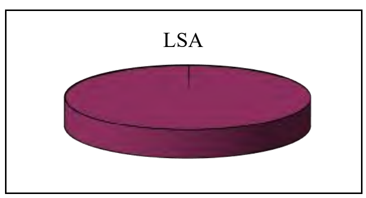
Attribute	Value	Rating
Structural diversity	0.5	Low
Species richness	12	Moderate
Unique species	1	Low
Provincially listed species	1	Low

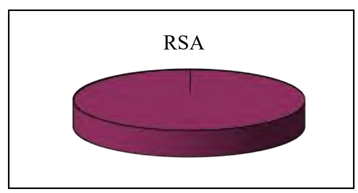
Unique species observed:
Few-flowered Spikerush (*Eleocharis quinqueflora*)

Provincially listed species observed:
Angle-leaved sundew (*Drosera anglica*)

Ecosite Supply

Areas occupied by BS20 comprised 4.8 ha (0.1%) of the LSA and 65.2 ha (0.2%) of the TSA.

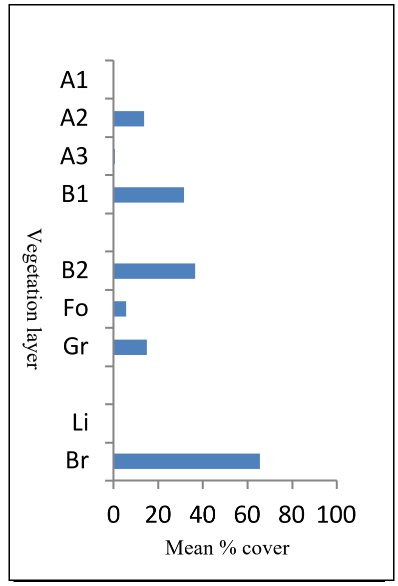




Ecological Interpretation

Open bogs are infrequently encountered in the study area. They tend to occur within treed or shrubby bogs (BS17 and BS18 respectively) which is why they more closely resemble those ecosites rather than graminoid bogs (BS19). Open bogs also tend to be wetter than their surrounding conditions. Over time, these ecosites could be expected to become a shrubby or treed bog.

BS21 **Tamarack treed fen: Wet fibric organic** (n=4)



Ecosite Description

BS21 ecosite has tamarack as the dominant tree species. Many of the shrub species encountered in fens are more commonly associated with moister conditions than that which would be found in bogs, such as gale and birch species. It is not uncommon for treed fens to have a water table at or near the surface. Treed fens are usually associated with an organic substrate but mineral soil substrates may also be encountered.

Species and Vegetation Layer Info

Average number plant and lichen species per plot (min, max): 19 (15, 21)

Tree Layer Info:

Tree Layer	Total # Species	Crown Closure	Mean Height	Mean DBH	Species Composition	Year of Origin
A1 (n=1):	1	<1%	9.9 m	15.9 cm	Lt10	1943
A2 (n=8):	2	14%	8.5 m	11.9 cm	Lt7 Sb3	1946
A3 (n=2):	2	<1%	8.3 m	9.3 cm	Lt5 Sb5	1970

Lower Vegetation Layer info:

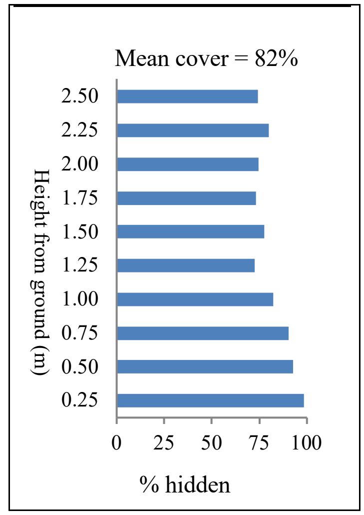
Vegetation Layer	Total # Species	Percentage Cover	Species Composition*
B1	7	32%	Betupum5 Picemar2 Larilar1 Betuocc1 Betugla1
B2	11	37%	Betupum5 Myrigal4
Forb	9	6%	Potepal4 Violpal3 Habeopt1 Mentarv1 Rubucha1
Graminoid	9	15%	Caredis4 Calacan3 Agrosca1 Careaqu1
Lichen			
Bryophyte	8	66%	Sphaang4 Sphasqu2 Tomenit2 Ptilpul1 Drepunc1

*Only including species that constitute 10% or more by composition.

BS21 Tamarack treed fen: Wet fibric organic (n=4)

Structural Attributes and Relative Rating

Structural Component	Attribute	Value	Rating
Snags	Mean # of snags/plot	0.3	Low
	Mean snag diameter (cm)	10.5	
	Mean snag height (m)	0.8	
	Mean snag decay Class	6.0	
Course Woody Debris	Mean frequency of CWD	0.0	Low
	Mean CWD diameter (cm)		
	Mean CWD decay class		
Mean Percent Ground Cover	Litter Cover	33.1	High
	Litter Depth (cm)	4.8	High
	Bare Soil	0.0	Low
	Bare Rock	0.0	Low
	Open Water	0.0	Low



Structural Diversity, Species Richness, and Unique and Rare Species Occurrence Evaluation

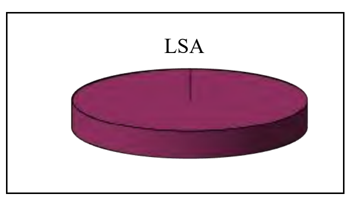
Attribute	Value	Rating
Structural diversity	1.6	High
Species richness	19	Moderate
Unique species	7	High
Provincially listed species	0	Low

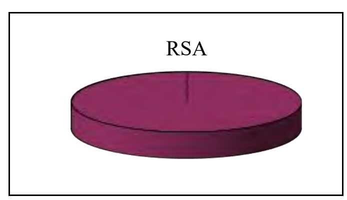
Unique species observed:
Calliergon moss (*Calliergon stramineum*), Brown moss (*Drepanocladus unciatus*), Threeleaf goldthread (*Coptis trifolia*), Blunt-leaved orchid (*Habenaria obtusata*), Northern reedgrass (*Calamagrostis inexpansa*), Sparseflower sedge (*Carex tenuiflora*), Autumn willow (*Salix serissima*)

Provincially listed species observed:
None

Ecosite Supply

Areas occupied by Tamarack treed fen comprised 14.7 ha (0.3%) of the LSA and 66.2 (0.2%) of the RSA.

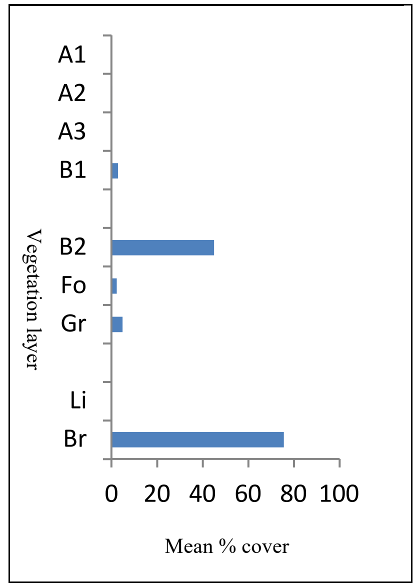




Ecological Interpretation

BS21 ecosites are a very uncommon wetland in the study area. They tend to occur in association with shrubby fens (BS22 and BS23) and resemble ribbons in the landscape along drainage ways. Following disturbance, these ecosites could be expected to become a shrubby fen (BS22). In the absence of disturbance these ecosites will likely remain in their current condition.

BS22 **Leatherleaf shrubby poor fen: Very wet fibric organic** (n=4)



Ecosite Description

In the study area, BS22 ecosite has tamarack, willow, and spruce as dominant tall shrub species. Ericaceous shrubs are common in the low shrub layer. Sedges are the dominant species in the herbaceous layer and *Sphagnum* mosses are very abundant. Shrubby poor fens frequently have a water table that is at or near the surface. The substrate for these ecosites is usually organic although a mineral substrate is also possible.

Species and Vegetation Layer Info

Average number plant and lichen species per plot (min, max): 15 (14, 15)

Tree Layer Info:

Tree Layer	Total # Species	Crown Closure	Mean Height	Mean DBH	Species Composition	Year of Origin
A1 (n=0):						
A2 (n=1):	1	<1%	5.8 m	8.4 cm	Sb10	1960
A3 (n=0):						

Lower Vegetation Layer info:

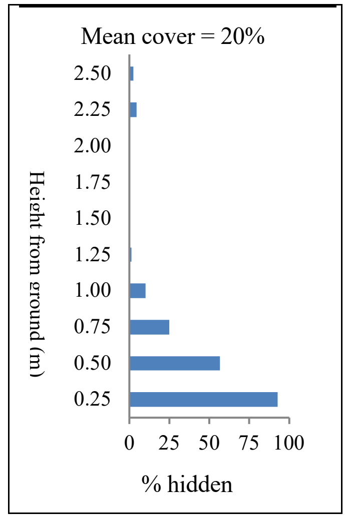
Vegetation Layer	Total # Species	Percentage Cover	Species Composition*
B1	4	3%	Picemar7 Salipla2 Larilar1
B2	12	45%	Chamcal7 Kalmpol1 Myrigal1
Forb	6	2%	Potepal6 Schepal3 Drosrot1
Graminoid	8	5%	Scircae2 Careutr2 Caremag2 Careaqu2 Carelim1
Lichen			
Bryophyte	7	76%	Sphaang4 Sphafus3 Sphagir2 Strastr1

*Only including species that constitute 10% or more by composition.

BS22 Leatherleaf shrubby poor fen: Very wet fibric organic (n=4)

Structural Attributes and Relative Rating

Structural Component	Attribute	Value	Rating
Snags	Mean # of snags/plot	0.0	Low
	Mean snag diameter (cm)		
	Mean snag height (m)		
	Mean snag decay Class		
Course Woody Debris	Mean frequency of CWD	0.0	Low
	Mean CWD diameter (cm)		
	Mean CWD decay class		
Mean Percent Ground Cover	Litter Cover	17.3	Moderate
	Litter Depth (cm)	1.8	Moderate
	Bare Soil	4.5	Moderate
	Bare Rock	0.0	Low
	Open Water	0.0	Low



Structural Diversity, Species Richness, and Unique and Rare Species Occurrence Evaluation

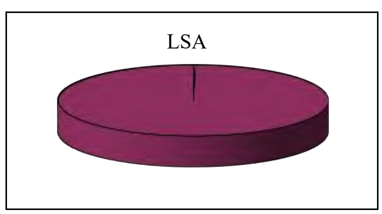
Attribute	Value	Rating
Structural diversity	1.0	Low
Species richness	15	Moderate
Unique species	1	Low
Provincially listed species	1	Low

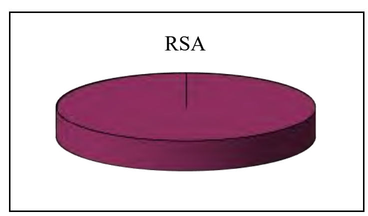
Unique species observed:
Filiform hypnum moss (*Hypnum cupressiforme var filiforme*)

Provincially listed species observed:
Angle-leaved sundew (*Drosera anglica*)

Ecosite Supply

Areas occupied by leatherleaf shrubby poor fen comprised 13.1 ha (0.3%) of the LSA and 28.4 ha (0.1%) of the RSA.

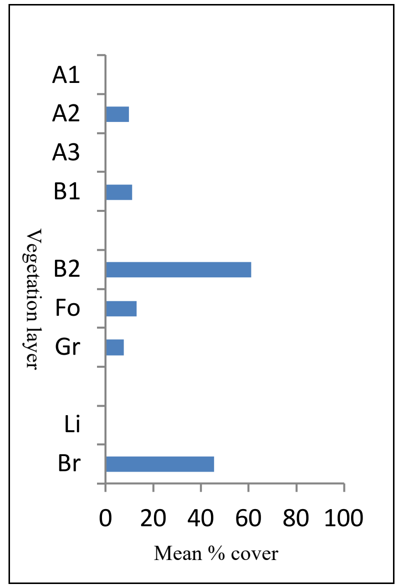




Ecological Interpretation

BS22 ecosites are common in the study area. Shrubby poor fens are sometimes associated with Tamarack treed fens (BS21). These sites tend to be wetter than shrubby bogs (BS18), and have a higher percentage of sedges.

BS23 **Willow shrubby rich fen: Wet fibric organic** (n=4)



Ecosite Description

BS23 has high cover values of willows. Other shrubs that could be found include birch species, tamarack and spruce. Grasses tend to be more common on the BS23 ecosite than sedges. Shrubby rich fens are more commonly associated with mineral soil substrate but will also occur on an organic substrate.

Species and Vegetation Layer Info

Average number plant and lichen species per plot (min, max): 19 (11, 27)

Tree Layer Info:

Tree Layer	Total # Species	Crown Closure	Mean Height	Mean DBH	Species Composition	Year of Origin
A1 (n=0):						
A2 (n=7):	3	10%	7.1 m	11.2 cm	Sb5 Pj4 Lt1	1957
A3 (n=0):						

Lower Vegetation Layer info:

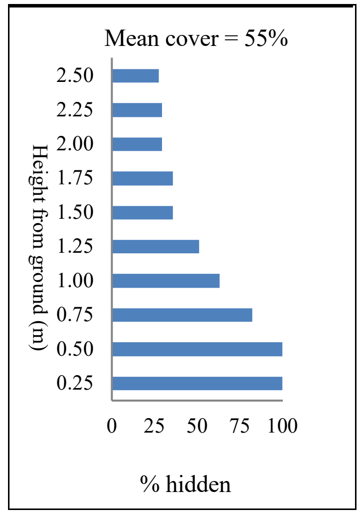
Vegetation Layer	Total # Species	Percentage Cover	Species Composition*
B1	10	11%	Betupum4 Picemar3 Pinuban1 Larilar1
B2	10	61%	Myrigal6 Saliped2
Forb	15	13%	Potepal4 Symppun2 Violren1 Rumeorb1 Mentarv1
Graminoid	5	8%	Calacan5 Careaqu3 Carecan1
Lichen			
Bryophyte	7	46%	Sphasqu4 Sphaang3 Strastr1 Rhizpse1 Plagell1

*Only including species that constitute 10% or more by composition.

BS23 Willow shrubby rich fen: Wet fibric organic (n=4)

Structural Attributes and Relative Rating

Structural Component	Attribute	Value	Rating
Snags	Mean # of snags/plot	1.5	High
	Mean snag diameter (cm)	12.2	
	Mean snag height (m)	5.7	
	Mean snag decay Class	4.0	
Course Woody Debris	Mean frequency of CWD	0.5	Low
	Mean CWD diameter (cm)	11.0	
	Mean CWD decay class	4.5	
Mean Percent Ground Cover	Litter Cover	45.0	High
	Litter Depth (cm)	5.9	High
	Bare Soil	0.0	Low
	Bare Rock	0.0	Low
	Open Water	0.0	Low



Structural Diversity, Species Richness, and Unique and Rare Species Occurrence Evaluation

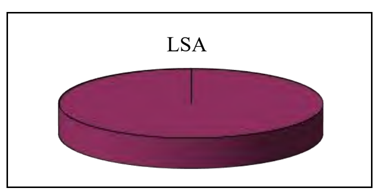
Attribute	Value	Rating
Structural diversity	1.5	High
Species richness	19	Moderate
Unique species	9	High
Provincially listed species	0	Low

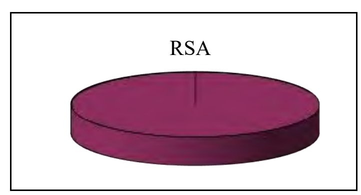
Unique species observed:
Common green bryum moss *(Bryum pseudotriquetrum*), Rhizomnium moss (*Rhizomnium pseudopunctatum*), Water-horehound (*Lycopus americanus*), Thufted loosestrife (*Lysimachia thyrsiflora*), Water dock (*Rumex orbiculatus*), Swamp Aster (*Symphyotrichum puniceum*), River alder (*Alnus rugosa*), Bristly black currant (*Ribes lacustre*), Gray willow (*Salix glauca*)

Provincially listed species observed:
None

Ecosite Supply

Areas occupied by willow shrubby rich fen comprised 3.2 ha (0.1%) of the LSA and 20.8 ha (0.1%) of the RSA.

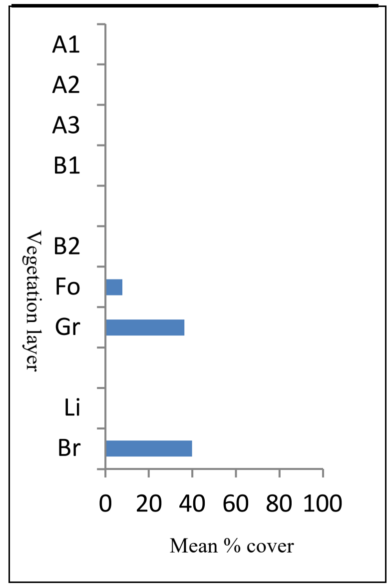




Ecological Interpretation

BS23 ecosites differ considerably from leatherleaf shrubby poor fens (BS22). Rich fen ecosites often occur adjacent to streams. They have a high occurrence of unique species. In the absence of disturbance these ecosites are self-sustaining. Following disturbance they will likely return to their former composition.

BS24 **Graminoid fen: Very wet humic organic** (n=4)



Ecosite Description

Graminoid fens often have various sedge species as well as marsh reed grass. They generally lack trees and shrubs. Sphagnum moss is the most common moss found in association with these sites. Graminoid fens usually have water at or near the surface. While graminoid fen ecosites are usually associated with organic soils, they may also occur with mineral substrates.

Species and Vegetation Layer Info

Average number plant and lichen species per plot (min, max): 8 (5, 10)

Tree Layer Info:

Tree Layer	Total # Species	Crown Closure	Mean Height	Mean DBH	Species Composition	Year of Origin
A1 (n=0):						
A2 (n=1):	1	<1%	6.4 m	11.5 cm	Sb10	1942
A3 (n=0):						

Lower Vegetation Layer info:

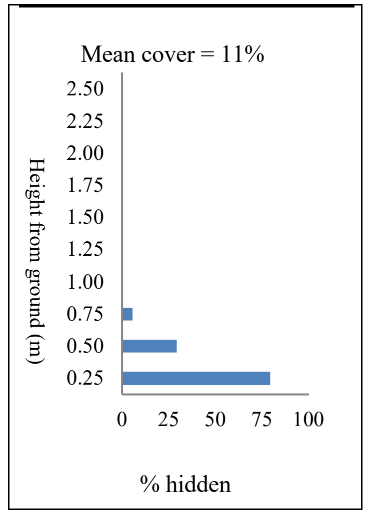
Vegetation Layer	Total # Species	Percentage Cover	Species Composition*
B1	2	<1%	Picemar5 Pinuban5
B2	4	<1%	Saliped6 Andrpol2 Kalmpol1 Oxycmic1
Forb	3	8%	Utriint7 Schepal2 Potepal1
Graminoid	8	37%	Careoli5 Careaqu2 Calacan1 Carelim1
Lichen			
Bryophyte	4	40%	Polycom6 Polystr2 Sphasqu2

*Only including species that constitute 10% or more by composition.

BS24 Graminoid fen: Very wet humic organic (n=4)

Structural Attributes and Relative Rating

Structural Component	Attribute	Value	Rating
Snags	Mean # of snags/plot	0.0	Low
	Mean snag diameter (cm)		
	Mean snag height (m)		
	Mean snag decay Class		
Course Woody Debris	Mean frequency of CWD	0.0	Low
	Mean CWD diameter (cm)		
	Mean CWD decay class		
Mean Percent Ground Cover	Litter Cover	9.5	Low
	Litter Depth (cm)	1.0	Moderate
	Bare Soil	0.0	Low
	Bare Rock	0.0	Low
	Open Water	50.0	High



Structural Diversity, Species Richness, and Unique and Rare Species Occurrence Evaluation

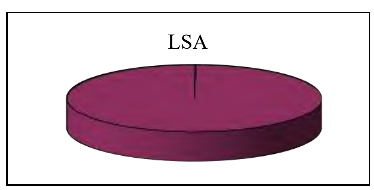
Attribute	Value	Rating
Structural diversity	1.0	Low
Species richness	8	Low
Unique species	2	Low
Provincially listed species	0	Low

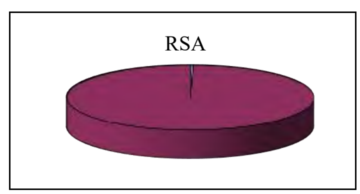
Unique species observed:
Flatleaf bladderwort (*Utricularia intermedia*), Capitate sedge (*Carex capitate*)

Provincially listed species observed:
None

Ecosite Supply

Areas occupied by a combination of BS24 and BS19 comprised 11.1 ha (0.2%) of the LSA and 171.2 ha (0.4%) of the RSA

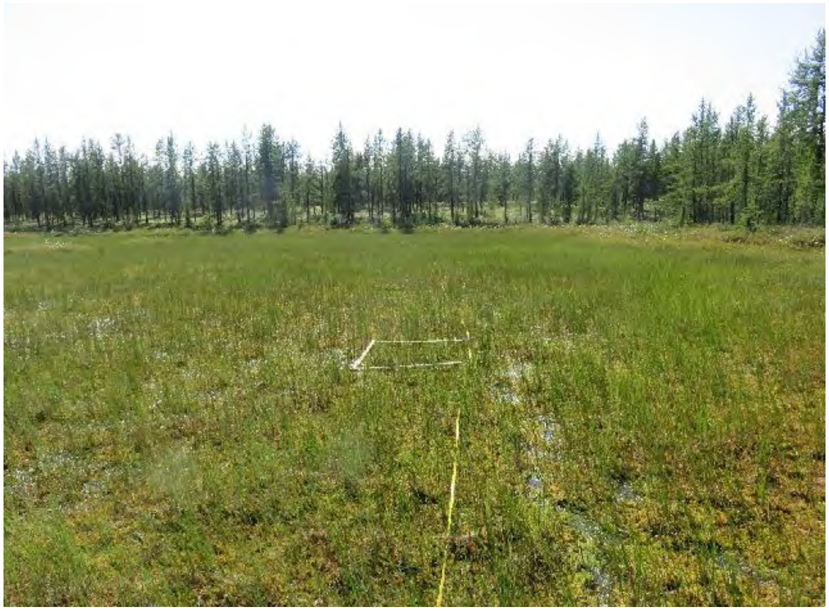


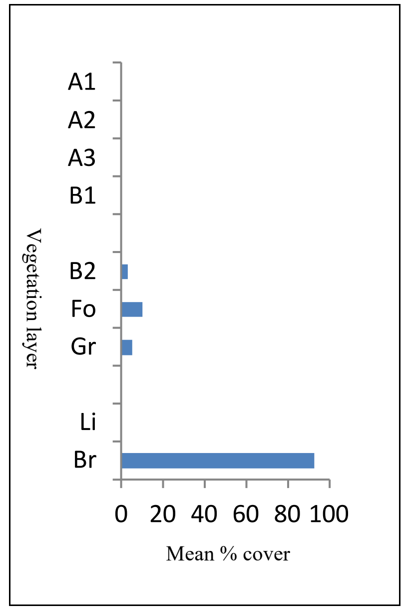


Ecological Interpretation

BS24 is occasionally found across the study area. They are often in close proximity to lake or creek shorelines. The high water table on these sites can provide the proper conditions for submergent plants. Following disturbance, such as ice action, these ecosites could be expected to return to graminoid fens.

BS25 **Open fen: Wet mesic organic** (n=2)





Ecosite Description

BS25 is conspicuous by the lack of any dominant form of vegetation with the exception of mosses. It is not uncommon for open fens to exhibit many of the vegetation species found in adjacent ecosites. The diversity of species and cover values are low. In terms of substrate, open fens can either have a mineral or organic substrate.

Species and Vegetation Layer Info

Average number plant and lichen species per plot (min, max): 10 (10, 10)

Tree Layer Info:

Tree Layer	Total # Species	Crown Closure	Mean Height	Mean DBH	Species Composition	Year of Origin
A1 (n=0):						
A2 (n=0):						
A3 (n=0):						

Lower Vegetation Layer info:

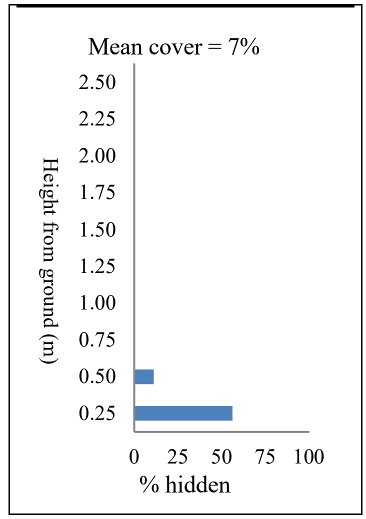
Vegetation Layer	Total # Species	Percentage Cover	Species Composition*
B1			
B2	3	3%	Andrpol7 Kalmpol3
Forb	4	10%	Schepal4 Menytri4 Drosrot1 Drosang1
Graminoid	5	5%	Carelim4 Eleonit3 Eleopal2 Caremag1
Lichen			
Bryophyte	3	93%	Sphasqu5 Sphang3 Sphacap2

*Only including species that constitute 10% or more by composition.

BS25 **Open fen: Wet mesic organic** (n=2)

Structural Attributes and Relative Rating

Structural Component	Attribute	Value	Rating
Snags	Mean # of snags/plot	0.0	Low
	Mean snag diameter (cm)		
	Mean snag height (m)		
	Mean snag decay Class		
Course Woody Debris	Mean frequency of CWD	0.0	Low
	Mean CWD diameter (cm)		
	Mean CWD decay class		
Mean Percent Ground Cover	Litter Cover	0.0	Low
	Litter Depth (cm)	0.0	Low
	Bare Soil	0.0	Low
	Bare Rock	0.0	Low
	Open Water	0.0	Low



Structural Diversity, Species Richness, and Unique and Rare Species Occurrence Evaluation

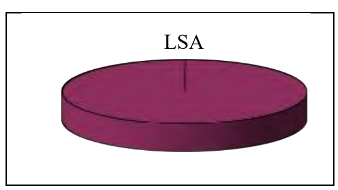
Attribute	Value	Rating
Structural diversity	0.6	Low
Species richness	10	Moderate
Unique species	2	Low
Provincially listed species	2	Moderate

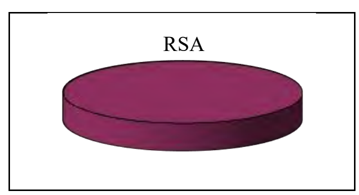
Unique species observed:
Peat moss (*Sphagnum capillifolium*), Neat Spike-rush (*Eleocharis nitida*)

Provincially listed species observed:
Angle-leaved sundew (*Drosera anglica*), Neat Spike-rush (*Eleocharis nitida*)

Ecosite Supply

Areas occupied by open fen comprised 2.1 ha (<0.1%) of the LSA and 5.7 ha (<0.1%) of the RSA.

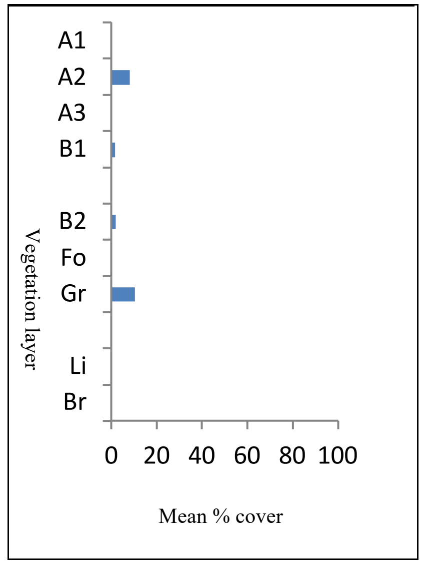




Ecological Interpretation

BS25 ecosites are uncommon across the study area. They exist as small pockets nested within other fen ecosites. Following disturbance these ecosites could be expected to return to open fens, but over time it is likely that they would become part of the adjacent fen ecosite.

BS26 Rush Sandy Shore: very moist sand (n=4)



Ecosite Description

BS26 ecosites are characterized by having a relatively low cover of rushes, grasses, and sedges and little else. The ground cover is mostly exposed soil; usually just sand.

Species and Vegetation Layer Info

Average number plant and lichen species per plot (min, max): 9 (5, 12)

Tree Layer Info:

Tree Layer	Total # Species	Crown Closure	Mean Height	Mean DBH	Species Composition	Year of Origin
A1 (n=1):	1	<1%	11.4 m	20.1 cm	Pj10	1902
A2 (n=3):	1	8	7.0 m	12.8 cm	Pj10	1934
A3 (n=0):						

Lower Vegetation Layer info:

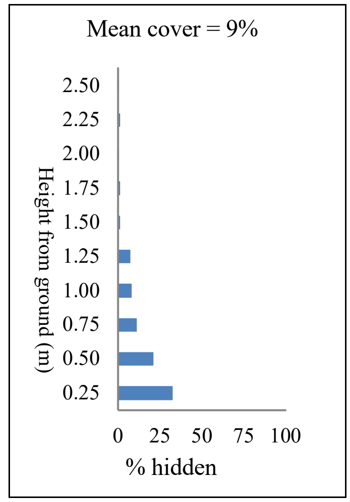
Vegetation Layer	Total # Species	Percentage Cover	Species Composition*
B1	5	2%	Pinuban5 Betupap2 Alnucri1 Picemar1 Salibeb1
B2	5	2%	Myrigal8 Chamcal1
Forb	3	<1%	Polyach4 Potenor3 Epilang2
Graminoid	10	11%	Careaqu5 Calastr3 Juncalp2
Lichen			
Bryophyte			

*Only including species that constitute 10% or more by composition.

BS26 Rush Sandy Shore: very moist sand (n=4)

Structural Attributes and Relative Rating

Structural Component	Attribute	Value	Rating
Snags	Mean # of snags/plot	0.8	Moderate
	Mean snag diameter (cm)	15.4	
	Mean snag height (m)	5.2	
	Mean snag decay Class	3.3	
Course Woody Debris	Mean frequency of CWD	0.0	Low
	Mean CWD diameter (cm)		
	Mean CWD decay class		
Mean Percent Ground Cover	Litter Cover	10.9	Moderate
	Litter Depth (cm)	0.4	Low
	Bare Soil	88.6	High
	Bare Rock	0.0	Low
	Open Water	0.0	Low



Structural Diversity, Species Richness, and Unique and Rare Species Occurrence Evaluation

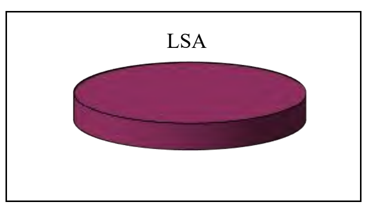
Attribute	Value	Rating
Structural diversity	1.2	Moderate
Species richness	9	Low
Unique species	4	Moderate
Provincially listed species	0	Low

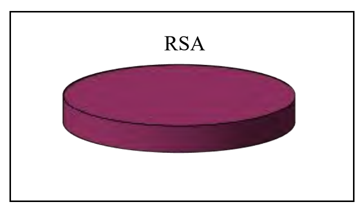
Unique species observed:
Striate Knotweed (*Polygonum achoreum*), Narrow-leaved reed grass (*Calamagrostis stricta ssp. Stricta*), Lens-fruited Sedge (*Carex lenticularis*), Red fescue (*Festuca rubra*)

Provincially listed species observed:
None

Ecosite Supply

Areas occupied by rush sandy shores comprised 0.9 ha (<0.1%) of the LSA and 15.0 ha (<0.1%) of the RSA.

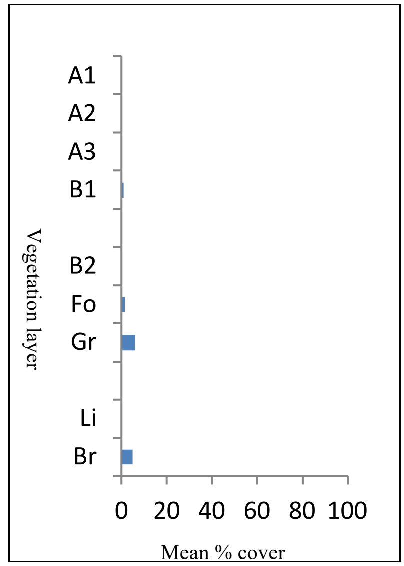




Ecological Interpretation

Rush sandy shores are almost always narrow linear features adjacent to lakes or ponds. This particular ecosite was defined based on data almost exclusively from the Athabasca Dunes ecodistrict.

BS27 **Sedge Rocky Shore: very moist sand** (n=4)



Ecosite Description

BS27 ecosites are sparsely vegetated sites that may have a variety of water tolerant species (e.g., tamarack, sweet gale, and sedges) present but in very low quantities. They are often predominantly rock on the surface and the water table is near the surface and usually visible.

Species and Vegetation Layer Info

Average number plant and lichen species per plot (min, max): 9 (6, 12)

Tree Layer Info:

Tree Layer	Total # Species	Crown Closure	Mean Height	Mean DBH	Species Composition	Year of Origin
A1 (n=1):	1	<1%	5.6 m	6.8 cm	Sb10	1971
A2 (n=0):						
A3 (n=0):						

Lower Vegetation Layer info:

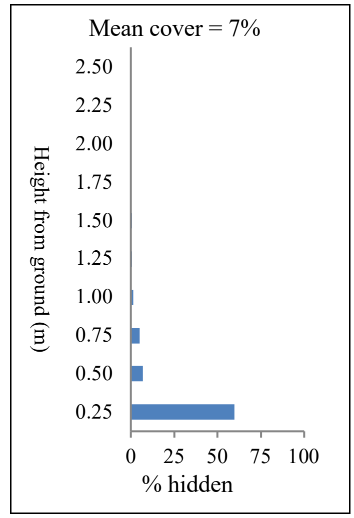
Vegetation Layer	Total # Species	Percentage Cover	Species Composition*
B1	3	1%	Picemar8 Larilar1 Pinuban1
B2	2	<1%	Myrigal6 Larilar4
Forb	7	1%	Caltpal3 Callver2 Drosrot2 Epilpal1 Ranupen1
Graminoid	12	6%	Careaqu4 Agrosca2 Careutr1 Juncdud1
Lichen			
Bryophyte	3	5%	Marsema7 Jungexs2 Tomenit1

*Only including species that constitute 10% or more by composition.

BS27 Sedge Rocky Shore: very moist sand (n=4)

Structural Attributes and Relative Rating

Structural Component	Attribute	Value	Rating
Snags	Mean # of snags/plot	0.0	Low
	Mean snag diameter (cm)		
	Mean snag height (m)		
	Mean snag decay Class		
Course Woody Debris	Mean frequency of CWD	0.0	Low
	Mean CWD diameter (cm)		
	Mean CWD decay class		
Mean Percent Ground Cover	Litter Cover	1.5	Low
	Litter Depth (cm)	0.1	Low
	Bare Soil	27.5	High
	Bare Rock	17.0	High
	Open Water	43.5	High



Structural Diversity, Species Richness, and Unique and Rare Species Occurrence Evaluation

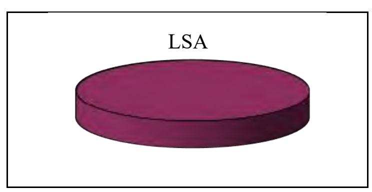
Attribute	Value	Rating
Structural diversity	1.2	Moderate
Species richness	9	Low
Unique species	7	High
Provincially listed species	0	Low

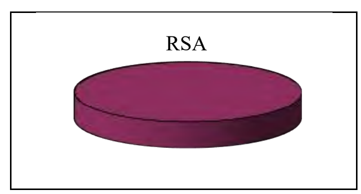
Unique species observed:
Jungermannia exsertifolia, Notched Rustwort (*Marsupella emarginata*), Vernal Water-starwort (*Callitriche verna*), Bristly Buttercup (*Ranunculus pensylvanicus*), Inland Sedge (*Carex interior*), Dudley's Rush (*Juncus dudleyi*), Nuttall's Salt-meadow Grass (*Puccinellia nuttalliana*)

Provincially listed species observed:
None

Ecosite Supply

Areas occupied by sedge rocky shores comprised 4.2 ha (<0.1%) of the LSA and 29.2 ha (<0.1%) of the RSA.

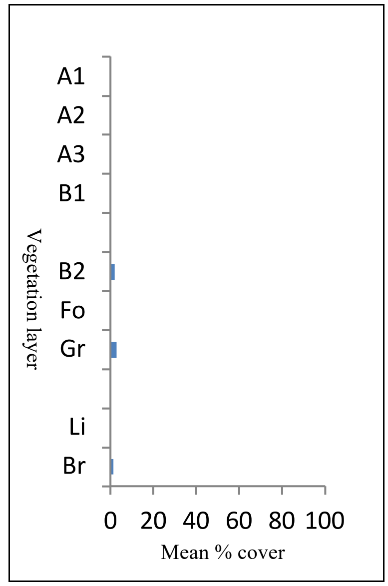




Ecological Interpretation

Whereas BS26 ecosites more closely reflect the condition of the Athabasca Dunes ecodistrict, this ecosite (BS27) applies to the rocky-sandy shore conditions in other areas of the Boreal Shield ecozone. Like BS26, this ecosite also occurs as a narrow feature adjacent to lakes and ponds.

DL1 **Disturbed lands - vegetated** (n=4)



Ecosite Description

DL1 ecosite type is characterized by previous removal of naturally occurring vegetation (and in some cases soil) and the absence of a tree layer. Some sites include an open shrub layer including by willows, green alder, and jack pine. Graminoids and forbs are also present, however, mainly consisting of planted or invasive species. A cover of mosses can also be found on the ground, but bare soil is a predominant feature in this ecosite type.

Species and Vegetation Layer Info

Average number plant and lichen species per plot (min, max): 4 (3, 5)

Tree Layer Info:

Tree Layer	Total # Species	Crown Closure	Mean Height	Mean DBH	Species Composition	Year of Origin
A1 (n=0):						
A2 (n=0):						
A3 (n=0):						

Lower Vegetation Layer info:

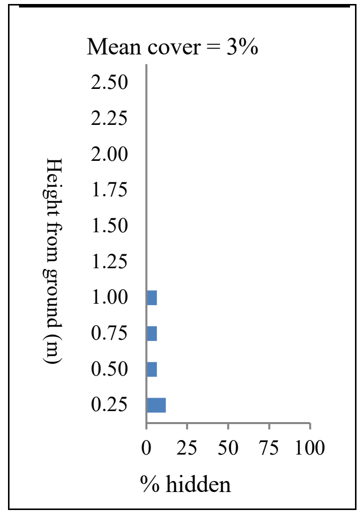
Vegetation Layer	Total # Species	Percentage Cover	Species Composition*
B1	1	<1%	Pinuban10
B2	4	2%	Vaccmyr8 Pinuban1 Vaccvit1
Forb	3	<1%	Epilang8 Chenalb1 Saxitri1
Graminoid	3	3%	Agrosca6 Carebre4
Lichen	1	<1%	Cladmit10
Bryophyte	1	1%	Polyjun10

*Only including species that constitute 10% or more by composition.

DL1 **Disturbed lands - vegetated** (n=4)

Structural Attributes and Relative Rating

Structural Component	Attribute	Value	Rating
Snags	Mean # of snags/plot	0.0	Low
	Mean snag diameter (cm)		
	Mean snag height (m)		
	Mean snag decay Class		
Course Woody Debris	Mean frequency of CWD	0.0	Low
	Mean CWD diameter (cm)		
	Mean CWD decay class		
Mean Percent Ground Cover	Litter Cover	7.2	Low
	Litter Depth (cm)	0.4	Low
	Bare Soil	89.4	High
	Bare Rock	0.0	Low
	Open Water	0.0	Low



Structural Diversity, Species Richness, and Unique and Rare Species Occurrence Evaluation

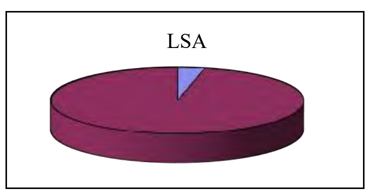
Attribute	Value	Rating
Structural diversity	1.2	Moderate
Species richness	4	Low
Unique species	3	Moderate
Provincially listed species	0	Low

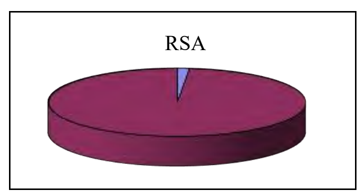
Unique species observed:
Lamb's-Quarters (*Chenopodium album*), Three-toothed saxifrage (*Saxifraga tricuspidata*), Fescue Sedge (*Carex brevior*)

Provincially listed species observed:
None

Ecosite Supply

Areas occupied by anthropogenic disturbance comprised 165.8 ha (3.5%) of the LSA and 596.4 ha (1.5%) of the RSA.





Ecological Interpretation

DL1 ecosites are poor in species diversity. They do have a moderate number of unique species, however, these species are generally actively seeded (such as red fescue) or invasive (such as narrow-leaved hawk's beard and dandelion). The ecosites are the result of previously cleared developed sites (e.g. road right-of-ways and airstrips) where some kind of natural revegetation has taken place, as well as areas where active reclamation has occurred.

2.3 Linear Feature Natural Regeneration Assessment

2.3.1 Background

Environment Canada (EC) (2012) assessed the capacities of caribou ranges to maintain self-sustaining local populations of boreal caribou across Canada. They utilized a methodology that linked calf recruitment to levels of disturbance within specific ranges. The objective was to identify range-specific disturbance based on management thresholds. For SK1, in 2018, ECCC indicated that to ensure sustainable caribou populations total buffered anthropogenic disturbance should not exceed five percent and that total disturbance (natural + buffered anthropogenic) should not exceed 40 percent. Currently, under this scheme, the Denison project area is considered to be completely disturbed when taking into account buffered anthropogenic disturbance in the LSA and is 82% disturbed in the RSA. Linear disturbances, in the form of exploration lines, temporary exploration trails and all season and seasonal roads were most common (see Section 2.1.2).

The increase in linear disturbances has the potential to increase the hunting opportunities and efficiencies of wolves (James *et al.* 2004; Dickie *et al.* 2017) and black bears (Latham *et al*. 2011a; Tigner *et al.* 2014, DeMars and Boutin 2017). Dickie *et al*. (2017) demonstrated that wolves move faster and farther on right-of-way's (ROW) (especially wider ROWs) than in interior forests. Latham *et al*. (2011b) observed that legacy seismic lines in Alberta were the most important movement corridors for wolves during the snow-free season, and Tigner *et al.* 2014 also found that black bears used linear features more frequently than undisturbed forest interior. This increased carnivore use of linear features could lead to higher levels of woodland caribou mortality.

Additive footprint, from the proposed Wheeler River Project, will result in an increase to baseline disturbance levels and prolong the natural recovery timeline of these and existing disturbances. The network of linear footprint, particularly where it occurs within or nearby effective caribou habitat, may present the best opportunity for compensatory reclamation activities. However, not all existing disturbances may be currently disturbed because natural succession has likely begun on many older features.

Visual or physical obstruction by vegetation is thought to be an important functional habitat attribute for wildlife, either as hiding cover, or as a factor affecting movement. Ungulate flight responses are likely governed by several factors and the amount of hiding cover is likely one important factor (Nudds 1977). This section presents two approaches for investigating *current* visual and physical obstruction as well as one approach for investigating *potential future* visual and physical obstruction on linear features. The approaches for current visual obstruction include measurements of hiding cover (percentage hidden) and vegetation regrowth (percent cover or stem count by vegetation layer). The approach for examining *potential future* visual obstruction involves investigating regeneration of ericaceous shrub and tree species composition. Ericaceous shrubs, such as blueberry, Labrador tea and leatherleaf (see McLaughlan *et al*. 2010) will generally not grow taller than 1 m and will not contribute considerably in terms of line blocking, physical or line of sight. Tree species (such as jack pine and black spruce) on the other hand will, given there are no fires or human traffic, grow tall enough to block line of sight. The abundance of tree species regeneration on a linear feature (although currently less than 1 m tall) would therefore be an important predictor of future regrowth and visual obstruction potential on a linear feature. A paired sampling design was used to compare current conditions along existing disturbance features to adjacent reference sites.

2.3.2 Methods

Sample Site Selection

Field sampling was conducted between July 23 and 31, 2019, with full vegetation green-up. Sampling sites were stratified by lowland, upland sites and then by mature or regenerating forest classes. Sample sites were stratified randomly using a 1:20,000 anthropogenic feature and vegetation cover type map (see Section 2.1.1 and 2.1.2). In addition, due to the relatively homogenous vegetative characteristics of the study area, specific sites with higher levels of linear feature regeneration were intentionally selected to provide adequate representation. All sample sites chosen were to be accessible safely by ATV. Sampled disturbance types included handcut exploration lines (1-2 m wide), temporary trails (3-7 m wide) and roads (6-10 m wide).

Paired reference transects were run along the same bearing and parallel to linear feature transects in suitable interior (reference) habitat 30 m away. A total of 46 sites were sampled. The locations of transects are provided in Figure 2.3-1. Transect details are provided in Appendix 3.

Sample Site Layout and Sampling Design

Each sampling site consisted of a 30-m transect along which five 20 cm x 50 cm sub-plots, five 1 m x 1 m sub-plots and three 2 m x 5 m sub-plots were systematically distributed at 5 m intervals (Figure 2.3-2). A series of vegetative and structural attributes were estimated or measured. Visual estimates along a continuous scale to the nearest percent were made at each sub-plot as described in British Columbia Ministry of Forests (1998). The percent cover of bare soil, rock/stones, litter, mulch, terrestrial lichen, feather moss, and sphagnum moss were recorded in the 5, 20 cm x 50 cm sub-plots. The depth of litter and mulch were also recorded. In each of the 1 m x 1 m sub-plots, the 10 most abundant low shrubs (<1 m in height) were recorded and given a rank order from 1 (most abundant) to 10 (least abundant). Forbs, grasses and sedges/rushes were grouped together and recorded and ranked in the same manner. Total percent cover and median height of low shrubs, forbs, grasses, sedges/rushes and standing water was recorded for each sub-plot. Tall shrub saplings were surveyed in the 2 m x 5 m sub-plot. Saplings were divided into 2 groups: 1-<3-m and ≥3-5-m heights. Species and height was recorded for each sapling. Structural data included frequency of occurrence of coarse woody debris and hiding cover. Coarse woody debris was recorded along the length of the 30-m transect. The total number of intercepts, the diameter and the decay class (1-7) of all pieces >10 cm were measured or estimated (Lee et al. 1995).

Horizontal and vertical visual obstruction from vegetation was estimated in both east and west directions from the transect centre and along each disturbance and corresponding reference transects adapting methods by Nudds (1977). A red and white colour-coded cloth measuring 2.5 m in height was held upright 15 m from the observed at the transect centre (Figure 2.2-4). The observer viewed the cloth from both caribou and wolf eye levels (1.7 m and 1.2 m above ground respectively, as per Kansas *et al.* 2015). An estimate of percent obstructed/hidden (by vegetation) was recorded for each of the ten 25 x 25 cm squares.

Analysis

Three types of analyses were completed to assess natural regeneration of disturbed linear features and paired reference transects, including:

1) Level of visual obstruction provided by vegetation on linear features.
2) Level of vegetation regrowth (percentage cover or stem counts).
3) Analysis of low shrub cover, focused on dominant species type (ericaceous shrub or tree) to determine the percentage of species that has the potential to reach caribou eye level and beyond (to predict whether a line is likely to be naturally revegetated over time).

For each of these three analyses, four classes of features were investigated, including features:

1) that have burned after creation (Appendix 4 - Photograph 2.3-1) versus those that have not burned since creation (Appendix 4 - Photograph 2.3-2).
2) in upland (Appendix 4 - Photograph 2.3-3) versus lowland (bogs and fens) (Appendix 4 - Photograph 2.3-4) areas.
3) in old (> 40 years since fire) (Appendix 4 - Photograph 2.3-3) versus young forest (< 40 years since fire) (Appendix 4 - Photograph 2.3-2).
4) with varying degree of human use, ranging from None (Appendix 4 - Photograph 2.3-5), Low (Appendix 4 - Photograph 2.3-6), Low/Moderate (Appendix 4 - Photograph 2.3-7), Moderate (Appendix 4 - Photograph 2.3-8), Moderate/High (Appendix 4 - Photograph 2.3-9), and High (Appendix 4 - Photograph 2.3-10). Level of use was based on observations in the field including flattened vegetation, percentage of bare soil, presence and extent of tire tracks, etc.

Seven different vegetation cover/stem density metrics (lichens, mosses, forbs, graminoids, shrubs < 1 m, shrubs 1-2 m, and shrubs 3-5 m) and two vegetation structure metrics (wolf hiding cover and caribou hiding cover) were analyzed. The average values for all vegetation layers as well as the average values for visual obstruction up to 2-m height from both caribou and wolf eye levels for the sampling by stratified sites were calculated in both the linear feature transects (treatment) and the paired and adjacent natural transects (reference).

For the low shrub layer, the 10 most abundant shrub species (<1 m in height) were recorded and given a rank order from 1 (most abundant) to 10 (least abundant) for each sub-plot. The ranks were converted to a numerical value (1 = 100, 2 = 90, 3 = 80, …, 10 = 10), and the values from each sub-plot were added to provide a total amount for each transect (thereby taking into consideration both ranking and occupancy for the sub-plots). This value was then normalized so each species received a value between 0 (not observed in any sub-plot) to 100 (overall highest ranking and most commonly recorded in sub-plots).

Using this information, two levels of analysis were undertaken. First, a comparison between disturbance and reference for each site type (e.g. Upland - Disturbed vs. Upland - Reference) were analysed. Second, a comparison of the level of natural regeneration between disturbed areas in different site types (e.g. Upland - Disturbed vs. Lowland - Disturbed) was analysed. To investigate the variation between reference and disturbance transects (rather than the variation within each of these groups), the precision of the mean value was quantified by calculating standard error of the mean (SE).

For the first level analysis, paired t-tests were run to verify if differences in mean values between compared variables were statistically significant ($P<0.05$). For the second level analysis, two-sample t-tests, not assuming equal variance, were run to verify if differences in mean values between compared variables were statistically significant ($P<0.05$). All data was analyzed using Minitab v. 17.3.1 (Minitab Inc., State College, PA, USA).

Assumptions and limitations

Natural vegetation recovery, at any given site, will depend on a variety of factors. There is no information on when linear features were created, how they were created, how they were used and for how long they may have been used, among other factors. Therefore, this variable cannot be fully accounted for. The analyses therefore did not take age of disturbance into consideration. For each of the four sets of analyses, several additional assumptions and limitations were identified:

1) Burned before or after creation of linear disturbance
   - Since there is no information available on when linear features were created, the designation of burned before or after line creation was based on evidence observed during the field trip, such as presence of stumps and/or deadfall from tree felling (see Photograph 2.3-5 in Appendix 4).
   - Transects included in this analysis are all:
     i. No/Low human use (to investigate effect of fire only (not human use)).
     ii. Trail or Handcut (as roads had minimal natural recovery irrespective of fire age)
     iii. In young upland regenerating forest (to compare similar ages of fire)

2) Upland versus lowland comparisons include transects that:
   - Have No/Low human use (to investigate effect of moisture only (not human use)).
   - Are Trail or Handcut (as roads have minimal recovery irrespective of moisture regime).
   - Represent areas of between 30 to 100 years since fire, since there is most overlap for these ages).

3) Old versus Young comparisons include transects that:
   - Are upland areas only (very limited young lowland transects).
   - Have not burned since the line was cut.
   - Are divided into young (<40 years since fire) and old (>40 years since fire).
   - Have No/Low human use (to investigate effect of age only (not human use)).
   - Are Trail or Handcut (as roads had minimal recovery irrespective of fire age).

4) Levels of Human Use, transects that include:
   - All landcover types (uplands and lowlands)
   - All ages
   - All types of features

- All categories of human use

2.3.3 Results

The key findings and trends for each of the three analyses, *including Visual Obstruction, Vegetation Recovery and Ericaceous shrubs vs. Tree Species ar*e provided in Table 2.3.1. Detailed results for each analysis are provided below.

2.3.3.1 Visual Obstruction

Line cut before versus after fire

No significant differences in visual obstruction in any layers were observed between disturbed versus reference transects for areas that had burned after the line was cut (Figure 2.3-3A). This indicates that, for trails and hand cuts and in absence of continued human use, wildfires will, to some extent, "reset" the disturbance and initiate the natural recovery process such that vegetation conditions will be similar on and off disturbance. In situation where lines were cut after fires, wolf visual obstruction was significantly higher for reference transects from 0.25 to 1.25 m layers ($P<0.03$), and caribou visual obstruction was significantly higher for reference transects in the 0.25 to 0.75 m layers, indicating poor vegetation regrowth in areas cut after fire (Figure 2.3-3B).

Upland versus lowland

Lowlands generally had a slightly higher visual obstruction in the lower height layers compared with uplands. In lowlands, caribou visual obstruction was significantly different for all layers, except 0.25 and 0.5 m above ground ($P<0.05$), however in uplands these lower layers were also significantly different between reference and disturbance (Figure 2.3-4A). Wolf visual obstruction was similar for both lowlands and uplands as both displayed no significant differences in the 0.25 to 1 m layers (Figure 2.3-4B). Comparison of recovery for disturbed areas, for lowlands versus uplands, indicated that a higher visual obstruction in the lowest height layer occurred. Both wolf and caribou visual obstruction were significantly different in the 0.25 m layer but displayed no significant difference in any of the higher layers.

Young forest versus old forest

There was a greater difference between reference and disturbed areas for young forests than for old forest. Overall, hiding cover (all layers combined) was significantly different between disturbed and reference for both wolf ($P=0.001$) and caribou ($P<0.001$). Both wolf and caribou were also significantly different in every height layer ($P<0.05$) (Figure 2.3-5A). For old forests this difference was not as prominent, since the lower height layers showed no significant difference between disturbed and reference (Figure 2.3-5B). This difference, between old and young forests, was not a result of differences in recovery rates, however. Since older forests were generally more open and had lower visual obstruction overall, compared to younger forests, there was an inherently smaller difference between reference and disturbed areas in old forests. The recovery rates (based on visual obstruction) were similar for both young and old forest, and there were no significant differences in any layers for either wolf (P=0.345) or caribou (P=0.466) (Figure 2.3-5C).

Level of human Use

Human use significantly affected vegetation regrowth (based on visual obstruction). There was no significant difference between no use and low use (Figures 2.3-6A and 2.3-6B), nor between moderate and high use (Figures 2.3-6C and 2.3-6D). There was however a significant difference between low use and moderate use for both caribou (P=0.015) and wolf (P=0.013), indicating that rather than a gradual change in vegetation recovery with increasing disturbance, there is a threshold of human use after which natural vegetation recovery drops drastically.

2.3.3.2 Vegetation Recovery

Line cut before versus after fire

Average cover of lichens, mosses and low shrubs were similar in reference and disturbed areas for areas burned before and after line creation. Tall shrubs (1-3 m) were observed in disturbed areas in young forests (12-15 years since fire) only if the area was burned after the line was created (Figure 2.3-7), emphasizing the importance of fires for initiating regrowth on disturbed linear features and the potential need for manual intervention should management objectives desire regrowth on these features (i.e. reduce the overall level of disturbance).

Upland versus lowland

Lowlands generally had higher moss and low shrub cover, and a lower lichen cover than uplands (Figure 2.3-8). This is likely due to site conditions (e.g. soil moisture) rather than as a result of disturbance since there were no significant differences between reference and disturbed areas for either the lowland or upland transects.

Young forest versus old forest

There was a significantly higher cover of lichen in old forests compared to young forests regardless of disturbance levels (Figure 2.3-9). However, there were no significant differences in natural regrowth of disturbed sites between old and young forests.

Level of human Use

As the case was for visual obstruction, human use significantly affected vegetation regrowth. There was no significant difference between reference and disturbance for the no use and low use areas. However, moderate and high use areas had minimal regrowth (Figure 2.3-10). This highlights the deleterious effects of continued human use of disturbance features on natural regrowth.

2.3.3.3 Ericaceous Shrub versus Tree Species Composition

Line cut before versus after fire

Features that had burned after the line was created showed a similar abundance of jack pine for both reference (56) and disturbed (60) areas (Table 2.3-2). Areas that were burned prior to line creation had a much lower abundance of jackpine in the disturbed areas (18) compared to reference (59). This supports the findings of visual obstruction and vegetation regrowth in that wildfires for trails and hand cuts and in absence of continued human use, reset the disturbance and initiate recovery, and that recovery post fire is similar on and off disturbance.

Upland versus lowland

Lowlands had a higher abundance of black spruce in disturbed areas (55) compared to reference areas (37), indicating these lines are on a trajectory towards natural recovery (Table 2.3-3). Upland areas had a very low abundance of tree species in both reference (jackpine: 4, black spruce: 4) and disturbed areas (jackpine: 6 and black spruce: 4), indicating there is minimal natural recovery in upland areas where no fire disturbance has occurred.

Young forest versus old forest

When looking at old (>40 years old) versus young (< 40 years old) upland areas, the abundance of tree species was similar in disturbed and reference areas for both age types (Table 2.3-4). However, the abundance of tree species was much higher for young upland forest than for old upland forests. This indicates old forests are likely not recovering naturally and would need active reclamation to instigate vegetation regrowth.

Level of human Use

Areas with no human use and low human use had similar abundance of tree species, whereas both moderate and high use areas had very low abundance of tree species (Table 2.3-5). Again, this highlights the deleterious effects of continued human use of disturbance features on natural regrowth.

2.3.4 Key Take-aways

- Wildfires (in absence of continued human use), can reset the disturbance for trails and hand cuts, and instigate a post fire recovery that is similar on and off disturbance features. No reclamation efforts will be needed in these areas.
- Natural vegetation recovery of tree/shrub height and abundance on disturbed features is relatively high in lowland habitats. Reclamation efforts are likely not needed in these areas.
- Human use is an important factor affecting vegetation regrowth. Reduced access to trails would be an important factor affecting reclamation success. Restricting access could also enhance natural recovery in some areas.

- Results indicate that natural vegetation recovery, on disturbances, is lower (tree/shrub height and abundance) in mature upland habitats. For caribou management, these are areas where reclamation efforts should be prioritized.

- Based on the above results, the reclamation efforts that likely would create the greatest contribution to overall habitat improvement would target trails and handcuts in mature upland habitat. Management strategies should include visual and physical obstruction, reduced line of sight and restricted access (human use).

2.4 Rare Vascular Plant Surveys

The rare vascular plant survey was completed with the primary objectives of:

- Documenting rare vascular plant occurrence(s) within the proposed Denison Wheeler Project footprint
- Providing a scientifically defensible baseline for potential follow-up/monitoring requirements
- Describe rare plant-Ecosite affiliations

2.4.1 Methods

Sampling Protocol

The rare plant survey was completed according to the Government of Saskatchewan (2017) Rare Vascular Plant Survey Protocol. Using available Saskatchewan Ecosite mapping, the survey transects were laid out randomly in all of the available Ecosites within the disturbance footprint for the proposed Denison Wheeler River project. Given that the landscape consists of boreal conifer forests, the most appropriate sampling unit was determined to be 100 m transects and the number of transects in each Ecosite was determined using the following formula as per the Government of Saskatchewan (2017) Rare Vascular Plant Survey Protocol:

$$y = (0.8\ x/z) + (40/z)$$

Where:

y is the number of 100 m transects
z is the total transect width in meters
x is the area of each habitat in hectares

The transects were randomly laid out in a geographic information system (GIS) prior to the field work (Figure 2.4-1) and the resulting transects were then loaded onto handheld GPS units. When possible a minimum of 10 transects per Ecosite were placed, however in some cases given the orientation and shape of the Ecosite polygons on the landscape this was not always possible. Using random transects laid out in each Ecosite, rather than a meandering search approach, transect based searches of high probability rare plant habitat reduce bias and allow for a replicate of the transects if desired. This approach also allows for calculation of search effort (Henderson 2009).

The stratification of transects by Ecosite type is displayed Table 2.4-1.

Field Work

Two rare vascular plant surveys were completed in the proposed Denison Wheeler River Project footprint. The first survey was designed to survey a subset of the 74 random transects. The purpose of this survey was to assess the accuracy of the predictive Ecosite mapping and provide replicate survey locations in the areas of the footprint most likely to remain static as the proposed footprint was, and still is, preliminary in nature. The rare plant surveys were completed by two surveyors travelling on foot along each predetermined 100 m transect using handheld GPS units and recording all vascular plant species encountered within 2 m on each side of the 100 m transect as per the guidelines. All plant species observed were recorded and details of the Ecosite affiliation, population, and distribution of all rare vascular plants recorded. In addition to the prescribed transects, rare Ecosite searches were completed when encountered. Two observers walked a meandering path through the rare Ecosite to survey its entirety.

Where possible, plant identification was completed in the field. Plants that were not immediately identifiable were collected for later determination using additional references.

In Saskatchewan, rare plant species are those with S1, S2, or S3 conservation ranks as per the most recent SKCDC vascular plant database (SKCDC 2019a) (Table 2.4-2).

Post Field Work

The identification of all plants or plant photographs were verified using additional references (Leighton 2012, Harms and Leighton 2011, Kershaw *et al*. 2001, Moss 1994) and online databases including the BC E-flora database (Klinkenberg 2011). Some plant specimens that had very small distinguishing characteristics (e.g. grasses, sedges, and other aquatic plants) were identified using a dissecting microscope.

2.4.2 Results

During the first survey, a total of 20 100 m transects and two rare Ecosite searches were completed. The survey was completed between July 9 and 12, 2017. The total transect area searched was 8,000 m^2 (20 x 100 m length x 4 m wide). The additional rare Ecosite searches resulted in 2,000 m^2 (500 m x 4 m) searched in BS19 (graminoid bog) and 4,400 m^2 (1,100 m x 4 m) searched in BS18 (Labrador tea shrubby bog) (Figure 2.4-1).

A second rare vascular plant survey was completed between July 28 and August 2, 2017. A total of 74 transects, including 20 replicates from the first survey, were completed for a total survey area of 29,600 m^2 (74 transects x 100 m length x 4 m wide) (Figure 2.4-1). The field surveys found fewer Ecosites than the predictive Ecosite mapping indicated. As a result, more transects were completed than the Government of Saskatchewan (2017) rare plant survey protocol required. Table 2.4-3 outlines the number of transects completed per Ecosite as identified during the field survey.

Plant Inventory

In total there were 66 vascular plant species and eight identifiable non-vascular species recorded in all 74 transects across both surveys (Appendix 5 and 6). The first survey (July 9-12) identified 44 vascular plant species. The second survey (July 28-Aug 4) identified 65 vascular plants. The relatively low number of vascular species reflects the low plant species richness associated with primarily upland immature jack pine stands in the boreal Athabasca Plain ecoregion in northern Saskatchewan.

There were no invasive non-native plant species recorded along any of the transects.

Rare Plants

There were two rare plant species observed (Table 2.4-4), with one species observed at nine locations along eight different transects (Figure 2.4-1). A GPS polygon or waypoint of the rare plant population was recorded and photos of the plants and the plant community were taken of each species observed as well as a full description of the habitat. All rare plant observations were recorded in the recently updated Saskatchewan load form under the plant tab and submitted to the SKCDC. The two rare species included:

- Alaskan clubmoss (*Diphasiastrum sitchense*)

Description
Alaskan clubmoss is a low-growing evergreen forb with ground-trailing horizontal stems that are often half buried in the lichen and duff on the forest floor (Harms and Leighton 2011). The cones are sessile and borne terminally on some branches; upright shoots are mostly less than 15cm; leaves are 5-ranked; stems are 3-4 mm wide (Figure 2.4-2). Alaskan clubmoss is ranked S2 in Saskatchewan.
Population and Habitat
There were nine patches of Alaskan clubmoss recorded on eight transects with population estimates ranging between 15 to 940 clumps covering 6 to 1,611 m^2 (Figures 2.4-1, 2.4-2, 2.4-3; Table 2.4-4). This species was associated with open transitional zones between upland jack pine (*Pinus banksiana*) and forested bogs (Figure 2.4-4). One population was also found in the transition between mature and immature jack pine stands at the base of a slope. Alaskan clubmoss was found growing in association with blueberry (*Vaccinium myrtilloides*), common Labrador tea (*Rhododendron groenlandicum*), leatherleaf (*Chamaedaphne calyculata*), and pale laurel (*Kalmia polifolia*).

- Three-seeded sedge (*Carex trisperma*)

Description
Three-seeded sedge was observed during both surveys. Three-seeded sedge is a loosely cespitose sedge species 10-60 cm high, with leaves 0.5-1.5 mm wide (Leighton 2012). This species has 2-4 spikes in the inflorescence all alike with female flowers above male flowers, spikes 4-6 mm long and 3-4 mm wide; perigynia 1-5 per spike, 2.5-3.7 mm long, ovate to elliptic tapering to the 0.5 mm beak, glabrous, finely veined and punticulate; lowest spike is remote (1-4 cm below the upper spikes); lowest spike bract reaching the spike above or often overtopping the inflorescence (Figure 2.4-5). Three-seeded sedge is ranked S3 in Saskatchewan.
Population and Habitat
There was one patch of three-seeded sedge observed in a wet depression in the riparian area of a creek. This patch had an estimated 100 plants of this species and was found growing in association with two-seeded sedge (*Carex disperma*), common Labrador tea (*Rhododendron groenlandicum*), and bluejoint (*Calamagrostis canadensis*) (Figures 2.4-1, 2.4-5, 2.4-6; Table 2.4-4).

2.4.3 2019 Rare Plant Survey Requirement Assessment

As detailed in Section 2.4.1, rare plant surveys were completed in 2017 according to the Saskatchewan Government protocol 20.0 Rare Prarie Plants (2015). However, after the surveys were completed the Wheeler River project footprint was altered (access corridor and proposed mine footprint). In some places, substantial adjustments were made, but in many other locations the shift was small. Overall, the proposed development, and associated footprint, remained in the same local vicinity and the adjusted access corridor and project footprint were in very close proximity to the previous alignment.

However, per the Rare Vascular Plant protocol, extensive new sampling would be required. Our preliminary assessment of the 2017 sampling was that the scale, intensity and spatial distribution of the sampling was adequate to inform an Environmental Impact Statement (EIS) under the condition that site specific rare plant pre-disturbance surveys would accompany a project approval. To confirm this, Omnia consulted with the Saskatchewan Government (S. Vingemazer) to confirm the status of the existing survey data and potential requirements for new surveys. After consultation, it was agreed upon that the surveys already completed were adequate to satisfy the requirements of an EIS but additional surveys would be required for locations where new proposed footprint overlapped with Ecosites that were not sampled during the 2017 surveys. In addition, Denison committed to completed pre-disturbance rare plant surveys, where required, once the project footprint had been finalized and prior to construction.

Map overlays were completed, and results indicated that the new alignment/footprint overlapped two Ecosites not surveyed in 2017 including:

- BS7- Black spruce-blueberry-lichen (0.3 Ha)
- BS9- Black spruce-jack pine/feathermoss (1.5 Ha)

Following the guidance provided by S. Vingemazer (pers. comm), in the spring of 2019, a reconnaissance field trip was completed to assess mapping accuracy and evaluate the need for additional rare plant surveys. Prior to the field trip, the centroids of each candidate polygon were derived from the GIS and uploaded to a hand-held GPS.

A total of 26 candidate BS7 and/or BS9 polygons were visited to ground truth predictive Ecosite mapping and assess the need for additional rare plant surveys (Figure 2.4-7). Only one site was mapped accurately as a BS9, an approximately 40 x 15 m polygon (Figure 2.4-8). Table 2.4-5 details the findings of the ground truthing survey.

A rare plant survey was not completed on the black spruce-jack pine/feathermoss (BS9) polygon. Due to the small size of the polygon it is likely the final footprint can be adjusted to avoid rare plant impact to this Ecosite. In addition, Denison has committed to completing pre-disturbance rare plant surveys on the finalized footprint, should the finalized design include disturbance to the black spruce-jack pine/feathermoss (BS9) Ecosite.

2.5 Vegetation and Soil Collection and Chemistry Analysis

The vegetation and soil sampling program consisted of three components: (1) the collection of blueberry stems, leaves, and fruit (currents years' growth), (2) the collection of terrestrial lichen, and (3) the collection of soil samples. The primary objectives of this survey were to:

- Determine baseline conditions of physical properties, inorganic ions, metals and radionuclides in vegetation (blueberry and lichen) and soil samples
- Establish baseline sampling to support future monitoring, mitigation, and impact assessment

2.5.1 Methods

Vegetation and soil samples were collected from pre-established Radon permanent sample plots (PSP). The sampling consisted of three components: the collection of terrestrial lichen, current year's growth of blueberry (leaf, stem and berry), and a soil sample. The terrestrial lichen was collected by hand and all debris (leaves, needles and dirt) was removed from the sample. Latex gloves were worn during the collection to prevent contamination of the samples and a new pair of gloves was utilized at each site. A total wet volume of 500 g was collected and placed in a plastic bag to be frozen until chemical analysis. The blueberry vegetation was collected by using Teflon coated scissors to remove leaves, stems and berries from the current year's growth. Scissors were cleaned with distilled water between sample sites to prevent contamination. Latex gloves were worn during any handling of the samples and replaced after each sample site (pers. comm. D. Chorney 2017). A total wet volume of 500 g was collected, placed in a plastic bag and frozen until laboratory analysis.

Soil samples were collected using a small spade shovel. The shovel was cleaned with distilled water between sample sites to prevent contamination. The organic "duff" layer was removed from the sample and mineral soil was collected to a depth of five centimeters. Latex gloves were worn while removing the duff layer to prevent contamination and gloves were replaced after each sample site. A total wet volume of 100 g of soil was collected, placed in a plastic bag and frozen until laboratory analysis.

The samples were collected as close to the pre-established PSP locations as possible. Sample collection ranged from 25 to 200 m total distance from the Radon sample site to fulfil the weight requirements.

All samples were shipped frozen or dried to the Saskatchewan Research Council (SRC) for chemical analysis. The vegetation and soil samples were analyzed for both metal and radionuclide parameters.

The metals parameters that were analyzed included:

- Aluminum
- Antimony
- Arsenic
- Barium
- Beryllium
- Boron
- Cadmium
- Chromium
- Cobalt
- Copper
- Iron
- Lead
- Manganese
- Molybdenum
- Nickel
- Selenium
- Silver
- Strontium
- Thallium
- Tin
- Titanium
- Uranium
- Vanadium

The radionuclide parameters that were analyzed included:

- Lead-210
- Polonium-210
- Radium-226
- Thorium-230

The metal parameters were analyzed by inductively coupled plasma - mass spectronomy and radionuclides were analyzed by extraction and beta counting (Pb-210) or alpha spectroscopy (Po-210, Ra-226, Th-230) (pers. comm. D. Chorney 2017).

2.5.2 Results

Vegetation (lichen and blueberry) and soil samples were collected from 10 sample sites between August 2 and 7, 2017 (Figure 2.5-1). The results of the lichen chemical analysis are presented in Table 2.5-1, blueberry chemical analysis results are presented in Table 2.5-2, and the soil chemical analysis results are presented in Table 2.5-3.

Lichen radionuclide levels were relatively consistent across all sample sites. However, several metal parameters were elevated in sample site RSV10, including: aluminum, beryllium, boron, cadmium, chromium, cobalt, iron, lead, nickel, titanium, uranium, and zinc compared to other sample sites.

Blueberry radionuclide levels were also relatively consistent across sample sites. However, similar to lichen samples, higher levels of some elements including Lead-210 and Polonium-210 were observed in sample site RSV10 and higher levels of Thorium-230 in sample site RSV4. Metal parameters were variable but relatively consistent, aside from elevated levels of aluminium, chromium, iron, lead, titanium, and vanadium in RSV6.

Radionuclide levels in soil were also variable but relatively consistent. Sample site RSV9 showed higher levels of Lead-210 and Polonium-210 compared to other sample sites. Metal parameters were relatively consistent with only sample site RSV 9 showing elevated levels of calcium, copper, lead, and manganese compared to other sample sites.

Although the primary objective of this survey was to provide a characterization of background and baseline levels for the Wheeler site, a comparison of soil and vegetation chemistry to Rio Tinto's Roughrider Project, completed in northern Saskatchewan is presented in Table 2.5-4 (Rio Tinto 2014). Soil and vegetation chemistry was similar between the two project areas. Soil metal parameter concentrations were generally higher in the Roughrider project area and radionuclide parameters higher in the Wheeler River project area. Lichen and blueberry metal parameters where generally higher in the Wheeler River project area. Radionuclide parameters for lichen were higher in the Wheeler river project area while blueberry radionuclide parameter concentrations were lower in the Wheeler River project area.

2.6 Winter Track Count Survey

The three primary objectives of the winter tracking survey were to:

- Determine the presence/not-absence of winter-active animals
- Determine the relative abundance of winter-active animals
- Enhance the project specific area understanding of species-Ecosite affiliations
- Provide a scientifically defensible baseline for potential follow-up/monitoring requirements

2.6.1 Methods

Two types of winter track count surveys were utilized. The first was driving/walking roads/anthropogenic areas within the LSA and recording all intersections of animal trails along the existing and proposed road alignments. The second method utilized triangle shaped transects. Triangle transects measured 7.5 km in length (2.5 km per side) and were located using a stratified random approach across the LSA and RSA. In addition to the triangle transects, a series of opportunistic riparian transects were also sampled to ensure representation of this less common wildlife habitat type.

Data was collected at 50 m intervals (termed a 'sub-transect') along each transect. Methodology was developed with guidance from the Saskatchewan Ministry of Environment (2014a) Species Detection Survey Protocol: Snow Track Surveys and the tracking triangle approach was adopted from long-term monitoring techniques originating in Finland (Linden *et al.* 1996) and adopted by the Alberta Biodiversity Monitoring Program (Shank and Farr 1999). Hand-held global positioning systems (GPS) were used for navigation and orientation purposes and to measure transect and sub-transect lengths. The road/anthropogenic transect routes were recorded using the track-log function in a hand held GPS, recording points every ten seconds.

The number of fresh animal trails crossing the transect path since the last snowfall event were recorded by species. Animal tracks were identified to species by print, stride and straddle. Multiple-pass hare and red squirrel trails were enumerated as five animals. Fresh bed sites (since last snowfall event) and ungulate foraging events (current winter browse associated with fresh trails) were recorded within a 3 m band on either side of the transect path. Detailed information on anthropogenic features (i.e., cut lines, roads etc.) was also recorded; including occurrence, human use and wildlife use at the end of each 50 m sub-transect. Wildlife tracking data was collected a minimum of 24 hours after a snowfall event and continued until the track record was obliterated by wind, snow melt, or new snowfall. Tracking data and snow depth measurements were completed at the end of each 50 m sub-transect. A Universal Transverse Mercator (UTM) coordinate marking the start and end of each 50 m sub-transect was recorded.

The number of kilometer-days (length of transect multiplied by the days since last snowfall) was calculated for each transect and sub-transect. The number of animal trails per km-day by species was calculated by project area, Ecosite type, and transect.

2.6.2 Results

A total of 11 triangle transects (82 km), five riparian transects (2.7 km) and three road/anthropogenic transects (18 km) were completed between January 25 and February 3, 2017. Nine of 11 triangle transects (67 km), the five riparian transects and portions of the road/anthropogenic transects (11.5 km) were replicated between February 1 – 3 and March 2 – 12, 2018. (Figure 2.6-1). Sampling intensity was 440 km-days in 2017 and 179 km-days in 2018 for the entire project area. The trails of thirteen different species/species group were detected during winter tracking surveys across 15 Ecosites (Table 2.6-1 and Table 2.6-2). Listed below in descending order are species and corresponding mean trail densities for the entire project area:

- Snowshoe hare (*Lepus americanus*) – 7.48 trails per km-day
- Red squirrel (*Tamiasciurus hudsonicus*) – 1.52
- Grouse (*Phasianidea spp.*) or Ptarmigan (*Lagopus spp.*) – 0.60
- Marten (*Martes americana*) – 0.34
- Microtine rodent species – 0.23
- Ermine (*Mustela erminea*) – 0.12
- Canada Lynx (*Lynx canadensis*) – 0.11
- Mink (*Mustela vison*) – 0.07
- Woodland caribou (*Rangifer tarundus*) – 0.05
- Fisher (*Pekania pennanti*) – 0.01
- Otter (*Lontra canadensis*) – 0.01
- Red fox (*Vulpes vulpes*) – 0.01
- Moose (*Alces alces*) – 0.01

Ungulates

Two species of ungulates trails were observed during winter tracking surveys (moose and woodland caribou). Moose trails were observed on transects 5, 11 and the road/anthropogenic. Transect 11 had the highest mean density of moose trails at 0.09 trails per km-day. Transect 11 also had the highest trails per km day in 2017 (0.17), while transect 5 had the highest density (0.11) in 2018. Woodland caribou trails were observed on transects 2, 9, and 11 and were only detected during 2017 surveys. The highest trail densities observed in 2017 were on transect 11 (0.69) and transect 2 (0.67). Transect 11 had the highest mean trail density at 0.34 trails per km day. No woodland caribou trails were observed along road/anthropogenic or creek transects (Figure 2.6-1 and Table 2.6-1).

Moose trails were observed in four Ecosites: BS17 (black spruce treed bog), BS18 (Labrador tea shrubby bog), road/anthropogenic (polygonal and linear disturbance) and RF2 (regenerating forest – tall shrub dominated). Trail densities were highest at 0.02 trails per km day in RF2 (regenerating forest – tall shrub dominated) during 2017 surveys and 0.41 in BS17 (black spruce treed bog) during 2018 surveys. The mean density was also highest in BS17 (black spruce treed bog) at 0.20 trails per km day. (Table 2.6-2).

Woodland caribou trails were detected in six Ecosites during the 2017 surveys: BS3 (jack pine/blueberry/lichen), BS7 (black spruce/blueberry/lichen), BS9 (black spruce-jack pine/feathermoss), BS17 (black spruce treed bog), RF2 (regenerating forest – tall shrub dominated) and on Water/Lake Ice. Trail density was highest in BS9 (black spruce - jack pine/feathermoss) at 1.43 per km day, followed by BS7 (black spruce/blueberry/lichen) (0.65) and BS17 (black spruce treed bog) (0.64). The highest mean density of trails occurred in the BS9 (black spruce - jack pine/feathermoss) Ecosite at 0.71 trails per km day (Table 2.6-2). No fresh trails were detected during 2018 surveys.

Woodland caribou feeding activity (fresh and old) was recorded at five different locations on transects 2 and 9 during 2017 surveys. Four were ground feeding craters and one was arboreal feeding. All observations were within the BS3 (jack pine/blueberry/lichen) Ecosite. The 2018 surveys detected 13 old ground feeding craters/crater complexes along transects 2, 9 and 12. Eight observations occurred in the BS3 (jack pine/blueberry/lichen) Ecosite and five observation in the RF2 (regenerating forest – tall shrub dominated) Ecosite.

Carnivores

The trails of seven species of carnivores were detected during winter tracking surveys including: marten, ermine mink, fisher, red fox, lynx and otter. Carnivore trails were observed in 74% (14/19) Ecosites (Figure 2.6-1 and Tables 2.6-1 and 2.6-2).

Marten trails were observed on all three transects types (triangle, creek, and road/anthropogenic). Transects 9 (1.51 trails/km-day), 2 (0.66), and 12 (0.59) had the highest trail densities during the 2017 surveys and transects 9 (1.64), 11 (1.62), and 12 (0.58) had the highest trail densities during the 2018 surveys. The highest mean density of marten trails was observed on transect 9 (1.57).

Marten trails were detected in 58% (11/19) of Ecosites across both sampling years. Marten trails were most often observed in the BS3 (0.83 trails/km-day) (jack pine/blueberry/lichen), BS4 (0.61) (jack pine – black spruce/feathermoss), and BS16 (0.58) (black spruce/balsam poplar/river alder swamp) Ecosites during 2017 surveys. The 2018 surveys detected marten trails most commonly in the BS4 (1.06) (jack pine – black spruce/feathermoss), BS7 (0.76) (black spruce/blueberry/feathermoss) and RF2 (0.68) (regenerating forest – tall shrub dominated) Ecosites. The highest mean density of marten trails was observed in Ecosite BS4 (0.83) (jack pine – black spruce/feathermoss)

Ermine trails were recorded on all three transect types. Trails were widespread during the 2017 surveys with detections on 65% (11/17) transects, while 2018 surveys detected ermine trails on 20% (3/15) transects. Creek 4 (1.69 trails/km-day), creek 3 (1.11), and transect 8 (0.69) had the highest trail densities during 2017 surveys. Creek 4 also had the highest trail density during 2018 surveys (2.35) and the highest mean trail density (2.02).

Ermine trails were detected in 58% (11/19) of Ecosites across both sampling years. Ecosites BS21 (1.61 trails/km-day) (tamarack treed fen), BS17 (1.01) (black spruce treed bog), and BS23 (0.61) (willow shrubby fen) had the highest trail densities in 2017. The 2018 survey detected ermine trails most frequently in the BS16 (6.47) (black spruce/balsam poplar/river alder swamp) Ecosite. The highest mean trail density was detected in Ecosite BS16 (3.23) (black spruce/balsam poplar/river alder swamp).

Mink trails were observed along all three transect types. Creek 3 (1.11 trails/km-day), creek 4 (0.48), and transect 12 (0.07) had the highest densities of trails in 2017 and transect 11 (0.90), transect 9 (0.72) and transect 12 (0.12) in 2018. Creek 3 had the highest mean mink trail density at 0.56 trails per km-day.

Mink trails were detected in 11 of 19 Ecosites (65%) but showed a marked preference for BS17 (black spruce treed bog), BS21 (tamarack treed fen) and BS18 (Labrador tea shrubby bog), with mean trail densities of 0.80, 0.61 and 0.43 trails per km-day respectively.

Fisher trails were only observed during 2017 surveys; along the road/anthropogenic transect and one triangle transect. Fisher mean trail densities were 0.09 on the road/anthropogenic transects and 0.02 on triangle transect 2. Fisher trails were detected in the anthropogenic (0.08 trails/km-day), RF1 (0.03) (regenerating forest – tree dominated) and BS3 (0.01) (jack pine/blueberry/lichen) Ecosites.

Lynx trails were detected on all transect types. The highest trail densities were observed on transects 4 (0.69 trails/km-day), transect 1 (0.49), and transect 6 (0.42) during 2017 surveys and creek 3 (2.51), transect 10 (0.62), and transect 7 (0.11) in 2018. The highest mean density was detected on creek 4 (1.25).

Lynx trails were detected in 37% (7/19) of the Ecosites surveyed across both sampling years. Ecosites BS18 (0.39 trails/km-day) (Labrador tea shrubby bog), RF2 (0.30) (regenerating forest – tall shrub dominated), and RF1 (0.26) (regenerating forest – tree dominated) hosted the highest density of lynx trails in 2017. The 2018 surveys detected lynx trails most frequently in Ecosites BS23 (2.51) (willow shrubby rich fen), RF3 (0.31) (regenerating forest – low shrub dominated) and RF2 (0.22) (regenerating forest – tall shrub dominated). The highest mean trail density across both sampling years was observed in BS23 (1.25) (willow shrubby rich fen). A single lynx bed site was recorded along transects 6 in the RF2 (regenerating forest – tall shrub dominated) Ecosite in 2017.

Otter trails were only observed in 2017; along triangle and creek transects. The highest trail densities were detected on Creek 4 (0.24), transect 11 (0.17), and transect 12 (0.10) during 2017 surveys and creek 4 yielded the highest mean density (0.12). Otter trails were detected in 32%

(6/19) of the Ecosites sampled. Ecosites BS18 (0.13) (Labrador tea shrubby bog), and BS17 (0.09) (black spruce treed bog) and Water/Lake ice (0.05) had the highest trail densities.

Red fox trails were detected on triangle and road/anthropogenic transects. Red fox trails were detected on transect 11 (0.34 trails/km-day) and along the road/anthropogenic transects (0.02) in 2017 and transect 12 (0.06) along the road/anthropogenic transect (0.05) in 2018. The highest mean trail density was observed on transect 11 (0.17).

Red fox trails were detected in 21% (4/19) of the Ecosites across both sampling years. Ecosites RF3 (regenerating forest – low shrub), Anthropogenic (polygonal and linear disturbance) and RF2 (regenerating forest – tall shrub dominated) had trail densities of 0.13 trails per km-day, 0.02 and 0.01 in 2017. The 2018 survey detected red fox trails in the anthropogenic (polygonal and linear disturbances) and Water/Lake ice Ecosites both at densities of 0.04 trails per km-day. The mean trail density was highest in the RF3 (regenerating forest – low shrub dominated) Ecosite at 0.06 trails per km-day.

Small Mammal Prey and Game Birds

The trails of four different species or species groups of small mammals and game birds were observed during winter tracking surveys including: snowshoe hare, red squirrel, grouse/ptarmigan, and microtine rodents (Figure 2.6-1 and Tables 2.6-1 and 2.6-2).

Snowshoe hare trails were the most commonly observed trails in the Project area. Snowshoe hare trails were observed along all three transects types with the highest densities of trails per km-day on transect 1 (24.89), transect 6 (18.03), and transect 7 (15.68) in 2017 and transect 10 (28.72), transect 6 (27.04), and transect 7 (10.51) in 2018. The highest mean snowshoe hare trail density was detected along transect 6 (22.53).

Snowshoe hare trails were observed in 63% (12/19) of the Ecosites surveyed across both sampling years. Snow shoe hare trails were most commonly observed in RF2 (20.60 trails/km-day) (regenerating forest – tall shrub dominated), RF1 (20.00) (regenerating forest – tree dominated), and BS4 (19.67) (jack pine - black spruce/feathermoss) in 2017 and RF2 (24.29) (regenerating forest – tall shrub dominated), RF1 (10.28) (regenerating forest – tree dominated), and BS7 (2.28) (black spruce/blueberry/lichen) in 2018. The Ecosite with the highest mean trail density observed was RF2 (22.45) (regenerating forest – tall shrub dominated).

Red squirrel trails were also detected along all three transect types. Creek 3 (5.2), transect 4 (4.57), and transect 6 (3.93) hosted the highest trail densities in 2017, while 2018 surveys detected the highest red squirrel trail densities along transect 10 (6.38), creek 4 (4.72), and transect 7 (2.71). The highest mean trail density was observed along transect 10 (3.78).

Red squirrel trails were widespread and observed in 79% (15/19) of the Ecosites across both sampling years. The highest red squirrel trail densities were detected in B21 (4.83 trails/ km-day) (tamarack treed fen), BS23 (4.27) (willow shrubby rich fen), and BS9 (3.83) (black spruce – jack pine/feathermoss) in 2017 and BS16 (6.47) (black spruce/balsam poplar/river alder swamp), BS24

(3.96) (graminoid fen), and BS7 (2.78) (black spruce/blueberry/lichen). Ecosite BS16 (3.82) (black spruce/balsam poplar/river alder swamp) had the highest mean red squirrel trail density.

Grouse/ptarmigan trails were observed along all three transects types. The highest trail densities were detected along creek 5 (3.27), transect 8 (1.41), and transect 1 (1.1) in 2017 and creek 3 (35.95), creek 4 (18.87), and transect 11 (0.72) in 2018. The highest mean trail density was observed along creek 3 (17.97).

The trails of grouse/ptarmigan were recorded in 13 of 19 (68%) of Ecosites sampled. The highest trail densities were detected in the BS24 (10.53 trails/km-day) (graminoid fen), BS19 (5.69) (graminoid bog) and BS18 (2.48) (Labrador tea shrubby bog) during 2017 surveys. The 2018 surveys detected the highest trail densities in the BS23 (35.95) (willow shrubby rich fen), BS16 (3.23) (black spruce/balsam poplar/river alder swamp), and BS17 (3.04) (black spruce treed bog) Ecosites. The highest mean trail density was observed in Ecosite BS23 (17.97) (willow shrubby rich fen).

The trails of microtine rodents were observed along all three transect types. The highest density of microtine rodent trails was observed along transect 9 (1.92), creek 3 (1.11), and the road/anthropogenic transects (0.84) in 2017; and transect 7 (0.65), transect 9 (0.51), and transect 11 (0.27) in 2018. Transect 9 had the highest mean trail density (1.22).

Microtine rodent trails were observed in 63% (12/19) of Ecosites across both sampling years. Microtine rodent trail densities were highest in BS19 (1.90 trail/km-day) (graminoid bog), BS23 (1.22) (willow shrubby rich fen), and Anthropogenic (0.67) (polygonal and linear disturbances) in 2017. The 2018 surveys detected the highest microtine rodent trail densities in Ecosites: BS9 (0.56) (black spruce – jack pine/feathermoss), BS3 (0.21) (jack pine/blueberry/lichen), and RF2 (0.15) (regenerating forest – tall shrub dominated). The highest mean trail density was observed in the BS19 (0.95) (graminoid bog) Ecosite.

2.7 Spring Ungulate Pellet Group/Browse Availability Survey

Pellet group/browse availability transects replicated the terrestrial portion of the established winter tracking triangle transects and creek transects throughout the LSA and RSA. In addition, pellet group/browse availability transects were completed along the proposed access corridor and existing Phoenix anthropogenic disturbance. The objectives of this survey were to:

- Collect data on the presence/not-absence of ungulates (moose and woodland caribou) and carnivores in the project area and by transect and Ecosite
- Collect data on the relative abundance of ungulates (moose and woodland caribou) and carnivores in the project area and by transect and Ecosite
- Collect data on browse availability and use of woody forage species for moose
- Describe the frequency of occurrence and abundance of terrestrial and arboreal lichen for woodland caribou
- Collect data on the presence/not-absence and relative abundance of game birds (grouse/ptarmigan species)

- Develop a scientifically defensible baseline to support impact assessment and to allow for potential future follow up/monitoring requirements

2.7.1 Methods

A handheld GPS and satellite imagery was used by the observer(s) to navigate the pre-established transects (i.e. same transects used for winter track counts). Observers searched for ungulate pellet groups and carnivore scats one meter on either side of the transect line. Each transect was broken into 50 m sub-transects. A UTM coordinate for the start and end point of each 50 m sub-transect was recorded. Winter (non-growing season) pellet groups were recorded separately from summer (growing season) pellet groups based on shape and texture. Pellet groups observed that were deposited before the previous winter were also recorded but were labelled as “Old”.

At the end of each 50 m sub-transect a detailed browse availability/use plot was completed using a 5.6 m radius (100 m2) plot. The percent cover class of each woody shrub species available within the plot was recorded. Cover classes included: nil (0%); very low (0 to 5%); low (5 to 25%); moderate (25 to 50%); and high (>50%) (Daubenmire 1959). An estimate of the percent of available twigs browsed was also completed using the same classes. The browse use classes measured forage use of woody plants by all ungulates and did not make a distinction as to the actual ungulate species using these plants. Terrestrial lichen cover was estimated using a representative 1 m x 1 m plot nested within the larger 5.6 m radius plot. Arboreal lichen cover was estimated using five relative abundance cover classes as per the methods of Armleder *et al*. (1992).

Pellet group/browse survey transects were overlain onto Ecosite mapping within a geographic information system (GIS). Each sub-transect was assigned an Ecosite type using field notes and GIS query data. A count was made of the number of pellets or scats per total sub-transect sampling area (50 m x 2 m or 100 m2) for all segments. The resultant measure of ungulate use was the number of pellet groups/ha per animal species and Ecosite type. Frequency of occurrence (constancy) and mean percent canopy coverage (midpoints of canopy closure classes) of each available woody browse species was calculated for sub-transects by vegetation cover type. These two values were multiplied to provide an availability index value for each browse species and vegetation type. The frequency of use and mean percent browsing (midpoints of vegetation cover classes) of woody browse species was calculated for each species and vegetation cover type. These two values were multiplied to determine a browse use index value for each woody browse species and Ecosite type.

2.7.2 Results

A total of 11 triangle transects, five riparian transects, one proposed access route transect and one existing anthropogenic route transect were surveyed between June 9 and 20, 2017. The triangle, riparian, and access route transects were replicated between June 7 and 14. 2018. The total search effort was 16 hectares in each year (Figure 2.7-1). All transects, with the exception of the proposed access transect, were replicates of the winter track count program. The pellets or scats of eight species or species groups pellet groups were detected during the survey (Table 2.7-1). Listed below, in descending order, are the mean pellet group densities in the project area for each species detected:

- Grouse/ptarmigan – 17.28 pellet groups/ha
- Woodland caribou – 1.48 (combined summer/winter)
- Moose – 0.97 (combined summer/winter)
- Black bear – 0.19
- Wolf – 0.06
- Red Fox – 0.06
- Mink – 0.03
- Marten – 0.03

Pellet Group Densities

Ungulates

Two species of ungulates pellet groups were observed during the survey including moose and woodland caribou.

Moose winter pellet groups were observed on eight different transects and summer pellet groups on four transects. Winter pellet groups were detected most frequently along creek 3 (19.2 pellet groups/ha), transect 11 (3.9/ha), and transect 8 (2.4/ha) in 2017 and along creek 3 (9.4/ha), transect 1 (2.0/ha), and the access transect (1.0/ha) in 2018. Summer pellet groups were observed on creek 4 (12.5/ha) and transect 10 (1/ha) in 2017. In 2018 summer pellet groups were detected along transect 4 (3.8/ha) and transect 6 (0.8/ha). The highest mean pellet group density for winter pellets was observed along creek 3 (14.3/ha), while the highest mean summer pellet group density was detected along creek 4 (6.3/ha). No moose pellet groups were observed along the existing anthropogenic disturbance transects (Figure 2.7-1 and Table 2.7-1).

Moose occurred widely but demonstrated a habitat focused distribution. Moose winter pellet groups were detected in four Ecosites/vegetation cover types and summer pellet groups were detected in three Ecosites/vegetation cover types across both sampling years. Ecosites/vegetation cover types with winter pellet groups in 2017 included: BS7 (3.5 pellet groups/ha) (black spruce/blueberry/lichen), RF2 (1.9/ha) (regenerating forest – tall shrub dominated), RF3 (1.2/ha) (regenerating forest - low shrub dominated) and RF1 (1.2/ha) (regenerating forest – tree dominated). Ecosites/vegetation cover types with winter pellet groups in 2018 included: RF2 (1.3/ha) (regenerating forest – tall shrub dominated) and RF1 (0.3/ha) (regenerating forest – tree dominated). The highest mean winter pellet group density was detected in the BS7 (1.8/ha) (black spruce/blueberry/lichen) Ecosite. Summer pellet groups were detected in Ecosites/vegetation cover types BS16 (24.6/ha) (black spruce/balsam poplar/river alder swamp) and RF2 (0.2/ha) (regenerating forest – tall shrub dominated) in 2017. The 2018 survey detected summer pellet groups in the RF2 (1.1/ha) (regenerating forest – tall shrub dominated) and RF1 (0.3/ha) (regenerating forest – tree dominated) Ecosites/vegetation cover types. The highest mean summer pellet group density was detected in Ecosite BS16 (12.3/ha) (black spruce/balsam poplar/river alder swamp) (Table 2.7-2).

Woodland caribou pellet groups were observed on five transects. Winter pellet groups were detected at a density of 1.3 pellets per hectare on transect 9 and 0.7 pellets per hectare on transect

5 during the 2017 surveys. Summer pellets were only detected on transect 9 (0.7 / ha) in 2017. The 2018 surveys detected the highest densities of winter pellet groups on transects creek 5 (13.4/ha), transect 2 (9.9 / ha) and transect 12 (9.7 / ha). No woodland caribou summer pellet groups were detected during the 2018 surveys. The highest mean density of winter woodland caribou pellet groups was observed along creek 5 (6.7/ha), while the highest mean density of summer pellet groups was detected on transect 9 (0.3/ha). No woodland caribou pellet groups were observed along the proposed access or existing anthropogenic transects (Figure 2.7-1 and Table 2.7-1).

Woodland caribou pellet groups were detected in 25% (5/20) Ecosites/vegetation cover types. Winter pellet groups were only detected in BS3 (jack pine/blueberry/lichen) Ecosite/vegetation cover type at a frequency of 0.7 pellet groups per hectare during the 2017 survey. The 2018 survey detected winter pellet groups most frequently in the BS7 (61.7/ha) (black spruce/blueberry/lichen), BS3 (6.3/ha) (jack pine/blueberry/lichen), and BS17 (1.6/ha) (black spruce treed bog). The highest mean density of winter pellet groups was detected in the BS7 (30.8/ha) (black spruce/blueberry/lichen). Summer pellet groups were detected in the BS18 (Labrador tea shrubby bog) Ecosite/vegetation cover type at a frequency of 3.0 pellet groups per hectare during the 2017 survey and no summer pellet groups were detected in 2018 (Table 2.7-2).

Carnivores

Five species of carnivore scat were detected during pellet group surveys including black bear, fox, wolf, mink, and marten. Black bear scat was detected on 28% (5/18) of transects. The highest mean black bear scat density was observed on creek 3 (4.7 scat/ha). Fox scat was detected on transect 6 and transect 1, with a mean density of 0.4/ha and 0.4/ha respectively. Wolf scat was detected along creek 5 and transect 9, with mean densities of 3.3/ha and 0.3/ha. Mink scat was detected on transect 9 with a mean density of 0.3/ha. Marten scat was detected on transect 11 (0.5/ha). No carnivore scat was detected along the proposed access or existing anthropogenic transects (Figure 2.7-1 and Table 2.7-1).

Carnivore scat was detected in five Ecosites/vegetation cover types. Black bear scat was detected in five Ecosites/vegetation types, with the highest mean scat densities observed in BS9 (4.5/ha) (black spruce – jack pine/feathermoss) and BS17 (0.8/ha) (black spruce treed bog). Wolf scat was detected in Ecosites/vegetation cover types BS17 (0.8/ha) (black spruce treed bog) and BS3 (0.1/ha) (jack pine/blueberry/lichen). Fox scat was detected in RF2 (0.2/ha) (regenerating forest – tall shrub dominated). Mink scat was detected in BS17 (0.8/ha) (black spruce treed bog), and marten scat was detected in BS3 (0.1/ha) (jack pine/blueberry/lichen) (Table 2.7-2).

Upland Game Birds

Grouse/ptarmigan pellet groups were observed frequently in the project area with detections along 12 transects. Transect 6 (32.3 pellet groups/ha), proposed access transect (29.1/ha), and transect 9 (25.1/ha) had the highest mean densities of grouse/ptarmigan pellet groups. No pellet groups were observed along the creek or anthropogenic transects (Figure 2.7-1 and Table 2.7-1).

Grouse/ptarmigan pellet groups were detected in 12 Ecosites/vegetation cover types with the highest densities observed in the BS19 (68.8/ha) (graminoid bog), BS7 (30.8/ha) (black spruce/blueberry/lichen), and BS9 (28.8/ha) (black spruce – jack pine/feathermoss) (Table 2.7-2).

Woody Browse and Lichen Availability

Terrestrial Lichen

Terrestrial lichen was observed in all Ecosite/vegetation cover types sampled except for BS23 (willow shrubby rich fen), and recent burn. Frequency of occurrence was very high (greater than 98%) in Ecosites/vegetation cover types BS3 (jack pine/blueberry/lichen), BS4 (jack pine – black spruce/feathermoss), BS7 (black spruce/blueberry/lichen), BS9 (black spruce – jack pine/feathermoss), BS21 (tamarack treed fen), RF1 (regenerating forest – tree dominated), and RF2 (regenerating forest – tall shrub dominated). Terrestrial lichen importance values (frequency of occurrence X mean percent cover) was highest in Ecosites/vegetation cover types BS3 (jack pine/blueberry/lichen), BS7 (black spruce/blueberry/lichen), and RF2 (regenerating forest – tall shrub dominated). Terrestrial lichen was very abundant. The project area had a 96% terrestrial lichen frequency of occurrence and a mean cover of 52% (Appendix 7).

Arboreal Lichen

Arboreal lichen occurred in 80% (16/20) of Ecosites/vegetation cover types surveyed. Arboreal lichen occurred most frequently in BS3 (jack pine/blueberry/lichen), BS7 (black spruce/blueberry/lichen), BS16 (black spruce/balsam poplar/river alder swamp), BS21 (tamarack treed fen), and BS23 (willow shrubby rich fen). However, it should be noted that the sampling intensity in BS16 (black spruce/balsam poplar/river alder swamp), BS21 (tamarack treed fen), and BS23 (willow shrubby rich fen) was low so these results should be interpreted with caution. Arboreal lichen was present at 55% of the project area sample sites but lichen loads were light (Class 1 recorded at 61% of the sites and Class 2 at 37%) (Appendix 7).

Woody Browse

The availability and use of nine species or species groups of woody browse recorded in the Denison Wheeler River project area are detailed in Appendix 8. The most commonly encountered species were alder spp. (17% of segments), willow spp. (4%), and sweet gale (3%). Alder was observed in 45% (9/20) of the Ecosites/vegetation cover types sampled, willow in 80% (16/20), and sweet gale in 65% (13/20). Alder, willow, and sweet gale were also the only woody species browsed. Willow had the highest overall frequency of browse at 2%, while both alder and sweet gale were browsed less than 1%. Browse was observed in the BS3 (jack pine/blueberry/lichen, BS16 (black spruce/balsam poplar/river alder swamp), BS22 (leatherleaf shrubby poor fen), RF3 (regenerating forest - low shrub dominated) and RF2 (regenerating forest – tall shrub dominated) Ecosites/vegetation cover types.

2.8 Small Mammal Trapping Survey and Tissue Analysis

Mice, voles, and shrews are a primary prey for a number of mammalian carnivore species including fisher, marten, and ermine (Pattie and Fisher 1999). Avian raptors such as owls and hawks also rely on small mammals as prey. Small mammals are often also used as bio-indicators. In support of the project, the objectives of this survey were to:

- Determine the species composition and relative abundance of voles, mice and shrews
- Determine Ecosite-small mammal habitat associations for the study area
- Collect micro-habitat information at trap sites to assist in the future development of optimum reclamation targets geared towards small mammal species
- Collect small mammal specimens for baseline/background metal and radionuclide tissue analysis

2.8.1 Methods

Trapping/Inventory

Sampling was stratified by Ecosite but completed in areas with potential to be impacted by the proposed project footprint (Gryphon and Phoenix deposits) and in suitable reference areas. Small mammal trap lines consisted of 15 trap stations spaced 10 m apart. Each trap station consisted of two Victor snap traps spaced 3 meters apart. In addition, three pit-fall traps were deployed along the transect for the capture of shrews, which are not always readily captured using snap-traps. The pit-fall traps were equally spaced along the trap-line. Traps and pit-falls were left in place for three consecutive trap nights. Snap traps and pit-fall traps were baited with a mixture of peanut butter and oats. Trap lines were checked once a day and all captures were recorded. Captured animals were collected using zip-lock bags and were marked with the date of capture, species, trap line, and trap station. Specimens were frozen and stored for future tissue analysis.

Habitat Characterization

Vegetation cover and structure plots (5 m x 2 m) were established at each trapping station to quantify habitat attributes present along each trap line and at each trap station. The objective was to quantify and describe the micro-habitat characteristics of each Ecosite/vegetation cover type. Micro-habitat associations can then be used to help guide future reclamation prescriptions to accommodate small mammal species. At each trap site, measurements/estimates of the following variables were completed:

- Percent cover of graminoids
- Percent cover of forbs
- Percent cover of shrubs (<2.5m)
- Percent cover of shrubs (2.5-5m)
- Percent cover of trees (>5m)
- Tree diameter at breast height (DBH)
- Tree species composition
- Percent cover of surface litter

- Surface litter depth (cm)
- Graminoid height (cm)
- Forb height (cm)
- Low shrub height (cm)
- Tall shrub height (m)
- Percent cover of bare soil
- Percent cover of deadfall (0-10 cm)
- Percent cover of deadfall (10-25 cm)
- Percent cover of deadfall (>25 cm)
- Percent cover of rock
- Percent cover of standing water
- Percent cover of sphagnum
- Percent cover of feather moss
- Percent cover of lichen

Data for all variables were pooled and summarized by Ecosite/vegetation cover type.

Baseline Tissue Analysis – Metals and Radionuclides

All specimens captured during the small mammal trapping program were collected and frozen for future metal and radionuclide analysis by the Saskatchewan Research Council (SRC) lab. In conjunction with Denison, subsets of the specimens were selected for analysis. Red-backed voles were selected as the species to be analyzed as a result of abundance, spatial location of specimen and because of the suitability of this species for follow-up programs. Samples collected from each of the two future impact sites were combined to provide baseline metal and radionuclide levels in each of the three study areas. The reference area was further sub-divided into three sub-samples.

The metals parameters being analyzed were:

- Aluminum
- Antimony
- Arsenic
- Barium
- Beryllium
- Boron
- Cadmium
- Chromium
- Cobalt
- Copper
- Iron
- Lead
- Manganese
- Molybdenum
- Nickel
- Selenium
- Silver
- Strontium
- Thallium
- Tin
- Titanium
- Uranium
- Vanadium

The radionuclide parameters that were analyzed included:

- Lead-210

- Polonium-210
- Radium-226
- Thorium-230

The metal parameters were analyzed by inductively coupled plasma – mass spectronomy and radionuclides were analyzed by extraction and beta counting (Pb-210) or alpha spectroscopy (Po-210, Ra-226, Th-230).

2.8.2 Results

The small mammal trapping program was completed between September 24 and October 2, 2016. A total of 26 trap lines sampled in 17 different Ecosites/vegetation cover types, resulting in a total trapping effort of 2,562 trap nights (Table 2.8-1 and Table 2.8-2). The small mammal trap lines were stratified by three general areas: Gryphon deposit, Phoenix deposit, and reference (Figure 2.8-1).

Trapping/Inventory and Habitat Characterization

A total of 197 individual small mammals of three species were captured. Red-backed voles (*Clethrionomys gapperi*) were most abundant with 140 captures (5.8/100 trap nights), followed by meadow voles (*Microtis pennsylvanicus*) (40 or 1.6/100 trap nights), and dusky shrews (*Sorex monticolus*) (9 or 0.4/100 trap nights). The overall capture rate was 7.7 captures per 100 trap nights.

Incidental capture of six gray jays also occurred. Captures were either live released or disposed of.

Red-backed Vole

Red-backed voles were captured along 24 of 26 trap lines (92%) and in 15 of 17 Ecosites/vegetation cover types (88%). The most productive Ecosites/vegetation cover types included black spruce treed bog (BS17), willow shrubby rich fen (BS23), and jack pine – black spruce/feathermoss (BS4), with capture rates of 12.0, 12.0, and 10.0 red-backed voles per 100 trap nights respectively (Table 2.8-1 and Table 2.8-2).

The three Ecosites/vegetation cover types yielding the highest capture rates also had some of the highest percentages of low shrub cover and coarse woody debris as determined during the micro site habitat assessment (Table 2.8-3). Coarse woody debris and shrub cover are two major components of red-backed vole habitat (Carey and Johnson 1995, Sullivan *et al.* 2011) and should be incorporated into future reclamation.

Meadow Vole

Meadow voles were captured along 10 of 26 trap lines (38%) and in 10 of 17 Ecosites/vegetation cover types (59%) sampled. The most productive Ecosites/vegetation cover types included graminoid bog (BS19), tamarack treed fen (BS21), willow shrubby fen (BS23), and open bog (BS20), with capture rates of 12.0, 6.0, 4.0, and 4.0 per 100 trap nights respectively (Table 2.8-1 and Table 2.8-2).

The relative abundance of meadow voles was highest in four Ecosites/vegetation cover types including: BS19 (graminoid bog), BS21 (tamarack treed fen), BS23 (willow shrubby rich fen), and BS20 (open bog). These Ecosites/vegetation cover types had high a percentage of low ground cover as a result of abundant low shrub and/or graminoid species. In addition, these four habitats have high moisture regimes as evidenced by the presence of open water and/or sphagnum moss (Table 2.8-3). Peles and Barrett (1996) found that standing vegetation and litter abundance are key components in habitat selection for meadow voles, while Dehn *et al.* (2017) found that by adjusting cover to a higher density, meadow voles were more active, foraged more, and produced more offspring. The results of the current study support the findings of Peles and Barrett (1996) and Dehn *et al.* (2017) and suggest that providing a well-developed shrub layer with substantial litter cover (often achieved through the presence of graminoids) would be a useful strategy for reclamation.

Dusky Shrew

Dusky shrews were captured along 6 of 26 trap line (23%) and in 3 of 17 Ecosites/vegetation cover types (18%) sampled. The three Ecosites/vegetation cover types with captures were Labrador tea shrubby bog (BS18), black spruce treed bog (BS17), and jack pine – black spruce/feathermoss (BS4). Capture rates were 2/100 trap nights in BS18 (Labrador tea shrubby bog), 1.5/100 trap nights in BS17 (black spruce treed bog), and 0.7/100 trap nights in BS4 (jack pine – black spruce/feathermoss) (Table 2.8-1 and Table 2.8-2).

The Ecosites/vegetation cover types where dusky shrews were captured all had some combination of high shrub cover, litter cover, coarse woody debris and/or moss. BS17 (black spruce treed bog) and BS18 (Labrador tea shrubby bog) had high shrub cover and sphagnum moss values, while BS4 (jack pine – black spruce/feathermoss) had high shrub cover, litter cover and coarse woody debris cover values (Table 2.8-3). Whitaker Jr. (1963) found that moss is an important component in shrew habitat, while Wrigley *et al*. (1979) found hydric habitats dominated by either shrubs or graminoid/sedge were most suitable for shrews. To provide adequate reclamation for a variety of shrew species it is important to ensure the presence of interspersed wet habitats, such as fens and riparian areas. Creating habitats with a combination of graminoid cover, shrub cover, and moss will provide essential habitat for a variety of shrew species.

Baseline Tissue Analysis – Metals and Radionuclides

A total of 124 red-backed vole specimens were submitted for metals and radionuclide analysis. The phoenix deposit site sample consisted of transects 11-15 and 29 red-backed voles were composited for testing. The gryphon deposit site consisted of transects 1-3, 9-10 and 18 red-backed voles were composited for testing. In consultation with Denison, the reference areas were broken into three sub-sets for analysis based on their locations within the study area. Reference 1 consisted of transects 4-8 and composited 20 red-backed voles. Reference 2 and 3 consisted of transects 17-21 and were divided nearly equally to provide two composite samples (i.e. 28 and 29) for the two respective reference areas. Results of the metals and radionuclide analysis are presented in Table 2.8-4. Samples collected at the phoenix deposit indicated elevated levels of aluminum, titanium, uranium and Radium-226 in comparison to other sites.

2.9 Amphibian Nocturnal Call and Visual Search Surveys

The primary objective of these surveys was to establish the presence/not-absence and relative abundance of amphibian species within the Pheonix project area. Four species have the potential to occur including: Canadian toad (*Bufo hemiophrys*), northern leopard frog (*Rana pipens*), wood frog (*Lithobates sylvaticus*), and boreal chorus frog (*Pseudacris maculata*). Canadian toad and northern leopard frog are identified as sensitive species in Saskatchewan and as such have setback distances dependent on the level and type of disturbance. Canadian toad has setbacks ranging from 0 to 90 meters, while northern leopard frogs setbacks range from 10 to 500 meters (SkMOE 2017). Northern leopard frog is also listed as *Special Concern* by COSEWIC with a SARA Schedule 1 status (GOC 2017).

2.9.1 Methods

Nocturnal survey sites for amphibians were established within the project area at approximately 800 m intervals along linear features, where safe night time access was possible. The Saskatchewan Ministry of Environments species detection protocol for amphibian auditory surveys (2014b) was used to establish methodology for the amphibian nocturnal call surveys. Sites were surveyed beginning thirty minutes after sunset and ending at approximately 1 am. Surveying was not carried out at temperatures below 6° C as amphibian calling declines markedly below this temperature, or with winds higher than a Beaufort level 3.

At each survey site a one minute "quiet down" was honoured to allow amphibians disturbed by vehicular noise to resume calling, followed by a three minute listening period. Calls were identified to species and a qualitative assessment made as to the number present – one or two, several (3 to 5), and many (>5). Weather conditions – temperature, wind speed (Beaufort scale), and percentage cloud cover – were recorded at the start of each night's survey. The survey site locations were recorded using a hand-held GPS unit.

The visual search surveys were completed in areas of potential amphibian breeding habitat. The Saskatchewan Ministry of Environments species detection protocol for amphibian visual surveys (2014c) was used to establish methodology for the amphibian visual search surveys. The visual survey was completed by two observers slowing walking the perimeter of a waterbody and recording any observations of amphibian eggs, larvae, young or adults. The survey was completed during daylight hours and in sunny conditions. The survey route was recorded using the tracklog function on a hand-held GPS unit.

2.9.2 Results

Amphibian auditory surveys were completed between June 16 and 20, 2017 and June 6 and 9, 2018. A total of 61 sites were surveyed, 32 in the LSA and 29 in the RSA during the 2017 survey. The 2018 survey replicated 26 previously completed survey sites, 19 in the LSA and 7 in the RSA (Figure 2.9-1). The 2017 survey detected one species, wood frogs, at one location within the LSA. The detection rate of wood frogs was 2% (1/61 plots) for the entire project area and no detections occurred within the LSA (Table 2.9-1). The 2018 auditory survey detected boreal chorus frogs only. The detection rate was 19% (5/26 plots) for the project area and 21% for the LSA (4/19 plots) (Table 2.9-2). The difference in detection rates and species observation is likely a result of seasonal differences between years. The spring of 2018 was substantially wetter than the previous year due to heavy snow pack in the previous winter.

Visual search surveys were completed between June 7 and 14, 2018. A total of 4.6 km of shoreline was searched. Two wood frogs were detected during the visual search, resulting in a detection rate of 0.43 observations per km surveyed (Figure 2.9-1). No formal visual search surveys were completed during the 2017 surveys; however boreal chorus frogs were detected incidentally during other field surveys.

A comparison to regional results showed that wood frogs have been observed in five of six studies. Boreal chorus frogs have been observed in four of six studies and northern leopard frogs in one study. Boreal chorus frogs and wood frogs were detected less frequently in the Denison Wheeler River project area than other regional studies; however Cameco's Millennium project (very close proximity) also reported similarly low detection rates (Table 2.9-3).

2.10 Breeding Songbird Point Count Call Survey

Breeding songbird point count surveys were undertaken within the Pheonix project area to:

- Document the diversity of breeding songbirds within the project area
- Describing the relative abundance and diversity of breeding songbirds by Ecosite/vegetation cover types
- Determine the presence/not-absence of known or potential avian species at risk

2.10.1 Methods

The breeding songbird point count call survey methodology was developed with guidance from the Saskatchewan Ministry of Environments species detection survey protocol for forest bird surveys (SkMOE 2014d). Point counts were established within representative habitat types (Ecosites/vegetation cover types) in the project area and spaced at least 250 m apart. Point counts were predominantly located at minimum 100 m from any anthropogenic features. However due to the scarcity and spatial juxtaposition of some habitat types, point counts occasionally fell within 100 m. All point count locations were recorded using a hand held GPS unit.

Point counts were completed between sunrise and the following four hours. Each point count consisted of a one minute quiet down period followed by a 10 minute listening/observation period. The 10-minute count was broken down into a zero-to-three minute time period and a three-to 10 minute time period. All birds observed visually or aurally within the 100 m radius plot were recorded to species. Each bird observed/heard was recorded as an indicated pair (i.e. representing a mating pair). Species detected outside the survey plot were also recorded and included as incidentals. Descriptive weather data (temperature, sky condition, wind – Beaufort wind scale was recorded at the beginning of each point count. Surveys were not completed when temperatures fell below zero degrees Celsius, during precipitation or when winds reached Beaufort level 3.

Analysis of breeding songbird data included species richness and diversity, species presence, relative abundance (by species and habitat), habitat use, and detection of species at risk. The Shannon-Wiener Diversity Index (H) was used to quantify diversity for a given area or habitat. Species evenness (E) was calculated using (H) and the natural logarithm of (S). Evenness refers to how close in numbers each species in an environment are. Evenness values will range from 0-1, where variation in species richness decreases as values approach 1(complete evenness). These calculations are detailed below:

$$H = -\text{sum}\ (P_i \ln[P_i])$$
$$E = H/\ln (S)$$

where:

S = total number species in a habitat;
Pi = proportion of S made up of the ith species; and,
E= equability of species distribution.

2.10.2 Results

Breeding songbird point count surveys were completed within the Pheonix project area between June 7 and 17, 2017. A total of 101 survey points were completed across 21 Ecosites/vegetation cover types (Figure 2.10-1 and Table 2.10-1). A total of 319 indicated pairs, representing a mean detection rate of 3.2 pairs per survey point, and a Shannon-Wiener diversity index of 2.9 with an evenness value of 0.8, were observed in the project area (Table 2.10-2). Thirty-six unique species were detected during the survey (Table 2.10-3). The ten most commonly detected species in descending order were:

- Ruby-crowned Kinglet (51)
- Dark-eyed Junco (40)
- Gray Jay (34)
- Yellow-rumped Warbler (31)
- Swainson's Thrush (18)
- Hermit Thrush (18)
- Lincoln Sparrow (15)
- Chipping Sparrow (15)
- Fox Sparrow (15)
- American Robin (13)

Avian Species by Ecosite/Vegetation Cover Type

Species richness was highest in the regeneration – tree dominated (RF1 - 13 species), leatherleaf shrubby poor fen (BS22 – 12), black spruce treed bog (BS17 – 11), tamarack treed fen (BS21 – 11), and regeneration – tall shrub dominated (RF2 – 11) Ecosites/vegetation cover types. The lowest species richness was observed in open fen (BS25 – 1), graminoid bog (BS19 – 2), and graminoid fen (BS24 – 3) (Table 2.10-2).

The highest mean number of breeding songbird pairs was detected in the jack pine – white birch/feathermoss (BS5 – 7 pairs), jack pine – black spruce/feathermoss (BS4 – 5.2), and black spruce/blueberry/lichen (BS7 – 4.6) Ecosites/vegetation cove types. The lowest mean number of pairs were detected in the open fen (BS25 – 0.5), graminoid fen (BS24 – 0.8), and graminoid bog (BS19 – 1) (Table 2.10-2).

The Ecosites/vegetation cover types with the highest Shannon-Wiener diversity index were leatherleaf shrubby poor fen (BS22 – 2.4), regeneration – tree dominated (RF1 – 2.3), Labrador tea shrubby bog (BS18 – 2.2), and tamarack treed fen (BS21 – 2.2). The lowest Shannon-Wiener index was recorded in the open fen (BS25 – 0), graminoid bog (BS19 – 0.7), and graminoid fen (BS24 – 1) Ecosites/vegetation cover types (Table 2.10-2).

Ecosites/vegetation cover types with the highest evenness value included: graminoid bog (BS19), willow shrubby rich fen (BS23), open bog (BS20), sedge rocky shore (BS27), Labrador tea shrubby bog (BS18), rush sandy shore (BS26), and leatherleaf shrubby poor fen (BS22) with a value of one. The Ecosite/vegetation with the lowest evenness value was black spruce/blueberry/lichen with a value of 0.8. All remaining Ecosites/vegetation cover types had a value of 0.9 (Table 2.10-2).

A total of 34 avian species were observed incidentally during the breeding songbird survey and are listed in Appendix 1.

2.11 Semi-aquatic Furbearer Shoreline Survey

Semi-aquatic furbearing mammals (muskrat, mink, beaver and otter) are important species for fur trapping and traditional lifestyles. In addition, muskrats for example, have a widespread distribution, are generally abundant, are adaptable, and are a good indicator of aquatic ecosystem health (Westworth Associates 2002). Semi-aquatic furbearer shoreline surveys were completed to:

- Provide quantitative data on the occurrence and relative abundance of semi-aquatic furbearing mammals
- Provide spatial data on the distribution of semi-aquatic furbearer sign within the Wheeler River Project area

2.11.1 Methods

Semi-aquatic furbearer shoreline surveys were completed along the shorelines of select creeks, lakes, and ponds. Two observers paddled the shorelines of pre-selected sites and detailed notes were recorded to document the location and type of semi-aquatic mammal sign including:

- Territorial scent stations
- Foraging platforms and/or sign of foraging
- Resting platforms
- Scat
- Houses/lodges, dams or runs

The perimeters of select water bodies were paddled and the survey routes were mapped using the track-log function in a hand held GPS unit. The locations of all observations, including incidental sightings were recorded (UTM). The track-log route path data was recorded at five second intervals. All observations were summarized by species and water body. The resultant measure was the number of observations per km of shoreline.

2.11.2 Results

A total of 23 water bodies were surveyed (17 lakes/ponds and portions of 6 creeks) between September 29 and October 3, 2016 (Figure 2.11-1). The total distance of shoreline surveyed was 96 km, with approximately 42 km in the LSA and 65 km in the RSA. Signs of three target species, muskrat (*Ondatra zibethicus*), beaver (*Castor canadensis*), and river otter (*Lontra canadensis*) were observed during the survey.

Muskrat sign was noted in both the LSA and RSA. Muskrat sign was lumped into three types of observations including: burrows/houses, feeding/scent, and scat. A total of 70% (16/23) of water bodies had muskrat sign of some kind. Scat was the most commonly observed muskrat sign averaging 0.92 observations per km for the entire survey, while densities in the LSA and RSA were 1.8/km and 0.5/km respectively. Creek 6 (4.3/km), creek 5 (3.8), and lake 11 (3.6/km) had the highest scat densities. Feeding and scent sign was observed along the shores of 48% (11/23) of water bodies surveyed and consisted of sedge clippings, tuber/roots, and various emergent and submergent aquatic vegetation chewing/harvesting and scent platforms. Feeding/scent sign was observed at a rate of 1.0/km in the LSA and 0.3/km in the RSA. Lake 11 (7.3/km), creek 5 (3.8/km), and lake 9 (3.6) had the highest feeding/scent sign observation rates. Muskrat houses or runs were only observed in the LSA (0.2/km) on Lake 11 at a rate of 5.5/km (Table 2.11-1).

Beaver sign was also categorized into three types of observations including: runs/scent/feeding, active houses, and old/inactive houses. Beaver sign was observed in the LSA and RSA. Run/scent/feeding sign was observed at a rate of 0.3/km in the LSA and 0.1/km in the RSA. Run/scent/feeding sign was observed along the shores of 22% (5/23) of the water bodies surveyed, with the highest concentrations at lake 10 (3.0/km) and lake 7 (2.8/km), while lake 2 had the next highest density at 0.3/km. Old and inactive beaver houses, classed as such by their dilapidated, overgrown appearance and lack of fresh sign or feed beds, were observed in both the LSA and RSA at rates of 0.1/km and 0.1/km respectively. A total of 26% (6/23) of the lakes surveyed had old/inactive beaver houses present. Lake 14 (1.1/km), lake 7 (0.5/km), and creek 4 (0.3/km) had the highest densities. In addition, old run/scent/feeding sign was noted in the LSA and RSA. Forty three percent (10/23) of water bodies paddled had old run/scent/feeding sign (Table 2.11-1).

River otter sign was broken into two types including: scent/feeding and scat. River otter sign was recorded in the RSA only. Scent/feeding sign was detected at a rate of 0.03/km with observations on lake 6 (0.04/km) and lake 9 (0.4/km). Scat was observed on creek 2 (3.0/km) and creek 4 (0.8/km) for an overall density of 0.09/km in the RSA (Table 2.11-1).

2.12 Aerial Waterfowl and Raptor Stick Nest Survey

The aerial waterfowl and raptor stick nest survey was completed for the proposed Wheeler River project to:

- Document the presence/ not-absence, diversity, and abundance of breeding waterfowl
- Documenting the occurrence of active, inactive and old raptor nests (e.g. bald eagle, osprey and red-tailed hawk)
- Document the occurrence of species at risk

2.12.1 Methods

Lakes, streams and wetland areas were surveyed by helicopter at the maximum altitude that allowed identification of birds. A total of three observers completed the survey, with two observers documenting waterfowl observations and one observer documenting stick nest observations. Surveys were completed under appropriate environmental conditions that would not deter waterfowl from being exposed on open water (low wind speed and no precipitation). Weather conditions were recorded at the beginning of each survey and monitored throughout. All birds observed were identified to species, when possible, and total observations by lake/river/wetland complex were recorded. Survey sections varied in area searched (combined area of water bodies) from 2.2 ha to 450 ha as well as in the number of water bodies per section. Therefore, the abundance (number of birds observed) and species richness (number of species observed) in each survey section was divided by area searched to allow comparison between sections. For each survey section, factors such as average size of water bodies, density of water bodies, as well as mapped Ecosite within 100 m buffer of each water body was considered when attempting to identify important attributes for waterfowl within the Wheeler River Project area.

Raptor nest locations were recorded using a hand held GPS unit and nests were classified as active, inactive or old. Notes pertaining to species and clutch size/number of eggs were recorded for all active nests.

2.12.2 Results

A total of 33 survey sections containing 353 water bodies were surveyed on June 15 and 16, 2017 (Figure 2.12-1). The survey recorded 20 confirmed unique species and six species groups, for a total of 681 individual waterfowl/raptor(s) (Table 2.12-1). The ten most commonly observed species were:

- Ring-necked Duck (107)
- Common Merganser (93)
- Common Loon (75)
- Mallard (70)
- Unknown White-headed Gull (67)
- Bald Eagle (47)
- Canada Goose (37)
- Lesser Scaup (30)

- Yellowlegs Spp. (24)
- Bufflehead (23)

Thirty of the 33 survey sections observed waterfowl or raptors utilizing them. The survey sections with the highest species diversity were section 15 (11 species), section 31 (10 species) and sections 1, 18, and 21 (9 species). The highest individual abundance was observed in section 15 (67 individuals), section 31 (49 individuals), section 7 (47 individuals), and section 20 (40 individuals) (Table 2.12-2). However, based on area searched, the survey sections with the highest species diversity per hectare were survey section 7 (2.7 species/ha), survey section 13 (0.3 species/ha) and survey sections 3, 11, 27, 28 and 30 (0.2 species/ha). The highest individual abundance (density of birds per ha) was observed in survey section 7 (20.8 birds/ha), sections 28 and 30 (0.8 birds/ha), section 27 (0.6 birds/ha), and sections 11 and 13 (0.5 birds/ha) (Figure 2.12-1, Table 2.12-3).

Likely factors contributing to a high density of birds and species richness appear to be related to the size of the water body. All survey sections with the highest bird densities and species richness had sizes of 5 ha or less (Table 2.12-3). The overall density and species diversity, in relation to average size of water body, is displayed in Figure 2.12-2.

Connectivity between and proximity to neighbouring water bodies may also be important. As an example, no birds were observed in section 24 although this section was comprised of small water bodies. The water bodies in this section, were however, all isolated from each other (Figure 2.12-1). Section 7 was the only section comprised by a creek. The creek was predominantly narrow, and therefore did not cover a large area overall, however it provided a variety of micro habitats (ponds, low flowing water, as well as rapids) which may have contributed to the observation of high diversity and density which was not observed elsewhere within the study area.

Adjacent Ecosite type did not appear to affect density or diversity as three of the highest ranked sections were bordered by bogs and fens, whereas the other three were bordered by upland coniferous forest types (Table 2.12-3).

A total of 24 active (currently occupied), inactive (not currently occupied), and old (dilapidated) nests were observed in the project area (Figure 2.12-1). Eleven nests were active including four bald eagle nests (*Haliaeetus leucocephalus*), four osprey (*Pandion haliaetus*) nests, one raven (*Corvus corax*) nest, one herring gull (*Larus argentatus*) nest, one common loon nest, and one mew gull (*Larus canus*) colony of 12-15 nests (Table 2.12-4).

2.13 Regional Ungulate Aerial Surveys

No ungulate aerial surveys were completed as part of this baseline investigation. However several ungulate aerial surveys have been completed in several portions of the Boreal Shield of Saskatchewan (Woodland Caribou Management Unit : SK1) since 2008. Eight aerial surveys were completed for existing or potential mining projects in the Wheeler River Project area by other industrial operators in the area. These included five surveys for Cameco's Key Lake Mine, two surveys for Cameco's proposed Millennium project, and one survey for Cameco's McArthur River Mine. The Millennium Project site is located approximately 13 km from the Wheeler River Project area and the Key Lake and McArthur River Mines are approximately 35 km away. McLoughlin *et al.* (2016) provided a brief summary of the methods and results of these surveys.

It should be noted that an aerial survey was planned for the Wheeler River Project area; however SkMOE disscussions advised against the survey and would not grant a permit to complete the work.

2.13.1 Methods

Detailed methodology was not available for all the surveys. However, generalized methodology was provided in McLoughlin *et al.* (2016). Surveys were completed using helicopters and a viewing window of 200 m was used. Surveys were completed in December, February and March. The extent of survey area ranged from 320 to 2,285 km^2 and coverage ranged from 40 to 100% of the blocks surveyed.

2.13.2 Results

The mean woodland caribou density for all 16 surveys was 0.04 observations per km^2 but ranged from 0 to 0.13/km^2. Moose density was 0.05 observations per km^2 but ranged from 0.01 to 0.12/km^2. The mean density of woodland caribou detected during aerial surveys completed for projects in the vicinity of the Wheeler River Project area (Key Lake, Millennium, and McArthur River) was 0.04 observations per km^2. The mean density of moose detections for projects in the vicinity of the Wheeler River Project area was also 0.04 per km^2.

The densities of woodland caribou in surveys completed near the Wheeler River Project were consistent with the average of all surveys. The Millennium site, which is located close enough to the Wheeler River Project to assume that the 2,285km^2 aerial survey overlaps the Wheeler River Project area had low woodland caribou densities at 0.005 detections per km^2. Moose detections during the Millennium surveys were consistent with the average of all surveys at 0.04 per km^2.

Detailed results of ungulate aerial surveys, as derived from McLoughlin *et al.* (2016), can be found in Table 2.13-1.

2.14 Acoustic Bat Surveys

Acoustic bat surveys were completed to determine the presence/non-absence, diversity and relative abundance of bat species in the Wheeler River Project area. Acoustic surveys measure bat passes and feeding buzzes.

2.14.1 Methods

Surveys commenced one half hour after sunset and ended one half hour before sunrise. Survey stations were established 500 m apart along linear features where safe night travel was possible. Surveys were only completed during appropriate weather conditions, with weather attributes (temperature, sky condition and wind (Beaufort scale)) recorded throughout the survey.

Each survey site consisted of a five-minute listening period using a Wildlife Acoustics Echo Meter Touch 2 Pro. The detector was held with the microphone at a 45 degree angle and slowly rotated 360 degrees for the duration of the sampling period. If a bat was detected the detector was held stationary for 15 seconds to avoid duplicate counts.

Total detector hours were calculated for the Project area and by ecosite/vegetation cover type. Ecosite/vegetation cover type for each survey point was established by utilizing the dominate ecosite/vegetation cover type within a 50 m radius of the survey point.

Acoustic Bat Call Analysis

Data was analyzed using Wildlife Acoustics Kaleidoscope software. Echolocation call characteristics were used to identify bat species. Call characteristics used to establish species included:

- minimum frequency
- maximum frequency
- call duration
- call slope
- call shape

Call characteristics were compared to reference calls in literature and call libraries (WDNR 2016, WNDD 2016, Keinath 2011, Adams 2003). In addition, reference calls within Omnia's call library were used where possible.

2.14.2 Results

Passive acoustic bat surveys were complete in the Project area between July 22 and 23, 2019. Sixty-one acoustic bat survey locations were surveyed for a total of 305 minutes (Figure 2.14-1). Two bat species or species groups were detected during the survey, little brown myotis (*Myotis lucifugus*) and little brown myotis/northern myotis (*Myotis septentrionalis*). Bat species or species group were detected in 30% (18/61) of survey locations at a rate of 3.5 echolocation observations per hour. Feeding buzzes were detected in 3% (2/61) of survey locations at a rate of 0.4 feeding buzzes per hour. Detailed results by survey location and species/species group can be found in Table 2.14-1.

A total of five mapped ecosites were sampled during the passive bat acoustic surveys. The most commonly sampled ecosites/vegetation cover types were BS3 (jack pine/blueberry/lichen) (2.17 hrs), RF2 (regenerating forest – tall shrub dominated) (2.17hrs) and Anthropogenic (polygonal and linear disturbance) (0.42 hrs). Little brown myotis passes and feeding buzzes were most commonly detected in the BS9 (black spruce – jack pine/feathermoss) ecosite at 72 passes/hr and 60 feeding buzzes/ hr respectively. It should be noted the sample size in this ecosite was limited. The BS3 ecosite detected little brown myotis passes (5.5/hr) and feeding buzzes (0.9/hr) second most frequently. Little brown myotis/northern myotis passes were most frequently detected in the BS3

(3.7/hr) and Anthropogenic (2.4) ecosites. No feeding buzzes were detected for the little brown myotis/northern myotis group (Table 12.14-2).

2.15 Covert Camera Survey

Covert camera surveys are an effective and non-invasive way to gather wildlife observation data. They collect data remotely and continuously for a range of species and can be deployed in the field for months at a time; with minimal maintenance. The primary objectives of this survey were to:

- Determine the presence/non-absence and spatial distribution of wildlife species within the project study area
- Identify the relative use of linear features (roads, trails, and hand-cut lines) by wildlife and humans in the study area

2.15.1 Methods

A total of 20 Reconyx HyperFire 2 Professional Covert IR cameras were deployed within the Wheeler River Project area. Camera locations were determined using a combination of a stratified random and targeted approach. The stratified random approach allowed for coverage across the Project area, while a targeted approach allowed for the inclusion of rare attributes and camera placement to minimize theft.

The cameras were located on three linear feature types including road, trail/rough road and hand-cut line. Cusack *et al*. (2015) found that camera placement (random versus game trail based) was unlikely to affect community level inferences, given adequate sampling effort. Road sites were selected with the intention of further division into two sub-classes including an all-season road and a seasonal road. The feature types were defined as:

- Road – A maintained or seasonally accessible road supporting truck traffic or larger.
- Trail / Rough road – A cleared disturbance over 2 m in width.
- Hand-cut Line – A cleared disturbance under 2 m in width.

The study area was divided into four geographic units to ensure spatial distribution of the covert cameras across the study area. Cameras were stratified across mature and regenerating forest types as well as various levels of linear feature natural regeneration. Linear features were randomly selected within the geographic units to be ground trothed for camera locations ensuring distribution across ecosites/age classes and various linear feature regeneration levels. In addition, camera locations were purposely selected to minimize the potential for theft. Seven cameras were located on each of: trail / rough road and hand-cut line and six cameras were placed along roads. The six road cameras were established with the intention of further sub-division into all-season and seasonal roads based on winter maintenance (i.e. plowed vs. un-plowed in winter).
Cameras were mounted on stable trees, 1.5 m above the ground to capture a variety of species and pointed towards the targeted linear feature. All cameras faced north, or as close as feasible, to optimize lighting and avoid sun glare (Dunne 2007). Each camera was tested at its field location to ensure proper function. Camera settings included: high sensitivity trigger and motion sensors, three photographs per activation, one second photograph intervals and no quiet period between activations.

Camera photographs were examined to determine the number of individuals of each species captured. Each animal photographed was considered as an individual, since most species present in the study area are not distinguishable by pelage. Multiple photographs of the same individual (i.e. standing in front of camera, milling back and forth) were considered one observation event. Anthropogenic presence was also of interest so photographs containing humans/human use (vehicles, heavy equipment, recreational use, etc.) were also examined. The number of captures was divided by the number of camera deployment days to provide a relative abundance of species and human use.

2.15.2 Results

The 20 covert cameras were deployed between June 5 and 6, 2019 (Figure 2.15-1). Results were available from all 20 camera locations, totaling 2,929 camera days. The study recorded 11.9 wildlife captures per 100 camera days across all species in the Project area. Trails/rough roads and roads had the highest frequency of wildlife detection at 15.4 and 9.7 captures per 100 camera days. Snowshoe hare (2.2/100 camera days), woodland caribou (1.6) and black bears (1.2) were the most commonly photographed species. Table 2.15-1 and Table 2.15-2 detail the wildlife capture results by camera, species and feature type.

Human use in the study area was also quantified along linear features. The study recorded 201.4 human use events per 100 camera days across the Project area. Roads accounted for 99% (200.1/100 camera days) of human use observed in the Project area. Passenger vehicles (trucks, cars and vans) were the most commonly detected human use at 132.9 detections per 100 camera days. Table 2.15-3 and Table 2.15-4 detail human use captures by camera, vehicle group and feature type.

It is important to note that detections collected using covert cameras represent the minimum detection rate as cameras can malfunction or be misaligned due to tampering from animals or humans.

A sample of covert camera wildlife photograph captures can be viewed in Appendix 9. The covert camera survey is currently ongoing and a second data collection will occur in 2020.

3.0 SPECIES AT RISK AND SENSITIVE SPECIES

A total of 13 sensitive or federally/provincially listed species at risk were observed within the Denison Wheeler River Project area (Table 3-1). Sensitive species were defined as a species having a ranking of S3 or lower by the Saskatchewan Conservation Data Centre (SKCDC) or a species with a disturbance setback outlined in the Saskatchewan Ministry of Environment Activity Restriction Guidelines for Sensitive Species (2017). A total of nine species observed have seasonal setback distances based on the activity restrictions guidelines (Table 3-1).

Figure 3-1 displays the spatial distribution of sensitive and species at risk observations in the project area. These include olive-sided flycatcher and common nighthawk, which were observed frequently within the LSA and along areas of proposed disturbance/footprint. Species such as woodland caribou were only observed in the RSA, with observations concentrated in the northeast and southeast portions of the RSA.

Figure 3-2 displays the spatial distribution of sensitive and species at risk requiring setbacks under the Saskatchewan Activity Restriction Guidelines for Sensitive Species (2017). Specific setback distances and seasonal applicability are detailed in Table 3-1. Species and features such as olive-sided flycatcher, bald eagle nests and common nighthawk nests were all detected near the proposed footprint and will need to be considered in project planning.

4.0 REGIONAL FUR HARVEST DATA

4.1 Methods

Fur harvest return information for the 1985-86 to 2017-18 (33 years) was obtained from Lois Koback, Fur and Problem Wildlife Support with the Ministry of Environment Fish, Wildlife and Lands Branch. Data was obtained and summarized for all species for Fur Conservation Area (FCA) N-18 (Cree Lake) (Table 4.1-1), which incorporated the entire Wheeler River Project area. A summary of the total and average (plus minimum and maximum) annual number of furbearers harvested for FCA N-18 per year is provided.

4.2 Results

In FCA N-18, from the period 1985-86 to 2017-18, fur returns for 14 different species/species groups were reported. These included, in descending order of total captures, marten (4, 167), mink (2,761), muskrat (702), red squirrel (255), fox spp. (241), beaver (227), otter (192), fisher (149), weasel spp. (72), lynx (64) coyote (14), black bear (8), wolf (5) and wolverine (5) (Table 4.1-1). The three species with the highest average capture rates over the 33 year period were marten (138.9), mink (95.2), and muskrat (63.8).
Caution must be used when interpreting this data. Capture rates can vary widely and may reflect trapper effort and fur prices as much as animal abundance.

5.0 INDIGENOUS AND LOCAL KNOWLEDGE

5.1 Regional Indigenous Land Use

The Wheeler River Project area is located within the English River First Nation (ERFN) traditional territories. The ERFN has identified an estimated caribou range, cabins, traditional trails, winter trails, reserve lands and burial sites in the Wheeler River Project area and the surrounding region. Appendix 10, Figures 10-1 and 10-2 detail the EFRN traditional territories boundary traditional land uses in context with the Wheeler River Project Area.
Consultation was completed with the Kineepik Metis Local located in the Northern Village of Pinehouse, Saskatchewan in 2018 to complete a Use-and-Occupancy Map. The purpose of this Use-and Occupancy mapping was to provide a baseline inventory of harvesting and fixed cultural sites that residents have used during their lifetimes. In 2018 55 individuals were interviewed to supplement an existing 2011 survey completed outside the Wheeler River Project area. The 2018 consultation focused on the Key Lake Road corridor intersecting the Wheeler River Project Area. The resulting Use-and Occupancy Map is provided in Appendix 10 Figure 10-3.

5.2 Local Indigenous Assistants

During baseline field surveys for terrestrial mammal, avian and plant species, Omnia engaged local ERFN field assistants on many of the baseline surveys. Table 5.2-1 details local indigenous assistants and the level of involvement.

5.3 Local Indigenous Land User

Omnia, in conjunction with Denison, hosted a local indigenous land user (Mr. John) at the Wheeler River Project site to conduct an in-person interview on October 29, 2019. Mr. John has multiple cabins in the Wheeler River Project area and actively traps, hunts and commercial fishes in the Project area.
Mr. John discussed several topics with Omnia and Denison personnel including:

- Cabin locations
- Outfitting
- Trapping
- Commercial Fishing
- Country Food
- The Wheeler River Aquatic Baseline
- The Wheeler River Terrestrial Baseline
- Land Use and Lake Names
- Climate Change
- The Wheeler River Project Options and General Discussion

Several of Mr. John's comments pertaining to wildlife in the Wheeler River Project Area aligned with the findings of the terrestrial baseline. Specifically, Mr. John indicated that he observed woodland caribou more frequently than moose, Omnia also observed this (Table 2.6-1 and 2.7-1).

In addition, the locations Mr. John indicated observing woodland caribou and moose agreed with Omnia's findings (Table 2.6-1 and 2.7-1).

Mr. John indicated that Marten are much more commonly observed than fisher and are captured 90% of the time versus fisher while trapping. Omnia also found marten trails to be detected much more frequently than fisher trails (Table 2.6-1).

In addition, his comments have been incorporated to provide comparison and local indigenous land user knowledge, where relevant, throughout the wildlife baseline summary.

6.0 LITERATURE CITED

Acton, D.F., G.A. Padbury. and C.T. Stushnoff. 1998. The Ecoregions of Saskatchewan. Saskatchewan Environment and Resource Management. 205pp.

Adams, R.A. 2003. Bats of the Rocky Mountain West: Natural History, Ecology and Conservation. University Press of Colorado. Boulder, CO.

Armleder, H.M., S.K. Stevenson, and S.D. Walker. 1992. Estimating the Abundance of Arboreal Forage Lichens. BC Min. Forest Land Management Handbook, Field Guide Insert 7, Victoria, B.C. 22pp.

Banfield, A.W.F. 1974. The Mammals of Canada. National Museums of Canada. University of Toronto Press. 438 pp.

Cameco Corporation (Cameco). 2013. Key Lake Extension Project Environmental Impact Statement. 2121-11th Street West, Saskatoon, Saskatchewan. Submitted to the Saskatchewan Ministry of Environment and Canadian Nuclear Safety Board. 769pp.

Cameco Corporation (Cameco). 2009. Millennium Project Environmental Impact Statement. 2121-11th Street West, Saskatoon, Saskatchewan. Prepared for the Saskatchewan Ministry of Environment and Canadian Nuclear Safety Board. 731pp.

Carey, A.B. and M.L. Johnson. 1995. Small mammals in managed, naturally young, and old growth forests. Ecological Applications. 5(2): 336-352.

Charlebois, M. L., H. G. Skatter, J. L. Kansas, and D. P. Crouse. 2015. Using LiDar, coloured infrared imagery, and ground truth data for mapping and characterizing vegetation succession on disturbance types: implications for woodland caribou (Rangifer tarandus caribou) management. Canadian Wildlife Biology & Management 4: 119-136.

Chorney. D. 2017. Senior Technologist, Radiochemistry. Saskatchewan Research Council. 102-422 Downey Road, Saskatoon, SK, S7N 4N1.

Council on Environmental Quality. 1993. Incorporating biodiversity considerations into environmental impact analysis under the National Environmental Policy Act. Council on Environmental Quality, Executive Office of the President. Washington, D.C. 29 pp.

Cusack J., A. Dickman, J. Rowcliffe, C. Carbone. 2015. Random versus Game Trail-Based Camera Trap Placement Strategy for Monitoring Terrestrial Mammal Communities. PLoS One: pp 1–14.

Daubenmire, R. 1959. A Canopy-Coverage Method of Vegetational Analysis. Northwest Science 33:43-64.

Dehn, M.M., R.C. Ydenberg, L.M. Dill. 2017. Experimental Addition of Cover Lowers the Perception of Danger and Increases Reproduction in Meadow Voles (*Microtus pennsylvanicus*). Canadian Journal of Zoology. 95(7): 463-472.

DeMars, C.A. and Boutin, S., 2017. Nowhere to hide: Effects of linear features on predator–prey dynamics in a large mammal system. Journal of Animal Ecology, 87(1), pp. 274-284.

Dickie, M., R. Serrouya, C. DeMars, J. Cranston, and S. Boutin. 2017. Evaluating functional recovery of habitat for threatened woodland caribou. Ecosphere 8(9):e01936. 10.1002/ecs2.1936

Dunne B. 2007. Effectiveness of Above-ground Pipeline Crossing Structures for the Movement of Moose and Other Large Mammals. M.Sc. Thesis. University of Calgary. Calgary, Alberta. 217 pp.

Environment Canada (EC). 2012. Recovery Strategy for the Woodland Caribou (*Rangifer tarandus caribou*), Boreal population, in Canada. Species at Risk Act Recovery Strategy Series. Environment Canada, Ottawa. xi + 138pp.

Environment and Climate Change Canada (ECCC). 2015. Anthropogenic disturbance footprint within boreal caribou ranges across Canada - As interpreted from 2015 Landsat satellite imagery. http://data.ec.gc.ca/data/species/developplans/2015-anthropogenic-disturbance- footprint-within-boreal-caribou-ranges-across-canada-as-interpreted-from-2015-landsat-satellite- imagery/

Golder and Associates (Golder). 2013. Terrestrial Environment Baseline Report – Tazi Twe Hydroelectric Project. Submitted to SaskPower. 248pp.

Government of Canada (GOC), Species at Risk Public Registry. 2019. A to Z Species Index. Accessed Online November 5, 2019:
https://www.registrelep-sararegistry.gc.ca/sar/index/default_e.cfm

Government of Canada (GOC), Species at Risk Public Registry. 2017. Species Profile Northern Leopard Frog Western Boreal/Prairie populations. Accessed Online June 29, 2017: http://www.registrelep-sararegistry.gc.ca/species/speciesDetails_e.cfm?sid=552

Government of Saskatchewan. 2017. Species detection survey protocol: 20.0 Rare Vascular Plant. April 2017 Update. Saskatchewan Ministry of Environment, Fish, Wildlife and Lands Branch, Regina Saskatchewan. 27 pp.

Harms, V. and Leighton, A. 2011. Flora of Saskatchewan. Fascicle 1: Ferns and fern allies of Saskatchewan. Nature Saskatchewan. Regina, Saskatchewan, 192 pp.

Henderson, D. 2009. Occupancy Survey Guidelines for Prairie Plant Species At Risk. Canadian Wildlife Service, Prairie and Northern Region. Saskatoon, Saskatchewan. 45 pp. http://publications.gc.ca/site/archiveearchived.html?url=http://publications.gc.ca/collections/coll ection_2011/ec/En4-130-2010- ng.pdf Accessed December 2, 2017.

James, A.R.C., S. Boutin, D.M. Hebert, and A.B. Rippin. 2004. Spatial separation of caribou from moose and its relation to predation by wolves. J. Wildl. Manage. 68(4): 799–809.

Jones, D. 2019. Geomatics Services Branch, Ministry of Environment and Ministry of Saskatchewan Environment, Wildfire Management Branch.

Kansas, J.L., Vargas, J., Skatter, H.G., Balicki, B., and McCullum K. 2016. Using Landsat imagery to backcast fire and post-fire residuals in the Boreal Shield of Saskatchewan – Implications for woodland caribou management. International Journal of Wildland Fire. 25(5) 597-607.

Kansas, J.L., Charlebois, M.L., and Skatter, H.G. 2015. Vegetation recovery on low impact seismic lines in Alberta's Oil Sands and visual obstruction of wolves (Canis lupus) and woodland caribou (Rangifer tarandus caribou). Can. Wildl. Biol. Manage. 4(2): 137–149.

Keinath D.A. 2011. Draft Wyoming ANABAT Call Key. Wyoming Natural Diversity Database, Laramie, Wyoming. 4pp

Kershaw, L., J. Gould, D. Johnson and J. Lancaster. 2001. Rare Vascular Plants of Alberta. University of Alberta Press. Edmonton, AB. 484 pp.

Kimmins, H. 1997. Balancing Act: Environmental issues in forestry. 2nd Edition. UBC Press, Vancouver, BC. 305pp.

Klinkenberg, Brian. (Editor) 2011. E-Flora BC: Electronic Atlas of the Plants of British Columbia [eflora.bc.ca]. Lab for Advanced Spatial Analysis, Department of Geography, University of British Columbia, Vancouver. [November 2017]

Latham, A.D.M, M.C. Latham, and M.S. Boyce. 2011a. Habitat Selection and Spatial Relationships of Black Bear (Ursus americanus) with Woodland Caribou (Ranifer tarandus caribou) in Northeastern Alberta. Canadian Journal of Zoology 89: 267-277.

Latham, A. D. M., M. C. Latham, M. S. Boyce, and S. Boutin. 2011b. Movement responses by wolves to industrial linear features and their effect on woodland caribou in northeastern Alberta. Ecological Applications 21:2854–2865.

Lee, P.C, S. Crites, and J.B. Stelfox. 1995. Changes in forest structure and floral composition in a chronosequence of aspen mixedwood stands in Alberta. Pp. 29-48. *In* Relationships between stand age, stand structure, and biodiversity in aspen mixedwood forests in Alberta. J.B. Stelfox (editor). Alberta Environmental Centre and Canadian Forest Service, Edmonton, AB.

Leighton, A. 2012. Flora of Saskatchewan. Fascicle 3: Sedges (Carex) of Saskatchewan. Nature Saskatchewan. Regina, Saskatchewan, 280 pp.

Linden, H., E. Helle, P. Helle, and M. Wikman. 1996. Wildlife Triangle Scheme in Finland: Methods and Aims for Monitoring Wildlife Populations. Finnish Game Res. 49: 4-11.

McLoughlin, Philip D., K. Stewart, C. Superbie, T. Perry, P. Tomchuk, R. Greuel, K. Singh, A. Truchon-Savard, J. Henkelman and J.F. Johnstone. 2016. Population dynamics and critical habitat of woodland caribou in the Saskatchewan Boreal Shield. Interim Project Report, 2013-2016. Department of Biology, University of Saskatchewan, Saskatoon. 162pp.

McLaughlan, M.S., R.A. Wright and R.D. Jiricka. 2010. Field guide to the Ecosites of Saskatchewan's provincial forests. Saskatchewan Ministry of Environment, Forest Service. Prince Albert, Saskatchewan. 338pp.

Meffe, G.K., C.R. Carroll and contributors. 1997. Principles of conservation biology 2nd edition. Sinauer Associates, Inc. Sunderland, MA. 729 pp.

Moss, E.H. 1994. Flora of Alberta. 2nd Ed. University of Toronto Press. Toronto, ON. 687 pp.

Natural Resource Canada (NRCAN). 2017. CanVec Product Specifications., Natural Resources Canada, Earth Sciences Sector, Canada Centre for Mapping and Earth Observation GeoGratis Client Services. 20pp.

Noss, R.F. 1990. Indicators for monitoring biodiversity: a hierarchical approach. Conservation Biology Vol.4 No. 4:355-364.

Nudds, T.D. 1977. Quantifying the vegetative structure of wildlife cover. Wildlife Society Bulletin. 5:113-117.

Pattie, D. and C. Fisher. 1999. Mammals of Alberta. Lone Pine Publishing, Edmonton, Canada. 240 pp.

Peles, J.D. and G.W. Barrett. 1996. Effects of vegetative cover on the population dynamics of meadow voles. Journal of Mammalogy. 77(3): 857-869.

Rio Tinto Canada Uranium Corporation (Rio Tinto). 2014. Roughrider Advanced Exploration (ADEX) Program Environmental Impact Statement – Appendix C. 233 Faithfull Crescent, Saskatoon, Saskatchewan. Submitted to Saskatchewan Ministry of Environment.

Saskatchewan Conservation Data Centre (SKCDC). 2019a. Saskatchewan Vascular Plant Taxa List. Regina, Saskatchewan. Retrieved from www.biodiversity.sk.ca/SppList.htm [Accessed November 5, 2019].

Saskatchewan Conservation Data Centre (SKCDC). 2019b. Tracked Taxa List: Vertebrates. Accessed Online November 5, 2019: http://www.biodiversity.sk.ca/SppList/vertstrack.pdf

Saskatchewan Conservation Data Centre (SKCDC). 2017. Saskatchewan Vascular Plant Taxa List. Regina, Saskatchewan. Retrieved from www.biodiversity.sk.ca/SppList.htm [Accessed December 6, 2017].

Saskatchewan Ministry of Environment (SkMOE). 2017. Fish and Wildlife Branch. April 2017. Activity Restriction Guidelines for Sensitive Species. Regina, Saskatchewan. 4pp.

Saskatchewan Ministry of Environment (SkMOE). 2015. Fish and Wildlife Branch. Rare Prairie Plant Survey Protocol. Technical Report No. 2015-20. 3211 Albert Street, Regina, Saskatchewan. 8pp.

Saskatchewan Ministry of Environment (SkMOE). 2014a. Snow track survey protocol. Fish and wildlife Branch Technical Report No. 2014-19. 3211 Albert Street, Regina, Saskatchewan. 8pp.

Saskatchewan Ministry of Environment (SkMOE). 2014b. Amphibian auditory survey protocol. Fish and Wildlife Branch Technical Report No. 2014-1.0. 3211 Albert Street, Regina, Saskatchewan. 11pp.

Saskatchewan Ministry of Environment (SkMOE). 2014c. Amphibian visual survey protocol. Fish and Wildlife Branch Technical Report No. 2014-2.0. 3211 Albert Street, Regina, Saskatchewan. 9pp.

Saskatchewan Ministry of Environment (SkMOE). 2014d. Forest birds survey protocol. Fish and Wildlife Branch Technical Report No. 2014-10. 3211 Albert Street, Regina, Saskatchewan. 9pp.

Saskatchewan Research Council (SRC). 2013. Gunnar Site Remediation Project Environmental Impact Statement Revised Volume 2. Prepared for the Saskatchewan Ministry of Environment and Canadian Nuclear Safety Board. 338pp.

Shank, C.C. and D.R. Farr. 1999. Alberta Forest Biodiversity Monitoring Program: Proposed Protocols for Monitoring Terrestrial Vertebrates. Alberta Forest Biodiversity Monitoring Program Technical Report #3. (Draft, March 1999).

Skatter, H.G., M.L. Charlebois, S. Eftestøl, D. Tsegaye, J.E. Colman, J.L. Kansas, K. Flydal, and B. Balicki. 2017. Living in a burned landscape: Woodland caribou use of residual patches for calving in a high fire/low anthropogenic Boreal Shield of Saskatchewan. Canadian Journal of Zoology. 95: 975-984.

Skatter, H.G., Kansas, J.L., Charlebois, M.L. & Balicki, B. 2014. Recovery of terrestrial lichens following wildfre in the boreal shield of Saskatchewan: Early seral foraging availability for Woodland Caribou (Rangifer tarandus caribou) — Canadian Wildlife Biology and Management 3: 1-14.

Smith, A.R. 1996. Atlas of Saskatchewan Birds. Special Publication No. 22 of the Saskatchewan Natural History Society, Regina, SK. 456 pp.

Sullivan T., Sullivan D., Lindgren P., Ransome D., Bull J., Ristea C. 2011. Bioenergy or biodiversity? Woody debris structures and maintenance of red-backed voles on clearcuts. Biomass and Bioenergy. 35, 4390-4398pp.

Tigner, J., E. M. Bayne and S. Boutin. 2014. Black bear use of seismic lines in Northern Canada. The Journal of Wildlife Management 78 (2): 282-292.

Westworth Associates Environmental Ltd. (Westword Associates) 2002. A review and assessment of existing information for key wildlife and fish species in the Regional Sustainable Development Strategy study area (Volume 1: Wildlife; Volume 2: Fish). Prepared for the Cumulative Environmental Management Association – Wildlife and Fish Working Group.

Whitaker, Jr., J.O. 1963. Zapus hudsonicus. The American Society of Mammalogists, Mammalian species No.11. 7 pp.

Wisconsin Department of Natural Resources Bureau of Natural Heritage Conservation (WDNR). 2016. Bats of Wisconsin. 16pp. Accessed Online at: http://wiatri.net/Inventory/Bats/AboutBats/images/batsofwisc.pdf

Wrigley R., Dubois J., Copland H. W. R. 1979. Habitat, Abundance, and Distribution of Six Species of Shrews in Manitoba. Journal of Mammalogy, Vol. 60, No. 3, 505-520pp.

Wyoming Natural Diversity Database (WNDD). 2016. Wyoming Bat Call Library. Accessed Online at: http://www.uwyo.edu/wyndd/data-dissemination/priority-data-comp/wyoming-bat-call-library/#Library

7.0 TABLES

Table 2.1-1. Refined Mapping of Anthropogenic Disturbance (Unbuffered) in the Denison Wheeler River Project LSA and RSA.

Disturbance Feature	LSA		RSA	
	km^2	%	km^2	%
Cutline	0.49	0.010	2.01	0.005
Road	0.54	0.011	1.03	0.003
Rough Road	0.27	0.006	0.82	0.002
Right-of-way	-	-	0.10	0.000
Transmission Right-of-way	0.07	0.001	0.45	0.001
Trail	0.13	0.003	0.75	0.002
Industrial Clearing	0.53	0.011	0.92	0.002
Total	**2.03**	**0.043**	**6.08**	**0.015**

Table 2.1-2. Linear Feature Density in the Denison Wheeler River Project Area.

Linear Feature	LSA (km/km^2)		RSA (km/km^2)	
	ECCC (2015)	Refined Mapping	ECCC (2015)	Refined Mapping
Cutline	0.01	5.98	0.03	2.91
McArthur-Key Haul Road	1.03	0.08	0.36	0.06
Road		0.28		0.06
Rough Road		1.07		0.38
ROW				0.10
Trail		0.67		0.47
Transmission ROW		0.04	0.03	0.03
Total	**1.04**	**8.11**	**0.42**	**4.01**

Table 2.1-3. Comparison of Updated and Improved Anthropogenic Footprint with the ECCC (2015) Footprint. Both Datasets Include a 500 m Buffer.

Study Area		Anthropogenic (500 m buffer included)		Total Area (km^2)
		ECCC (2015)	Refined Mapping	
LSA	km^2	32.80	47.45	47.50
	%	69.1	99.9	
RSA	km^2	129.31	331.07	400.01
	%	32.3	82.8	

Table 2.1-4. Overview of Historical Fires from 1945 to 2018 in the LSA and RSA for the Wheeler River Project Area.

Forest Age (Years)	Fire Years	LSA (km^2)	LSA (%)	RSA (km^2)	RSA (%)
0-10	none	0	0	0	0
11-20	2004, 2007, 2008	3.47	7.3	59.28	14.8
21-30	1990, 1998	0	0	0.54	0.1
31-40	1981	15.96	33.6	163.56	40.9
41-70	1973	2.53	5.3	33.8	8.5
70+	none	0	0	0	0

Table 2.1-5. Ecosites in the Denison Wheeler River Project Area.

Ecosite Code	Ecosite Name/Description	LSA (Ha)	RSA (Ha)	LSA (%)	RSA (%)
RF3-C	Regenerating coniferous forest - low shrub <1 m tall (5-20 years)	237.1	4536.9	5.0	11.3
RF3-B	Regenerating bog - low shrub <1 m tall (5-20 years)	0.0	20.2	0.0	0.1
RF2-C	Regenerating coniferous forest - tall shrub 1-5 m tall (20-40 years)	1822.5	10480.5	38.4	26.2
RF2-B	Regenerating bog - tall shrub 1-5 m tall (20-40 years)	0.0	2.0	0.0	0.0
RF1-C	Regenerating coniferous forest - treed >5 m tall (30-50 years)	199.3	2401.8	4.2	6.0
BS3	Jack pine/ blueberry/ lichen	1605.8	10330.5	33.8	25.8
BS4	Jack pine- black spruce/ feathermoss	22.8	331.3	0.5	0.8
BS7	Black spruce/ blueberry/ lichen	9.6	279.8	0.2	0.7
BS9	Black spruce- jack pine/ feathermoss	15.1	147.8	0.3	0.4
BS14	White birch/ lingonberry- Labrador tea	0.3	1.8	0.0	0.0
BS16	Black spruce/ balsam poplar/ river alder swamp	0.0	8.7	0.0	0.0
BS17	Black spruce treed bog	82.1	1152.1	1.7	2.9
BS18	Labrador tea shrubby bog	101.0	963.4	2.1	2.4
BS19/24	Graminoid bog/ graminoid fen	11.1	171.2	0.2	0.4
BS20	Open bog	4.8	65.2	0.1	0.2
BS21	Tamarack treed fen	14.7	66.2	0.3	0.2
BS22	Leatherleaf shrubby poor fen	13.1	28.4	0.3	0.1
BS23	Willow shrubby rich fen	3.2	20.8	0.1	0.1
BS25	Open fen	2.1	5.7	0.0	0.0
BS26	Rush sandy shore	0.9	15.0	0.0	0.0
BS27	Sedge rocky shore	4.2	29.2	0.1	0.1
AN	Anthropogenic	165.8	596.4	3.5	1.5
Waterbody	Waterbody	434.3	8345.8	9.1	20.9
Total		**4749.8**	**40000.8**	**100.0**	**100.0**

Table 2.3-1. Key Findings and Trends for Each Analysis, Including *Visual Obstruction*, *Vegetation Recovery* and *Ericaceous* shrubs vs. Tree Species Occurrence.

Variable	Main findings/trends for disturbed areas
Visual Obstruction	
Line cut before vs. after fire	Significantly higher visual obstruction in areas burned after vs. before line creation.
Upland vs. Lowland	Significantly higher visual obstruction in lowlands vs. uplands for the 0.25 m layer.
Young forest vs. Old Forest	No difference in visual obstruction in disturbed areas between old and young forest.
Level of Human Use	Significantly higher visual obstruction in areas with No/Low vs. Moderate/High human use.
Vegetation Recovery	
Line cut before vs. after fire	Significantly higher stem counts of Shrubs (1-3m) in areas burned after vs. before line creation.
Upland vs. Lowland	Significantly higher low shrub and moss cover, and lower lichen cover in lowlands vs. uplands.
Young forest vs. Old Forest	Significantly higher lichen cover in old vs. young forest.
Level of Human Use	Significantly higher vegetation recovery in areas with No/Low vs. Moderate/High human use.
Ericaceous Shrub vs. Tree Species	
Line cut before vs. after fire	Higher tree species occurrence in areas burned after vs. before line creation.
Upland vs. Lowland	Higher tree species occurrence in in lowlands vs. uplands.
Young forest vs. Old Forest	Higher tree species occurrence in young vs. old forest.
Level of Human Use	Higher tree species occurrence in areas with No/Low vs. Moderate/High human use.

Table 2.3-2. Species Ranking and Compositional Information for Shrub Species (< 1m tall) in Areas Burned Before and After Line was Cut - Reference Versus Disturbed.

Rank	Area burned after line was created 12-15 years since fire (n=3)		Area burned before line was created 12-15 years since fire (n=3)		Area burned before line was created 20-30 years since fire (n=2)	
	Reference	Disturbed	Reference	Disturbed	Reference	Disturbed
1	Vaccmyr (100)	Pinuban (60)	Vaccmyr (64)	Vaccmyr (68)	Vaccmyr (99)	Vaccmyr (97)
2	Pinuban (56)	Vaccmyr (54)	Pinuban (59)	Vaccvit (40)	Vaccvit (59)	Vaccvit (73)
3	Ledugro (25)	Chamcal (31)	Vaccvit (5)	Pinuban (18)	Pinuban (47)	Ledugro (58)
4	Chamcal (23)	Ledugro (31)			Ledugro (27)	Pinuban (30)
5	Andrpol (9)	Andrpol (17)				Picemar (8)
6	Picemar (9)					
7	Vaccvit (4)					

Coniferous tree species (green)

Ericaceous shrub species (orange)

Notes:

Values in brackets show abundance of each species.
This is not a percentage cover value, but a normalized relative abundance of each species compared to other species (values: 0-100).

Table 2.3-3. Species Ranking and Compositional Information for Shrub Species (< 1m tall) in Lowland and Upland Areas - Reference Versus Disturbed.

Rank	Lowland (Bog/Fen) (n=8)		Upland (n=12)	
	Reference	Disturbed	Reference	Disturbed
1	Ledugro (96)	Ledugro (95)	Vaccmyr (97)	Vaccmyr (100)
2	Chamcal (86)	Chamcal (79)	Vaccvit (59)	Vaccvit (55)
3	Andrpol (68)	Andrpol (75)	Ledugro (26)	Ledugro (30)
4	Vaccvit (40)	Picemar (55)	Chamcal (6)	Arctuva (6)
5	Oxycmic (40)	Oxycmic (52)	Arctuva (5)	Pinuban (6)
6	Picemar (37)	Vaccvit (27)	Pinuban (4)	Alnucri (5)
7	Vaccmyr (6)	Vaccmyr (21)	Andrpol (4)	Chamcal (5)
8		Empenig (7)	Picemar (4)	Picemar (4)
9		Pinuban (2)	Betupum (2)	Andrpol (2)
10			Alnucri (2)	Empenig (2)

Green	Coniferous tree species
Orange	Ericaceous shrub species
Blue	Deciduous low shrub species

Notes:

Values in brackets show abundance of each species.
This is not a percentage cover value, but a normalized relative abundance of each species compared to other species (values: 0-100).

Table 2.3-4. Species Ranking and Compositional Information for Shrub Species (< 1m tall) in Old (> 40 years) Upland Forest and Young (< 40 years) Upland Forest - Reference Versus Disturbed.

Rank	Old upland forest (n=8)	
	Reference	Disturbed
1	Vaccmyr (100)	Vaccmyr (97)
2	Vaccvit (57)	Vaccvit (61)
3	Ledugro (8)	Ledugro (20)
4	Arctuva (7)	Arctuva (5)
5	Picemar (5)	Empenig (3)
6	Pinuban (5)	Picemar (3)
7		
8		
9		

Young upland forest (n=12)	
Reference	Disturbed
Vaccmyr (91)	Vaccmyr (84)
Pinuban (40)	Vaccvit (38)
Vaccvit (34)	Ledugro (34)
Ledugro (32)	Pinuban (32)
Chamcal (12)	Chamcal (13)
Andrpol (6)	Andrpol (7)
Picemar (2)	Alnucri (5)
Betupum (2)	Picemar (4)
Alnucri (2)	Arctuva (3)

Coniferous tree species

Ericaceous shrub species

Deciduous low shrub species

Notes:

Values in brackets show abundance of each species.
This is not a percentage cover value, but a normalized relative abundance of each species compared to other species (values: 0-100).

Table 2.3-5. Species Ranking and Composition Information for Shrub Species (< 1m tall) by Level of Human Use - Reference Versus Disturbed.

Rank	No human use (n=22)		Low human use (n=12)		Moderate human use (n=4)		High human use (n=8)	
	Reference	Disturbance	Reference	Disturbance	Reference	Disturbance	Reference	Disturbance
1	Vaccmyr (65)	Vaccmyr (61)	Ledugro (64)	Vaccmyr (69)	Vaccmyr (100)	Vaccmyr (36)	Vaccmyr (78)	Picemar (5)
2	Vaccvit (34)	Ledugro (40)	Vaccmyr (61)	Ledugro (50)	Vaccvit (72)	Vaccvit (15)	Vaccvit (62)	
3	Ledugro (34)	Vaccvit (39)	Vaccvit (55)	Vaccvit (36)	Arctuva (9)	Empenig (10)	Ledugro (49)	
4	Chamcal (30)	Chamcal (27)	Chamcal (35)	Chamcal (34)	Alnucri (5)		Pinuban (12)	
5	Andrpol (22)	Andrpol (20)	Andrpol (28)	Andrpol (32)	Picemar (5)		Picemar (7)	
6	Pinuban (18)	Pinuban (18)	Picemar (20)	Picemar (22)	Ledugro (4)		Betupum (5)	
7	Oxycmic (11)	Oxycmic (13)	Oxycmic (12)	Oxycmic (14)			Arctuva (4)	
8	Picemar (8)	Picemar (13)	Pinuban (10)	Empenig (5)			Andrpol (4)	
9	Arctuva (3)	Arctuva (3)	Alnucri (3)	Arctuva (3)			Oxycmic (4)	
10	Betupum (1)	Alnucri (3)		Alnucri (3)			Chamcal (2)	

Coniferous tree species

Ericaceous shrub species

Deciduous low shrub species

Notes:

Values in brackets show abundance of each species.

This is not a percentage cover value, but a normalized relative abundance of each species compared to other species (values: 0-100).

Table 2.4-1 Rare Vascular Plant Survey Stratification Using Predictive Ecosite Mapping in the Denison Wheeler River Project Area – 2017.

Ecosites	Area of Ecosite (ha)	# of Predicted Transects
BS7 – Black spruce/blueberry/lichen	0.56	10
BS9 – Black spruce-jack pine/feathermoss	2.50	10
BS17 – Black spruce treed bog	3.09	10
BS3 – Jack pine/blueberry/lichen	47.47	17
BS4 – Jack pine-black spruce/feathermoss	11.88	11
BS5 – Jack pine-white birch/feathermoss	0.29	7
Waterbody	1.25	9
Total	**67.48**	**74**

Table 2.4-2. Conservation Rank Definitions - Saskatchewan Conservation Data Centre Database - 2019.

S1	Critically Imperiled/ Extremely rare	At very high risk of extinction or extirpation due to extreme rarity, very steep declines, high threat level, or other factors.
S2	Imperiled/Very rare	At high risk of extinction or extirpation due to a very restricted range, very few populations, steep declines, threats or other factors.
S3	Vulnerable/Rare to uncommon	At moderate risk of extinction or extirpation due to a restricted range, relatively few populations, recent and widespread declines, threats, or other factors.
S4	Apparently Secure	Uncommon but not rare; some cause for long-term concern due to declines or other factors.
S5	Secure/Common	Demonstrably secure under present conditions; widespread and abundant; low threat level.

Table 2.4-3. Rare Plant Survey Transects Completed per Ecosite in Denison Wheeler River Project Area – 2017.

Ecosites	# of Transects Surveyed
BS3 – Jack pine/blueberry/lichen	27
BS4 – Jack pine – black spruce/feathermoss	32
BS17 – Black spruce treed bog	4
BS18 – Labrador tea shrubby bog	4
BS19 – Graminoid bog	4
BS24 – Graminoid fen	3
Total	**74**

Table 2.4-4. Rare Plant Observations in the Denison Wheeler River Project Area – 2017.

Species	Centroid of Population		Count or Estimate	Area of Population (m2)	Habitat Description
	Easting (NAD 83)	Northing (NAD 83)			
Alaskan clubmoss	4754853	6377011	58	144	Open PJ-lichen stand
Alaskan clubmoss	475178	6376885	17	10	Open PJ-lichen stand
Alaskan clubmoss	475329	6376923	15	32	Open PJ-lichen stand at bottom of slope
Alaskan clubmoss	475460	6376439	80 (E)	203	Open area at transition from treed bog to upland pine/lichen stand
Alaskan clubmoss	475452	6376386	940 (E)	1611	Transition zone between shrubby bog and open immature PJ-lichen stand
Alaskan clubmoss	475727	6375972	100 (E)	246	Transition between creek riparian area and upland PJ-lichen stand
Alaskan clubmoss	475762	6375940	25 (E)	58	Transition between creek riparian area and upland pine/lichen stand
Alaskan clubmoss	475549	6375788	400 (E)*	444	Transition between mature PJ stand and immature Pj stand
Alaskan clubmoss	475532	6375840	400 (E)*	392	Immature PJ stand
Three-seeded sedge	475722	6375989	100 (E)	6	Wet depression beside permanent creek

E=Estimate
*Population intersects two transects

Table 2.4-5. Rare Plant Ecosite Ground Truthing in the Denison Wheeler Project Area – 2019.

Site	UTM-NAD 83		Confirmed Ecosite*
	Easting	Northing	
1	475405	6376230	RF2
2	475428	6376212	RF2
3	475452	6376131	RF2
4	475259	6377292	RF2
5	475544	6377292	RF2/Anthropogenic
6	475469	6377202	RF2
7	475358	6377130	RF1
8	475469	6377022	RF1
9	475529	6377022	RF1
10	**475585**	**6377022**	**BS9**
11	479338	6376542	RF2
12	479228	6376387	RF2
13	475349	6377434	RF2
14	475409	6377406	RF2
15	475621	6375672	RF2
16	475633	6375625	RF2
17	477449	6374772	RF2
18	475447	6377178	RF2/Anthropogenic
19	475559	6376992	RF2
20	475319	6377412	RF2
21	475602	6375732	RF2
22	475349	6377307	RF2
23	475584	6375792	RF2
24	475604	6376915	RF2
25	475409	6377100	RF1
26	474980	6376485	RF2/RF1

* Ecosite definitions and characteristics are provided in Section

Table 2.5-1. Summary of Metals and Radionuclides in Lichen Collected in the Denison Wheeler River Project Area – 2017.

Parameter	Units	RSV1	RSV2	RSV3	RSV4	RSV5	RSV6	RSV7	RSV8	RSV9	RSV10	Mean	Stand Dev
Physical Properties													
Moisture	%	60.09	66.31	11.31	13.31	6.55	4.96	5.87	6.93	7.3	7.35	**19.00**	22.27
Metals and Trace Elements													
Aluminum	ug/g	440	410	620	470	440	670	760	620	540	1700	**667**	361.14
Antimony	ug/g	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	**<0.1**	-
Arsenic	ug/g	0.11	0.1	0.12	0.13	0.09	0.16	0.18	0.18	0.1	0.24	**0.14**	0.045
Barium	ug/g	12	16	25	16	18	21	16	14	9.8	14	**16.18**	4.15
Beryllium	ug/g	0.01	0.01	0.02	0.01	0.01	0.02	0.02	0.02	0.02	0.06	**0.02**	0.01
Boron	ug/g	1	1	2	1	1	2	1	<1	2	3	**1.45**	-
Cadmium	ug/g	0.07	0.06	0.09	0.07	0.08	0.1	0.08	0.1	0.08	0.12	**0.09**	0.02
Chromium	ug/g	1	1.1	1.5	1.3	1	3.2	2.2	3.5	1.2	6.8	**2.28**	1.74
Cobalt	ug/g	0.08	0.08	0.1	0.08	0.09	0.23	0.17	0.32	0.14	0.39	**0.17**	0.11
Copper	ug/g	1.6	1.5	1.8	1.5	1.5	1.7	1.6	1.3	1.6	2	**1.61**	0.18
Iron	ug/g	220	190	280	230	180	350	390	370	260	840	**331**	183.65
Lead	ug/g	0.82	0.52	0.8	0.6	0.51	1	1.8	1.3	0.41	1.4	**0.92**	0.43
Manganese	ug/g	95	83	112	102	148	107	78	194	137	191	**124.7**	39.60
Molybdenum	ug/g	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	**<0.1**	-
Nickel	ug/g	0.67	0.94	0.94	0.9	0.58	1.6	1.1	1.7	0.7	3.3	**1.243**	0.77
Selenium	ug/g	0.11	0.09	0.2	0.1	0.12	0.14	0.12	0.12	0.05	0.14	**0.119**	0.04
Silver	ug/g	0.02	0.01	0.02	0.01	0.01	0.01	0.02	0.01	<0.01	0.03	**0.015**	-
Strontium	ug/g	4.2	6.3	10	5	6.2	8.3	5	4.6	4.6	7.1	**6.13**	1.78
Thallium	ug/g	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	**<0.05**	-
Tin	ug/g	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.06	<0.05	0.07	**0.03**	-
Titanium	ug/g	10	11	18	14	9.7	23	21	17	12	45	**18.1**	9.99
Uranium	ug/g	0.06	0.06	0.07	0.06	0.06	0.11	0.12	0.14	0.19	0.8	**0.17**	0.22
Vanadium	ug/g	0.6	0.5	0.8	0.6	0.5	1	1.1	1	0.7	2.2	**0.9**	0.48
Zinc	ug/g	13	11	14	14	14	16	14	21	20	26	**16.3**	4.36
Radionuclides													
Lead-210	Bq/g	0.55	0.51	0.52	0.55	0.4	0.51	0.63	0.61	0.31	0.63	**0.52**	0.10
Polonium-210	Bq/g	0.36	0.36	0.32	0.36	0.23	0.37	0.45	0.42	0.2	0.46	**0.35**	0.08
Radium-226	Bq/g	0.0033	0.0027	0.0021	0.003	0.0025	0.0024	0.0026	0.003	0.007	0.01	**0.004**	0.002
Thorium-230	Bq/g	0.0005	<0.0006	0.0007	0.002	0.0008	0.002	0.002	0.001	0.003	0.007	**0.0019**	-

Values below detection limits were set to half the value for calculating the mean.

Table 2.5-2. Summary of Metals and Radionuclides in Blueberry Collected in the Denison Wheeler River Project Area – 2017.

Parameter	Units	RSV1	RSV2	RSV3	RSV4	RSV5	RSV6	RSV7	RSV8	RSV9	RSV10	Mean	Stand Dev
Physical Properties													
Moisture	%	45.99	65.02	44.27	51.01	48.16	47.08	59.16	47.76	39.16	36.71	48.43	8.04
Metals and Trace Elements													
Aluminum	ug/g	43	63	73	120	50	370	28	45	69	86	94.7	94.99
Antimony	ug/g	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-
Arsenic	ug/g	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	-
Barium	ug/g	56	61	58	76	54	54	48	46	58	75	58.6	9.48
Beryllium	ug/g	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-
Boron	ug/g	7	8	17	22	12	12	7	13	9	10	11.7	4.52
Cadmium	ug/g	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-
Chromium	ug/g	<0.5	<0.5	<0.5	0.7	<0.5	4.5	<0.5	<0.5	<0.5	0.6	0.76	-
Cobalt	ug/g	0.11	0.03	0.24	0.04	0.02	0.08	0.03	0.04	0.07	0.03	0.07	0.06
Copper	ug/g	4.7	5.6	4.9	3.9	4.1	4.9	4.1	4.1	4	4.8	4.51	0.52
Iron	ug/g	30	37	55	69	28	190	24	26	40	43	54.2	47.2
Lead	ug/g	0.04	0.06	0.02	0.04	0.02	0.15	0.01	0.01	0.02	0.04	0.04	0.04
Manganese	ug/g	1050	1190	1820	1790	1570	1590	710	1210	940	2340	1421	465
Molybdenum	ug/g	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-
Nickel	ug/g	1.2	1.4	1.6	1.1	1	2.6	0.67	1.3	0.82	3	1.469	0.72
Selenium	ug/g	<0.05	0.05	0.1	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	0.05	-
Silver	ug/g	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-
Strontium	ug/g	5.8	22	9.4	6.4	6.8	6.1	4.2	8.2	12	8.3	8.92	4.82
Thallium	ug/g	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	-
Tin	ug/g	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	-
Titanium	ug/g	0.77	1.2	0.9	3.6	0.67	17	0.53	0.52	0.97	1.3	2.75	4.83
Uranium	ug/g	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	0.02	0.02	0.01	-
Vanadium	ug/g	<0.1	<0.1	<0.1	<0.1	<0.1	0.4	<0.1	<0.1	<0.1	<0.1	<0.1	-
Zinc	ug/g	10	16	13	13	12	16	9.9	14	12	15	13.09	2.09
Radionuclides													
Lead-210	Bq/g	0.014	0.017	0.022	0.01	0.016	0.012	0.013	0.007	0.025	0.037	0.017	0.008
Polonium-210	Bq/g	0.004	0.005	0.008	0.003	0.006	0.002	0.005	0.004	0.008	0.017	0.006	0.004
Radium-226	Bq/g	0.0026	0.003	0.005	<0.0003	<0.0002	0.003	<0.0002	0.0019	0.0037	0.0033	0.0023	-
Thorium-230	Bq/g	<0.0004	<0.0005	<0.001	0.0009	<0.0004	<0.001	<0.0004	<0.0004	<0.0004	<0.0004	0.000335	-

Values below detection limits were set to half the value for calculating the mean.

Table 2.5-3. Summary of Metals and Radionuclides in Soil Collected in the Denison Wheeler River Project Area – 2017.

Parameter	Units	RSV1	RSV2	RSV3	RSV4	RSV5	RSV6	RSV7	RSV8	RSV9	RSV10	Mean	Stand Dev
Metals and Trace Elements													
Aluminum	ug/g	4300	4900	4300	4600	3300	4800	4050	1980	1990	1580	3580	1212
Antimony	ug/g	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-
Arsenic	ug/g	0.8	0.8	0.8	1	0.5	0.8	0.6	0.4	0.4	0.4	0.7	0.21
Barium	ug/g	48	58	30	62	67	39	66	36	84	30	52	17.3
Beryllium	ug/g	0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	0.07	-
Boron	ug/g	3	2	3	4	3	5	2	1	2	<1	2.55	-
Cadmium	ug/g	0.3	0.2	0.2	0.3	0.4	0.6	0.3	0.6	0.4	0.6	0.4	0.15
Calcium	ug/g	750	600	530	700	490	530	790	350	2400	320	746	571
Chromium	ug/g	6.4	5.2	5.9	7	3.7	5	4.7	1.1	1.5	0.8	4.1	2.15
Cobalt	ug/g	0.5	0.3	0.3	0.4	0.2	0.2	0.3	<0.2	0.2	<0.2	0.26	-
Copper	ug/g	1.7	2.5	0.8	1.7	1.5	0.7	2.4	0.8	4.6	0.8	1.8	1.14
Iron	ug/g	4940	2680	3610	4390	1870	2240	2880	640	850	520	2462	1466
Lead	ug/g	4.4	3.2	2.6	2.7	2.7	2.7	3.4	1.6	6.4	1.8	3.2	1.32
Magnesium	ug/g	500	360	430	500	260	430	340	140	240	90	329	136
Manganese	ug/g	64	38	39	48	48	36	42	24	120	31	49	26
Molybdenum	ug/g	0.2	0.1	0.1	0.1	0.2	0.1	0.1	<0.1	0.1	<0.1	0.1	0.04
Nickel	ug/g	1.1	1.4	1	1.4	1.2	0.9	1.4	0.5	1.2	0.5	1.1	0.32
Selenium	ug/g	<0.1	0.2	<0.1	0.1	<0.1	<0.1	0.1	<0.1	0.1	<0.1	0.08	-
Silver	ug/g	0.3	0.2	0.1	0.2	0.3	0.6	0.1	0.5	0.2	0.4	0.3	0.16
Sodium	ug/g	440	240	290	300	390	640	290	400	160	290	344	125
Strontium	ug/g	16	19	16	21	18	20	19	18	18	18	18	1.49
Thallium	ug/g	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-
Tin	ug/g	0.5	0.4	0.5	0.5	0.2	0.4	0.4	<0.1	0.1	<0.1	0.31	-
Titanium	ug/g	550	370	450	490	230	400	340	90	90	74	308	168
Uranium	ug/g	0.6	0.4	0.6	0.6	0.4	0.6	0.4	0.2	0.2	0.2	0.4	0.17
Vanadium	ug/g	11	7.6	9.2	11	4.3	6.7	7.4	1.4	2.2	1.2	6.2	3.55
Zinc	ug/g	5.8	8.3	2.5	3.8	8.6	4.4	5.9	2.3	19	4	6.5	4.65
Nutrients													
Phosphorus	ug/g	130	250	150	150	80	160	140	30	300	40	143	80
Potassium	ug/g	1100	770	930	760	1400	1500	980	990	880	820	1013	241
Radionuclides													
Lead-210	Bq/g	0.16	0.05	0.11	<0.04	0.11	<0.04	0.09	<0.04	0.19	<0.04	0.079	-
Polonium-210	Bq/g	0.14	0.07	0.04	0.05	0.07	0.04	0.07	0.03	0.21	0.06	0.078	0.053
Radium-226	Bq/g	0.02	0.02	0.02	0.02	<0.01	0.02	0.02	<0.01	<0.01	<0.01	0.02	0
Thorium-230	Bq/g	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	-

Values below detection limits were set to half the value for calculating the mean.

Table 2.5-4. Comparison of Denison Wheeler River Project Vegetation and Soil Chemistry to the Roughrider Project[1].

Parameter	Units	Wheeler River Soil	Roughrider Soil	Wheeler River Lichen	Roughrider Lichen	Wheeler River Blueberry	Roughrider Blueberry
Metals and Trace Elements							
Aluminum	ug/g	3580	5500	667	213	94.7	64.5
Antimony	ug/g	<0.2	0.3	<0.1	0.1	<0.1	<0.1
Arsenic	ug/g	0.65	0.95	0.14	0.14	<0.05	<0.05
Barium	ug/g	52	19	16.2	4.7	58.6	79.5
Beryllium	ug/g	0.07	0.1	0.02	<0.01	<0.01	<0.01
Boron	ug/g	2.55	<1	1.45	<1	11.7	9
Cadmium	ug/g	0.39	<0.01	0.085	0.05	<0.01	0.01
Calcium	ug/g	-	-	-	-	-	-
Chromium	ug/g	4.13	7	2.28	<0.5	0.76	<0.5
Cobalt	ug/g	0.26	0.45	0.168	0.04	0.07	0.03
Copper	ug/g	1.75	1.5	1.61	0.64	4.51	4.85
Iron	ug/g	2462	5717	331	114	54.2	33.5
Lead	ug/g	3.15	1	0.916	0.32	0.04	0.04
Magnesium	ug/g	-	-	-	-	-	-
Manganese	ug/g	49	38	124.7	33	1421	1086
Molybdenum	ug/g	0.11	0.15	<0.1	<0.1	<0.1	0.1
Nickel	ug/g	1.06	1.65	1.24	0.29	1.47	1.37
Selenium	ug/g	0.08	0.1	0.12	0.07	0.05	<0.05
Silver	ug/g	0.29	<0.1	0.01	0.01	<0.01	<0.01
Sodium	ug/g	344	165	-	-	-	-
Strontium	ug/g	18.3	24	6.13	1.8	8.92	13
Thallium	ug/g	<0.2	<0.2	<0.05	<0.05	<0.05	<0.05
Tin	ug/g	0.31	0.55	0.03	<0.05	<0.05	<0.05
Titanium	ug/g	308	579	18	6.8	2.7	1.2
Uranium	ug/g	0.42	0.55	0.17	0.11	0.01	0.01
Vanadium	ug/g	6.2	12.5	0.9	0.3	<0.1	<0.1
Zinc	ug/g	6.46	4.75	16.3	9.2	13.1	16.5
Nutrients							
Phosphorus	ug/g	143	150.5	-	-	-	-
Potassium	ug/g	1013	520	-	-	-	-
Radionuclides							
Lead-210	Bq/g	0.08	<0.04	0.52	0.38	0.017	0.064
Polonium-210	Bq/g	0.08	0.01	0.35	0.3	0.006	0.014
Radium-226	Bq/g	0.02	0.03	0.004	0.002	0.002	0.013
Thorium-230	Bq/g	<0.02	0.02	0.002	0.001	0.0003	0.001

1 Source Rio Tinto Canada Uranium Corporation (2014)

Table 2.6-1. Number of Trails per km day by Transect in the Denison Wheeler River Project Area - 2017 & 2018.

Transect	Length (Km)		Km-days		Microtines		Red Squirrel		Snowshoe Hare		Grouse/ Ptarm.		Ermine		Mink	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
1	7.6	-	52.63	-	0.04	-	2.94	-	24.89	-	1.10	-	0.27	-	0	-
2	7.5	7.7	44.20	22.07	0.18	0	0.63	0.09	0.29	0	0.09	0.32	0	0	0.05	0
4	7.7	-	30.23	-	0.10	-	4.57	-	15.22	-	0.93	-	0.13	-	0.00	-
5	6.6	7.0	32.08	26.85	0.00	0	0.41	0.56	0	0	0.56	0.15	0	0	0	0
6	7.5	7.5	21.63	19.94	0.53	0	3.93	0.30	18.03	27.03	1.94	0.30	0.28	0	0	0
7	7.5	7.5	38.08	9.23	0.08	0.65	2.15	2.71	15.68	10.51	0.18	0.22	0.26	0.22	0.03	0
8	7.4	7.5	43.17	18.46	0.39	0.22	3.08	1.73	9.66	4.12	1.41	0.60	0.65	0.16	0	0.05
9	7.5	7.5	19.26	9.75	1.92	0.51	0.26	0.62	0	0	0.36	0.41	0.10	0	0	0.72
10	7.6	7.5	21.99	16.15	0.05	0.19	1.18	6.38	14.42	28.73	0.32	0.06	0.27	0	0	0
11	7.5	7.4	11.62	11.10	0.95	0.27	0.34	1.89	0.17	0.36	0.43	0.72	0	0	0	0.90
12	7.5	7.5	28.79	17.17	0.03	0.06	1.60	0.58	0	0.52	0.07	0.23	0	0	0.07	0.12
Creek 1	0.5	0.5	2.56	0.97	0.00	0	0.78	0	0	0	0	0	0	0	0	0
Creek 2	0.6	0.5	2.76	1.24	0.36	0	0.36	0	1.09	0	0	0	0.36	0	0	0
Creek 3	0.5	0.5	2.69	1.20	1.11	0	5.20	1.67	4.46	0	0	35.83	1.11	0	1.11	0
Creek 4	0.6	0.5	4.15	0.85	0.00	0	1.21	4.71	1.69	0	0.48	18.82	1.69	2.35	0.48	0
Creek 5	0.5	0.7	2.45	2.73	0.00	0	0	0	0	0	3.27	0	0	0	0	0
Road/ anthro	18.4	11.5	81.61	21.44	0.65	-	0.53	-	1.68	-	0.23	-	0.05	-	0.01	0
Total	**103.0**	**81.4**	**439.9**	**179.14**	**0.33**	**0.12**	**1.77**	**1.26**	**8.33**	**6.64**	**0.61**	**0.59**	**0.19**	**0.04**	**0.03**	**0.11**
Mean	**92.2**		**309.52**		**0.23**		**1.52**		**7.48**		**0.60**		**0.12**		**0.07**	

Notes:

"- " = not completed

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Table 2.6-1 Cont. Number of Trails per km day by Transect in the Denison Wheeler River Project Area - 2017 & 2018.

Transect	Length (Km)		Km-days		Marten		Fisher		Red Fox		Lynx		Otter		Moose		Woodland Caribou	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
1	7.6	-	52.63	-	0.02	-	0.00	-	0	-	0.49	-	0.02	-	0	-	0	-
2	7.5	7.7	44.20	22.07	0.66	0.09	0.05	0	0	0	0	0	0	0	0	0	0.43	0
4	7.7	-	30.23	-	0	-	0	-	0	-	0.69	-	0	-	0	-	0	-
5	6.6	7.0	32.08	26.85	0.53	0.22	0	0	0	0	0	0	0.03	0	0	0.11	0	0
6	7.5	7.5	21.63	19.94	0	0	0	0	0	0	0.42	0	0	0	0	0	0	0
7	7.5	7.5	38.08	9.23	0.32	0.11	0	0	0	0	0.05	0.11	0.05	0	0	0	0	0
8	7.4	7.5	43.17	18.46	0.09	0.38	0	0	0	0	0	0	0	0	0	0	0	0
9	7.5	7.5	19.26	9.75	1.51	1.64	0	0	0	0	0	0	0	0	0	0	0.67	0
10	7.6	7.5	21.99	16.15	0	0.43	0	0	0	0	0	0.62	0	0	0	0	0	0
11	7.5	7.4	11.62	11.1	0.34	1.62	0	0	0.34	0	0	0.09	0.17	0	0.17	0	0.69	0
12	7.5	7.5	28.79	17.17	0.59	0.58	0	0	0	0.06	0	0	0.10	0	0	0	0	0
Creek 1	0.5	0.5	2.56	0.97	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Creek 2	0.6	0.5	2.76	1.24	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Creek 3	0.5	0.5	2.69	1.2	0	0	0	0	0	0	0	2.50	0	0	0	0	0	0
Creek 4	0.6	0.5	4.15	0.85	0.24	0	0	0	0	0	0	0	0.24	0	0	0	0	0
Creek 5	0.5	0.7	2.45	2.73	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Road/ anthro	18.4	11.5	81.61	21.44	0.21	0.05	0.09	0	0.01	0.05	0	0.05	0	0	0	0.05	0	0
Total	**103.0**	**81.3**	**439.89**	**179.14**	**0.30**	**0.38**	**0.02**	**0**	**0.01**	**0.01**	**0.13**	**0.09**	**0.02**	**0**	**0.005**	**0.02**	**0.09**	**0**
Mean	**92.1**		**309.52**		**0.34**		**0.01**		**0.01**		**0.11**		**0.01**		**0.01**		**0.05**	

Notes:

"- " = not completed

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Table 2.6-2. Number of Trails per km day by Ecosite in the Denison Wheeler River Project Area - 2017 & 2018.

Ecosite	Length (Km)		Km-days		Microtines		Red Squirrel		Snowshoe Hare		Grouse/ Ptarm.		Ermine		Mink	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
BS3	23.32	22.50	97.55	56.53	0.44	0.21	2.66	1.59	1.29	0.57	0.37	0.25	0.06	0	0.02	0.04
BS4	0.78	0.60	3.30	0.95	0.61	0	3.33	0	19.67	0	0	0	0	0	0.30	0
BS7	1.34	1.52	6.19	3.95	0.32	0	2.59	2.78	0.97	2.28	0	0	0	0	0	0
BS9	1.02	0.83	4.20	1.78	0.24	0.56	3.81	0	4.05	0.56	0	1.12	0.24	0	0.24	0
BS16	0.24	0.20	1.71	0.31	0	0	1.17	6.47	0	0	0.58	3.23	0	6.47	0	0
BS17	2.50	2.42	10.87	4.93	0.28	0	0.55	0.41	1.20	0.81	1.10	3.04	1.01	0	0.18	1.42
BS18	1.91	1.91	7.65	4.62	0	0	0	0.43	3.79	0.43	2.48	0	0	0	0	0.87
BS19	0.14	0.05	0.53	0.12	1.90	0	0	0	0	0	5.69	0	0	0	0	0
BS21	0.25	0.26	1.24	0.60	0	0	4.83	0	2.42	0	0	0	1.61	0	0.81	0
BS22	0.38	0.29	1.82	0.56	0	0	0	0	0	0	0	0	0	0	0	0
BS23	0.33	0.49	1.64	1.20	1.22	0	4.27	1.67	3.66	0	0	35.95	0.61	0	1.22	0
BS24	0.10	0.10	0.57	0.25	0	0	0	3.96	0	0	10.53	0	0	0	0	0
BS25	0.10	0.10	0.49	0.37	0	0	0	0	0	0	0	0	0	0	0	0
BS26	0.05	0.00	0.21	0.00	0	0	0	0	0	0	0	0	0	0	0	0
RF1	8.26	5.62	37.90	13.42	0.26	0.07	2.24	0.75	20.00	10.28	1.35	0.60	0.32	0.15	0	0.07
RF2	28.84	20.07	120.03	41.28	0.16	0.15	2.50	2.37	20.60	24.29	0.99	0.51	0.32	0.07	0.01	0.07
RF3	3.77	2.32	15.95	3.23	0.19	0	1.32	1.55	1.32	0.00	0.06	0.00	0.56	0	0	0
Water/Lake Ice	10.66	10.17	44.37	22.61	0.05	0.09	0.09	0	0	0	0.02	0.09	0.02	0	0	0.13
Anthropogenic	19.02	11.92	83.68	22.43	0.67	-	0.56	-	1.78	-	0.23	-	0.05	-	0.01	0
Total	**102.99**	**81.37**	**439.89**	**179.14**	**0.33**	**0.12**	**1.77**	**1.26**	**8.33**	**6.64**	**0.61**	**0.59**	**0.19**	**0.04**	**0.03**	**0.11**
Mean	**92.18**		**309.52**		**0.23**		**1.52**		**7.48**		**0.60**		**0.12**		**0.07**	

Table 2.6-2 Cont. Number of Trails per km day by Ecosite in the Denison Wheeler River Project Area - 2017 & 2018.

Ecosite	Length (Km)		Km-days		Marten		Fisher		Red Fox		Lynx		Otter		Moose		Woodland Caribou	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
BS3	23.32	22.50	97.55	56.53	0.83	0.55	0.01	0	0	0	0.09	0	0.02	0	0	0	0.11	0
BS4	0.78	0.60	3.30	0.95	0.61	1.06	0	0	0	0	0	0	0	0	0	0	0	0
BS7	1.34	1.52	6.19	3.95	0.16	0.76	0	0	0	0	0	0	0	0	0	0	0.65	0
BS9	1.02	0.83	4.20	1.78	0.24	0	0	0	0	0	0	0	0	0	0	0	1.43	0
BS16	0.24	0.20	1.71	0.31	0.58	0	0	0	0	0	0	0	0	0	0	0	0	0
BS17	2.50	2.42	10.87	4.93	0.37	0.20	0	0	0	0	0	0	0.09	0	0	0.41	0.64	0
BS18	1.91	1.91	7.65	4.62	0.26	0	0	0	0	0	0.39	0	0.13	0	0	0.22	0	0
BS19	0.14	0.05	0.53	0.12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BS21	0.25	0.26	1.24	0.60	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BS22	0.38	0.29	1.82	0.56	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BS23	0.33	0.49	1.64	1.20	0	0	0	0	0	0	0	2.51	0	0	0	0	0	0
BS24	0.10	0.10	0.57	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BS25	0.10	0.10	0.49	0.37	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BS26	0.05	0.00	0.21	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RF1	8.26	5.62	37.90	13.42	0.26	0.07	0.03	0	0	0	0.26	0.15	0.03	0	0	0	0	0
RF2	28.84	20.07	120.03	41.28	0.08	0.68	0	0	0.01	0	0.30	0.22	0.02	0	0.02	0	0.07	0
RF3	3.77	2.32	15.95	3.23	0	0	0	0	0.13	0	0	0.31	0	0	0	0	0	0
Water/Lake Ice	10.66	10.17	44.37	22.61	0.05	0.04	0	0	0	0.04	0	0	0.05	0	0	0	0.09	0
Anthropogenic	19.02	11.92	83.68	22.43	0.20	0.09	0.08	0	0.02	0.04	0	0.04	0	0	0	0.04	0.00	0
Total	**102.99**	**81.33**	**439.89**	**179.14**	**0.30**	**0.38**	**0.02**	**0**	**0.01**	**0.01**	**0.13**	**0.09**	**0.02**	**0**	**0**	**0.02**	**0.09**	**0**
Mean	**92.16**		**309.52**		**0.34**		**0.01**		**0.01**		**0.11**		**0.01**		**0.01**		**0.05**	

Table 2.7-1. Pellet Groups per Hectare by transect in the Denison Wheeler River Project Area - 2017 & 2018.

Transect	Area (ha)		Species											
			Winter Moose		Summer Moose		Old Moose		Winter Caribou		Summer Caribou		Old Caribou	
	2017	2018.00	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
1	1.51	1.50	1.99	2.00	0	0	1.99	0	0	0	0	0	0	0
2	1.34	1.41	0	0	0	0	0	0	0	9.94	0	0	0	2.13
4	1.33	1.33	0.75	0	0	3.75	9.02	1.50	0	0	0	0	0	0
5	1.42	1.41	0	0	0	0	0	0	0.70	8.54	0	0	0	0
6	1.51	1.20	0.66	0	0	0.84	0.66	2.51	0	0	0	0	0	0
7	1.34	1.35	0	0	0	0	1.49	3.70	0	0	0	0	0	0
8	1.23	1.20	2.44	0.83	0	0	7.32	5.82	0	0	0	0	0	0
9	1.52	1.51	0	0	0	0	0	0	1.32	3.30	0.66	0	0	0.66
10	1.05	0.92	1.90	0	0.95	0	1.90	0	0	0	0	0	0	0
11	1.04	1.04	3.85	0.96	0	0	0.96	1.92	0	0	0	0	0	0
12	1.01	1.03	0	0	0	0	2.97	2.92	0	9.73	0	0	0	0
Creek 1	0.11	0.10	0	0	0	0	9.52	0	0	0	0	0	0	0
Creek 2	0.11	0.10	0	0	0	0	0	0	0	0	0	0	0	0
Creek 3	0.10	0.11	19.23	9.39	0	0	0	0	0	0	0	0	0	0
Creek 4	0.08	0.12	0	0	12.50	0	0	0	0	0	0	0	0	0
Creek 5	0.11	0.15	0	0	0	0	0	0	0	13.38	0	0	0	0
Access	1.05	1.03	0	0.98	0	0	0	1.95	0	0	0	0	0	0
Anthro	0.22	-	0	-	0	-	0	-	0	-	0	-	0	-
Total	**16.08**	**15.81**	**1.00**	**0.44**	**0.12**	**0.38**	**2.11**	**1.52**	**0.19**	**2.72**	**0.06**	**0.00**	**0.00**	**0.25**
Mean	**15.94**		**0.72**		**0.25**		**1.82**		**1.45**		**0.03**		**0.13**	

Notes:

"-" = not completed

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Table 2.7-1 Cont. Pellet Groups per Hectare by transect in the Denison Wheeler River Project Area - 2017 & 2018.

Transect	Area (ha)		Species											
			Grouse/ Ptarm		Fox		Mink		Marten		Bear		Wolf	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
1	1.51	1.50	23.84	16.01	0.66	0	0	0	0	0	0	0	0	0
2	1.34	1.41	11.21	37.63	0	0	0	0	0	0	0	0	0	0
4	1.33	1.33	12.78	18.76	0	0	0	0	0	0	0	0	0	0
5	1.42	1.41	9.86	36.28	0	0	0	0	0	0	0	0	0	0
6	1.51	1.20	10.60	55.16	0	0.84	0	0	0	0	0.66	0	0	0
7	1.34	1.35	2.99	2.96	0	0	0	0	0	0	0	1.48	0	0
8	1.23	1.20	4.07	15.81	0	0	0	0	0	0	0	0	0	0
9	1.52	1.51	5.26	44.92	0	0	0.66	0	0	0	0	0	0	0.66
10	1.05	0.92	5.71	6.49	0	0	0	0	0	0	0	0	0	0
11	1.04	1.04	3.85	3.83	0	0	0	0	0.96	0	0	0	0	0
12	1.01	1.03	12.87	30.15	0	0	0	0	0	0	0.99	0	0	0
Creek 1	0.11	0.10	0	0	0	0	0	0	0	0	0	0	0	0
Creek 2	0.11	0.10	0	0	0	0	0	0	0	0	0	0	0	0
Creek 3	0.10	0.11	0	0	0	0	0	0	0	0	0	9.39	0	0
Creek 4	0.08	0.12	0	0	0	0	0	0	0	0	0	0	0	0
Creek 5	0.11	0.15	0	0	0	0	0	0	0	0	0	6.69	0	6.69
Access	1.05	1.03	15.24	42.93	0	0	0	0	0	0	0	0	0	0
Anthro	0.22	-	0	-	0	-	0	-	0	-	0	-	0	-
Total	**16.08**	**15.81**	**9.58**	**24.99**	**0.06**	**0.06**	**0.06**	**0.00**	**0.06**	**0.00**	**0.12**	**0.25**	**0.00**	**0.13**
Mean	**15.94**		**17.28**		**0.06**		**0.03**		**0.03**		**0.19**		**0.06**	

Notes:

"-" = not completed

Table 2.7-2. Pellet Groups per Hectare by Ecosite/Vegetation Cover Type in the Denison Wheeler River Project Area - 2017 & 2018.

Ecosite/Veg Cover Type	Area (ha)		Species											
			Winter Moose		Summer Moose		Old Moose		Winter Caribou		Summer Caribou		Old Caribou	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
BS3	4.61	4.92	0	0	0	0	0	0.20	0.65	6.30	0	0	0	0.61
BS4	0.21	0.12	0	0	0	0	0	0	0	0	0	0	0	0
BS7	0.29	0.16	3.50	0	0	0	0	0	0	61.68	0	0	0	6.17
BS9	0.11	0.26	0	0	0	0	8.94	0	0	0	0	0	0	0
BS16	0.04	0.08	0	0	24.58	0	0	0	0	0	0	0	0	0
BS17	0.58	0.61	0	0	0	0	0	0	0	1.63	0	0	0	0
BS18	0.33	0.31	0	0	0	0	0	0	0	0	3.00	0	0	0
BS19	0.00	0.02	0	0	0	0	0	0	0	0	0	0	0	0
BS21	0.04	0.03	0	0	0	0	24.39	0	0	0	0	0	0	0
BS22	0.09	0.08	0	0	0	0	0	0	0	0	0	0	0	0
BS23	0.01	0.00	0	0	0	0	0	0	0	0	0	0	0	0
BS24	0.05	0.02	0	0	0	0	19.68	47.43	0	0	0	0	0	0
BS25	0.04	0.00	0	0	0	0	0	0	0	0	0	0	0	0
BS26	0.05	0.03	0	0	0	0	0	0	0	0	0	0	0	0
BS27	0.05	0.04	0	0	0	0	0	0	0	0	0	0	0	0
RF1	2.55	3.98	1.17	0.25	0	0.25	1.96	1.26	0	0.25	0	0	0	0
RF2	5.93	4.51	1.85	1.33	0.17	1.11	4.21	3.77	0	0	0	0	0	0
RF3	0.82	0.49	1.21	0	0	0	1.21	0	0	0	0	0	0	0
Recent Burn	0.03	0.03	0	0	0	0	0	0	0	0	0	0	0	0
Anthropogenic	0.22	0.11	0	0	0	0	0	0	0	0	0	0	0	0
Total	**16.08**	**15.81**	**1.00**	**0.44**	**0.12**	**0.38**	**2.11**	**1.52**	**0.19**	**2.72**	**0.06**	**0.00**	**0.00**	**0.25**
Mean	**15.94**		**0.72**		**0.25**		**1.82**		**1.45**		**0.03**		**0.13**	

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Table 2.7-2 Cont. Pellet Groups per Hectare by Ecosite/Vegetation Cover Type in the Denison Wheeler River Project Area - 2017 & 2018.

Ecosite/Veg Cover Type	Area (ha)		Species											
			Grouse/ Ptarm		Fox		Mink		Marten		Bear		Wolf	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
BS3	4.61	4.92	8.68	36.98	0	0	0	0	0.22	0	0	0	0	0.20
BS4	0.21	0.12	13.97	25.29	0	0	0	0	0	0	0	0	0	0
BS7	0.29	0.16	0	61.68	0	0	0	0	0	0	0	0	0	0
BS9	0.11	0.26	26.82	30.82	0	0	0	0	0	0	8.94	0	0	0
BS16	0.04	0.08	0	0	0	0	0	0	0	0	0	0	0	0
BS17	0.58	0.61	0	1.63	0	0	1.72	0	0	0	0	1.63	0	1.63
BS18	0.33	0.31	0	0	0	0	0	0	0	0	0	0	0	0
BS19	0.00	0.02	0	137.60	0	0	0	0	0	0	0	0	0	0
BS21	0.04	0.03	0	0	0	0	0	0	0	0	0	0	0	0
BS22	0.09	0.08	0	0	0	0	0	0	0	0	0	0	0	0
BS23	0.01	0.00	0	0	0	0	0	0	0	0	0	0	0	0
BS24	0.05	0.02	19.68	47.43	0	0	0	0	0	0	0	0	0	0
BS25	0.04	0.00	0	0	0	0	0	0	0	0	0	0	0	0
BS26	0.05	0.03	0	31.08	0	0	0	0	0	0	0	0	0	0
BS27	0.05	0.04	0	0	0	0	0	0	0	0	0	0	0	0
RF1	2.55	3.98	11.36	23.11	0	0	0	0	0	0	0.39	0.25	0	0
RF2	5.93	4.51	12.98	20.19	0.17	0.22	0	0	0	0	0	0.44	0	0
RF3	0.82	0.49	1.21	0	0	0	0	0	0	0	0	0	0	0
Recent Burn	0.03	0.03	0	0	0	0	0	0	0	0	0	0	0	0
Anthropogenic	0.22	0.11	0	28.46	0	0	0	0	0	0	0	0	0	0
Total	**16.08**	**15.81**	**9.58**	**24.99**	**0.06**	**0.06**	**0.06**	**0.00**	**0.06**	**0.00**	**0.12**	**0.25**	**0.00**	**0.13**
Mean	**15.94**		**17.29**		**0.06**		**0.03**		**0.03**		**0.19**		**0.06**	

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Table 2.8-1. Small Mammal Captures per Transect in the Wheeler River Project Area – 2016.

Transect	Total Trapping Effort (# of trap nights)	Trapping Success (# of individuals caught per 100 trap nights)		
		Red-Backed Vole	Meadow Vole	Dusky Shrew
1	99	2.02	0.40	0.00
2	99	2.02	12.12	0.00
3	99	7.07	2.02	1.01
4	99	1.01	0.00	0.00
5	99	0.00	0.00	0.00
6	99	12.12	4.04	0.00
7	96	0.00	1.04	0.00
8	99	7.07	0.00	2.02
9	99	2.02	2.02	3.03
10	99	3.03	0.00	0.00
11	99	6.06	0.00	0.00
12	99	2.02	1.01	0.00
13	99	18.18	0.00	1.01
14	99	2.02	0.00	0.00
15	99	1.01	0.00	0.00
16	99	6.06	0.00	0.00
17	99	9.09	0.00	0.00
18	99	15.15	0.00	1.01
19	99	17.17	1.01	1.01
20	99	4.04	8.08	0.00
21	99	12.12	4.04	0.00
22	99	5.05	0.00	0.00
23	99	2.02	1.01	0.00
24	99	2.02	0.00	0.00
25	99	8.08	0.00	0.00
26	90	3.33	0.00	0.00
Project Area	**2,562**	**5.78**	**1.56**	**0.35**

Table 2.8-2. Small Mammal Captures by Ecosite in the Wheeler River Project Area – 2016.

Ecosite Code	Ecosite Name	Total Trapping Effort (# of trap nights)	Trapping Success (# of individuals caught per 100 trap nights)		
			Red-Backed Vole	Meadow Vole	Dusky Shrew
BS3	Jack pine / blueberry / lichen: Moderately fresh sand	99	0	0	0
BS4	Jack pine - black spruce/ feathrmoss: Moderately dry	297	10.44	0.67	0.67
BS5	Jack pine - white birch/feathermoss: Moderately dry sand	99	6.06	0	0
BS7	Black spruce / blueberry / lichen: Moderately dry sand	288	2.08	0	0
BS9	Black spruce - jack pine / feathermoss: Moderately fresh sandy loam	99	9.09	0	0
BS17	Black spruce treed bog: Very moist mesic organic	198	12.12	0.51	1.52
BS18	Labrador tea shrubby bog: Moderately wet mesic organic	198	8.59	1.01	2.02
BS19	Graminoid bog: Very wet humic organic	99	2.02	12.12	0
BS20	Open bog: Moderately wet fibric organic	99	2.02	4.04	0
BS21	Tamarack treed fen: Wet fibric organic	198	8.08	6.06	0
BS23	Willow shrubby rich fen: Wet fibric organic	99	12.12	4.04	0
BS24	Graminoid fen: Very wet humic organic	96	0	1.04	0
BS26	Rush sandy shore: Very moist sand	99	8.08	0	0
BS27	Sedge rocky shore: Very moist sand	99	2.02	1.01	0
RF1	Regeneration - Tree Dominated	99	2.02	0	0
RF2	Regeneration - Tall Shrub Dominated	297	3.03	0	0
AN	Anthropogenic/disturbed	99	2.02	1.01	0

Table 2.8-3. Small Mammal Micro-Habitat Assessment in the Wheeler River Project Area – 2016.

Habitat Attribute	Transect ID / Ecosite																
	23	25	7	21	6/20	1	2	9/18	8/19	17	4/24/26	16	3/13	5/11	10/15/22	14	12
	BS27	BS26	BS24	BS23	BS21	BS20	BS19	BS18	BS17	BS9	BS7	BS5	BS4	BS3	Pj Tall Shrub Regen	Pj Treed Regen	Disturbed
Mean % trees (>5m)	0.00	1.33	-	-	17.33	-	-	1.50	9.17	33.67	26.00	16.33	19.90	19.00	1.82	16.33	1.00
Mean Tree dbh (cm)	-	12.53	-	-	11.04	-	-	7.72	8.44	11.01	10.01	5.33	11.03	9.72	5.87	6.18	11.35
Mean tree height (m)	-	8.33	-	-	9.43	-	-	6.72	8.02	10.27	9.39	7.25	9.31	9.21	6.00	6.42	9.50
Mean % shrubs (<2.5m)	0.80	17.33	5.47	82.33	1.67	21.00	0.13	73.83	57.83	16.13	20.97	54.00	46.73	32.00	35.33	16.67	5.20
Mean % shrubs (2.5-5m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.67	13.02	5.47	3.11	40.60	5.67	2.83	14.56	25.67	0.00
Mean Low shrub height (cm)	41.80	44.47	26.25	122.00	77.67	28.43	30.00	37.93	77.67	52.40	32.29	96.40	40.40	35.50	134.18	22.67	19.90
Mean Tall shrub height (m)	-	-	-	-	3.44	-	-	3.50	3.50	3.78	3.19	3.77	3.48	3.42	3.55	3.93	-
Mean % Forbes	0.63	0.00	0.07	2.20	4.72	0.07	0.50	2.13	4.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mean Forb Height (cm)	4.40	-	5.00	12.53	11.50	2.00	5.30	4.04	11.50	-	-	-	-	-	-	-	-
Mean % Graminoids	75.00	8.50	25.00	4.73	7.62	46.40	46.33	1.32	7.62	0.00	0.00	0.00	0.02	0.00	0.00	0.00	2.73
Mean Graminoid Depth (cm)	51.73	46.00	46.00	45.71	53.76	41.80	44.33	26.54	53.76	-	-	-	54.00	-	-	-	46.79
Mean % litter	6.70	3.03	0.00	0.00	0.92	0.43	0.50	0.55	0.92	1.30	0.88	25.33	7.05	4.30	4.77	3.90	5.97
Mean Litter depth (cm)	3.15	1.27	-	-	1.07	0.96	1.00	0.98	1.07	1.09	1.03	2.80	1.57	1.23	1.43	1.80	4.90
Mean % Bare soil	0.00	69.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.44	0.00	72.13
Mean % Deadfall (0-10 cm)	0.00	0.23	0.00	0.00	1.18	0.00	0.00	0.07	1.18	1.57	1.46	2.80	4.18	0.65	2.87	0.10	0.00
Mean % Deadfall (10-25 cm)	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.38	0.00	0.47	0.22	0.01	0.00	0.00
Mean % Deadfall (>25cm)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Overall % Deadfall	0.00	0.37	0.00	0.00	1.15	0.00	0.00	0.13	1.18	1.57	1.92	2.80	4.65	0.87	2.88	0.10	0.00
Mean % Rock	10.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.57	8.03	3.23	0.33	0.69	0.33	2.20
Mean % Water	6.03	5.67	51.13	10.00	5.97	3.67	24.70	0.35	5.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mean % Sphagnum	0.00	0.00	43.93	89.67	44.97	88.33	0.37	66.97	44.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mean % Feathermoss	0.00	0.00	0.00	0.00	46.00	0.00	0.00	2.48	46.00	51.70	44.78	3.37	17.45	19.02	0.42	0.00	0.00
Mean % Terrestrial Lichen	0.00	0.00	0.00	0.00	0.02	0.00	0.00	16.02	0.02	31.77	47.83	7.87	26.45	68.13	75.29	79.33	1.67

Table 2.8-4. Summary of Red-backed Voles Metals and Radionuclide Analysis in the Wheeler River Project Area – 2016.

Parameter	Units	Gryphon	Phoenix	Reference 1	Reference 2	Reference 3
Physical Properties						
Moisture	%	73.06	73.23	72.46	72.65	72.95
Metals and Trace Elements						
Aluminum	ug/g	7.8	34	5.1	5.7	7.8
Antimony	ug/g	<0.02	<0.02	<0.02	<0.02	<0.02
Arsenic	ug/g	0.01	0.02	<0.01	<0.01	0.01
Barium	ug/g	22.8	22.3	10.1	42.2	24.6
Beryllium	ug/g	<0.002	<0.002	<0.002	<0.002	<0.002
Boron	ug/g	0.3	0.3	0.3	0.3	0.4
Cadmium	ug/g	0.018	0.021	0.036	0.058	0.034
Chromium	ug/g	<0.1	<0.1	<0.1	<0.1	<0.1
Cobalt	ug/g	0.049	0.055	0.048	0.047	0.054
Copper	ug/g	2.8	2.6	2.5	2.7	2.4
Iron	ug/g	68	71	59	62	62
Lead	ug/g	0.027	0.035	0.027	0.038	0.039
Manganese	ug/g	6.8	9.4	7.7	8	7.6
Molybdenum	ug/g	0.02	0.05	0.04	0.04	0.04
Nickel	ug/g	0.09	0.09	0.1	0.08	0.12
Selenium	ug/g	0.44	0.66	0.43	0.16	0.29
Silver	ug/g	<0.002	<0.002	<0.002	<0.002	<0.002
Strontium	ug/g	0.82	1.7	1.4	2.4	2.2
Thallium	ug/g	<0.01	<0.01	<0.01	<0.01	<0.01
Tin	ug/g	<0.01	<0.01	<0.01	<0.01	<0.01
Titanium	ug/g	0.41	1.6	0.35	0.39	0.36
Uranium	ug/g	0.01	0.031	0.007	0.01	0.007
Vanadium	ug/g	<0.02	0.02	<0.02	<0.02	<0.02
Radionuclides						
Lead-210	Bq/g	0.011	0.006	0.009	0.008	0.011
Polonium-210	Bq/g	0.018	0.015	0.018	0.017	0.013
Radium-226	Bq/g	0.0017	0.0037	0.0014	0.002	0.0015
Thorium-230	Bq/g	<0.0003	<0.0003	<0.0004	<0.0003	<0.0003

Table 2.9-1. Amphibian Point Count Survey Results in the Wheeler River Project Area – 2017.

Date	Start Time	Site	Study Area	Easting NAD 83	Northing NAD 83	Weather Conditions			Amphibian Species
						Sky Code[a]	Temp (C)	Beaufort Wind[b]	Wood Frog
17/06/2017	22:30	1	RSA	471524	6379813	2	11	1	0
17/06/2017	22:37	2	RSA	472331	6379837	2	11	1	0
17/06/2017	22:46	3	RSA	472993	6379306	2	11	1	0
17/06/2017	22:54	4	RSA	473814	6379286	5	11	1	0
17/06/2017	23:01	5	RSA	474130	6378541	5	11	1	0
17/06/2017	23:08	6	RSA	474855	6378136	2	11	1	0
17/06/2017	23:15	7	RSA	475632	6377884	2	11	1	0
17/06/2017	23:22	8	RSA	475648	6377073	2	11	1	0
17/06/2017	23:30	9	LSA	475400	6376296	2	11	1	0
17/06/2017	23:39	10	RSA	474603	6376421	5	11	1	0
17/06/2017	23:53	11	LSA	475204	6375512	5	11	1	0
18/06/2017	0:00	12	LSA	474770	6374837	5	11	1	0
18/06/2017	0:07	13	RSA	474031	6374498	5	11	1	0
18/06/2017	0:18	14	LSA	475593	6374778	2	11	1	0
18/06/2017	0:25	15	LSA	474886	6374024	2	11	1	0
18/06/2017	0:32	16	RSA	474557	6373284	2	11	1	0
18/06/2017	0:39	17	LSA	474946	6372581	2	11	0	0
18/06/2017	0:46	18	LSA	475775	6372547	5	11	0	0
18/06/2017	0:52	19	LSA	476321	6373164	5	11	0	0
18/06/2017	1:00	20	LSA	477124	6373356	5	9	1	0
18/06/2017	22:31	21	LSA	475916	6371760	2	16	0	0
18/06/2017	22:37	22	LSA	476517	6371209	2	16	0	0
18/06/2017	22:43	23	LSA	477329	6371090	2	16	0	0
18/06/2017	22:49	24	LSA	478039	6371489	2	16	0	0
18/06/2017	22:57	25	LSA	477177	6370280	2	16	0	0
18/06/2017	23:02	26	LSA	476791	6369516	2	16	0	0
18/06/2017	23:10	27	LSA	478579	6370874	2	16	1	0
18/06/2017	23:16	28	LSA	478977	6371571	2	16	0	0
18/06/2017	23:23	29	LSA	479374	6370704	2	16	0	0
18/06/2017	23:30	30	LSA	480236	6370707	2	16	0	0

Notes:

[a]**Sky codes**: 0 = Few clouds; 1 = Partly Cloudy; 2 = Cloudy or Overcast; 4 = Fog or Smoke; 5 = Drizzle or light rain

[b]**Beaufort wind** 0 = Calm, smoke rises vertically; 1 =Light air, smoke drifts, weather vane inactive;

2 = Light breeze, leaves rustle, can feel wind on face; 3 = Gentle breeze, leaves and twigs move around, small flags extend;
4 = Moderate breeze, moves thin branches, raise loose papers (do not conduct survey)

[c]**Amphibian Calling Index:** 1, 2 or 3, Several = 3-5 or Many = > 5

Table 2.9-1 Cont. Amphibian Point Count Survey Results in the Wheeler River Project Area – 2017.

Date	Start Time	Site	Study Area	Easting NAD 83	Northing NAD 83	Weather Conditions			Amphibian Species
						Sky Code[a]	Temp (C)	Beaufort Wind[b]	Wood Frog
18/06/2017	23:40	31	LSA	478718	6370106	2	16	0	0
18/06/2017	23:47	32	LSA	478182	6369438	2	16	0	0
18/06/2017	23:52	33	RSA	477607	6368751	2	16	0	0
18/06/2017	23:54	34	RSA	477172	6368721	2	16	0	0
19/06/2017	0:05	35	RSA	476727	6367388	2	16	0	0
19/06/2017	0:10	36	RSA	476278	6366692	2	16	0	0
19/06/2017	0:20	37	LSA	479791	6371475	5	16	0	0
19/06/2017	0:26	38	RSA	480500	6371882	5	16	0	0
19/06/2017	0:32	39	RSA	481064	6372482	5	16	0	0
19/06/2017	0:38	40	RSA	481615	6373103	5	16	0	0
19/06/2017	0:45	41	RSA	482125	6373731	5	16	0	0
19/06/2017	0:53	42	RSA	482553	6374410	5	11	0	0
19/06/2017	22:34	43	RSA	477975	6381272	1	9	0	0
19/06/2017	22:40	44	RSA	477728	6380499	1	9	0	0
19/06/2017	22:47	45	RSA	477010	6380131	1	9	0	0
19/06/2017	22:54	46	RSA	476237	6379858	1	9	0	0
19/06/2017	23:02	47	RSA	475936	6379096	1	9	0	0
19/06/2017	23:09	48	RSA	476095	6378240	1	9	0	0
19/06/2017	23:17	49	RSA	476609	6377630	1	9	0	2
19/06/2017	23:25	50	LSA	477268	6377187	1	9	0	0
19/06/2017	23:33	51	LSA	477800	6376556	1	9	0	0
19/06/2017	23:39	52	LSA	477869	6375786	0	9	0	0
19/06/2017	23:45	53	LSA	478656	6375909	0	9	0	0
19/06/2017	23:51	54	LSA	479147	6376580	0	9	0	0
19/06/2017	23:57	55	LSA	479474	6377304	0	9	0	0
20/06/2017	0:08	56	LSA	477056	6375835	0	9	0	0
20/06/2017	0:15	57	LSA	476604	6375181	0	9	0	0
20/06/2017	0:23	58	LSA	477037	6374493	0	9	0	0
20/06/2017	0:30	59	LSA	477856	6374614	0	9	0	0
20/06/2017	0:46	60	RSA	474141	6372503	0	9	0	0
20/06/2017	0:52	61	RSA	473567	6371944	0	6	0	0

Notes:
[a]**Sky codes**: 0 = Few clouds; 1 = Partly Cloudy; 2 = Cloudy or Overcast; 4 = Fog or Smoke; 5 = Drizzle or light rain
[b]**Beaufort wind** 0 = Calm, smoke rises vertically; 1 =Light air, smoke drifts, weather vane inactive;
2 = Light breeze, leaves rustle, can feel wind on face; 3 = Gentle breeze, leaves and twigs move around, small flags extend;
4 = Moderate breeze, moves thin branches, raise loose papers (do not conduct survey)
[c]**Amphibian Calling Index:** 1, 2 or 3, Several = 3-5 or Many = > 5

Table 2.9-2. Amphibian Point Count Survey Results in the Wheeler River Project Area – 2018.

Date	Start Time	Site	Study Area	Easting NAD 83	Northing NAD 83	Weather Conditions			Amphibian Species
						Sky Code[a]	Temp (C)	Beaufort Wind[b]	Boreal Chorus Frog
08/06/2018	22:24	5	RSA	474130	6378541	0	20	0	
08/06/2018	22:31	6	RSA	474855	6378136	0	20	0	
08/06/2018	22:39	7	RSA	475632	6377884	0	20	0	
08/06/2018	22:47	8	RSA	475648	6377073	0	20	0	
08/06/2018	22:55	9	LSA	475400	6376296	0	15	0	
08/06/2018	23:05	10	RSA	474603	6376421	0	19	0	
08/06/2018	23:18	11	LSA	475204	6375512	0	17	0	
08/06/2018	23:25	12	LSA	474770	6374837	0	17	0	
08/06/2018	23:33	13	RSA	474031	6374498	0	15	0	
08/06/2018	23:44	14	LSA	475593	6374778	0	16	0	3
08/06/2018	23:51	15	LSA	474886	6374024	0	15	0	1
08/06/2018	23:58	16	RSA	474557	6373284	0	17	0	Many
09/06/2018	00:05	17	LSA	474946	6372581	0	14	0	
09/06/2018	00:14	21	LSA	475916	6371760	0	13	0	
09/06/2018	00:21	22	LSA	476517	6371209	0	12	0	1
09/06/2018	00:27	23	LSA	477329	6371090	0	14	0	
09/06/2018	00:34	24	LSA	478039	6371489	0	14	1	
09/06/2018	00:43	27	LSA	478579	6370874	0	10	1	
06/06/2018	22:22	52	LSA	477869	6375786	0	9	0	
06/06/2018	22:31	56	LSA	477056	6375835	0	8	0	
06/06/2018	22:42	57	LSA	476604	6375181	0	8	0	
06/06/2018	22:53	58	LSA	477037	6374493	0	6	0	
06/06/2018	23:03	59	LSA	477856	6374614	0	7	0	1
06/06/2018	23:14	20	LSA	477124	6373356	0	8	0	
06/06/2018	23:33	19	LSA	476321	6373164	0	6	0	
06/06/2018	23:41	18	LSA	475775	6372547	0	4	0	

Notes:
[a]**Sky codes**: 0 = Few clouds; 1 = Partly Cloudy; 2 = Cloudy or Overcast; 4 = Fog or Smoke; 5 = Drizzle or light rain
[b]**Beaufort wind** 0 = Calm, smoke rises vertically; 1 =Light air, smoke drifts, weather vane inactive;
2 = Light breeze, leaves rustle, can feel wind on face; 3 = Gentle breeze, leaves and twigs move around, small flags extend;
4 = Moderate breeze, moves thin branches, raise loose papers (do not conduct survey)
[c]**Amphibian Calling Index:** 1, 2 or 3, Several = 3-5 or Many = > 5

Table 2.9-3. Comparison of Wheeler River Project Area Amphibian Nocturnal Call Survey Results to Other Studies in Northern Saskatchewan.

Survey Area	Survey Dates	# of Survey Sites	% of Plots With Boreal Chorus Frogs	% of Plots with Wood Frogs	% of Plots with Canadian Toads	% of Plots with Northern Leopard Frogs
Denison-Wheeler River 2018	June 6-9, 2018	26	19	0	0	0
Denison-Wheeler River 2017	June 16-20, 2017	61	0	2	0	0
Sask Power/Black Lake First Nation- Tazi Twe Hydroelectric Project	May 28, June 2, June 13, 2012	28	50	32	0	0
Rio Tinto - Roughrider	June 6-8, 2012	17	53	6	0	0
SRC-Gunnar Mine*	August, 2009	N/A	Observed (3)	Observed (66)	Not Observed	Observed (6)
Cameco - Millennium	June 13-26, 2007	Unknown	0	Observed**	0	0

*Visual Survey
**Number of observations not quantified
Source: Rio Tinto (2014), Golder (2013), SRC (2013), and Cameco (2009)

Table 2.10-1. Mean Breeding Song Bird Pairs Detected per Vegetation Cover Type in the Wheeler River Project Area - 2017.

Species	**N**	**Ecosite and Sample Size**																				
		BS3	**BS4**	**BS5**	**BS7**	**BS9**	**BS16**	**BS17**	**BS18**	**BS19**	**BS20**	**BS21**	**BS22**	**BS23**	**BS24**	**BS25**	**BS26**	**BS27**	**RF1**	**RF2**	**RF3**	**AN**
	101	**7**	**5**	**1**	**7**	**7**	**5**	**7**	**5**	**2**	**3**	**4**	**4**	**2**	**5**	**2**	**3**	**5**	**7**	**7**	**7**	**6**
	Mean pairs																					
Alder Flycatcher	0.02								0.2			0.3										
American Robin	0.13	0.3	0.2			0.1		0.3				0.3			0.2		0.3	0.2	0.1	0.1	0.1	
Barn Swallow	0.04																					0.7
Belted Kingfisher	0.02																				0.3	
Blue-headed vireo	0.01																		0.1			
Boreal Chickadee	0.03							0.1			0.7											
Bufflehead	0.01																	0.2				
Cedar Waxwing	0.01																		0.1			
Chipping Sparrow	0.15	0.1	0.6	1.0	0.1	0.1		0.3					0.5	0.5					0.1		0.3	
Common Loon	0.02																	0.4				
Common Merganser	0.03																1.0					
Common Raven	0.01													0.5								
Dark-eyed Junco	0.40	0.3	0.2	3.0	0.3	0.4	0.4	0.2	0.4		0.3	1.3	0.3	0.5	0.4				0.1	0.7	0.7	
Fox Sparrow	0.15		0.2	2.0	0.3				0.2										0.4	0.7	0.1	
Gray Jay	0.34	0.3	0.4	1.0	1.4	0.3	0.2	0.6	0.2				0.5				0.3		0.1	0.6	0.3	0.2
Greater Yellowlegs	0.03		0.2										0.3					0.2				

Table 2.10-1 Cont. Mean Breeding Song Bird Pairs Detected per Vegetation Cover Type in the Wheeler River Project Area - 2017.

Species	N	Ecosite and Sample Size																			
		BS3	BS4	BS5	BS7	BS9	BS16	BS17	BS18	BS19	BS20	BS21	BS22	BS23	BS24	BS25	BS26	BS27	RF1	RF2	RF3	AN
	101	7	5	1	7	7	5	7	5	2	3	4	4	2	5	2	3	5	7	7	7	6
	Mean pairs																					
Herring Gull	0.01																	0.2				
Hermit Thrush	0.18	0.3			0.1	0.1		0.1					0.3						0.6	1.0	0.1	
Killdeer	0.02																0.3					0.2
Lincoln Sparrow	0.15					0.1	0.4	0.1	0.2	0.5	0.3	0.8	0.8				0.3				0.1	
Mew Gull	0.01																0.3					
Olive-sided Flycatcher	0.08							0.3				0.3	0.5	0.5	0.2					0.1		
Palm Warbler	0.09								0.2		0.3	0.3	0.8	1.0	0.2							
Ring-billed Gull	0.01																0.3					
Ruby-crowned Kinglet	0.50	0.7	1.4		1.3	0.9	0.6	1.0	0.2			0.3	0.3	0.5					1.0	0.4		
Solitary Sandpiper	0.04													0.5			0.3	0.4				
Spruce Grouse	0.01		0.2																			
Swamp Sparrow	0.05								0.2		0.3	0.3	0.3			0.5						
Swainson's Thrush	0.18	0.1	0.8		0.1	0.4		0.1	0.2	0.5	0.3	0.3							0.4	0.1		
Tennessee Warbler	0.01						0.2															
Tree Swallow	0.01																					0.2
Wilson's Warbler	0.04					0.1													0.3	0.1		

Table 2.10-1 Cont. Mean Breeding Song Bird Pairs Detected per Vegetation Cover Type in the Wheeler River Project Area - 2017.

Species	N	Ecosite and Sample Size																			
		BS3	BS4	BS5	BS7	BS9	BS16	BS17	BS18	BS19	BS20	BS21	BS22	BS23	BS24	BS25	BS26	BS27	RF1	RF2	RF3	AN
	101	7	5	1	7	7	5	7	5	2	3	4	4	2	5	2	3	5	7	7	7	6
	Mean pairs																					
Winter Wren	0.01						0.2															
White-throated Sparrow	0.05						0.2					0.3									0.4	
Yellow-bellied Flycatcher	0.02																		0.1	0.1		
Yellow-rumped Warbler	0.31	0.1	1.0		0.9	0.4	0.6	0.1	0.6			0.3	0.3	0.5			0.3		0.3	0.1	0.3	

Table 2.10-2. Songbird Diversity Indices by Ecosite in the Wheeler River Project Area - 2017.

Ecosite	**N**	**Diversity Indices**				**Decreasing Richness**		**Decreasing Pairs**		**Decreasing S-W**		**Decreasing Evenness**	
		Species Richness	**Mean # of Pairs**	**Shannon-Wiener Diversity**	**Evenness**	**Ecosite**	**Species Richness**	**Ecosite**	**Mean # of Pairs**	**Ecosite**	**Shannon-Wiener Diversity**	**Ecosite**	**Evenness**
BS3	**7**	8	2.3	1.9	0.9	Project Area	36	BS5	7.0	Project Area	2.9	BS19	1.0
BS4	**5**	10	5.2	2.0	0.9	RF1	13	BS4	5.2	BS22	2.4	BS23	1.0
BS5	**1**	4	7.0	1.3	0.9	BS22	12	BS7	4.6	RF1	2.3	BS20	1.0
BS7	**7**	8	4.6	1.7	0.8	BS17	11	BS21	4.5	BS18	2.2	BS27	1.0
BS9	**7**	10	3.1	2.1	0.9	BS21	11	BS22	4.5	BS21	2.2	BS18	1.0
BS16	**5**	8	2.8	2.0	0.9	RF2	11	RF2	4.3	BS17	2.1	BS26	1.0
BS17	**7**	11	3.7	2.1	0.9	BS4	10	BS23	4.0	RF2	2.1	BS22	1.0
BS18	**5**	10	2.6	2.2	1.0	BS9	10	RF1	4.0	BS26	2.1	BS3	0.9
BS19	**2**	2	1.0	0.7	1.0	BS18	10	BS17	3.7	BS9	2.1	BS16	0.9
BS20	**3**	7	2.7	1.9	1.0	BS26	9	BS26	3.7	RF3	2.1	BS24	0.9
BS21	**4**	11	4.5	2.2	0.9	RF3	9	Study Area	3.2	BS4	2.0	RF3	0.9
BS22	**4**	12	4.5	2.4	1.0	BS3	8	BS9	3.1	BS16	2.0	BS5	0.9
BS23	**2**	7	4.0	1.9	1.0	BS7	8	BS16	2.8	BS23	1.9	BS21	0.9
BS24	**5**	3	0.8	1.0	0.9	BS16	8	RF3	2.7	BS20	1.9	BS9	0.9
BS25	**2**	1	0.5	0.0	NA	BS20	7	BS20	2.7	BS3	1.9	RF1	0.9
BS26	**3**	9	3.7	2.1	1.0	BS23	7	BS18	2.6	BS27	1.7	BS17	0.9
BS27	**5**	6	1.6	1.7	1.0	BS27	6	BS3	2.3	BS7	1.7	RF2	0.9
RF1	**7**	13	4.0	2.3	0.9	AN	5	BS27	1.6	AN	1.4	BS4	0.9
RF2	**7**	11	4.3	2.1	0.9	BS5	4	AN	1.3	BS5	1.3	AN	0.9
RF3	**7**	9	2.7	2.1	0.9	BS24	3	BS19	1.0	BS24	1.0	BS7	0.8
AN	**6**	5	1.3	1.4	0.9	BS19	2	BS24	0.8	BS19	0.7	Project Area	0.8
Project Area	**101**	36	3.2	2.9	0.8	BS25	1	BS25	0.5	BS25	0.0	BS25	NA

Table 2.10-3. Breeding Songbird Observations in Descending order of Abundance in the Wheeler River Project Area – 2017.

Common Name	Scientific Name	Number of Pairs
Ruby-crowned Kinglet	*Regulus calendula*	51
Dark-eyed Junco	*Junco hyemalis*	40
Gray Jay	*Perisoreus canadensis*	34
Yellow-rumped Warbler	*Dendroica coronata*	31
Hermit Thrush	*Catharus guttatus*	18
Swainson's Thrush	*Catharus ustulatus*	18
Chipping Sparrow	*Spizella passerina*	15
Fox Sparrow	*Passerella iliaca*	15
Lincoln Sparrow	*Melospiza lincolnii*	15
American Robin	*Turdus migratorius*	13
Palm Warbler	*Setophaga palmarum*	9
Olive-sided Flycatcher	*Contopus cooperi*	8
Swamp Sparrow	*Melospiza georgiana*	5
White-throated Sparrow	*Zonotrichia albicollis*	5
Barn Swallow	*Hirundo rustica*	4
Solitary Sandpiper	*Tringa solitaria*	4
Wilson's Warbler	*Wilsonia pusilla*	4
Boreal Chickadee	*Poecile hudsonicus*	3
Common Merganser	*Mergus merganser*	3
Greater Yellowlegs	*Tringa melanoleuca*	3
Alder Flycatcher	*Empidonax alnorum*	2
Belted Kingfisher	*Megaceryle alcyon*	2
Common Loon	*Gavia immer*	2
Killdeer	*Charadrius vociferus*	2
Yellow-bellied Fylcatcher	*Empidonax flaviventris*	2
Bufflehead	*Bucephala albeola*	1
Cedar Waxwing	*Bombycilla cedrorum*	1
Common Raven	*Corvus corax*	1
Blue-headed vireo	*Vireo solitarius*	1
Herring Gull	*Larus smithsonianus*	1
Mew Gull	*larus canus*	1
Ring-billed Gull	*Larus delawarensis*	1
Spruce Grouse	*Falcipennis canadensis*	1
Tennessee Warbler	*Leiothlypis peregrina*	1
Tree Swallow	*Tachycineta bicolor*	1
Winter Wren	*Troglodytes hiemalis*	1

Table 2.11-1. Semi-Aquatic Furbearer Shoreline Survey Observations in the Wheeler River Project Area – 2016.

Water Body ID	Shoreline (km)	Observations per km								
		Muskrat			Beaver				Otter	
		Burrow/ House/ Run	Scent platform /Feed Sign	Scat	Run/ Scent/ Feed Sign	Old Run/ Scent/ Feed Sign	Active House	Inactive/ Old House	Scent/ Feed Sign	Scat
Lake 1	5.3	0	0	0	0	0	0	0	0	0
Lake 2	8.9	0	0	0.45	0.34	0.22	0	0	0	0
Lake 3	3.9	0	0.26	0.26	0	0.26	0	0	0	0
Lake 4	5.7	0	1.93	2.98	0	0	0	0	0	0
Lake 5	2.1	0	0.95	1.90	0	0	0	0	0	0
Lake 6	26.1	0	0.08	0.46	0.08	0.38	0	0.04	0.04	0
Lake 7	3.9	0	0.26	2.05	2.82	0.77	0	0.51	0	0
Lake 8	11.5	0	0.52	0.35	0	1.22	0	0.09	0	0
Lake 9	2.8	0	3.57	3.57	0	0	0	0	0.36	0
Lake 10	4.7	0	0	0.21	0	2.98	0	0	0	0
Lake 11	1.1	5.45	7.27	3.64	0	0	0	0	0	0
Lake 12	1.3	0	0	0	0	2.31	0	0	0	0
Lake 13	1.4	0	0	0	0	1.43	0	0	0	0
Lake 14	0.9	0	0	1.14	0	0	0	1.14	0	0
Lake 15	1.3	0	0	0	0	0	0	0	0	0
Lake 16	3.8	0	0	0	0	10.00	0	0	0	0
Lake 17	1.4	0	0	0	0	0	0	0	0	0
Creek 1	0.9	0	0	3.33	0	0	0	0	0	0
Creek 2	0.7	0	0	3.03	0	0	0	0	0	3.03
Creek 3	0.7	0	0	0	0	0	0	0	0	0
Creek 4	3.9	0	0.77	0.26	0.26	1.54	0	0.26	0	0.77
Creek 5	2.1	0	3.81	3.81	0	1.43	0	0	0	0
Creek 6	2.1	0	0.48	4.29	0	0	0	0	0	0
LSA	**31.9**	**0.19**	**0.97**	**1.79**	**0.34**	**0.41**	**0**	**0.06**	**0**	**0**
RSA	**64.5**	**0.00**	**0.34**	**0.50**	**0.09**	**1.29**	**0**	**0.06**	**0.03**	**0.09**
Total	**96.4**	**0.06**	**0.55**	**0.92**	**0.18**	**1.00**	**0**	**0.06**	**0.02**	**0.06**

Table 2.12-1. Aerial Waterfowl Survey Observations in Descending order of Abundance in the Wheeler River Project Area – 2017.

Common Name	Scientific Name	Number of Pairs
Ring-necked Duck	*Aythya collaris*	107
Common Merganser	*Mergus merganser*	93
Common Loon	*Gavia immer*	75
Mallard	*Anas platyrhynchos*	70
Unknown White-Headed Gull	*Larus spp.*	67
Bald Eagle	*Haliaeetus leucocephalus*	47
Canada Goose	*Branta canadensis*	37
Lesser scaup	*Aythya affinis*	30
Yellowlegs Spp.	*Tringa spp.*	24
Bufflehead	*Bucephala albeola*	23
Unknown Dabbler	*Anas spp.*	17
Mew Gull	*Larus canus*	15
Unknown Diver	*Aythya, Bucephala, or Mergus spp.*	13
Surf scoter	*Melanitta perspicillata*	10
Bonaparte's gull	*Larus philadelphia*	10
Sandpiper Spp.	*Actitus or Tringa spp.*	10
Osprey	*Pandion haliaetus*	8
Common Goldeneye	*Bucephala clangula*	6
Common Raven	*Corvus corax*	6
Herring gull	*Larus argentatus*	5
Red-tailed hawk	*Buteo jamaicensis*	2
White-winged Scoter	*Melanitta deglandi*	1
Ring-billed Gull	*Larus delawarensis*	1
Common Tern	*Sterna hirundo*	1
Unknown Gull	*Larus spp.*	1
Northern Harrier	*Circus cyaneus*	1
Unknown Hawk	*Accipter, Buteo or Circus spp.*	1

Table 2.12-2. Aerial Waterfowl and Stick Nest Survey Results in the Wheeler River Project Area - 2017.

Species	Survey Section ID																																
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**Total**
Canada goose	4				17		2	2				2															2	2	2		4			**37**
Mallard	1	2			2	1	16	2		1	1	2				2	5	3		4	4	2				5	3	9			3	2		**70**
Common merganser	2	4		16	3		24						5			2	11	2	14							3		7						**93**
Ring-necked duck			1			4	2	2			3		2		20			2	2	12	15						12		9	17	4			**107**
Lesser scaup															12			10					2				1	3		2				**30**
Bufflehead			1	1				1						6				2		2								3	1		6			**23**
Common Goldeneye														6																				**6**
Surf scoter										2							3				2				2					1				**10**
White-winged Scoter																					1													**1**
Common loon	3			3	5	3		2		1		7	1	3	1		3	5	2	8	4	3	1		2	5			3	1	5	4		**75**
Herring gull												1							1		1									2				**5**
Mew Gull	2												1		12																			**15**
Bonaparte's gull															4					3											3			**10**
Ring-billed Gull										1																								**1**
Common Tern																				1														**1**
Unknown white-headed Gull	9	1				1				1		2		10			1	2	2	10		1	2			1	3	1	3	5	11	1		**67**
Unknown Dabbler				1											10																6			**17**
Unknown Diver							1			2											2				1	2			1		4			**13**
Unknown Gull																											1							**1**
Bald Eagle	2	2		2	4		2	1		6		2	1		3	2	5	3	7							1		3				1		**47**
Red-tailed hawk															1												1							**2**
Northern Harrier												1																						**1**
Osprey	1														1			2			2											2		**8**
Common Raven															2																	4		**6**
Unknown Hawk															1																			**1**
Yellowlegs Spp.											3		2	4			2				2	1					2	1	1	3	3			**24**
Sandpiper Spp.	1															2						1			1	4			1					**10**
Total	**25**	**9**	**2**	**23**	**31**	**9**	**47**	**10**	**0**	**14**	**7**	**17**	**12**	**29**	**67**	**8**	**30**	**31**	**28**	**40**	**33**	**8**	**5**	**0**	**6**	**21**	**25**	**29**	**21**	**31**	**49**	**14**	**0**	**681**

Table 2.12-3. Information on Water Bodies Within Survey Sections for the Aerial Waterfowl Surveys in the Wheeler River Project Area - 2017.

Survey Section ID	# Water Bodies	Total Area Searched (ha)	Average Water Body Size (ha)	Density (# birds /ha)	Species diversity (# species /ha)	Ecosite Distribution Within a 100 m Buffer Adjacent to Water Body (Percentage by Composition)		
						Coniferous Upland	Deciduous Upland	Bogs and Fens
1	10	95	9	0.3	0.1	94.2	0.3	5.4
2	2	171	85	0.1	0.0	91.5	1.7	6.8
3	8	10	1	0.2	0.2	80.3	0.0	19.7
4	3	68	23	0.3	0.1	68.7	0.6	30.7
5	10	347	35	0.1	0.0	32.0	0.0	68.0
6	7	47	7	0.2	0.1	54.9	2.2	43.0
7	2	2	1	20.8	2.7	1.5	0.0	98.5
8	5	170	34	0.1	0.0	69.3	2.6	28.1
9	5	45	9	0.0	0.0	11.8	1.5	86.7
10	2	326	163	0.0	0.0	99.5	0.2	0.3
11	8	13	2	0.5	0.2	46.6	0.0	53.4
12	14	252	18	0.1	0.0	66.1	1.2	32.7
13	12	22	2	0.5	0.3	39.8	1.6	58.6
14	15	160	11	0.2	0.0	99.0	0.1	0.9
15	10	307	31	0.2	0.0	62.0	4.8	33.2
16	1	219	219	0.0	0.0	53.4	13.1	33.5
17	8	171	21	0.2	0.0	86.3	1.7	12.0
18	18	228	13	0.1	0.0	56.1	4.3	39.6
19	2	473	236	0.1	0.0	64.5	0.9	34.6
20	10	237	24	0.2	0.0	97.7	0.3	2.0
21	11	108	10	0.3	0.1	95.5	0.4	4.1
22	10	139	14	0.1	0.0	91.8	6.0	2.2
23	3	91	30	0.1	0.0	93.2	4.8	2.0
24	4	2	1	0.0	0.0	98.4	0.3	1.3
25	3	172	57	0.0	0.0	92.8	1.3	5.9
26	7	194	28	0.1	0.0	95.0	0.5	4.5
27	10	42	4	0.6	0.2	96.4	0.2	3.3
28	10	35	3	0.8	0.2	86.7	1.5	11.8
29	7	65	9	0.3	0.1	96.7	0.7	2.6
30	7	36	5	0.8	0.2	91.2	0.4	8.5
31	11	173	16	0.3	0.1	97.6	0.6	1.8
32	11	142	13	0.1	0.0	94.0	3.5	2.5
33	2	67	34	0.0	0.0	88.0	3.0	9.0

Table 2.12-4. Nest Sites Observed During Aerial Waterfowl Surveys in the Wheeler River Project Area - 2017.

Nest Description	Location (NAD 83)
Active bald eagle nest (male & female adults in nest)	13 V 474274 6374049
Active bald eagle nest (2 adults in nest)	13 V 479947 6374456
Active bald eagle nest (2 chicks)	13 V 479746 6372025
Active osprey nest (1 adult in nest)	13 V 473270 6362347
Active osprey nest (2 adults in nest)	13 V 481637 6376574
Active osprey nest (2 adults by nest; 3-4 eggs)	13 V 470727 6375318
Active osprey nest (2 adults in nest)	13 V 467131 6378408
Active raven nest (1 adult in nest)	13 V 480451 6371997
Active raven nest (4 birds in nest)	13 V 467080 6378261
Active mew gull colony of nests (12-15)	13 V 473788 6366773
Active herring gull nest (1 adult; 2 chicks)	13 V 470261 6374778
Active common loon nest (1 adult; 2 eggs)	13 V 468790 6371207
Inactive stick nest	13 V 476448 6370902
Inactive stick nest	13 V 477881 6374083
Inactive stick nest	13 V 478079 6373723
Inactive stick nest	13 V 477759 6373453
Inactive stick nest	13 V 479692 6369142
Inactive stick nest	13 V 472180 6376933
Inactive stick nest	13 V 479052 6379747
Inactive stick nest	13 V 468570 6369528
Inactive stick nest	13 V 467152 6378011
Old stick nest	13 V 473588 6366034
Old stick nest	13 V 469765 6378861
Old stick nest	13 V 473096 6382905
Old stick nest	13 V 468402 6379791

Table 2.13-1. Regional Ungulate Aerial Surveys in the SK1 (Boreal Shield) Region of Saskatchewan[a].

tudy	Survey Timing	Sample Area (km^2)	Survey Intensity (%)	Search Intensity	Species/km^2		Woodland Caribou Population Structure		
					Moose	Caribou	Bulls:Cow	Calf:Cow	Calves as a % of Total Population
Millennium TRSA	March 2014	2,285	40	1.7	0.040	0.005	1.600	0.000	0
Millennium LSA	March 2014	397	100	1.7	0.050	0.000	-	-	-
Key Lake 2014 (Unpublished)	March 3-12 2014	1616	40	1.7	0.030	0.030	-	-	-
Key Lake 2013 (Unpublished)	March 13-16 2013	1616	40	1.7	0.030	0.060	0.750	0.250	18
Key Lake 2012 (Unpublished)	March 15-17 2012	1616	40	1.5	0.05	0.09	0.310	0.130	9
Key Lake 2011 (Unpublished)	Dec 13-17 2011	1616	40	2	0.04	0.06	0.714	0.330	12
914	Mar 2011	554	-	-	-	0.000	-	-	-
McArthur River 2011 (HAB-TECH 2012)	Feb 7-9 2011	400	100	1.8	0.05	0.04	0.270	0.270	18
914	Feb 2011	554	-	-	-	0.004	-	-	-
914	Dec 2010	410	-	-	-	0.027	-	-	-
Cigar Lake 2011 (HAB-TECH 2011)	March 7-9 2010	320	100	1.4	0.01	0	-	-	-
Four Bear 2010 (HAB-TECH 2010a)	March 5-6 2010	350	100	1.5	0.08	0	-	-	-
Key Lake 2010 (HAB-TECH 2010b)	Feb 23-24 2009	384	100	1.7	0.02	0.05	0.250	0.000	0
Virgin River 2009 (HAB-TECH 2009b)	March 21-24 2009	376	100	1.8	0.050	0.130	0.320	0.400	20
Courtenany Lake, U of S 2015	Mar 17-18 2015	380	100	1.7	0.024	0.0950	0.357	0.180	11.1
Tamarack 2009 (HAB-TECH 2009a)	Feb 27-29 2008	324	100	1.9	0.12	0	-	-	-

[a]Source: McLoughlin *et al.* (2016).

Table 12.14-1. Acoustic Bat Survey Results in the Wheeler River Project Area – 2019.

Plot #	Date	Location (NAD83)		Passes Per Species/Species Group			
		Easting	Northing	Little Brown Myotis		Little Brown / Northen Myotis	
				Pass	Buzz	Pass	Buzz
1	22-Jul-19	479807	6377682	-	-	-	-
2	22-Jul-19	479456	6377297	-	-	-	-
3	22-Jul-19	479277	6376813	-	-	-	-
4	22-Jul-19	478937	6376395	-	-	-	-
5	22-Jul-19	478657	6375955	-	-	-	-
6	22-Jul-19	478146	6375790	-	-	-	-
7	22-Jul-19	477867	6376241	-	-	1	-
8	22-Jul-19	477681	6376716	-	-	5	-
9	22-Jul-19	477325	6377111	-	-	-	-
10	22-Jul-19	476877	6377352	-	-	-	-
11	22-Jul-19	476512	6377721	1	-	-	-
12	22-Jul-19	476133	6378105	-	-	-	-
13	22-Jul-19	476012	6378612	-	-	-	-
14	22-Jul-19	475650	6377895	-	-	-	-
15	22-Jul-19	475127	6377913	-	-	-	-
16	22-Jul-19	474710	6378266	-	-	-	-
17	22-Jul-19	475487	6377356	-	-	-	-
18	22-Jul-19	475709	6376883	-	-	-	-
19	22-Jul-19	475230	6376681	1	-	-	-
20	22-Jul-19	474701	6376688	-	-	-	-
21	22-Jul-19	475291	6376147	-	-	-	-
22	22-Jul-19	475295	6375628	-	-	-	-
23	22-Jul-19	474923	6375237	5	2	-	-
24	22-Jul-19	475322	6374945	-	-	-	-
25	22-Jul-19	475816	6374813	-	-	-	-
26	22-Jul-19	475183	6374448	1	-	-	-
27	22-Jul-19	474881	6373999	1	-	-	-
28	22-Jul-19	474693	6373544	-	-	-	-
29	22-Jul-19	474572	6372970	4	-	-	-
30	22-Jul-19	474948	6372584	-	-	-	-
31	23-Jul-19	480431	6370701	-	-	-	-
32	23-Jul-19	479907	6370702	-	-	-	-
33	23-Jul-19	479384	6370704	-	-	-	-
34	23-Jul-19	478997	6371050	1	-	-	-
35	23-Jul-19	479478	6371305	-	-	-	-
36	23-Jul-19	480100	6371675	1	-	-	-
37	23-Jul-19	478872	6370475	-	-	-	-

Table 12.14-1 Cont. Acoustic Bat Survey Results in the Wheeler River Project Area – 2019.

Plot #	Date	Location (NAD83)		Passes Per Species/Species Group			
		Easting	Northing	Little Brown Myotis		Little Brown / Northen Myotis	
				Pass	Buzz	Pass	Buzz
38	23-Jul-19	478666	6369939	-	-	-	-
39	23-Jul-19	478506	6370899	-	-	-	-
40	23-Jul-19	478013	6370955	-	-	-	-
41	23-Jul-19	477596	6370629	1	-	-	-
42	23-Jul-19	478036	6371460	1	-	-	-
43	23-Jul-19	478232	6371933	-	-	1	-
44	23-Jul-19	477503	6371078	-	-	-	-
45	23-Jul-19	477025	6371210	-	-	-	-
46	23-Jul-19	476521	6371222	-	-	1	-
47	23-Jul-19	476146	6371600	-	-	1	-
48	23-Jul-19	475733	6371873	-	-	-	-
49	23-Jul-19	475475	6372267	-	-	-	-
50	23-Jul-19	475802	6372680	-	-	-	-
51	23-Jul-19	476177	6373063	-	-	-	-
52	23-Jul-19	476503	6373489	-	-	-	-
53	23-Jul-19	477006	6373433	-	-	1	-
54	23-Jul-19	476844	6373875	-	-	-	-
55	23-Jul-19	477258	6374303	-	-	-	-
56	23-Jul-19	477698	6374559	1	-	-	-
57	23-Jul-19	477611	6375071	-	-	-	-
58	23-Jul-19	476892	6374678	-	-	-	-
59	23-Jul-19	476422	6374849	-	-	-	-
60	23-Jul-19	476719	6375267	6	5	-	-
61	23-Jul-19	476983	6375682	-	-	-	-
Total Passes or Buzzes Per Hour				**4.72**	**1.38**	**1.97**	**0**

Table 12.14-2. Acoustic Bat Survey Results by Ecosite in the Wheeler River Project Area – 2019.

Ecosite	**Survey Hours**	**Species**					
		Little Brown Myotis		**Little Brown / Northern Myotis**		**Total**	
		Pass/hr	**Buzz/hr**	**Pass/hr**	**Buzz/hr**	**Pass/hr**	**Buzz/hr**
BS3	2.17	5.5	0.9	3.7	0	**9.2**	**0.9**
BS9	0.08	72.0	60.0	0	0	**72.0**	**60.0**
RF1	0.25	0	0	0	0	**0**	**0**
RF2	2.17	2.3	0	0.5	0	**2.8**	**0**
Anthropogenic	0.42	2.4	0	2.4	0	**4.8**	**0**
Total	**5.08**	**4.72**	**1.38**	**1.97**	**0**	**7.48**	**1.38**

Table 2.15-1. Covert Camera Wildlife Capture Results in the Denison Wheeler River Project Area – 2019.

Camera ID	Associated Feature	Zone	Easting	Northing	Camera Days	Species Observations Per 100 Camera Days							
						Bear[1]	Bear Young	Caribou[1]	Caribou Young	Moose[1]	Moose Young	Wolf	Lynx
Camera 1	Trail	13 V	472440	6374145	147	-	-	-	-	-	-	0.68	0.68
Camera 2	Road	13 V	476630	6375211	146	2.05	-	-	-	-	-	2.74	-
Camera 3	Road - Winter plowed	13 V	475267	6372271	146	-	-	-	-	-	-	1.37	-
Camera 4	Handcut	13 V	473576	6374512	147	-	-	-	-	-	-	0.68	-
Camera 5	Road - Winter plowed	13 V	478753	6371007	145	0.69	-	2.07	-	-	-	-	-
Camera 6	Handcut	13 V	477352	6371130	146	-	-	-	-	-	-	-	-
Camera 7	Trail	13 V	478023	6381000	147	3.40	-	-	-	1.36	-	2.72	5.44
Camera 8	Trail	13 V	480952	6373587	147	2.04	-	-	-	-	-	-	-
Camera 9	Trail	13 V	468131	6378008	146	4.79	-	-	-	0.68	0.68	0.68	-
Camera 10	Handcut	13 V	474833	6378212	146	-	-	-	-	2.05	0.68	-	-
Camera 11	Handcut	13 V	472229	6373052	147	-	-	-	-	-	-	-	0.68
Camera 12	Handcut	13 V	482865	6374381	146	-	-	2.05	-	-	-	-	-
Camera 13	Road - Winter plowed	13 V	473289	6371751	147	1.36	0.68	-	-	-	-	5.44	2.04
Camera 14	Road - Winter plowed	13 V	476813	6371337	145	-	-	-	-	-	-	0.69	-
Camera 15	Road	13 V	480404	6378289	147	2.72	-	-	-	-	-	2.04	-
Camera 16	Handcut	13 V	481041	6370934	147	2.04	-	14.29	5.44	-	-	-	-
Camera 17	Trail	13 V	472576	6378989	146	1.37	-	-	-	0.68	-	-	0.68
Camera 18	Trail	13 V	474518	6378349	147	1.36	-	-	-	-	-	1.36	1.36
Camera 19	Handcut	13 V	475568	6375889	147	1.36	-	-	-	-	-	0.68	-
Camera 20	Trail	13 V	480387	6369930	147	0.68	-	13.61	5.44	-	-	-	-
Total					**2929**	**1.19**	**0.03**	**1.60**	**0.55**	**0.24**	**0.07**	**0.96**	**0.55**

* Age not specified- adult or unknown age

Table 2.15-1 Cont. Covert Camera Wildlife Capture Results in the Denison Wheeler River Project Area – 2019.

Camera ID	Associated Feature	Zone	Easting	Northing	Species Observations Per 100 Camera Days								
					Camera Days	Fox	Marten	Hare	Squirrel	Porcupine	Sandhill Crane	Other Birds[2]	Unknown Mammal
Camera 1	Trail	13 V	472440	6374145	147	-	-	13.61	4.76	1.36	-	2.04	2.72
Camera 2	Road	13 V	476630	6375211	146	-	-	-	4.79	-	-	0.68	-
Camera 3	Road - Winter plowed	13 V	475267	6372271	146	2.74	-	-	-	-	-	0.68	0.68
Camera 4	Handcut	13 V	473576	6374512	147	-	-	1.36	-	-	-	-	-
Camera 5	Road - Winter plowed	13 V	478753	6371007	145	-	-	-	-	-	-	-	-
Camera 6	Handcut	13 V	477352	6371130	146	-	-	-	-	-	-	-	-
Camera 7	Trail	13 V	478023	6381000	147	0.68	-	0.68	0.68	3.40	-	-	-
Camera 8	Trail	13 V	480952	6373587	147	-	-	-	-	-	-	-	-
Camera 9	Trail	13 V	468131	6378008	146	-	-	-	-	-	-	-	0.68
Camera 10	Handcut	13 V	474833	6378212	146	-	-	2.05	0.68	-	-	-	-
Camera 11	Handcut	13 V	472229	6373052	147	-	0.68	3.40	-	-	-	0.68	0.68
Camera 12	Handcut	13 V	482865	6374381	146	-	-	-	-	-	-	-	-
Camera 13	Road - Winter plowed	13 V	473289	6371751	147	1.36	-	14.97	-	1.36	-	7.48	8.16
Camera 14	Road - Winter plowed	13 V	476813	6371337	145	1.38	-	-	-	-	-	-	-
Camera 15	Road	13 V	480404	6378289	147	-	2.04	-	2.04	0.68	1.36	2.04	0.68
Camera 16	Handcut	13 V	481041	6370934	147	0.68	-	-	-	-	-	-	0.68
Camera 17	Trail	13 V	472576	6378989	146	-	-	1.37	-	-	-	-	2.05
Camera 18	Trail	13 V	474518	6378349	147	-	-	-	5.44	-	-	6.12	-
Camera 19	Handcut	13 V	475568	6375889	147	0.68	-	5.44	-	6.12	-	-	-
Camera 20	Trail	13 V	480387	6369930	147	2.04	-	-	-	8.16	-	0.68	1.36
Total					**2929**	**0.48**	**0.14**	**2.15**	**0.92**	**1.06**	**0.07**	**1.02**	**0.89**

[1] Age not specified- adult or unknown age

[2] Other bird species include: Canada Jay, Hairy Woodpecker, Grouse spp. and unknown

Table 2.15-2. Covert Camera Wildlife Capture Results by Feature Type in the Denison Wheeler River Project Area – 2019.

Associated Feature	Total Camera Days	Species observations per 100 camera days															
		Bear[1]	Bear Young	Caribou[1]	Caribou Young	Moose[1]	Moose Young	Wolf	Lynx	Fox	Marten	Hare	Squirrel	Porcupine	Sandhill Crane	Other Birds[2]	Unknown Mammal
Road	876	1.14	0.11	0.34	-	-	-	2.05	0.34	0.91	0.34	2.51	1.14	0.34	0.23	1.83	1.60
Hand-cut	1026	0.49	-	2.34	0.78	0.29	0.10	0.19	0.10	0.19	0.10	1.75	0.10	0.88	-	0.10	0.19
Trail	1027	1.95	-	1.95	0.78	0.39	0.10	0.78	1.17	0.39	-	2.24	1.56	1.85	-	1.27	0.97
Total	**2929**	**1.19**	**0.03**	**1.60**	**0.55**	**0.24**	**0.07**	**0.96**	**0.55**	**0.48**	**0.14**	**2.15**	**0.92**	**1.06**	**0.07**	**1.09**	**0.89**

[1] Age not specified- adult or unknown age

[2] Other bird species include: Canada Jay, Hairy Woodpecker, Grouse spp. and unknown

Table 2.15-3. Covert Camera Anthropogenic Capture Results in the Denison Wheeler River Project Area – 2019.

Camera ID	Associated Feature	Zone	Easting	Northing	Camera Days	Captures per 100 Camera Days				
						Heavy Equipment	Trucks, Cars, Vans	ATVs / Snowmobiles / UTV's	Human (non-motorized)	Unknown Vehicle
Camera 1	Trail	13 V	472440	6374145	147	-	-	-	-	-
Camera 2	Road	13 V	476630	6375211	146	-	6.16	73.29	-	6.85
Camera 3	Road - Winter plowed	13 V	475267	6372271	146	192.47	1880.82	440.41	2.05	191.78
Camera 4	Handcut	13 V	473576	6374512	147	-	-	-	-	-
Camera 5	Road - Winter plowed	13 V	478753	6371007	145	106.21	344.14	80.69	-	11.03
Camera 6	Handcut	13 V	477352	6371130	146	-	-	-	-	-
Camera 7	Trail	13 V	478023	6381000	147	-	-	4.08	-	-
Camera 8	Trail	13 V	480952	6373587	147	-	-	-	-	-
Camera 9	Trail	13 V	468131	6378008	146	-	-	-	-	-
Camera 10	Handcut	13 V	474833	6378212	146	-	-	-	-	-
Camera 11	Handcut	13 V	472229	6373052	147	-	-	-	-	-
Camera 12	Handcut	13 V	482865	6374381	146	-	-	-	-	-
Camera 13	Road - Winter plowed	13 V	473289	6371751	147	2.72	31.29	76.19	-	0.68
Camera 14	Road - Winter plowed	13 V	476813	6371337	145	114.48	323.45	109.66	0.69	7.59
Camera 15	Road	13 V	480404	6378289	147	-	0.68	17.69	-	1.36
Camera 16	Handcut	13 V	481041	6370934	147	-	-	-	-	-
Camera 17	Trail	13 V	472576	6378989	146	-	-	-	-	-
Camera 18	Trail	13 V	474518	6378349	147	-	-	18.37	-	-
Camera 19	Handcut	13 V	475568	6375889	147	-	-	-	-	-
Camera 20	Trail	13 V	480387	6369930	147	-	-	2.72	-	-
Total					**2929**	**20.66**	**128.71**	**41.00**	**0.14**	**10.93**

Table 2.15-4. Covert Camera Anthropogenic Capture Results by Feature Type in the Denison Wheeler River Project Area – 2019.

Associated Feature	Total Camera Days	Captures per 100 Camera Days				
		Heavy Equipment	Trucks, Cars, Vans	ATVs / Snowmobiles / UTV's	Human (non-motorized)	Unknown Vehicle
Road	876	69.06	430.37	132.88	0.46	36.53
Hand-cut	1026	-	-	-	-	-
Trail	1027	-	-	3.60	-	-
Total	**2929**	**20.66**	**128.71**	**41.00**	**0.14**	**10.93**

Table 3-1. Vertebrate Sensitive and Species at Risk Observations in the Wheeler River Project Area – 2017-2019.

Common Name	Scientific Name	Obs. Source	Obs. Type	Obs. Per Type	Total Obs.	SKCDC Status	COSEWIC Status	SARA Status	SARGSS	Setback Distance (high disturbance)
Common Loon	*Gavia immer*	Field Survey	Auditory and/or Visual	85	114	S5B, SUN, S5M	Not at Risk		Breeding Bird: May 15-July 15	200m
		Incidental	Auditory and/or Visual	28						
		Field Survey	Nest	1						
Woodland Caribou	*Rangifer tarandus caribou*	Field Survey	Track	72	200	S3	Threatened	Threatened		
		Field Survey	Visual (camera)	63						
		Field Survey	Pellet	47						
		Incidental	Track/Browse	5						
		Field Survey	Crater	13						
Bald Eagle	*Haliaeetus leucocephalus*	Field Survey	Visual	47	54	S5B, S5N, S4M	Not at Risk		Nest Site: Mar. 15-July 15	1,000m
		Incidental	Visual	3						
		Field Survey	Nest	4						
Common Nighthawk	*Chordeiles minor*	Incidental	Auditory and/or Visual	76	83	S4B, S4M	Special Concern	Threatened	Breeding Bird: May 1-Aug. 31	200m
		Incidental	Nest	2						
		SCDC	Visual	5						
Little Brown Myotis	*Myotis lucifugus*	Field Survey	Ultrasonic Detection	24	24	S4B, S4N	Endangered	Endangered	Roost/forgaing site: year	500m
Little Brown Myotis / Northern Myotis	*Myotis lucifugus / Myotis septentionalis*	Field Survey	Ultrasonic Detection	10	10	S4B, S4N / S3	Endangered	Endangered	Roost/forgaing site: year round	500m
Mew Gull	*Larus canus*	Field Survey	Auditory and/or Visual	16	29	S4B, S4M			Nesting Colony: May 1-July 15	400m
		Field Survey	Nest	13						

Table 3-1 Cont. Vertebrate Sensitive and Species at Risk Observations in the Wheeler River Project Area – 2017-2019.

Common Name	Scientific Name	Obs. Source	Obs. Type	Obs. Per Type	Total Obs.	SKCDC Status	COSEWIC Status	SARA Status	SARGSS	Setback Distance (high disturbance)
Osprey	*Pandion haliaetus*	Field Survey	Visual	8	12	S2B, S2M			Nest Site: May 1-Aug.	1,000m
Olive-sided Flycatcher	*Contopus cooperi*	Field Survey	Auditory and/or Visual	8	14	S4B, S4M	Threatened	Threatened	Breeding Bird May 1-Aug. 31	300m
		Incidental	Auditory and/or Visual	6						
River Otter	*Lontra canadensis*	Field Survey	Track	10	11	S3				
		Incidental	Visual	1						
Bonaparte's Gull	*Chroicocephalus philadelphia*	Field Survey	Visual	10	11	S4B, S4M			Nesting Colony May 1-July 15	400m
		Incidental	Visual	1						
Herring Gull	*Larus argentatus*	Field Survey	Auditory and/or Visual	6	7	S5B, S5M			Nesting Colony May 1-July 15	400m
		Field Survey	Nest	1						
Barn Swallow	*Hirundo rustica*	Field Survey	Auditory and/or Visual	4	4	S5B, S5M	Threatened			
Horned Grebe	*Podiceps auritus*	Incidental	Visual	1	1	S5B, S5M	Special Concern	Special Concern		
Common Tern	*Sterna hirundo*	Field Survey	Visual	1	1	S5B, S5M	Not at Risk		Nesting Colony May 1-July 15	400m

SKCDC Rankings:
2 = Imperiled/Very rare
3 = Vulnerable/Rare to uncommon
4 = Apparently Secure
5 = Secure/Common
M = for a migratory species, rank applies to the transient (migrant) population
B = for a migratory species, applies to the breeding population in the province
N= for a migratory species, applies to the non-breeding population in the province
U= status is uncertain in Saskatchewan because of limited or conflicting information (unrankable)
SARGSS: Saskatchewan Activity Restriction Guidelines for Sensitive Species

Table 4.1-1. Trapping Capture Rates per Year by Species in FCA N-18 (Cree Lake).

Year	N-18 Cree Lake																	
	1985-86	**1986-87**	**1987-88**	**1988-89**	**1989-90**	**1990-91**	**1991-92**	**1992-93**	**1993-94**	**1994-95**	**1995-96**	**1996-97**	**1997-98**	**1998-99**	**1999-00**	**2000-01**	**2001-02**	**2002-03**
Beaver	67	58	43	3	6	0	1	3	7	9	5	9	3	0	1	0	12	0
Coyote	3	3	0	0	0	0	0	0	0	0	0	2	3	0	0	0	2	0
Fisher	17	6	3	4	7	9	9	20	5	19	3	20	0	0	0	0	5	9
Red Fox	37	20	13	8	0	0	2	4	0	17	3	13	0	0	3	3	6	8
Cross Fox	16	10	6	6	0	0	3	3	0	2	5	3	0	0	0	2	3	0
Silver Fox	7	0	2	0	0	0	0	0	0	1	0	1	0	0	0	0	1	0
Total Fox	60	30	21	14	0	0	5	7	0	20	8	17	0	0	3	5	10	8
Lynx	23	24	1	0	1	1	0	3	2	2	0	3	0	0	0	0	1	0
Marten	125	69	177	63	82	72	81	49	22	107	154	258	94	106	54	153	191	170
Mink	306	233	458	120	137	69	109	51	19	87	94	180	43	76	53	43	152	55
Muskrat	9	274	79	3	51	0	0	0	8	0	81	7	0	0	0	0	143	22
Otter	37	25	31	6	7	2	2	8	0	9	12	7	1	0	1	6	14	9
Squirrel	84	46	81	0	7	0	0	0	0	4	0	0	0	0	0	0	2	0
Weasel	28	6	12	0	5	0	0	0	0	11	0	9	0	0	0	0	0	0
Wolf	1	1	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Black Bear	0	2	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	1
Wolverine	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**760**	**777**	**908**	**214**	**303**	**158**	**207**	**141**	**63**	**268**	**357**	**513**	**144**	**182**	**112**	**207**	**532**	**274**

* for captures > 0

Table 4.1-1 Cont. Trapping Capture Rates per Year by Species in FCA N-18 (Cree Lake).

Year	N-18 Cree Lake															Total	Mean (Min, Max)*
	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18		
Beaver	-	0	0	-	-	0	0	0	0	0	0	0	0	0	0	**227**	**16.2 (1, 67)**
Coyote	-	0	1	-	-	0	0	0	0	0	0	0	0	0	0	**14**	**2.33 (1, 3)**
Fisher	-	3	7	-	-	1	0	1	0	1	0	0	0	0	0	**149**	**7.84 (1, 20)**
Red Fox	-	0	1	-	-	1	0	2	3	4	3	1	3	0	1	**156**	**7.09 (1, 37)**
Cross Fox	-	0	2	-	-	0	2	1	2	5	1	0	0	0	0	**72**	**4.24 (1, 16)**
Silver Fox	-	0	0	-	-	0	0	0	1	0	0	0	0	0	0	**13**	**2.17 (1, 7)**
Total Fox	-	0	3	-	-	1	2	3	6	9	4	1	3	0	1	**241**	**10.48 (1, 60)**
Lynx	-	0	1	-	-	0	0	1	0	0	1	0	0	0	0	**64**	**4.92 (1, 24)**
Marten	-	81	187	-	-	116	77	175	306	317	366	57	114	114	230	**4167**	**138.90 (22, 366)**
Mink	-	83	104	-	-	54	13	69	22	54	43	18	7	0	9	**2761**	**95.21 (7, 454)**
Muskrat	-	0	25	-	-	0	0	0	0	0	0	0	0	0	0	**702**	**63.82 (3, 274)**
Otter	-	3	6	-	-	0	0	0	5	0	0	1	0	0	0	**192**	**9.60 (1, 37)**
Squirrel	-	0	0	-	-	0	0	31	0	0	0	0	0	0	0	**255**	**36.43 (2, 84)**
Weasel	-	0	0	-	-	0	0	1	0	0	0	0	0	0	0	**72**	**10.29 (1, 28)**
Wolf	-	0	0	-	-	0	0	0	0	0	0	0	0	0	0	**5**	**1.25 (1, 2)**
Black Bear	-	0	0	-	-	0	0	0	0	0	0	0	0	0	0	**8**	**2.67 (1, 5)**
Wolverine	-	0	2	-	-	0	0	1	1	0	0	0	0	0	0	**5**	**1.25 (1, 2)**
Total	-	**170**	**336**	**-**	**-**	**172**	**92**	**282**	**340**	**381**	**414**	**77**	**124**	**114**	**240**	**8862**	**571.74 (63, 908)**

* for captures > 0

Table 5.2-1. Local Assistants – Denison Wheeler River Project 2016-2019.

Local Assistant	Residence	Date	Task
Nathan Dawatsara	Patuanak, SK	Sep-Oct 2016	Assisted completing shoreline surveys
Adam Paul	Patuanak, SK	Jan-Feb 2017	Assisted completing winter tracking surveys
William Paul	Patuanak, SK	June 2017	Assisted completing Ungulate browse availability and pellet group surveys. Assisted completing Amphibian nocturnal call surveys
William Paul	Patuanak, SK	August 2017	Assisted with vegetation and soil collection for chemistry analysis
William Paul	Patuanak, SK	February 2018	Assisted completing winter tracking surveys
William Paul	Patuanak, SK	June 2018	Assisted completing Ungulate browse availability and pellet group surveys. Assisted completing Amphibian nocturnal call surveys

8.0 FIGURES

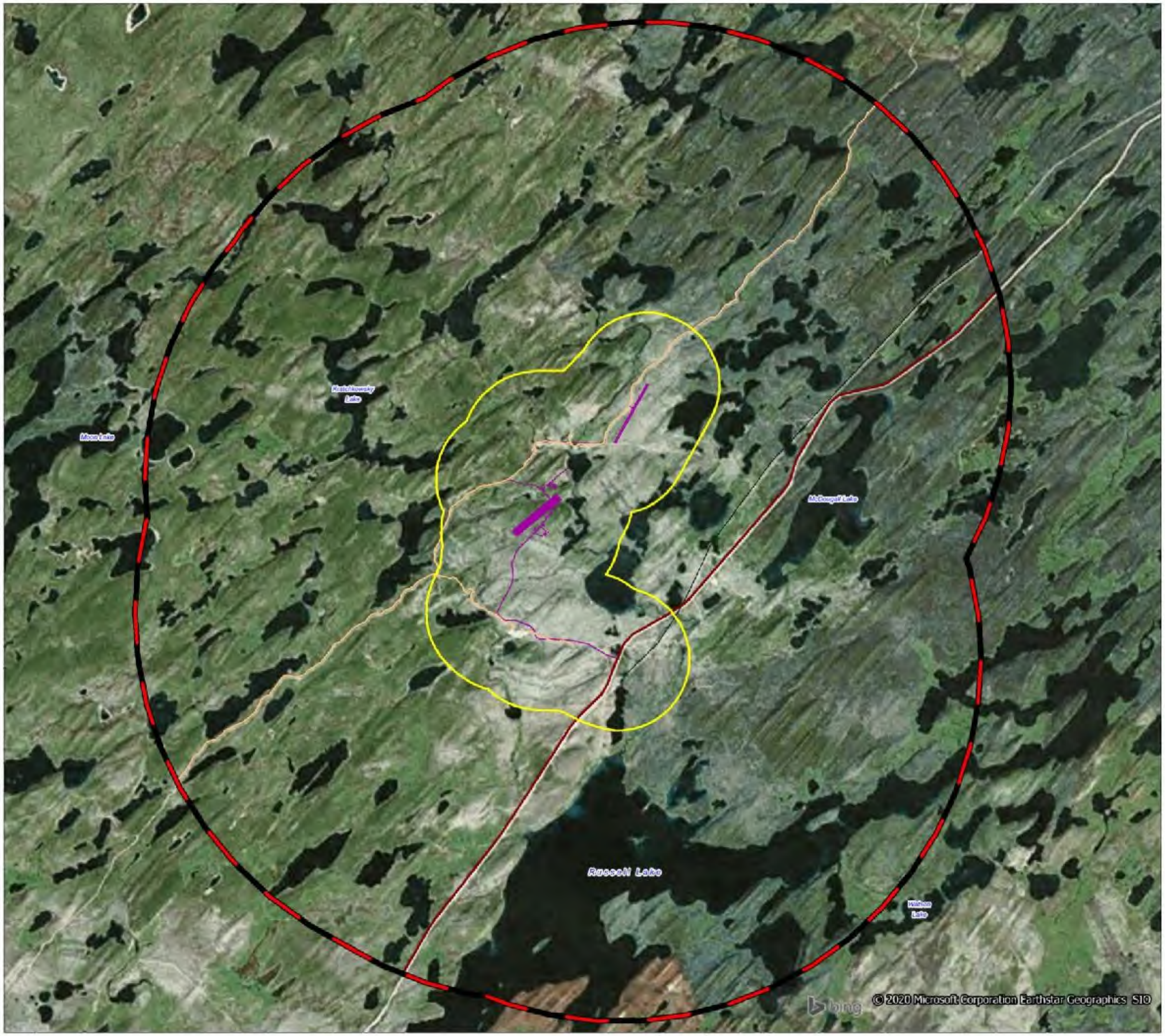

Figure 1.2-1 Terrestrial Baseline Project Area
- Denison Wheeler River Project

Legend

- Road
- McArthur-Key Haul Road
- Transmission ROW
- Planned Development Footprint
- Local Study Area (LSA)
- Regional Study Area (RSA)

0 5 10

kilometers

Scale = 1 : 90,000

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ECOLOGICAL SERVICES

Produced by Rich Ashton, Dec. 2019
Ref# O-F721a_11-17

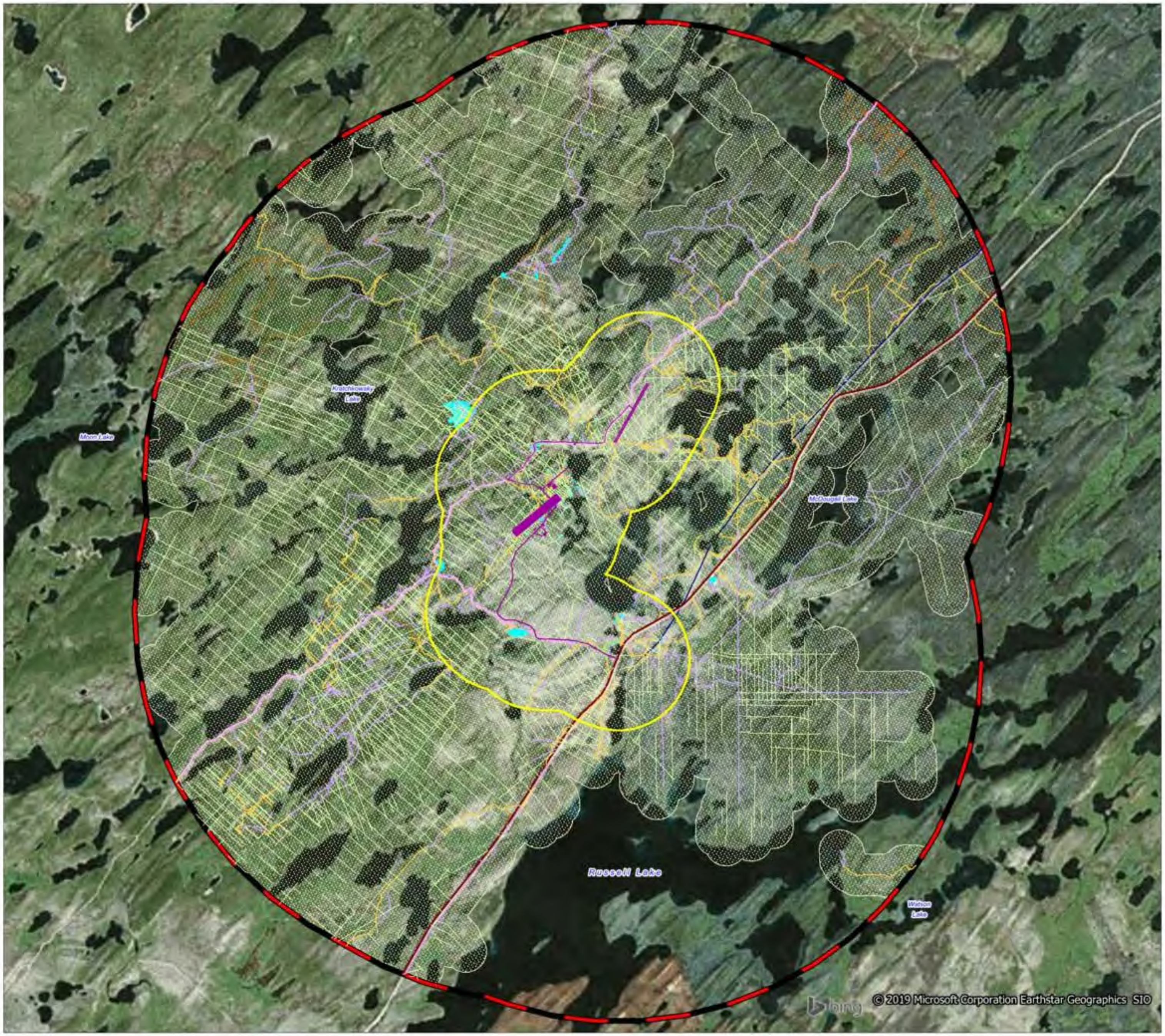

Figure 2.1-1 Anthropogenic Disturbance Mapping - Denison Wheeler River Project

Legend

Linear Disturbance Type

- McArthur-Key Haul Road
- Road
- Rough Road
- Trail
- ROW
- Cutline
- Transmission ROW

Clearing

500m CRS Buffer

Planned Development Footprint

Local Study Area (LSA)

Regional Study Area (RSA)

0 5 10

kilometers

Scale = 1 : 90,000

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Produced by Rich Ashton, Dec. 2019

Ref# O-F721a_11-17

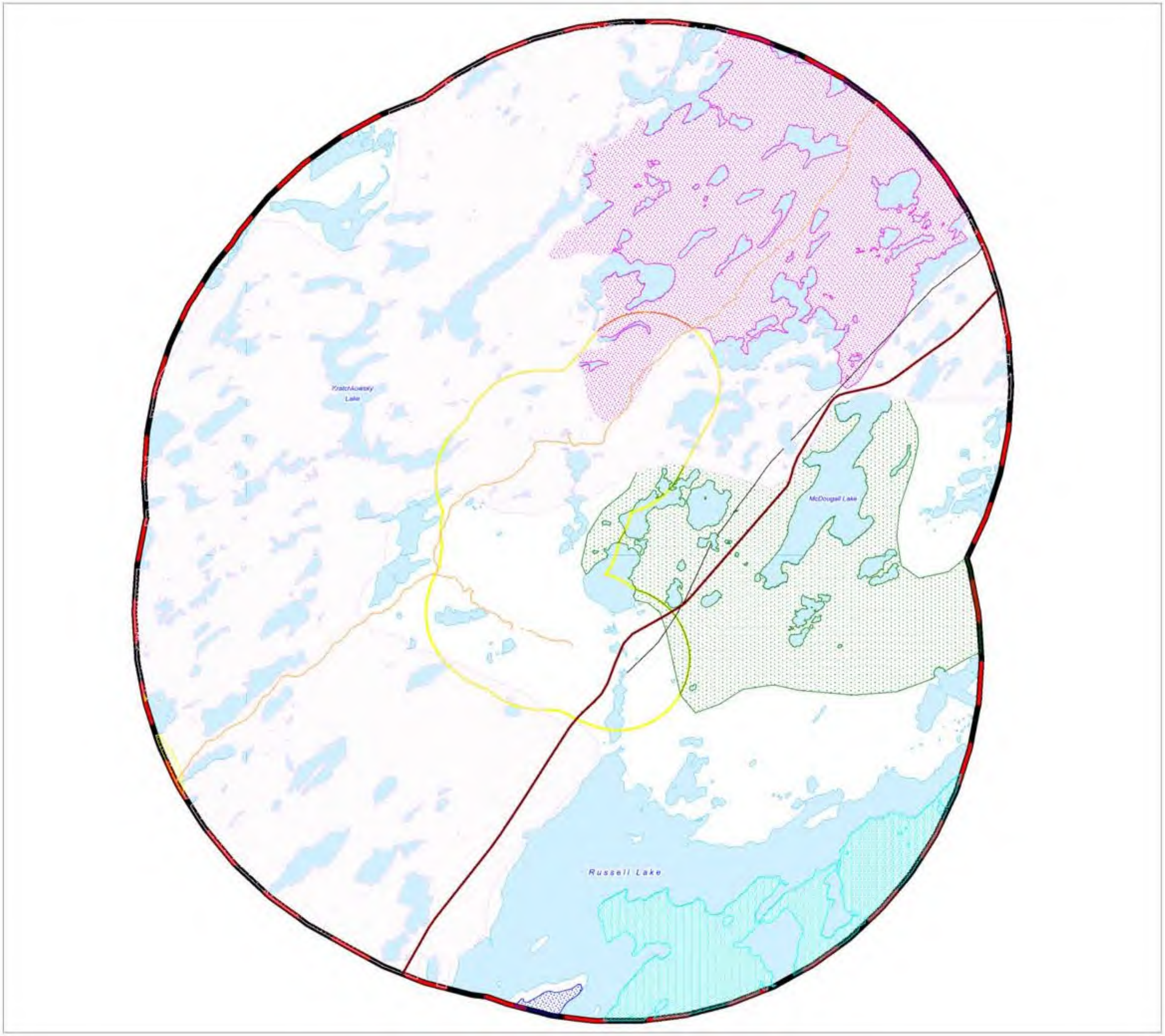

Figure 2.1-2 Historical Fire Mapping
- Denison Wheeler River

Legend

Historical Wild Fires
- 1,973
- 1,981
- 1,998
- 2,004
- 2,007
- 2,008

Main Linear Features
- McArthur-Key Haul Road
- Road
- Transmission ROW
- Waterbody
- Local Study Area (LSA)
- Regional Study Area (RSA)

N W E S

0 5 10

kilometers
Scale = 1 : 90,000

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Produced by Rich Ashton, Dec. 2019
Ref# O-F721a_11-17

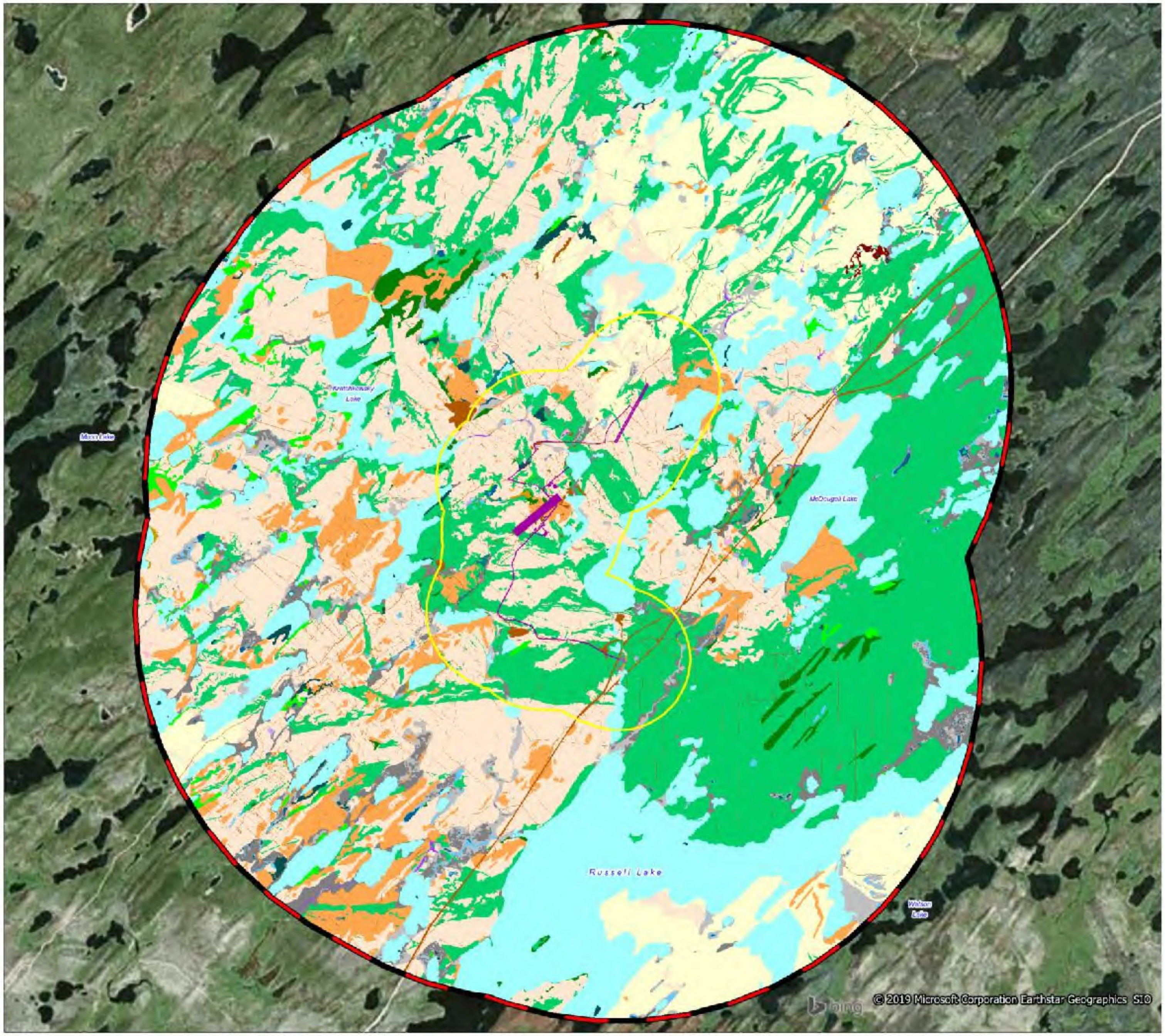

Figure 2.1-3 Interpreted Ecosite Mapping - Denison Wheeler River Project

Legend

Ecosite Type

- RF1 - Regenerating Forest > 5m tall
- RF2 - Regenerating Forest - 1-5m tall
- RF3 - Regenerating Forest <1m tall
- RF2 - Regenerating Bog - 1-5m tall
- RF1 - Regenerating Bog > 5m tall
- BS3 - Jack pine - blueberry / lichen
- BS4 - Jack pine - black spruce / featherm
- BS7 - Black spruce - blueberry / lichen
- BS9 - Black spruce - jack pine / featherm
- BS14 - White birch / lingonberry - labrad
- BS16 - Black spruce/ balsam poplar / riv
- BS17 - Black spruce treed bog
- BS18 - Labrador tea shrubby bog
- BS19 - Graminoid bog
- BS20 - Open bog
- BS19/BS24 - Graminoid bog / Graminoic
- BS21 - Tamarack treed fen
- BS22 - Leatherleaf shrubby poor fen
- BS23 - Willow shrubby rich fen
- BS24 - Graminoid fen
- BS25 - Open fen
- BS26 - Rush sandy shore
- BS27 - Sedge rocky shore
- AN - Anthropogenic
- Waterbody

- Planned Development Footprint
- Local Study Area (LSA)
- Regional Study Area (RSA)

N E S W

0 5 10

kilometers
Scale = 1 : 90,000

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Figure 2.2-1 Tree and shrub vegetation layer criteria for the Denison Wheeler Project area: A1: Super canopy; A2: Main tree canopy; A2 Sub-canopy; B1: Tall shrubs, and B2: Low shrubs

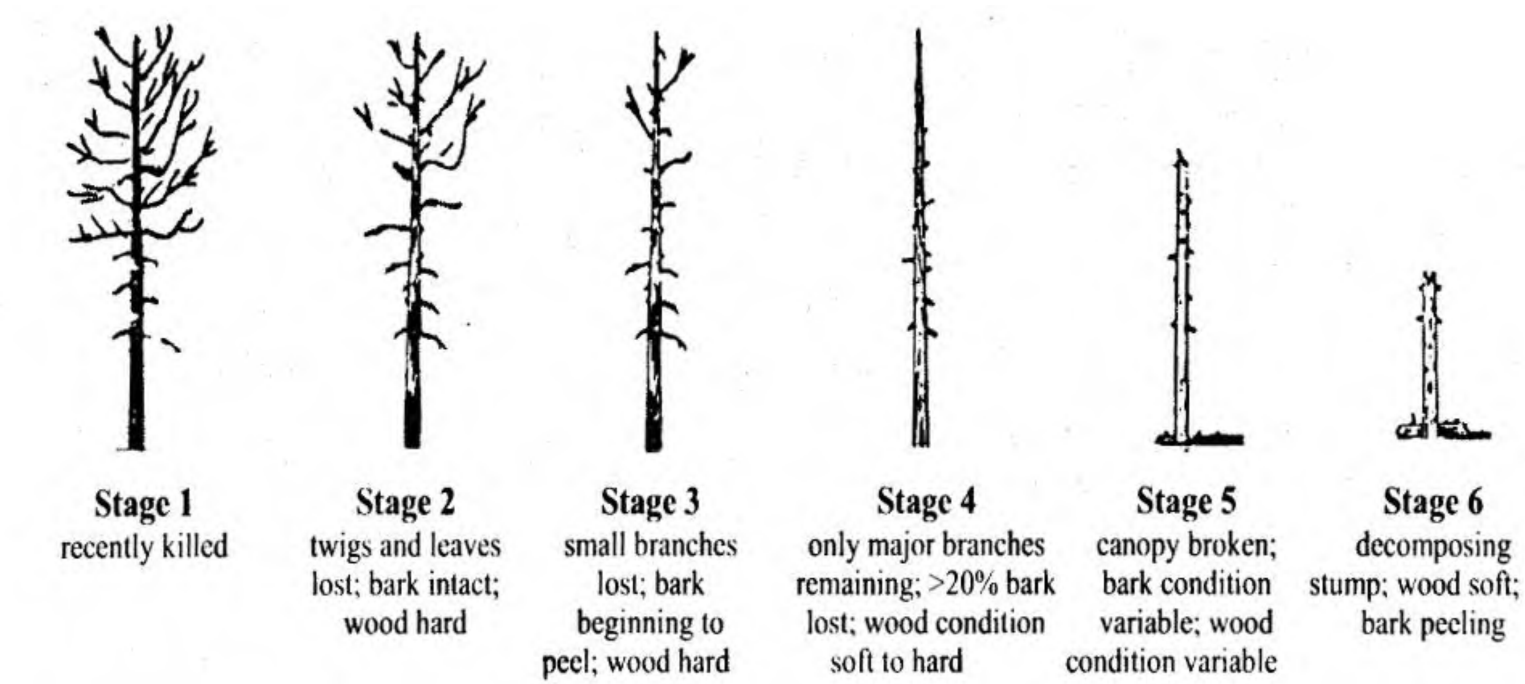


Figure 2.2-2. Decay classification system for snags in the Denison Wheeler Project area (Lee *et al.* 1995).

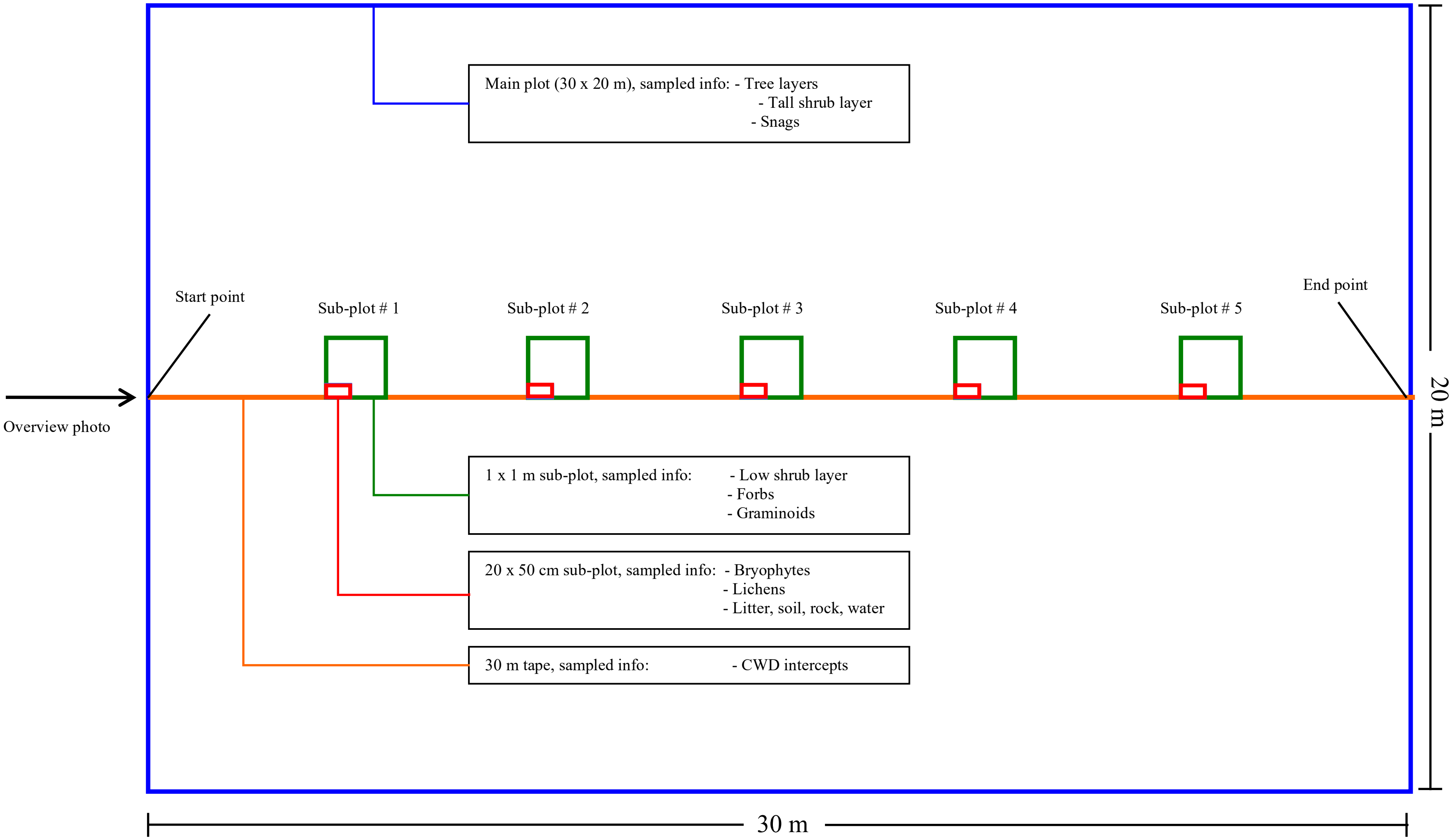


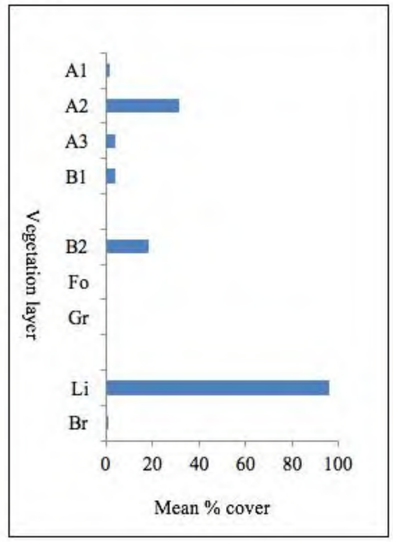
Figure 2.2-3. Layout of the vegetation sampling site.

Figure 2.2-4. Display of the hiding cover cloth.

2

1 → **BS3** **Jack pine/blueberry/lichen: Moderately fresh sand** (n=4)

3 →



5

4 → ***Ecosite Description***

BS3 is dominated by jack pine in the overstory. The vascular plant understory is relatively sparse but includes Labrador tea, blueberry, and bog cranberry. Herbs are virtually absent. The forest floor is covered with reindeer lichen. Lichen species diversity is high. The age for this ecosite ranges from approximately 80 years old in the study area.

6 → ***Species and Vegetation Layer Info***

Average number plant and lichen species per plot (min, max): 17 (15, 19)

Tree Layer Info:

Tree Layer	Total # Species	Crown Closure	Mean Height	Mean DBH	Species Composition	Year of Origin
A1 (n=0):						
A2 (n=5):	1	27%	9.2 m	13.4 cm	Pj10	1938
A3 (n=6):	2	2%	7.2 m	9.0 cm	Pj9 Sb1	1962

Lower Vegetation Layer info:

Vegetation Layer	Total # Species	Percentage Cover	Species Composition*
B1	2	4%	Pinuban10
B2	6	18%	Vaccmyr7 Vaccvit2 Ledugro1
Forb			
Graminoid			
Lichen	20	96%	Cladmit6 Cladunc2 Cladste1
Bryophyte	5	1%	Polypil6 Pholnut2 Polyjun1 Dicrpol1

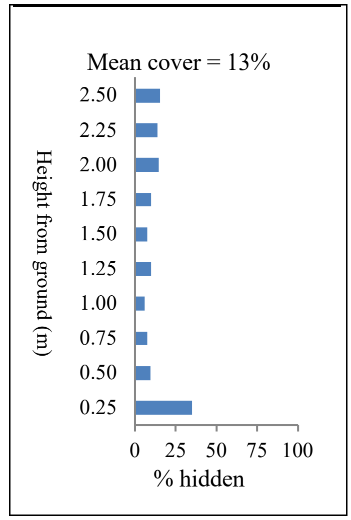
*Only including species that constitute 10% or more by composition.

Figure 2.2-5. Page 1 of the Ecosite fact sheets.

7 → **BS3** **Jack pine/blueberry/lichen: Moderately fresh sand** (n=4)

Structural Attributes and Relative Rating

Structural Component	Attribute	Value	Rating
Snags	Mean # of snags/plot	0.3	Low
	Mean snag diameter (cm)	10.1	
	Mean snag height (m)	0.9	
	Mean snag decay Class	5.0	
Course Woody Debris	Mean frequency of CWD	0.8	Moderate
	Mean CWD diameter (cm)	11.5	
	Mean CWD decay class	3.0	
Mean Percent Ground Cover	Litter Cover	25.5	Moderate
	Litter Depth (cm)	0.9	Moderate
	Bare Soil	1.8	Low
	Bare Rock	0.0	Low
	Open Water	0.0	Low



← 8

9 → ***Structural Diversity, Species Richness, and Unique and Rare Species Occurrence Evaluation***

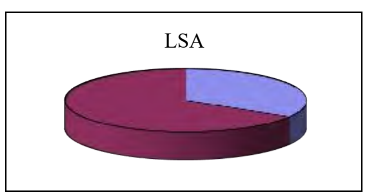
Attribute	Value	Rating
Structural diversity	1.0	Moderate
Species richness	17	Moderate
Unique species	3	Moderate
Provincially listed species	0	Low

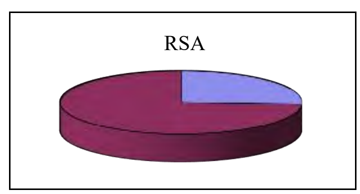
Unique species observed:
Pholia moss (*Pholia nutans*), Shingled Cladonia (*Cladonia scabriuscula*), Common bearberry (*Arctostaphylos uva-ursi*)

Provincially listed species observed:
None

10 → ***Ecosite Supply***

Areas occupied by Jack pine /blueberry /lichen forests comprised 1605.8 ha (33.8%) of the LSA and 10330.5 ha (25.8%) of the RSA.





11 → ***Ecological Interpretation***

BS3 ecosites are relatively dry and occur in almost every topographic position and with every slope class. They are associated with the hills of eskers and drumlins as well as level plains. Following disturbance, these ecosites will usually return to being pine dominated, provided an adequate cone crop existed prior to disturbance. When compared to BS4 ecosites these ecosites tend to be drier, have less understory, and more open canopy. In the absence of disturbance, these ecosites may transition toward the BS7 ecosite condition.

Figure 2.2-6. Page 2 of the Ecosite fact sheets.

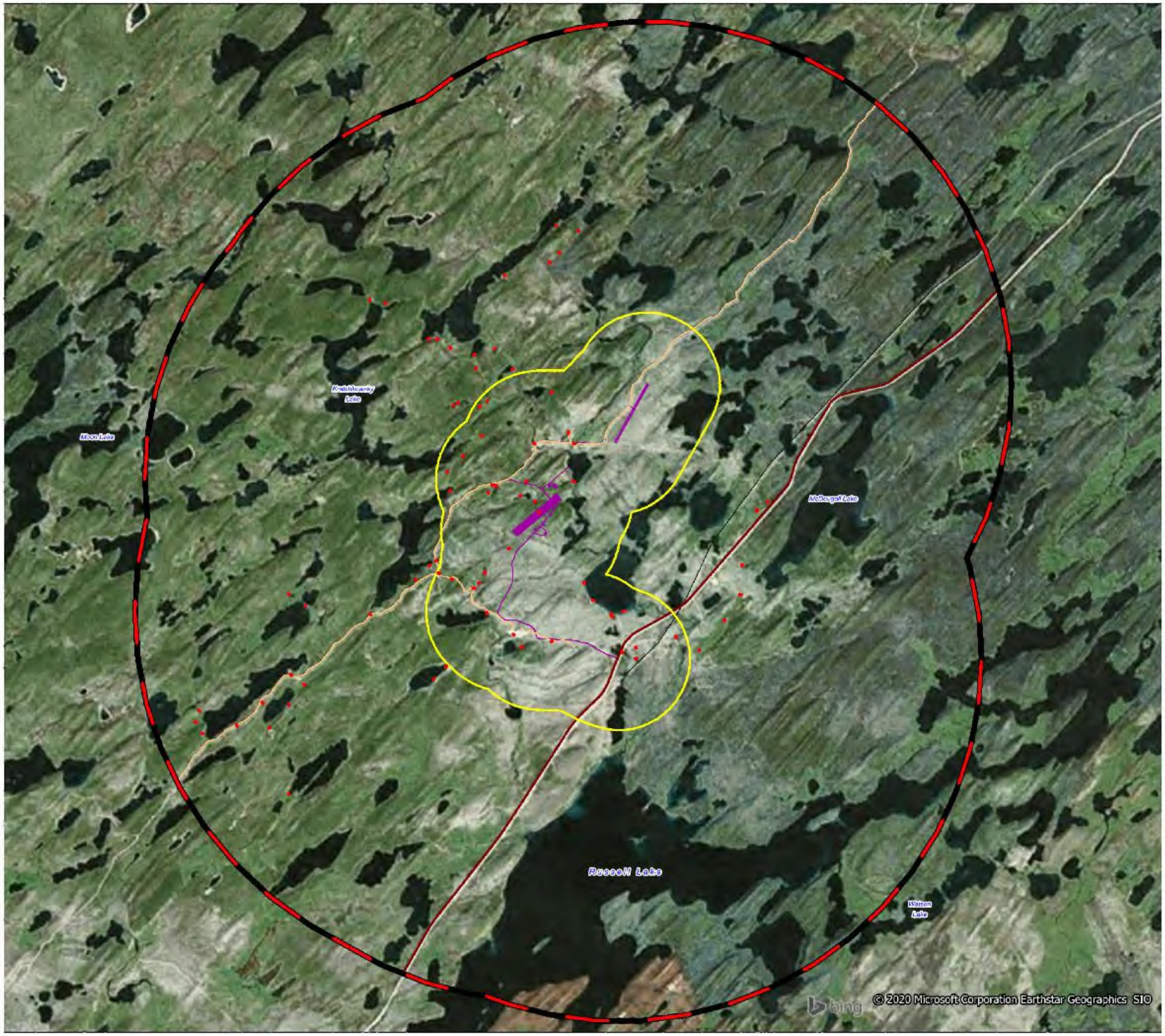


Figure 2.2-7 Vegetation Survey Plot Locations - Denison Wheeler River Project

Legend

- Veg Survey Plot
- Road
- McArthur-Key Haul Road
- Transmission ROW
- Planned Development Footprint
- Local Study Area (LSA)
- Regional Study Area (RSA)

0 5 10
kilometers
Scale = 1 : 90,000

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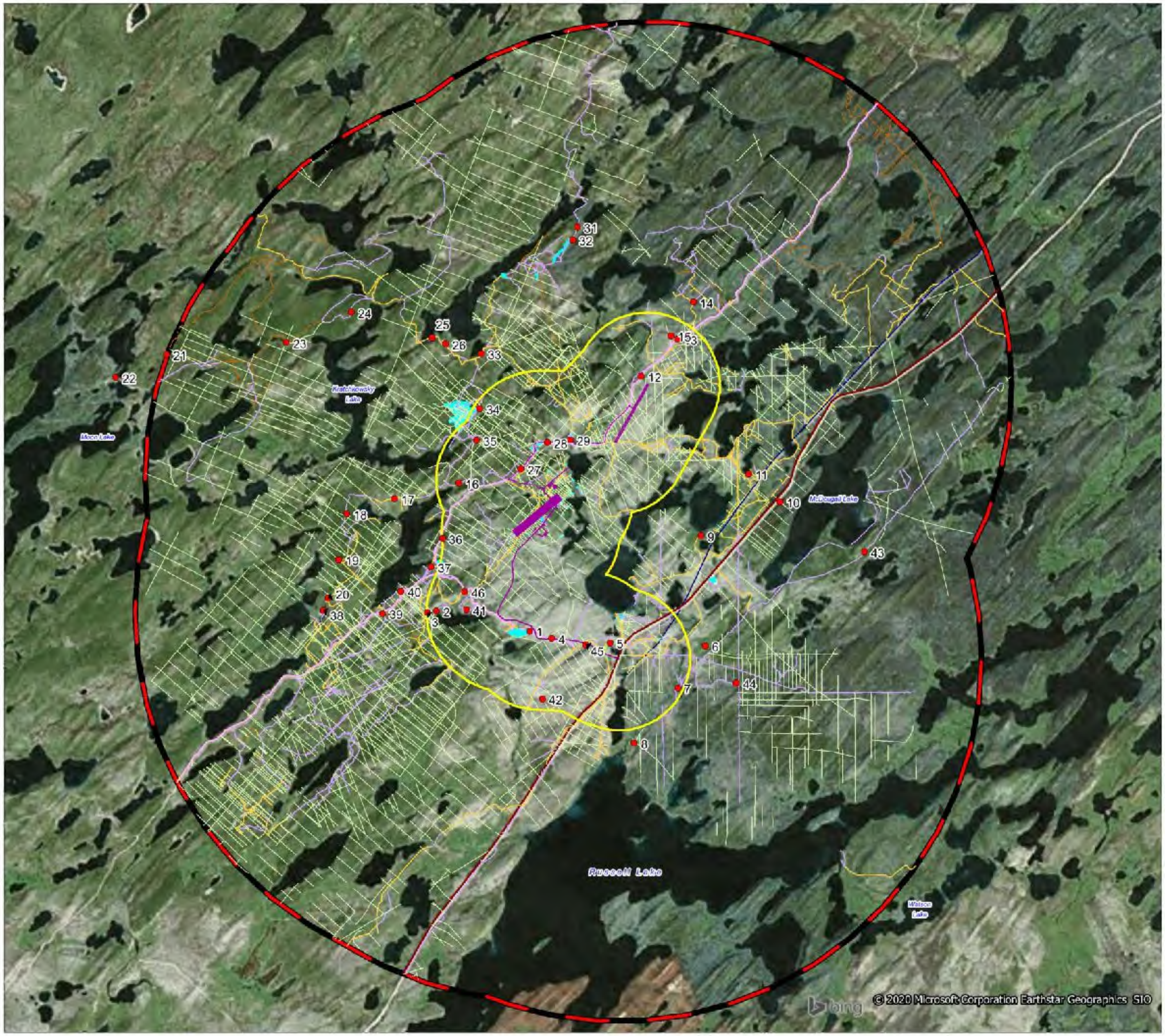

Figure 2.3-1 Linear Feature Natural Regeneration Assessment Transect Locations
- Denison Wheeler River Project

Legend

- Regeneration Assessment Location

Linear Disturbance Type
- McArthur-Key Haul Road
- Road
- Rough Road
- Trail
- ROW
- Cutline
- Transmission ROW

- Clearing
- 500m CRS Buffer
- Planned Development Footprint
- Local Study Area (LSA)
- Regional Study Area (RSA)

0 5 10
kilometers
Scale = 1 : 90,000

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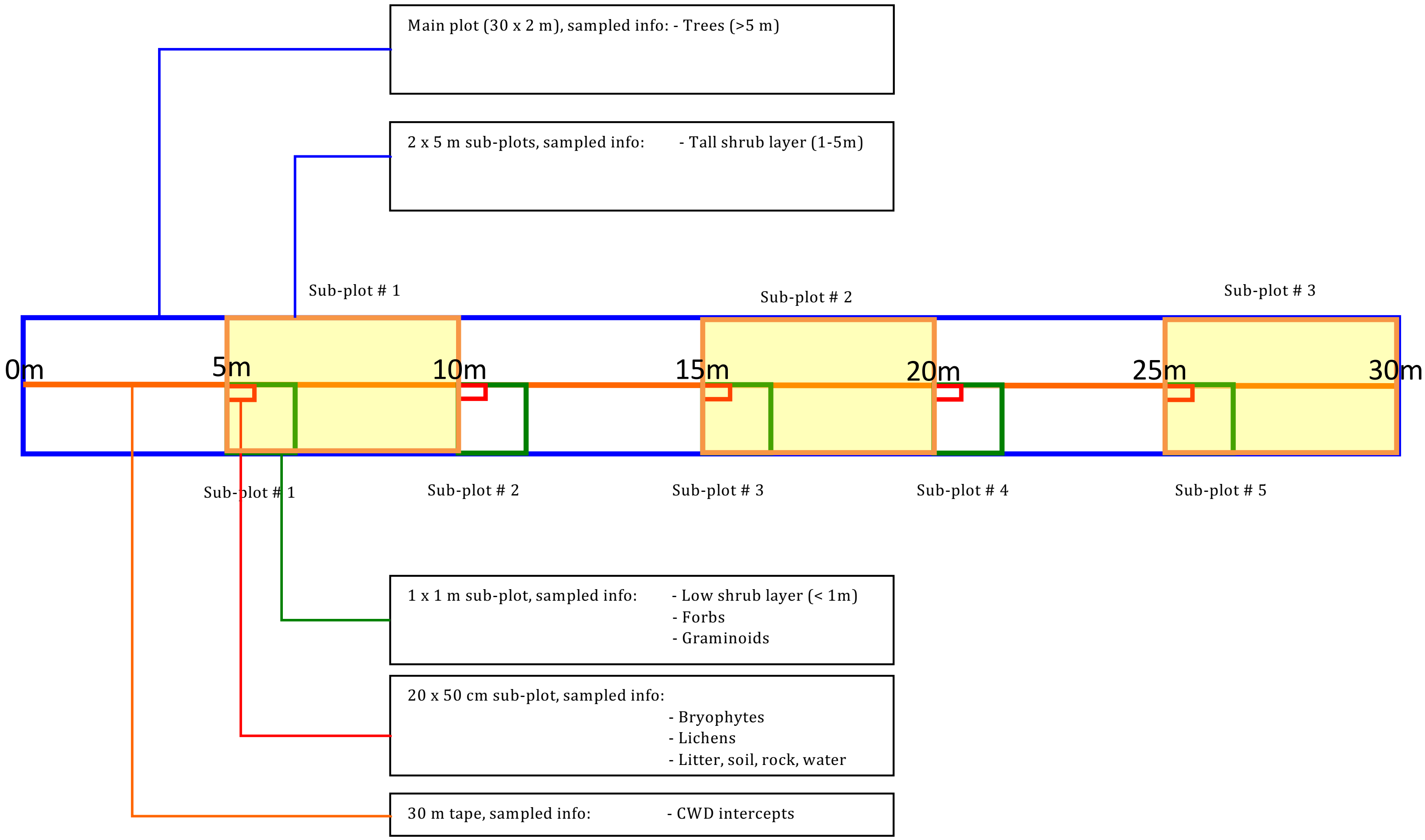

Figure 2.3-2 Ground sampling plot layout – Linear feature natural regeneration assessment.

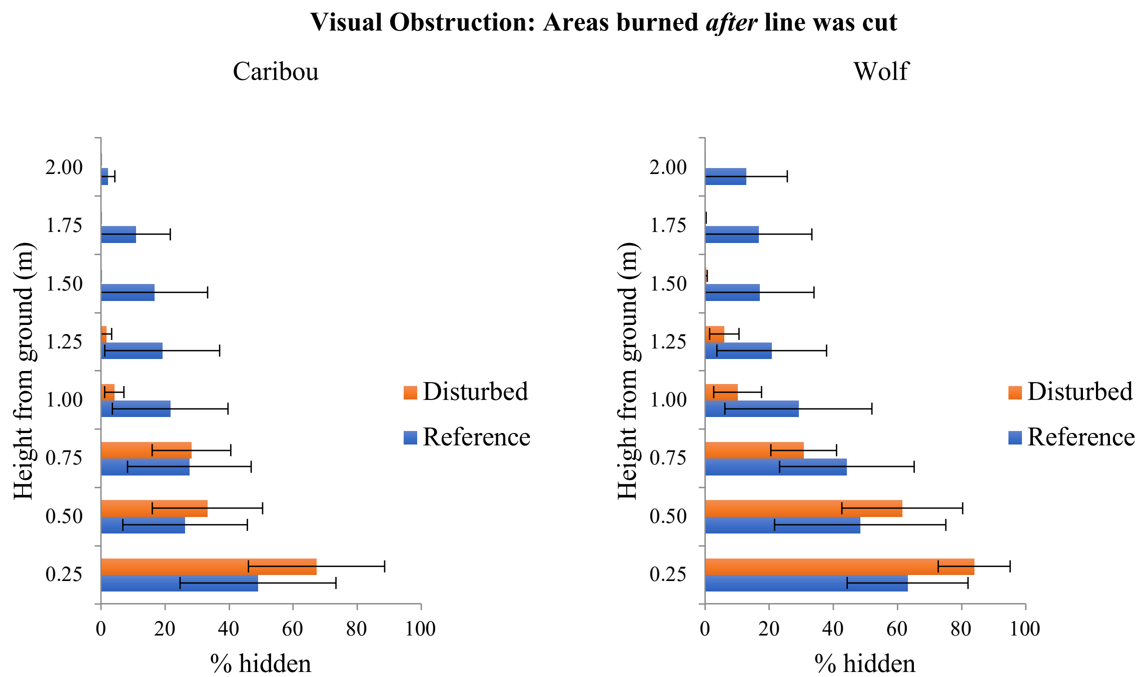

Figure 2.3-3A Visual obstruction in areas burned *after* line was cut for disturbance versus reference from caribou and wolf perspectives. The error bars are standard errors around the means. Fire occurred 12 to 15 years ago. No significant differences in hiding cover were found in any height layers for caribou or wolf (P>0.05) in Disturbance versus Control.

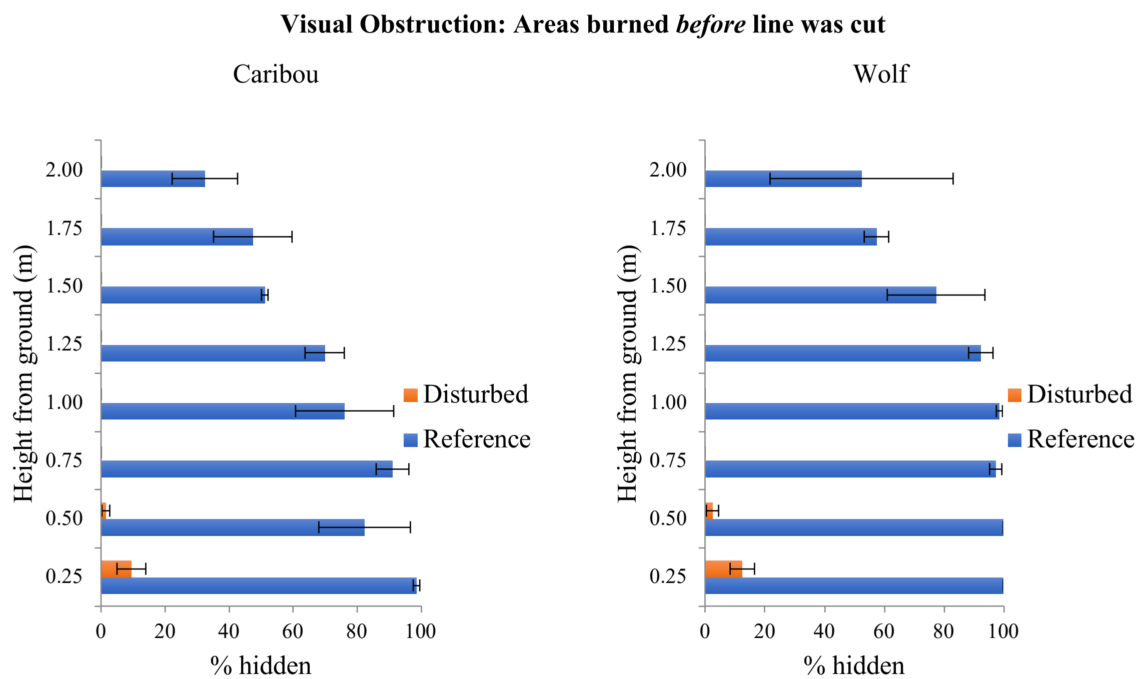

Figure 2.3-3B Visual obstruction in areas burned *before* line was cut for disturbance versus reference from caribou and wolf perspectives. The error bars are standard errors around the means. Fire occurred 12 to 15 years ago. Wolf visual obstruction was significantly higher for control plots in from 0.25 to 1.25 m layers (P<0.03). Caribou visual obstruction was significantly higher for control plots in the 0.25, 0.75, and 0.50 m layers.

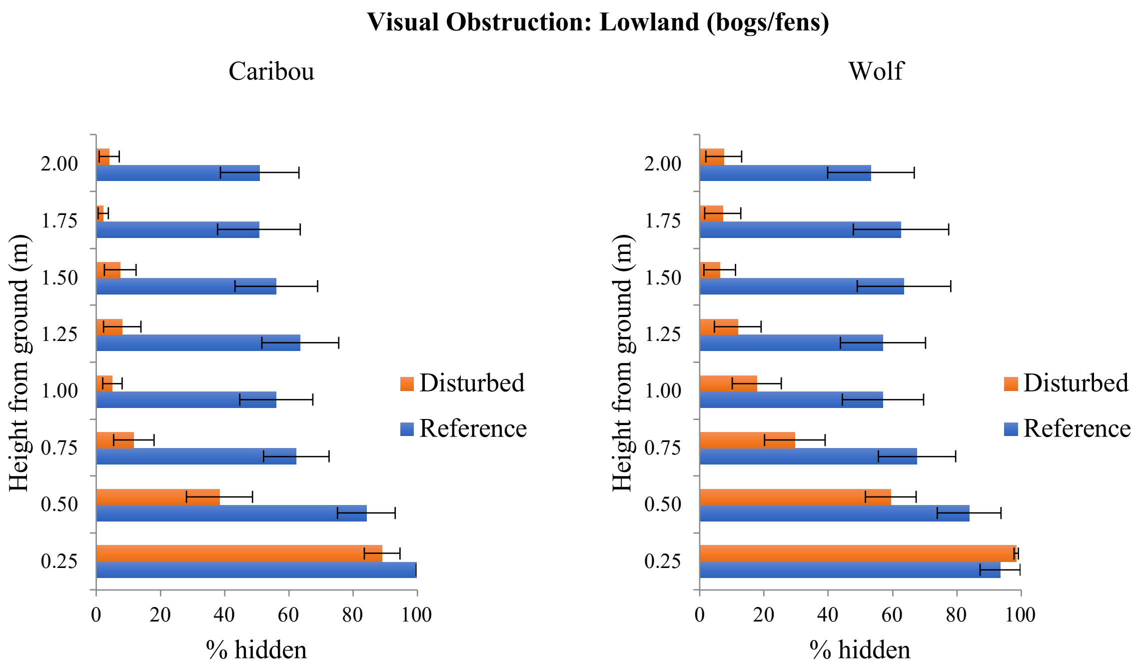

Figure 2.3-4A Visual obstruction in lowland (bogs/fens) for disturbance versus reference from caribou and wolf perspectives. The error bars are standard errors around the means. Caribou visual obstruction was significantly different for all layers, except 0.25 and 0.5 m above ground ($P<0.05$). Wolf visual obstruction was significantly different for all layers, except for 0.25 to 1 m above ground ($P<0.05$)

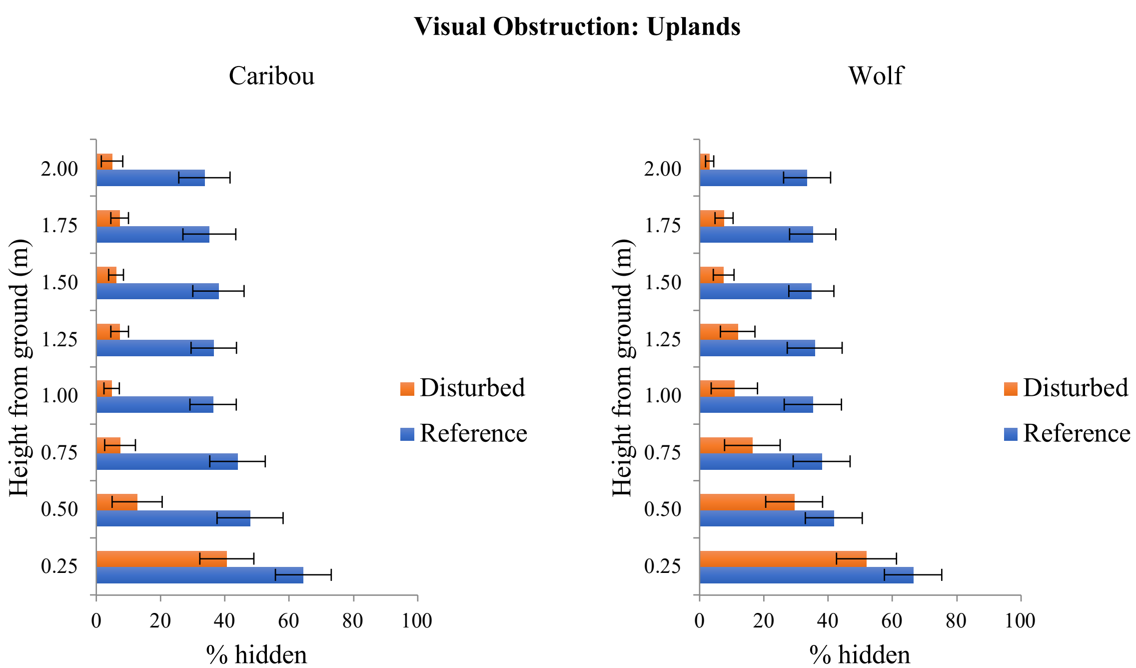

Figure 2.3-4B Visual obstruction in upland for disturbance versus reference from caribou and wolf perspectives. The error bars are standard errors around the means. Caribou visual obstruction was significantly different for all layers ($P<0.05$). Wolf visual obstruction was significantly different for all layers, except for 0.25 to 1 m above ground ($P<0.05$)

Visual Obstruction: Lowland vs. Upland in disturbed areas

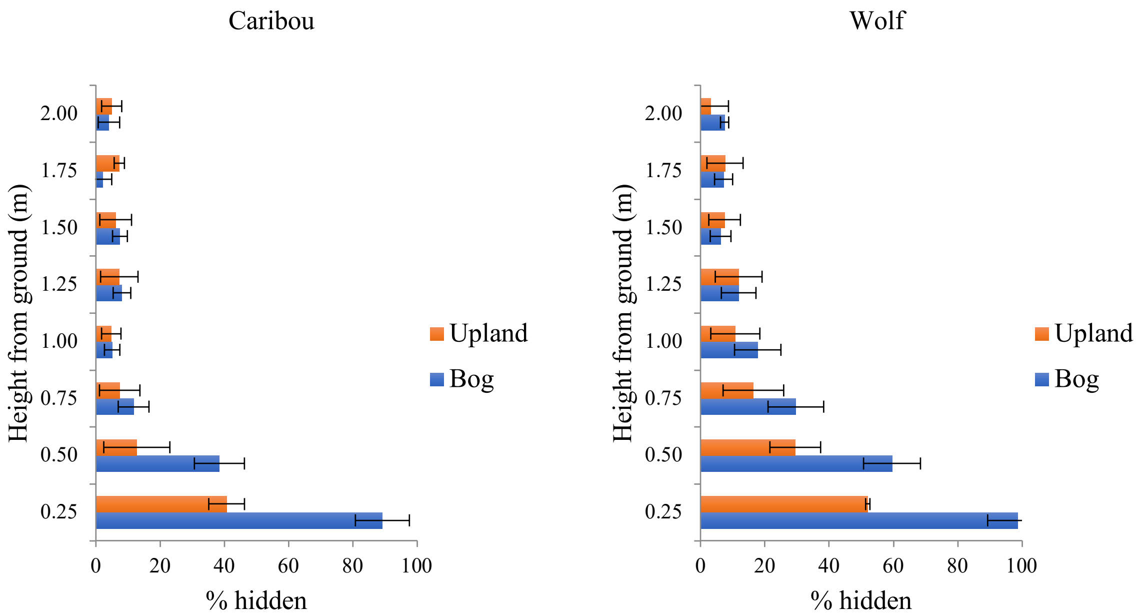

Figure 2.3-4C Visual obstruction in disturbed areas between lowland (bogs-fens) and upland from caribou and wolf perspectives. The error bars are standard errors around the means. Both wolf and caribou visual obstruction were significantly different in the 0.25 m layer, but displayed no significant difference in any of the higher layers.

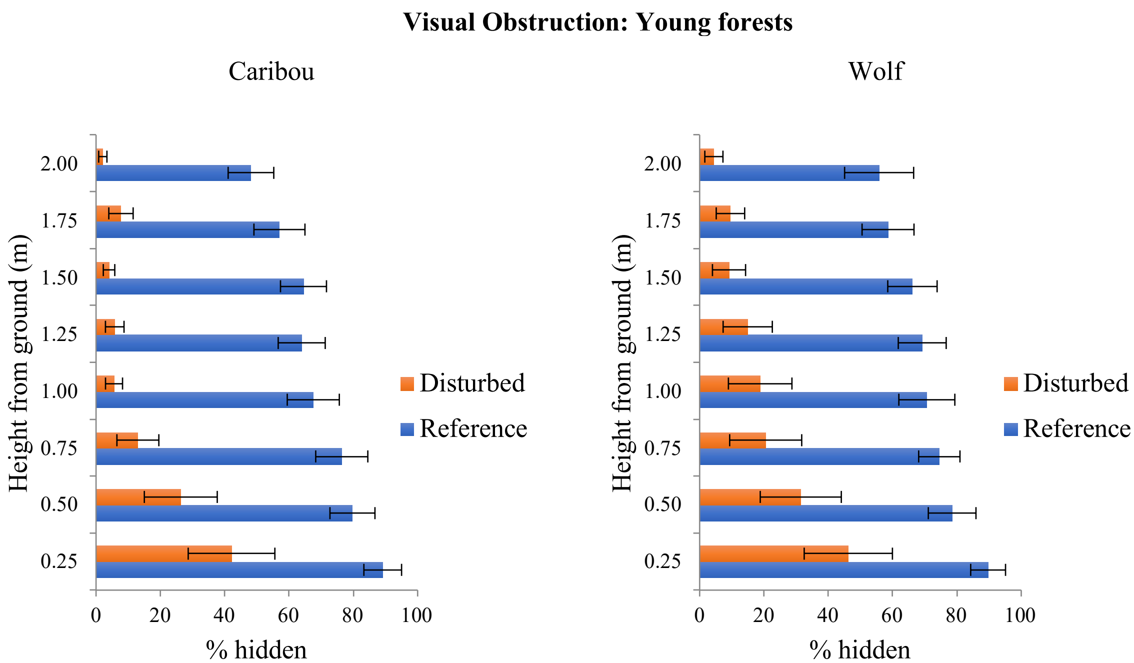

Figure 2.3-5A Visual obstruction in areas young forest (< 40 years old) for disturbance versus reference from caribou and wolf perspectives. The error bars are standard errors around the means. Overall hiding cover (all layers combined) significantly different between disturbance and control for both wolf (P=0.001) and caribou (P<0.001). Both wolf and caribou are also significantly different in every height layer (P<0.05).

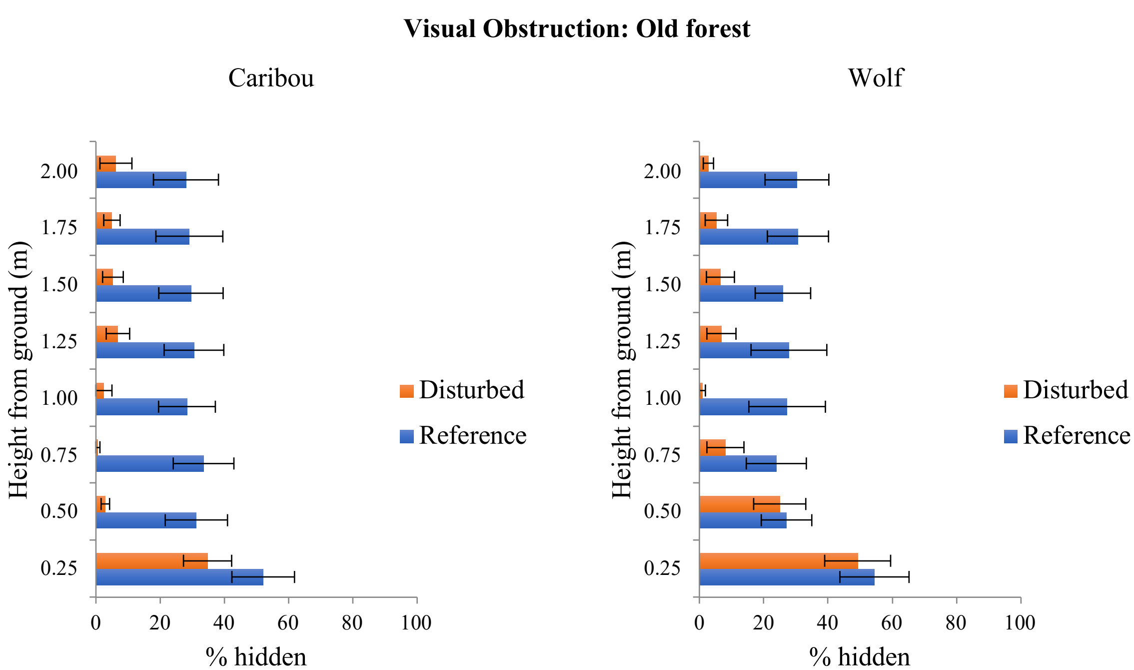

Figure 2.3-5B Visual obstruction in areas old forest (> 40 years old) for disturbance versus reference from caribou and wolf perspectives. The error bars are standard errors around the means. Overall hiding cover (all layers combined) significantly different between disturbance and control for both wolf (P=0.020) and caribou (P=0.016). Caribou had significant differences between control and disturbed for all layers except 0.25, 1.75 and 2 m (P>0.05), whereas wolf only had significant differences in the 1.75 and 2 m layers.

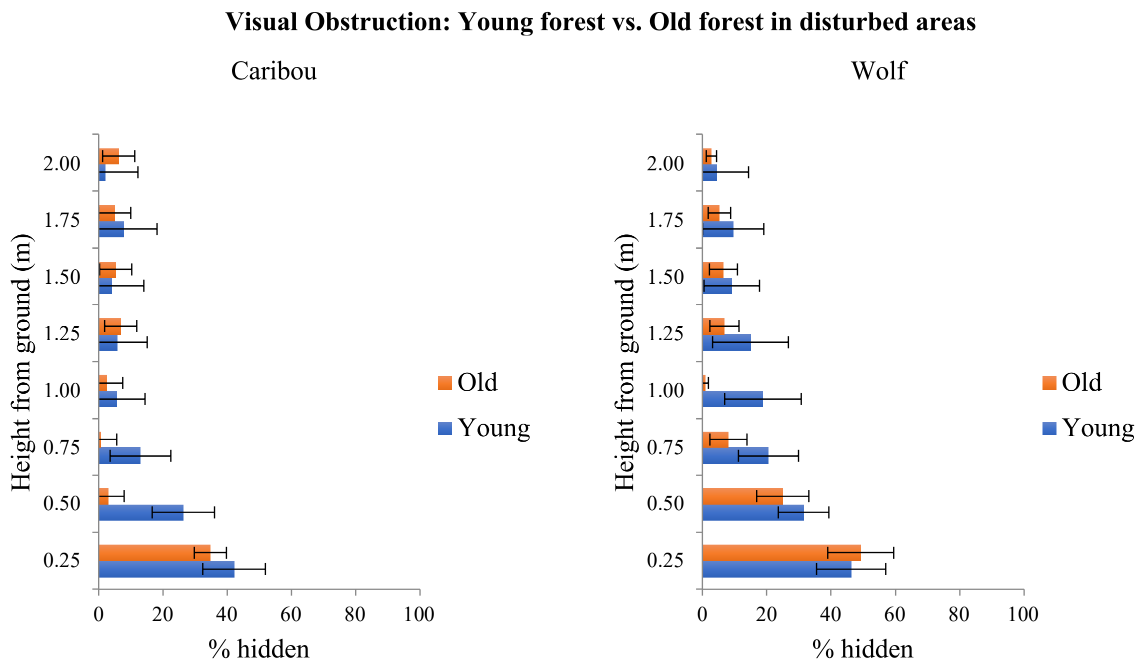

Figure 2.3-5C Visual obstruction in disturbed areas within old versus young forest from caribou and wolf perspectives. The error bars are standard errors around the means. There were no significant differences in any layers for either wolf (P=0.345) or caribou (P=0.466).

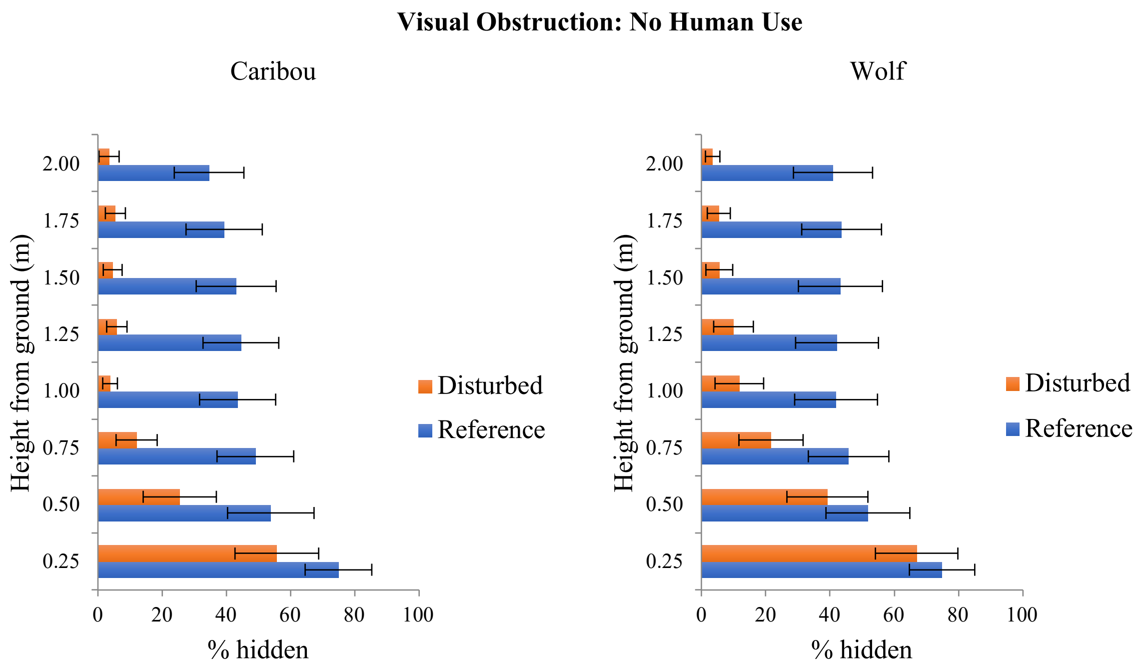

Figure 2.3-6A Visual obstruction in areas with no human use for disturbance versus reference from caribou and wolf perspectives. The error bars are standard errors around the means.

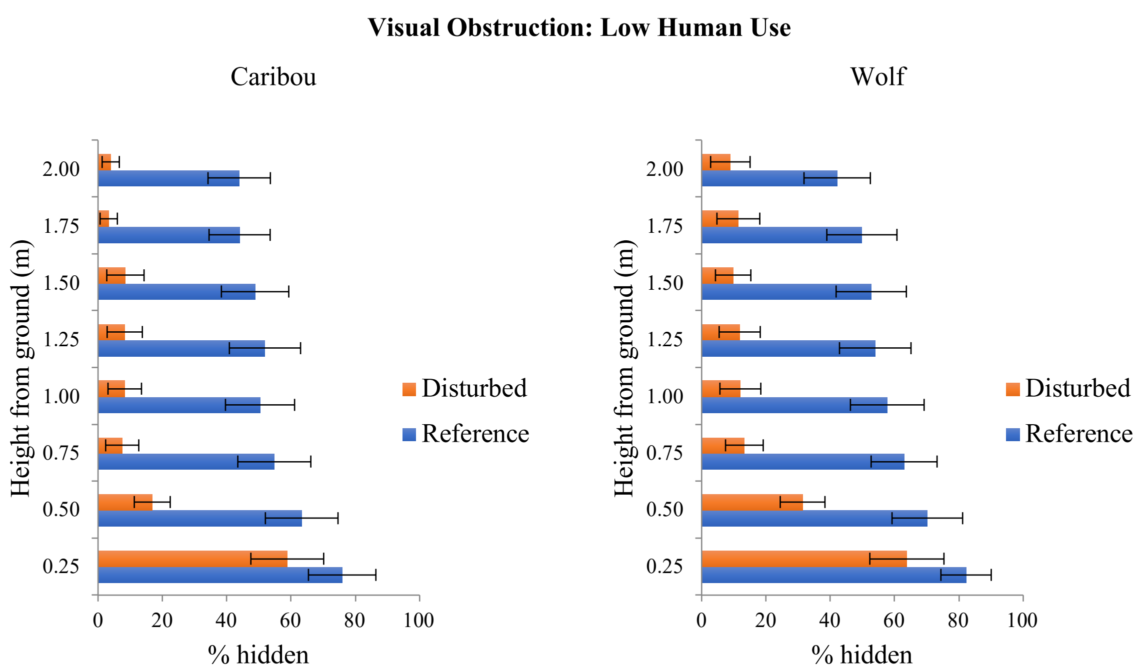

Figure 2.3-6B Visual obstruction in areas with low human use for disturbance versus reference from caribou and wolf perspectives. The error bars are standard errors around the means.

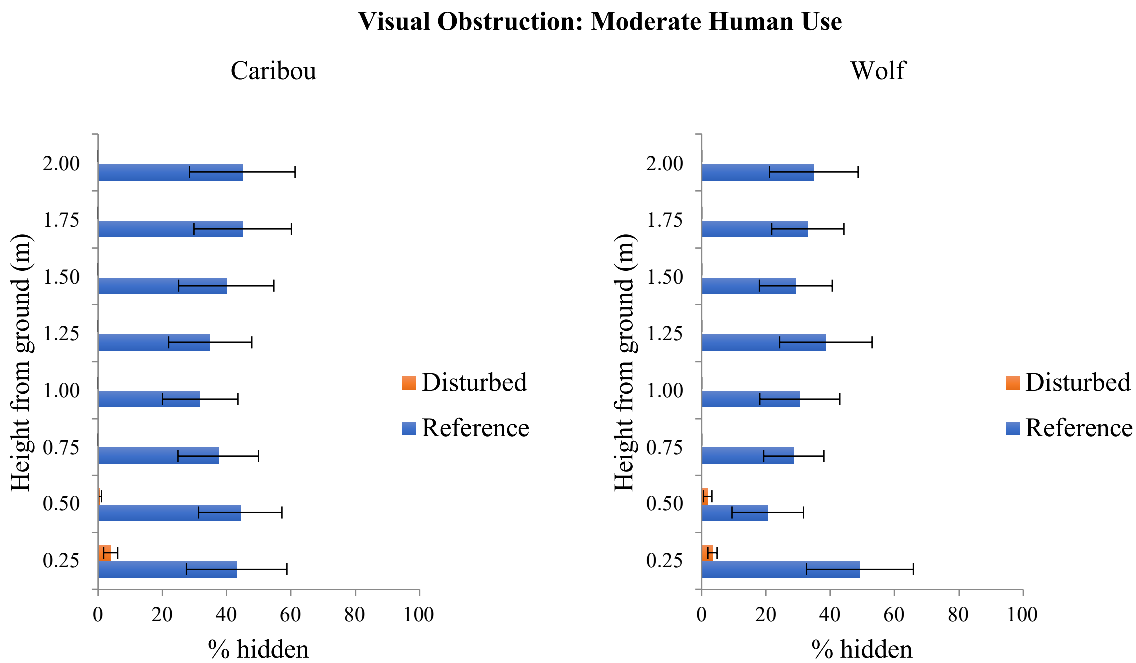

Figure 2.3-6C Visual obstruction in areas with moderate human use for disturbance versus reference from caribou and wolf perspectives. The error bars are standard errors around the means.

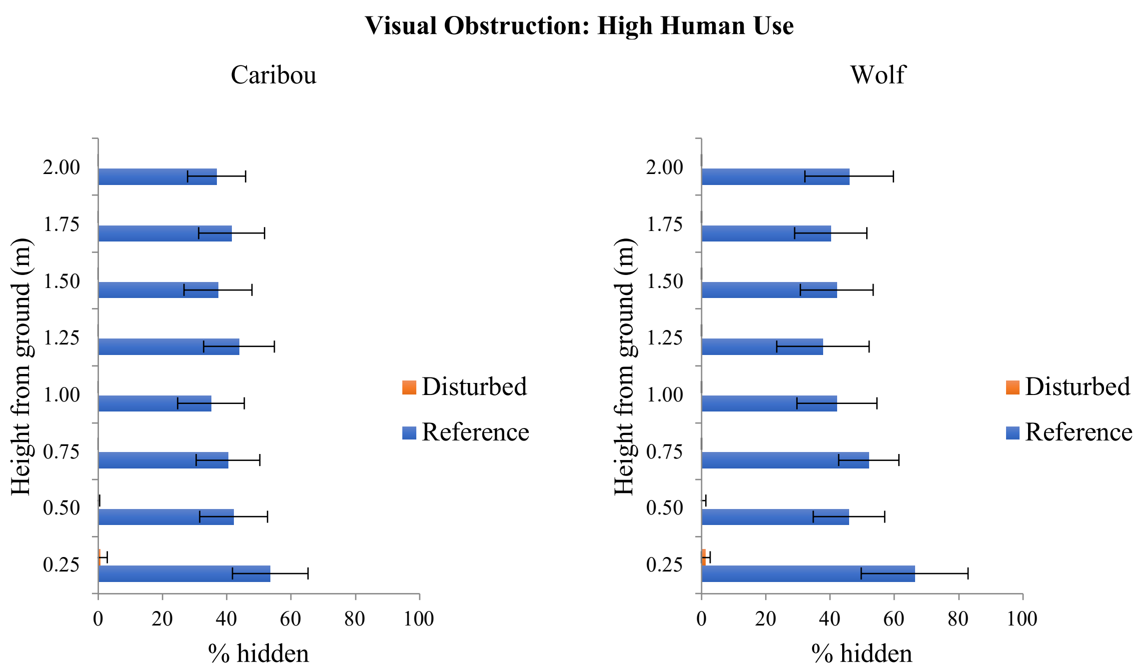

Figure 2.3-6D Visual obstruction in areas with high human use for disturbance versus reference from caribou and wolf perspectives. The error bars are standard errors around the means.

Vegetation Recovery: Areas burned before vs. after line was cut

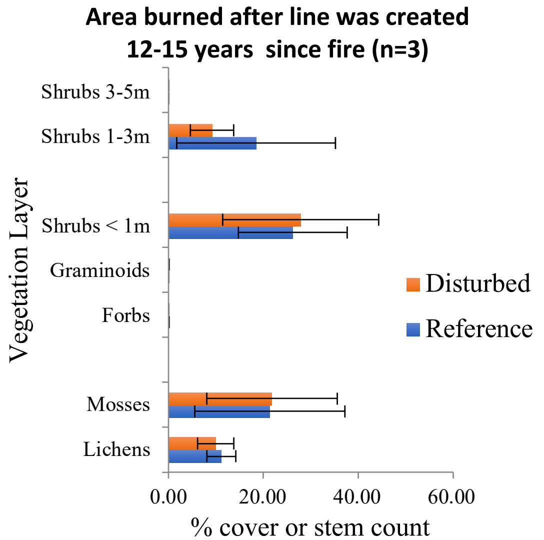

Figure 2.3-7A Average cover/stem count for disturbed versus reference in each vegetation layer for areas burned after line was created. The error bars are standard errors around the means.

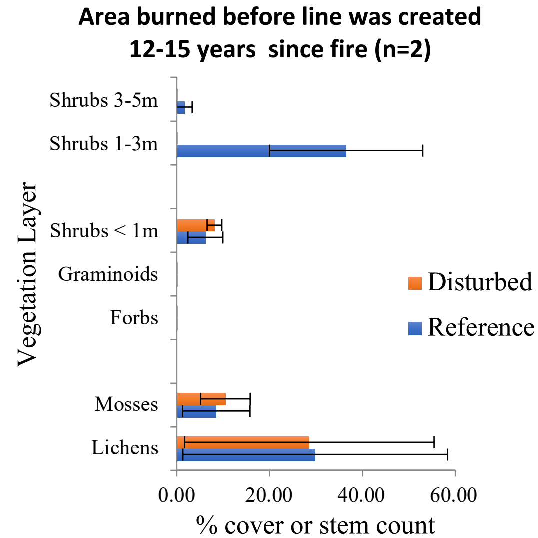

Figure 2.3-7B Average cover/stem count for disturbed versus reference in each vegetation layer for areas burned before line was created. The error bars are standard errors around the means.

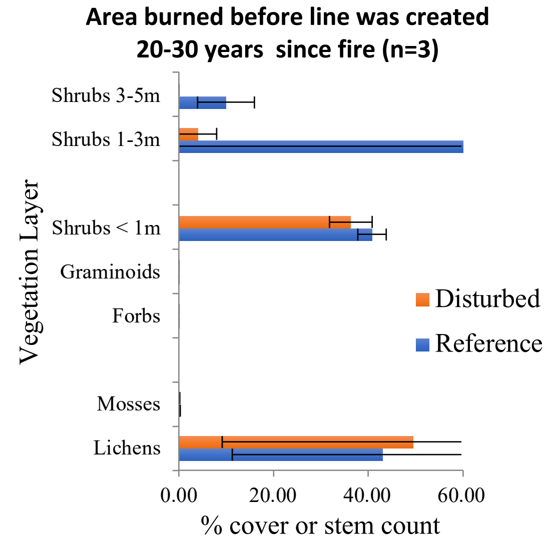

Figure 2.3-7C Average cover/stem count for disturbed versus reference in each vegetation layer for areas burned before line was created. The error bars are standard errors around the means.

Vegetation Recovery: Lowland (bogs/fens) vs. Upland

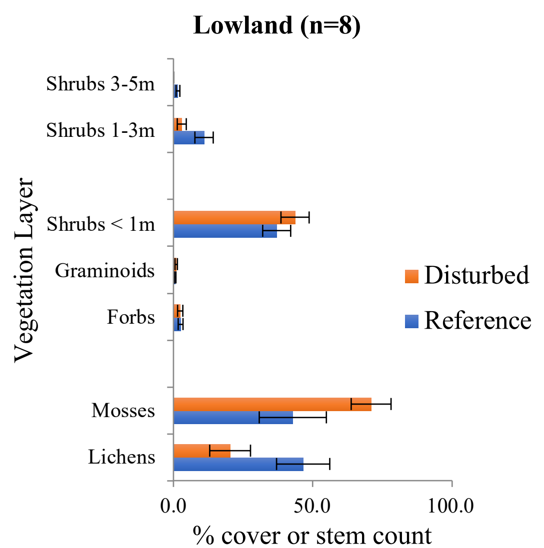

Figure 2.3-8A Average cover/stem count for disturbed versus reference in each vegetation layer for lowland (bogs/fens). The error bars are standard errors around the means.

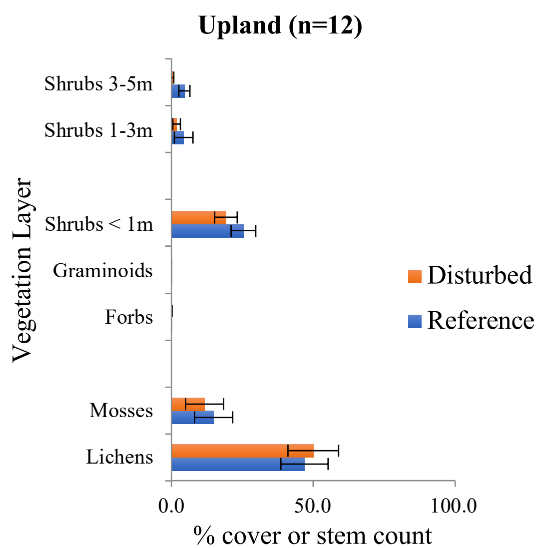

Figure 2.3-8B Average cover/stem count for disturbed versus reference in each vegetation layer for upland. The error bars are standard errors around the means.

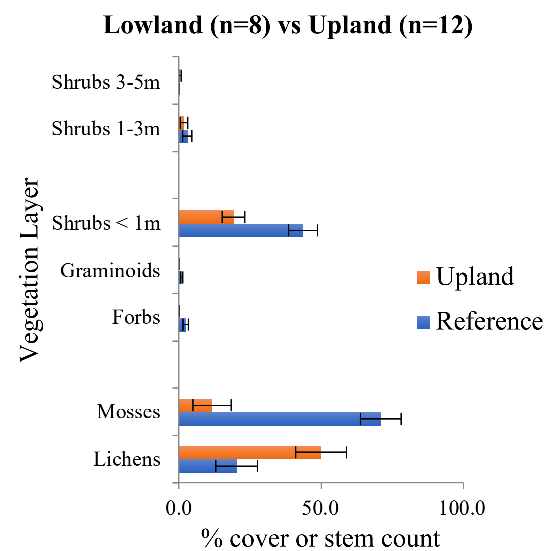

Figure 2.3-8C Average cover/stem count in disturbed areas between lowland (bogs-fens) and upland vs. reference. The error bars are standard errors around the means.

Vegetation Recovery: Old forest vs. Young forest

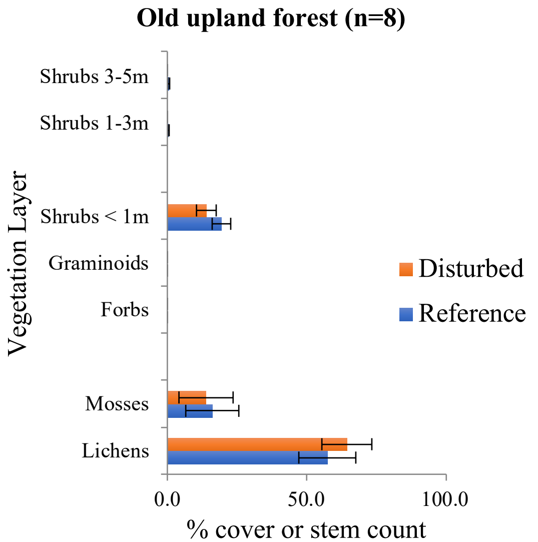

Figure 2.3-9A Average cover/stem count for disturbed versus reference in each vegetation layer for old upland forest. The error bars are standard errors around the means.

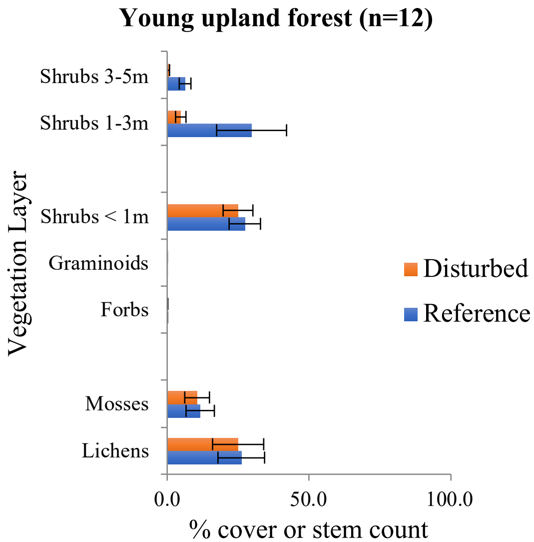

Figure 2.3-9B Average cover/stem count for disturbed versus reference in each vegetation layer for young upland forest. The error bars are standard errors around the means.

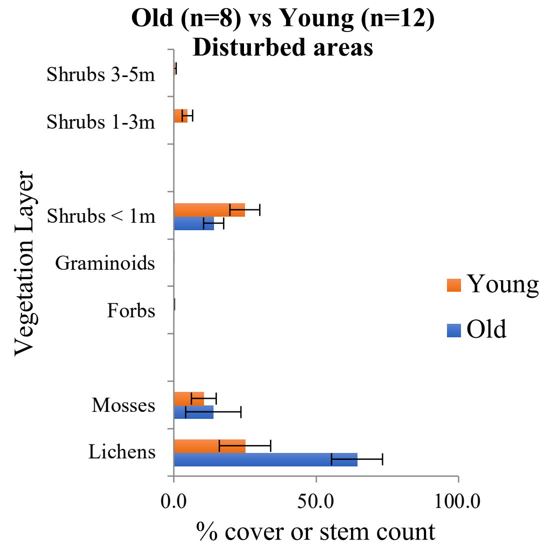

Figure 2.3-9C Average cover/stem count for disturbed areas in each vegetation layer for old versus young forest. The error bars are standard errors around the means.

Vegetation Recovery: Level of Human Use

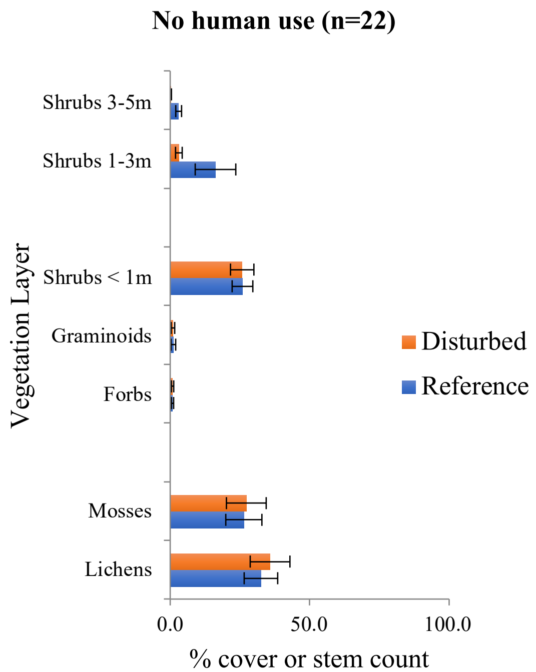

Figure 2.3-10A Average cover/stem count for disturbed versus reference in each vegetation layer for areas with no human use. The error bars are standard errors around the means.

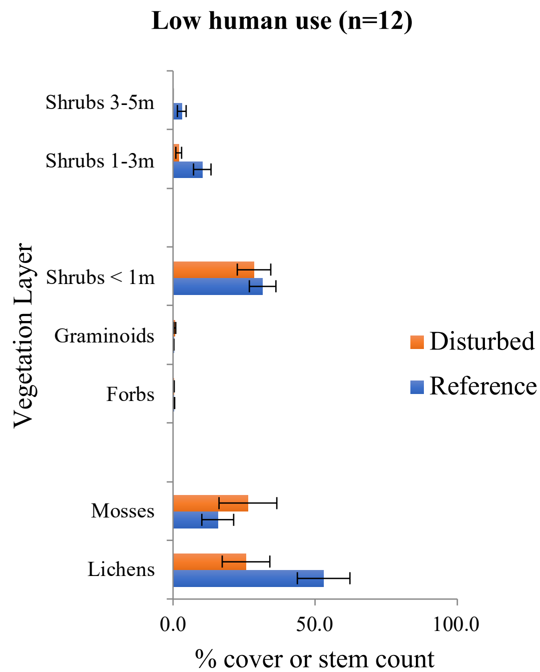

Figure 2.3-10B Average cover/stem count for disturbed versus reference in each vegetation layer for areas with low human use. The error bars are standard errors around the means.

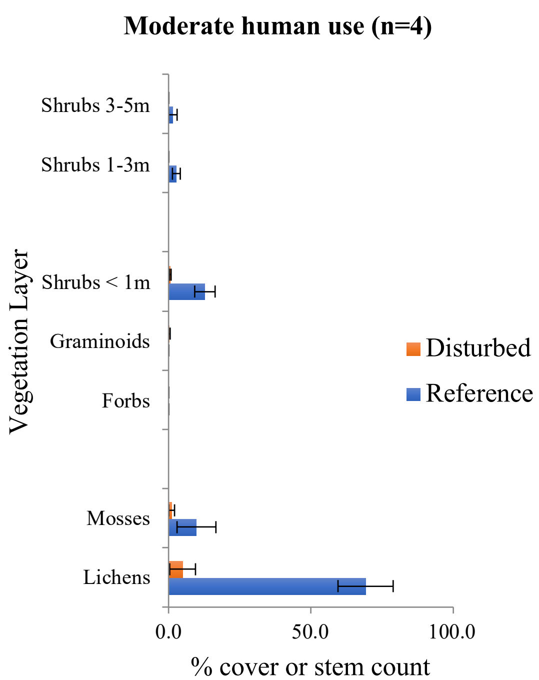

Figure 2.3-10C Average cover/stem count for disturbed versus reference in each vegetation layer for areas with moderate human use. The error bars are standard errors around the means.

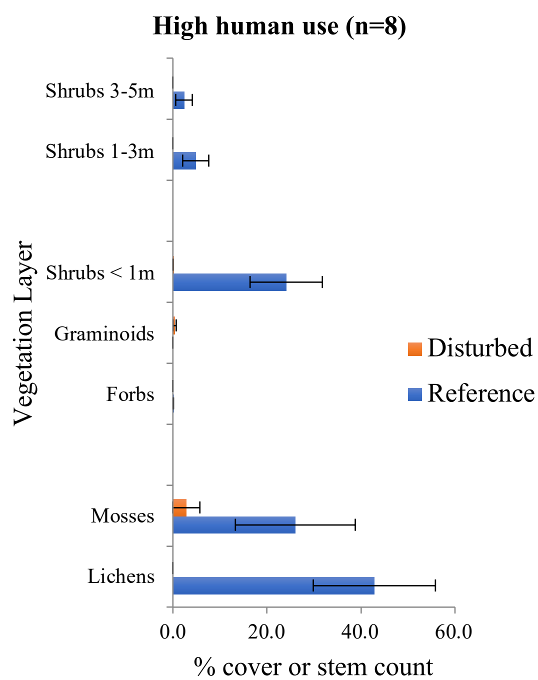

Figure 2.3-10D Average cover/stem count for disturbed versus reference in each vegetation layer for areas with high human use. The error bars are standard errors around the means.

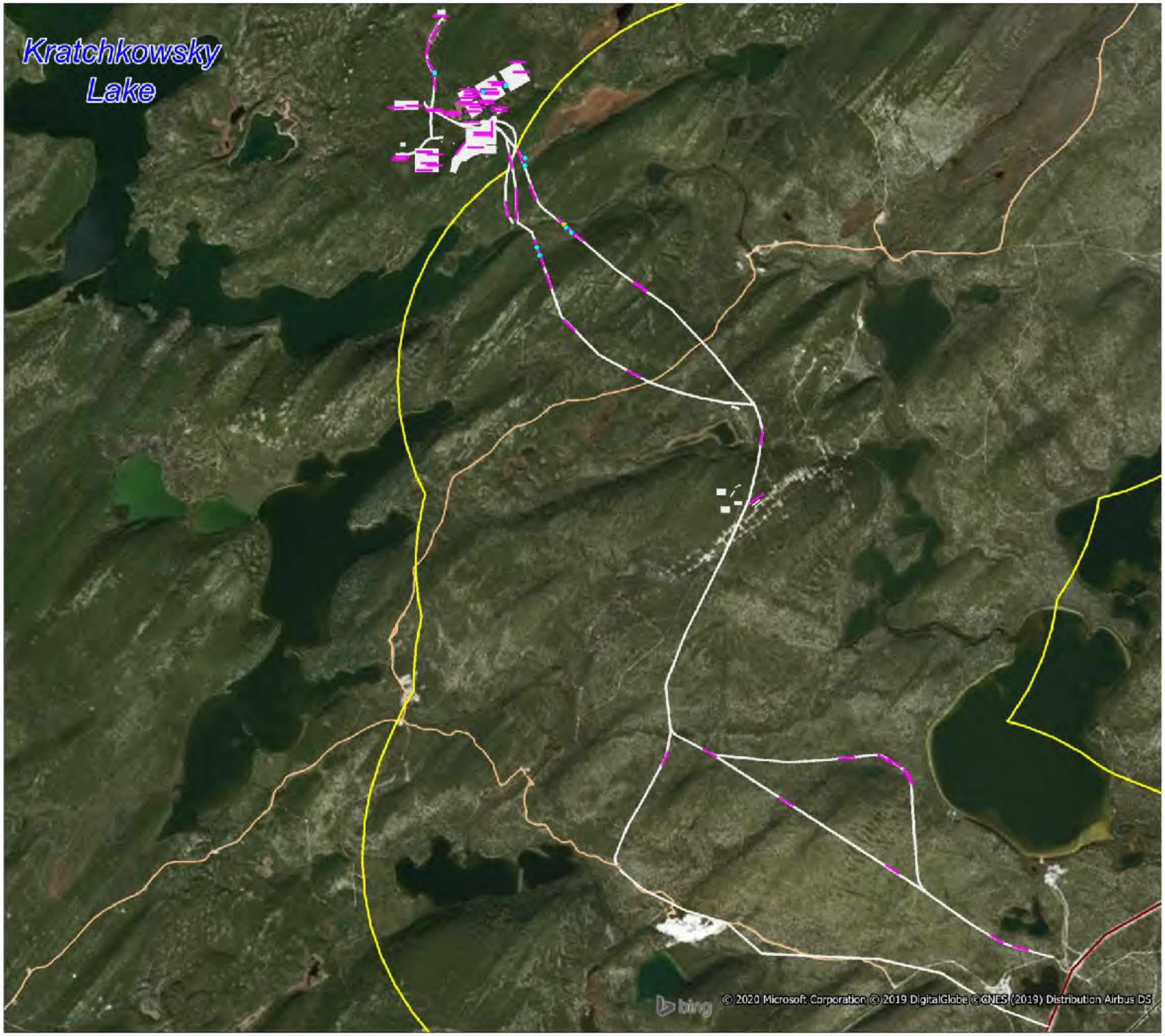

Figure 2.4-1 Rare Plant Survey Locations and Observations - Denison Wheeler River Project

Legend

Rare Plants Observed

- Diphasiastrum sitchense
- Carex trisperma

- Rare Plant Transect
- Road
- McArthur-Key Haul Road
- Transmission ROW
- 2017 Planned Development Footprint
- Local Study Area (LSA)

0 1 2
kilometers
Scale = 1 : 25,000

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Figure 2.4-2. Alaskan clubmoss partially buried in litter and lichen on the forest floor.

Figure 2.4-3. Alaskan clubmoss with horizontal stems.

Figure 2.4-4. Open immature jack pine stand with Alaskan clubmoss in the forb layer.

Figure 2.4-5. Close-up picture of three-seeded sedge flower and fruit structures.

Figure 2.4-6. Wet riparian depression with three-seeded sedge.

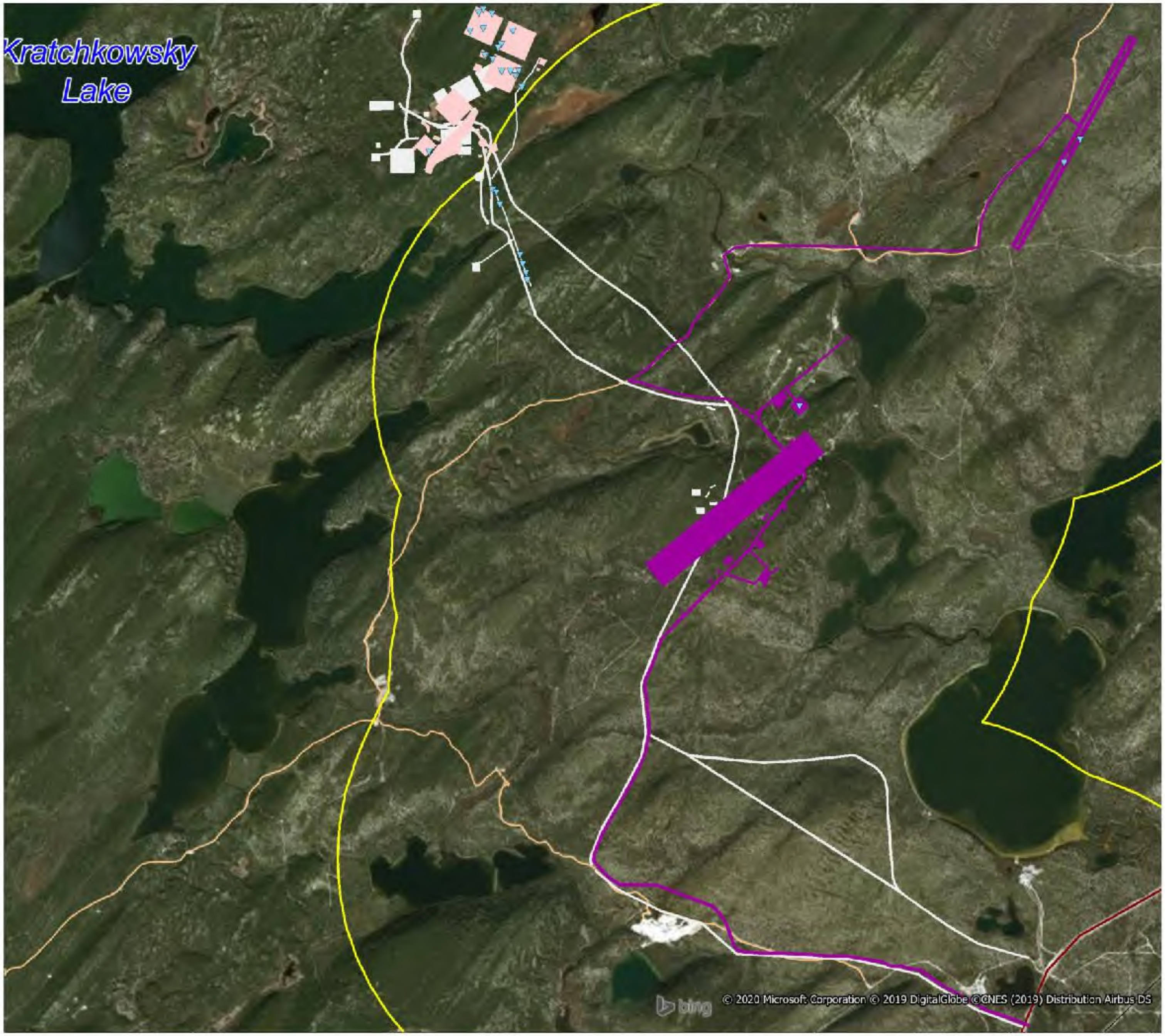

Figure 2.4-7 Rare Plant Survey Requirement Assessment - Denison Wheeler River Project

Legend

- Ground Verification Site
- Road
- McArthur-Key Haul Road
- Transmission ROW
- 2017 Planned Development Footprint
- 2018 Gryphon Planned Development Footprint
- 2019 Planned Development Footprint
- Local Study Area (LSA)

0 1 2
kilometers
Scale = 1 : 25,000

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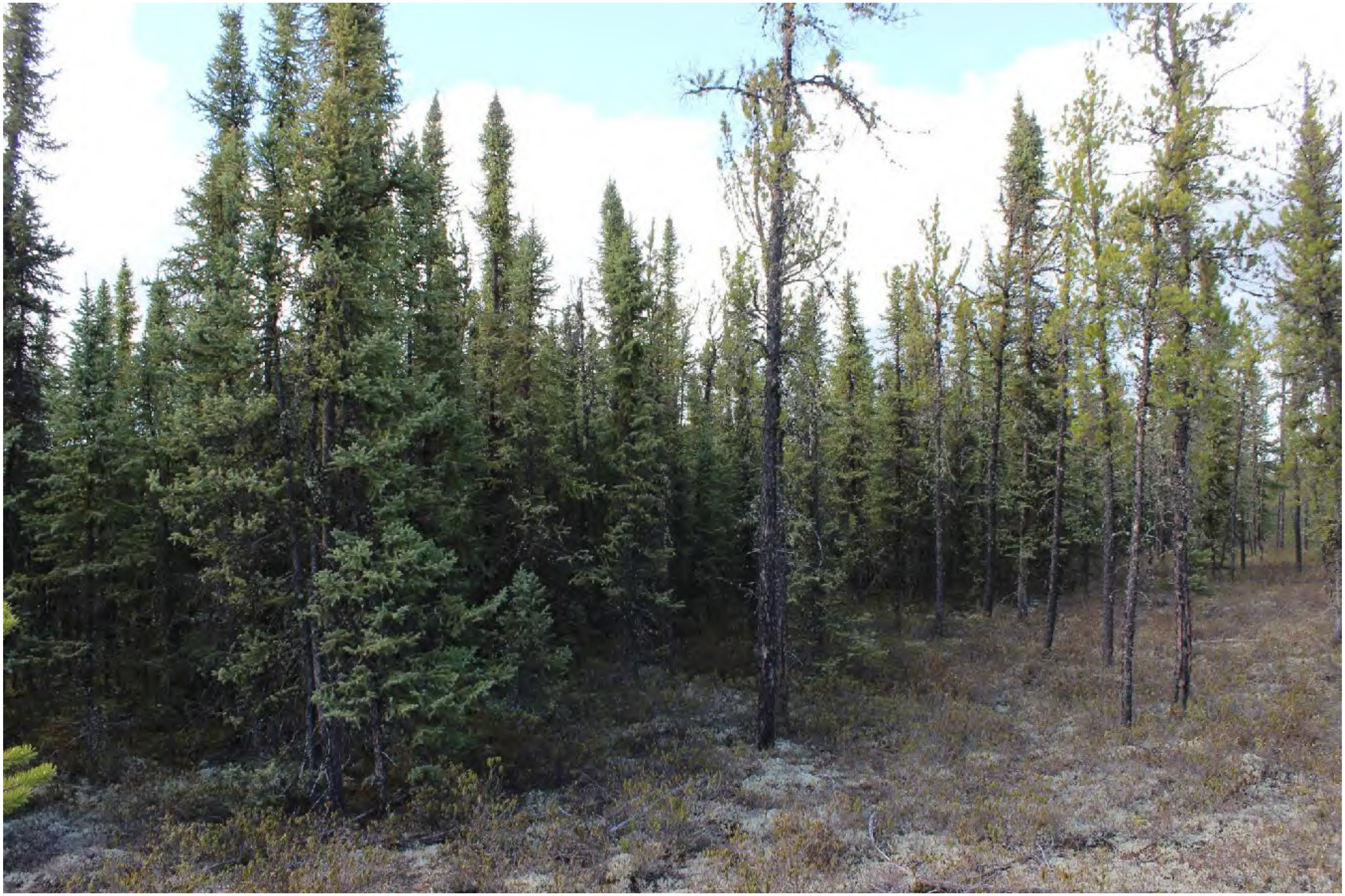

Figure 2.4-8. Black Spruce – Jackpine/Feathermoss (BS9) Polygon – Denison Wheeler River Project.

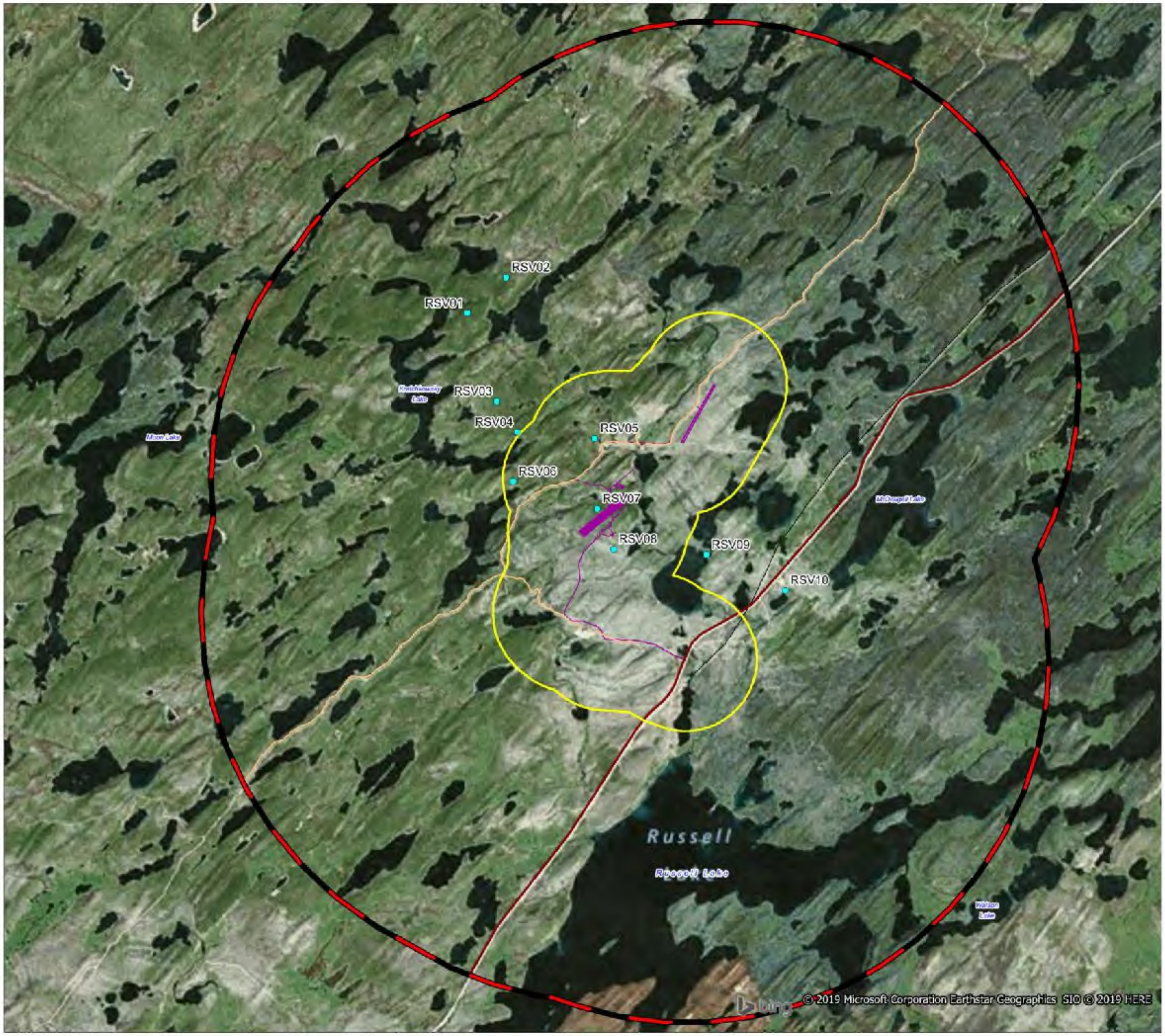

Figure 2.5-1 Vegetation and Soil Sampling Plot Locations - Denison Wheeler River Project

Legend

- Veg / Soil Sampling Plot
- Road
- McArthur-Key Haul Road
- Transmission ROW
- Planned Development Footprint
- Local Study Area (LSA)
- Regional Study Area (RSA)

N W E S

0 5 10

kilometers

Scale = 1 : 90,000

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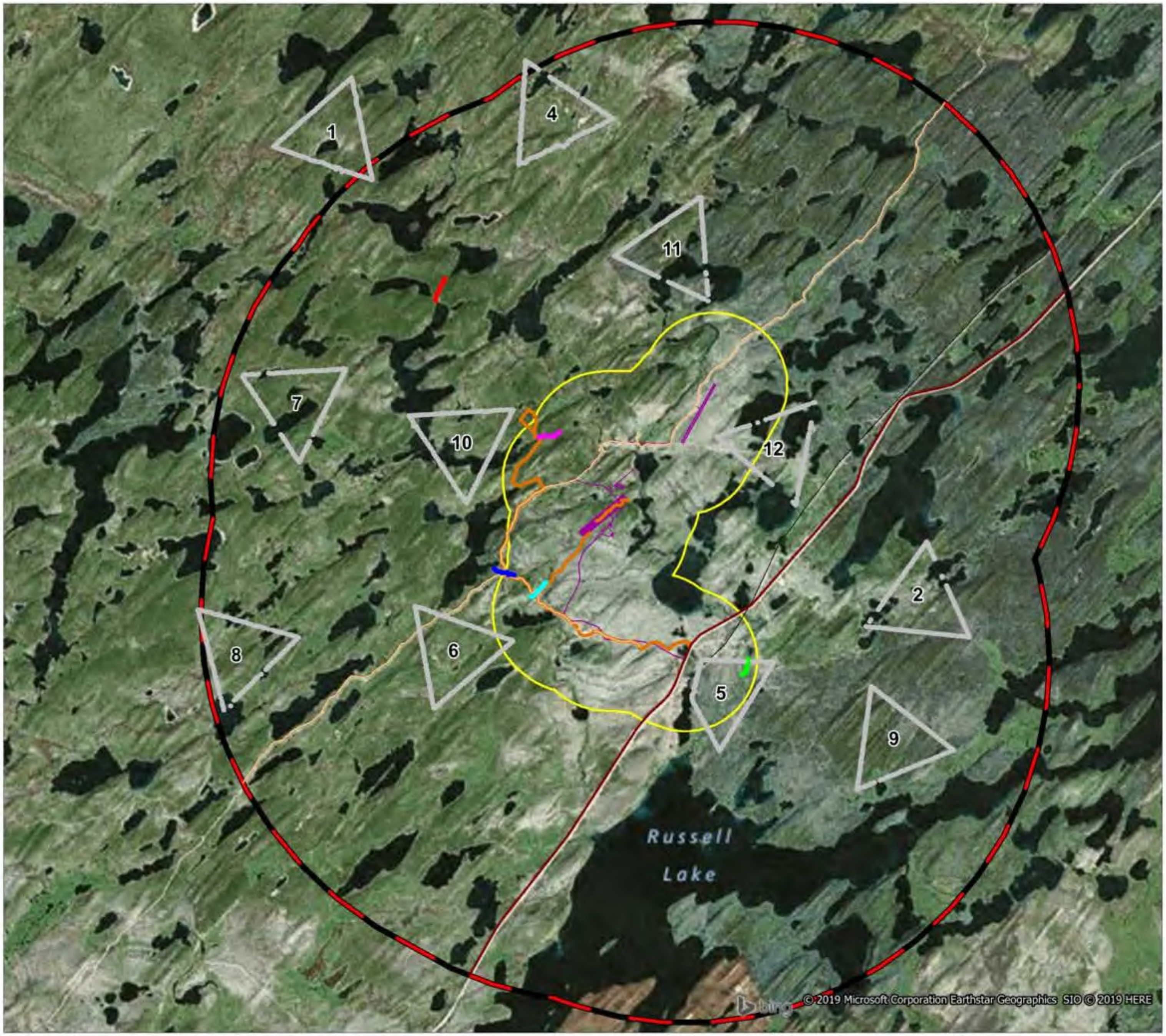

Figure 2.6-1 Winter Tracking Survey Transects
- Denison Wheeler River Project

Legend

Winter Tracking Transect

- Triangle
- Creek 1
- Creek 2
- Creek 3
- Creek 4
- Creek 5
- Road / Anthropogenic
- Road
- McArthur-Key Haul Road
- Transmission ROW
- Planned Development Footprint
- Local Study Area (LSA)
- Regional Study Area (RSA)

N
W E
S

0 5 10

kilometers
Scale = 1 : 90,000

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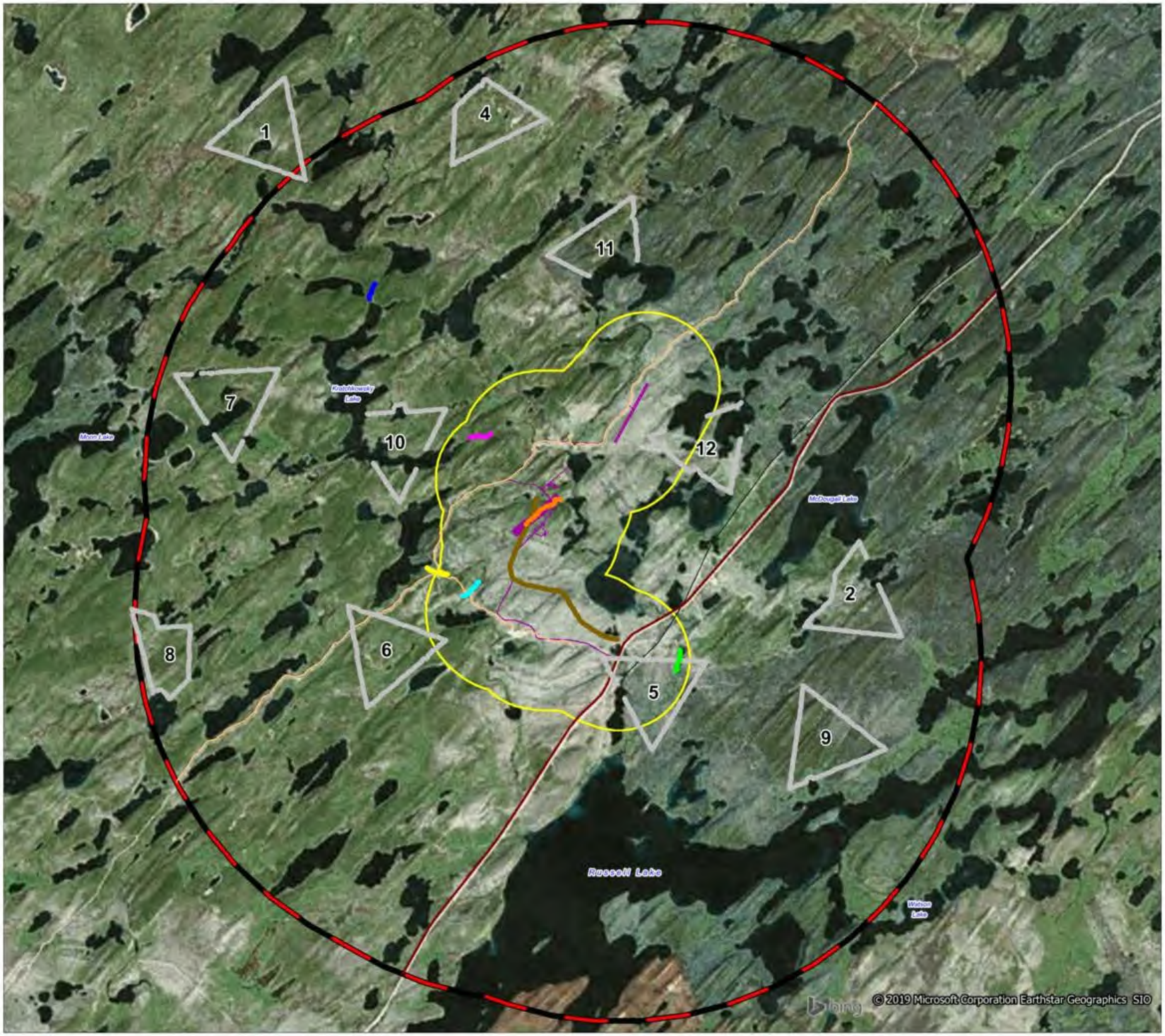

Figure 2.7-1 Ungulate Pellet Group/Browse Availability Transects - Denison Wheeler River Project

Legend

Pellet Group/browse Transect
- Proposed Access
- Creek 1
- Creek 2
- Creek 3
- Creek 4
- Creek 5
- Road / Anthropogenic
- Triangle

Road
McArthur-Key Haul Road
Transmission ROW
Planned Development Footprint
Local Study Area (LSA)
Regional Study Area (RSA)

0 5 10
kilometers
Scale = 1 : 90,000

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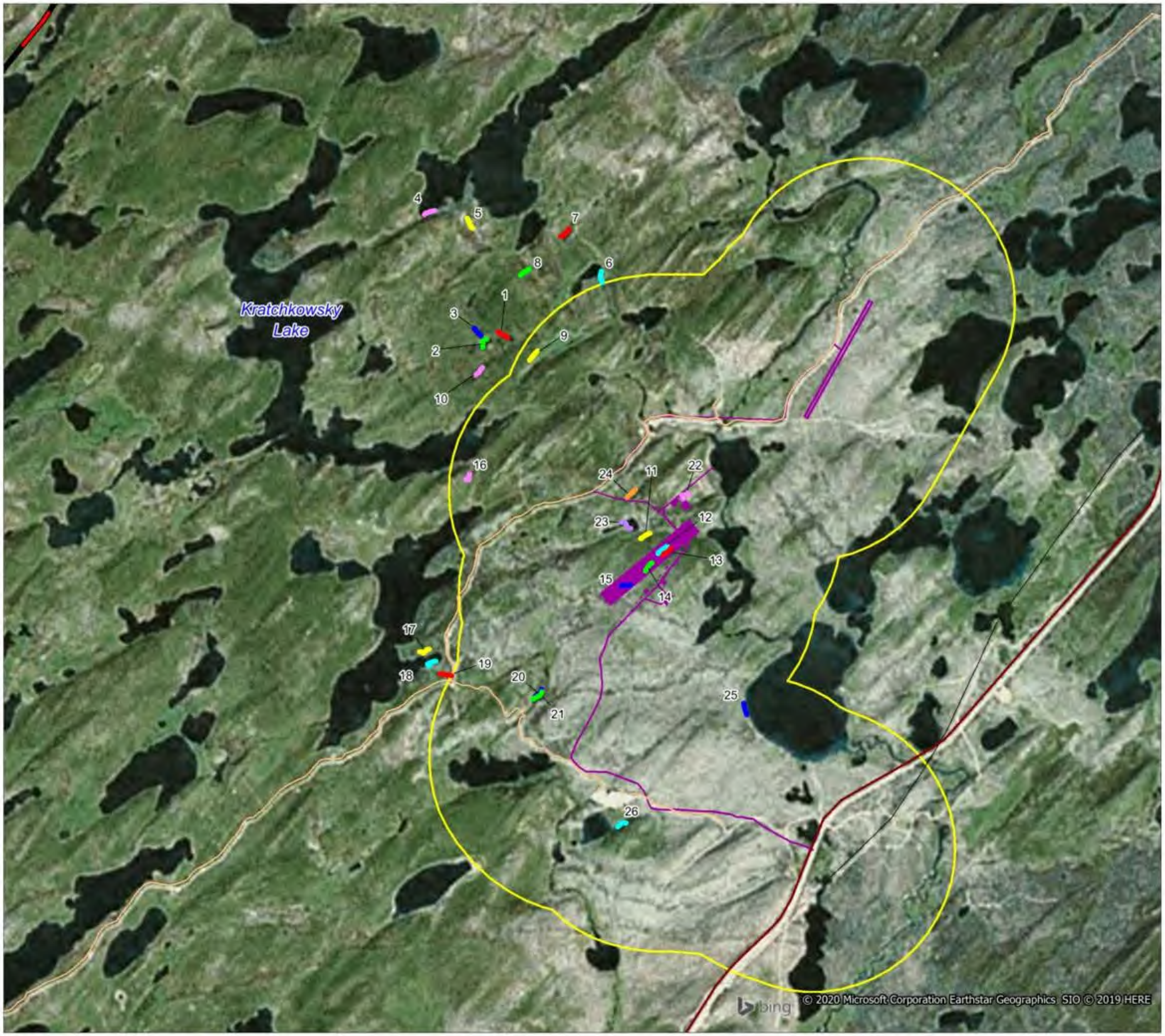

Figure 2.8-1 Small Mammal Trapping Transects - Denison Wheeler River Project

Legend

- Small Mammal Transect
- Road
- McArthur-Key Haul Road
- Transmission ROW
- Planned Development Footprint
- Local Study Area (LSA)
- Regional Study Area (RSA)

0 2.5 5

kilometers

Scale = 1 : 45,000

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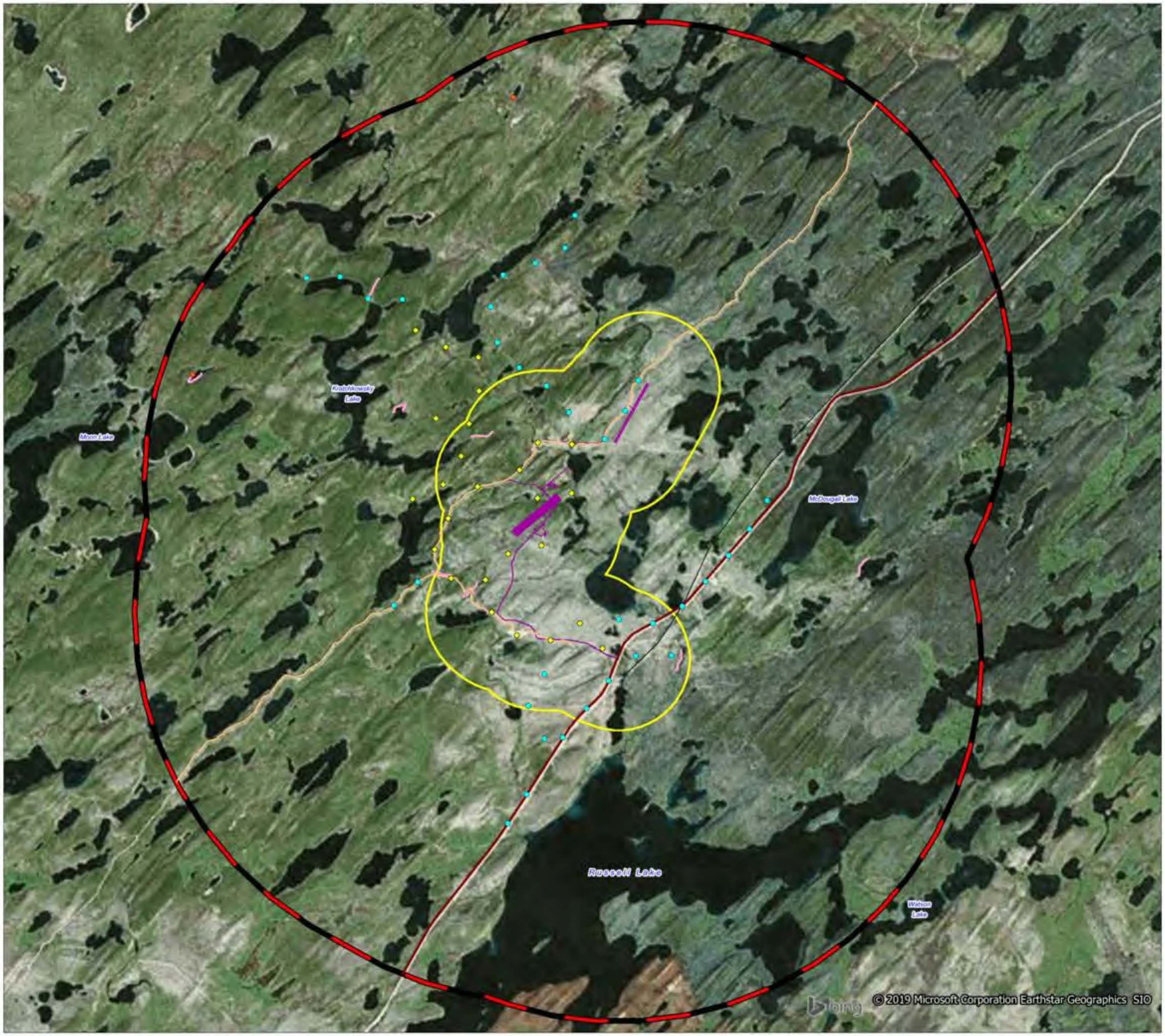

Figure 2.9-1 Amphibian Nocturnal Call Survey Plots and Visual Survey Routes - Denison Wheeler River Project

Legend

Pellet Group/browse Transect

- Nocturnal Call Survey Plot (2017, 2018)
- Nocturnal Call Survey Plot (2017)
- Wood Frog Visual Location
- Amphibian Visual Surveys 2018
- Road
- McArthur-Key Haul Road
- Transmission ROW
- Planned Development Footprint
- Local Study Area (LSA)
- Regional Study Area (RSA)

0 5 10

kilometers

Scale = 1 : 90,000

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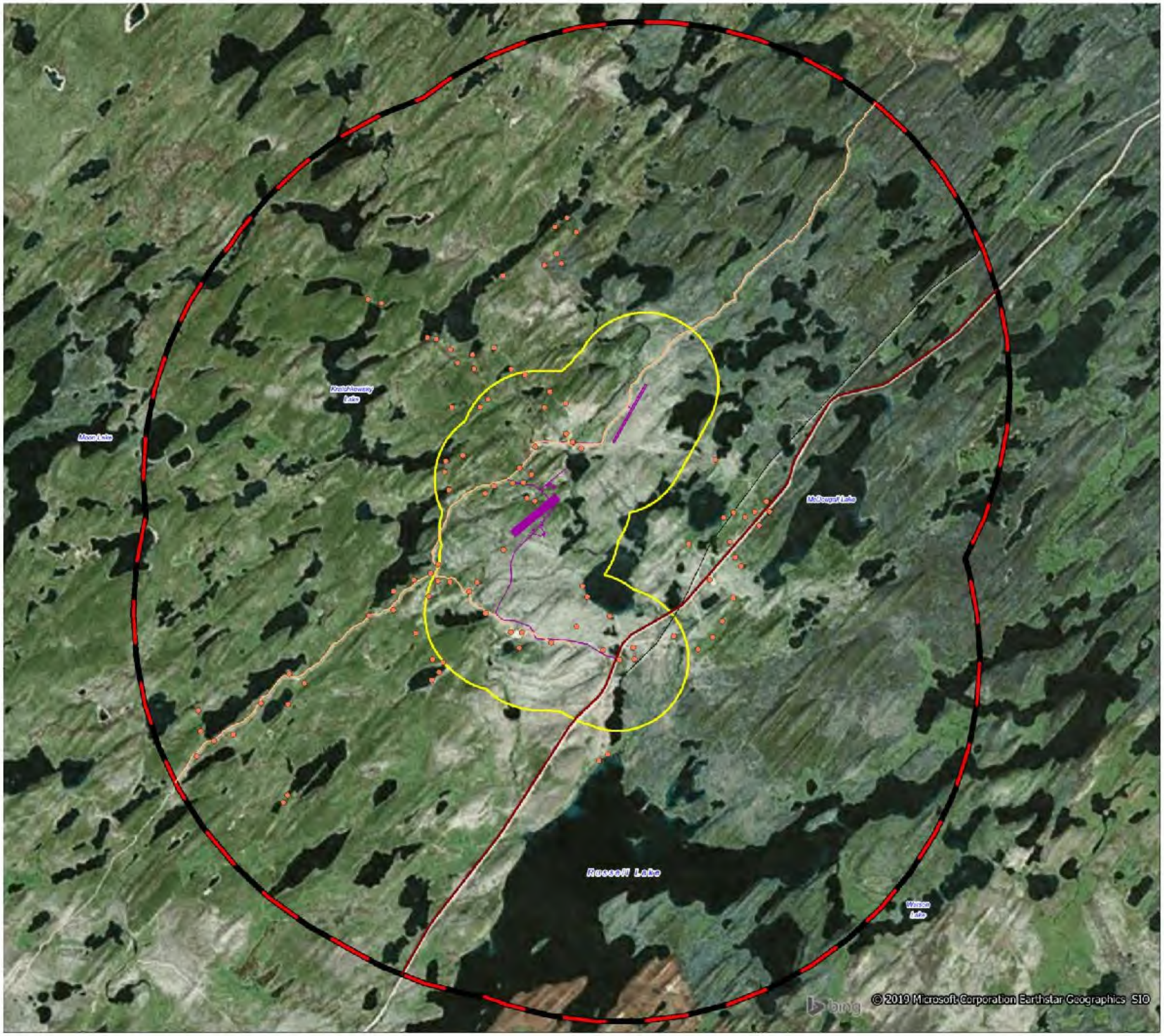

Figure 2.10-1 Breeding Songbird Point Count Survey Plots - Denison Wheeler River Project

Legend

- Veg / Soil Sampling Plot
- Road
- McArthur-Key Haul Road
- Transmission ROW
- Planned Development Footprint
- Local Study Area (LSA)
- Regional Study Area (RSA)

0 5 10
kilometers
Scale = 1 : 90,000

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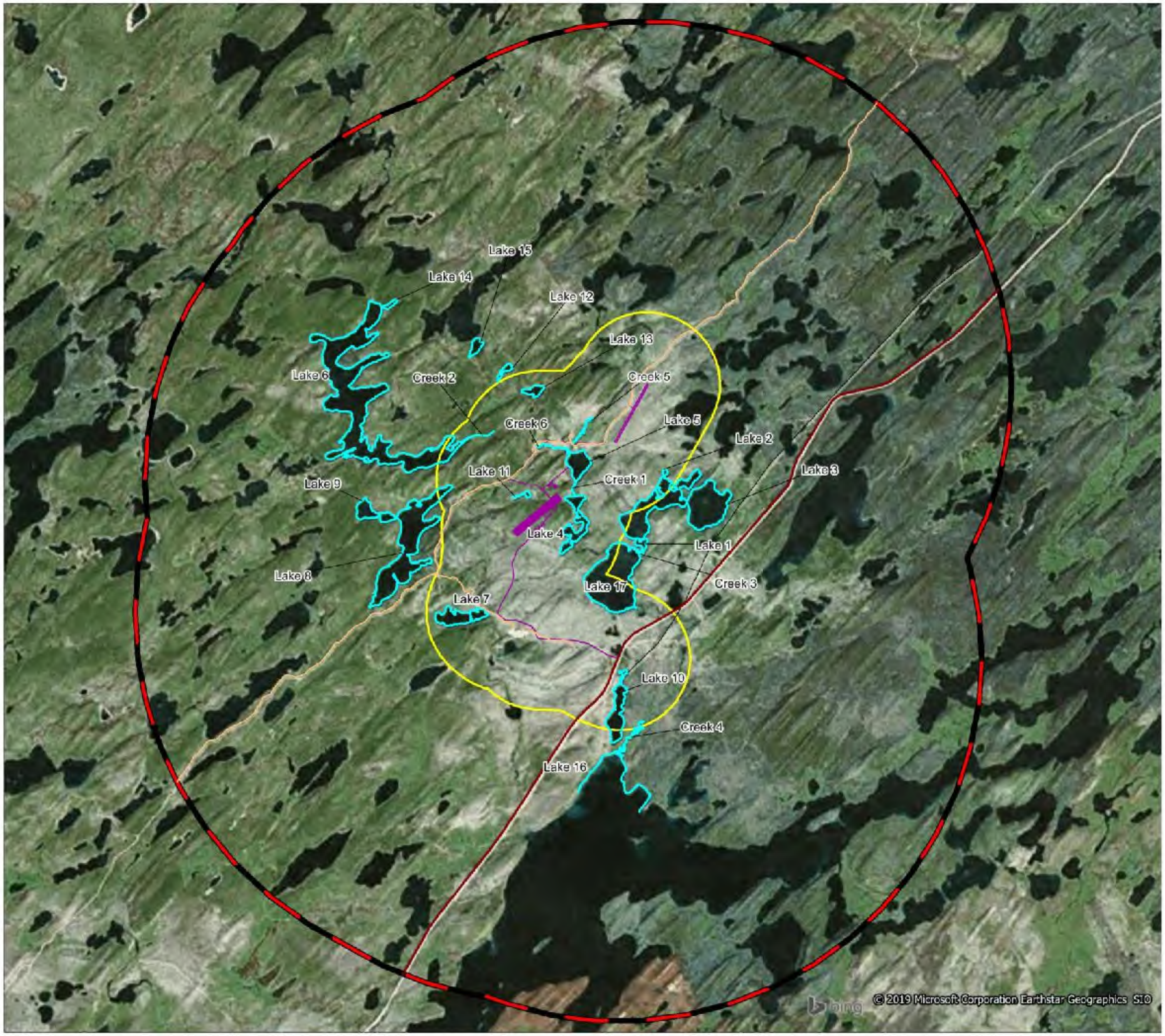
Figure 2.11-1 Semi-aquatic Furbearer Shoreline Survey Locations - Denison Wheeler River Project



Legend

- Shoreline Survey Route
- Road
- McArthur-Key Haul Road
- Transmission ROW
- Planned Development Footprint
- Local Study Area (LSA)
- Regional Study Area (RSA)

0 5 10

kilometers

Scale = 1 : 90,000

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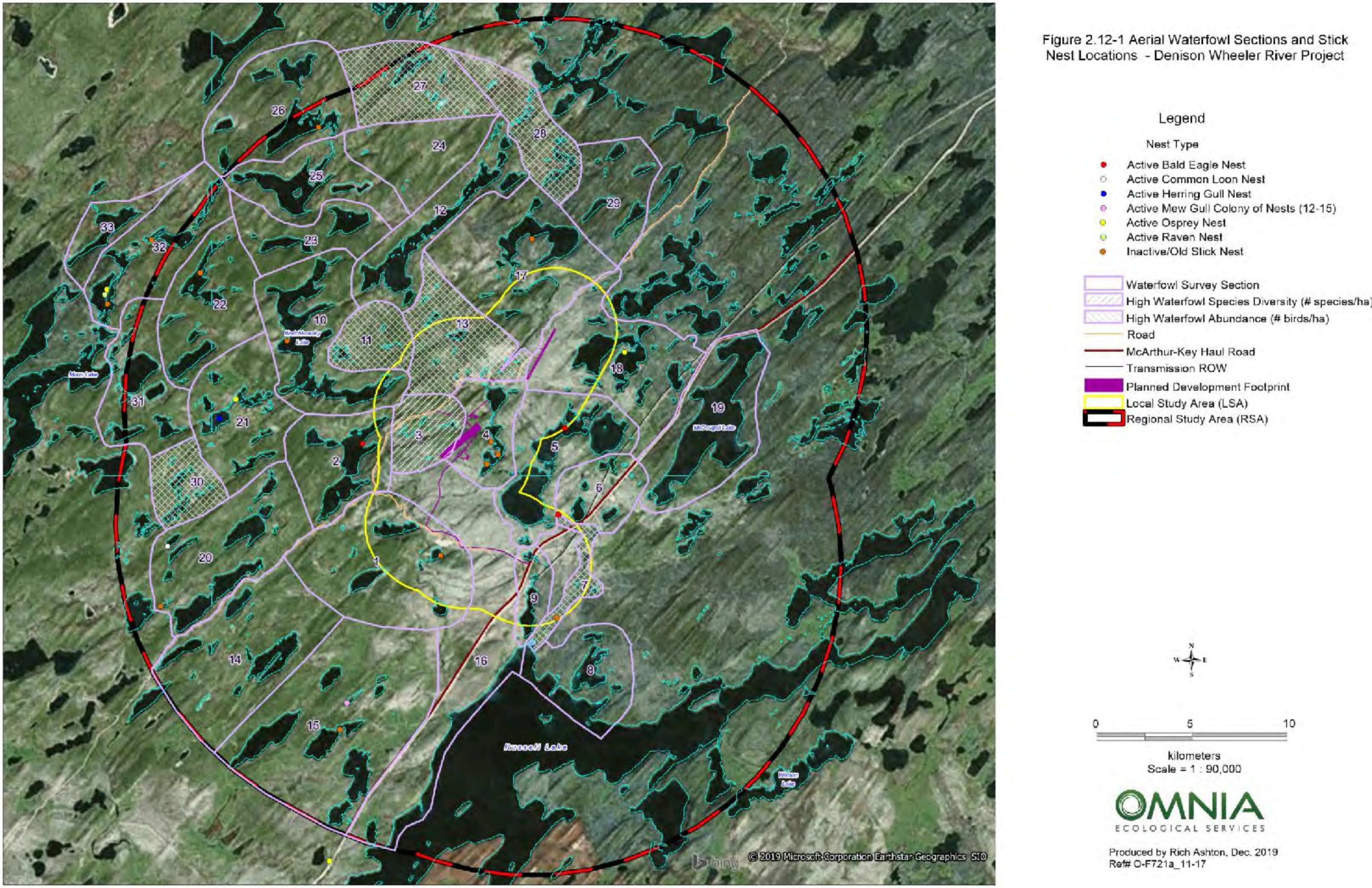

Figure 2.12-1 Aerial Waterfowl Sections and Stick Nest Locations - Denison Wheeler River Project

A

B

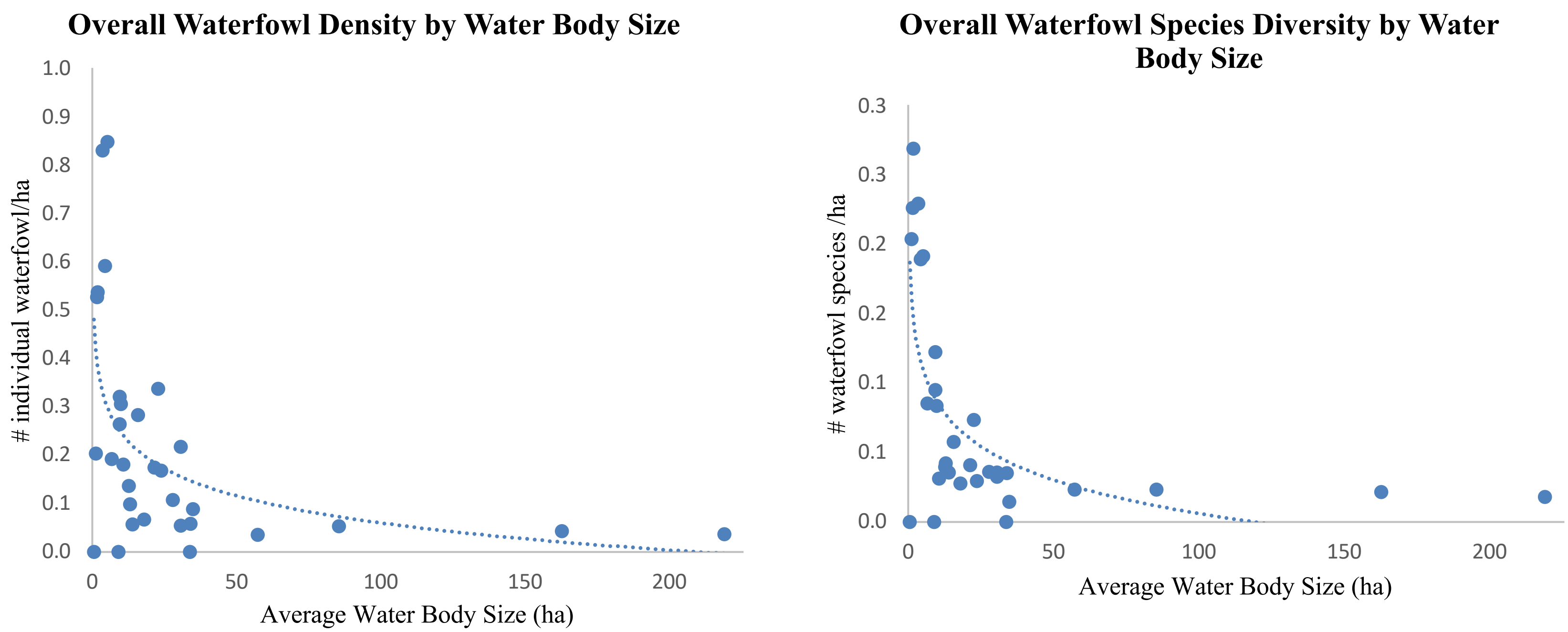

Figure 2.12-2 Relationship between average size of water body and (A) number of individual birds observed per hectare and (B) number of waterfowl species observed per hectare. Ponds and lakes included only.

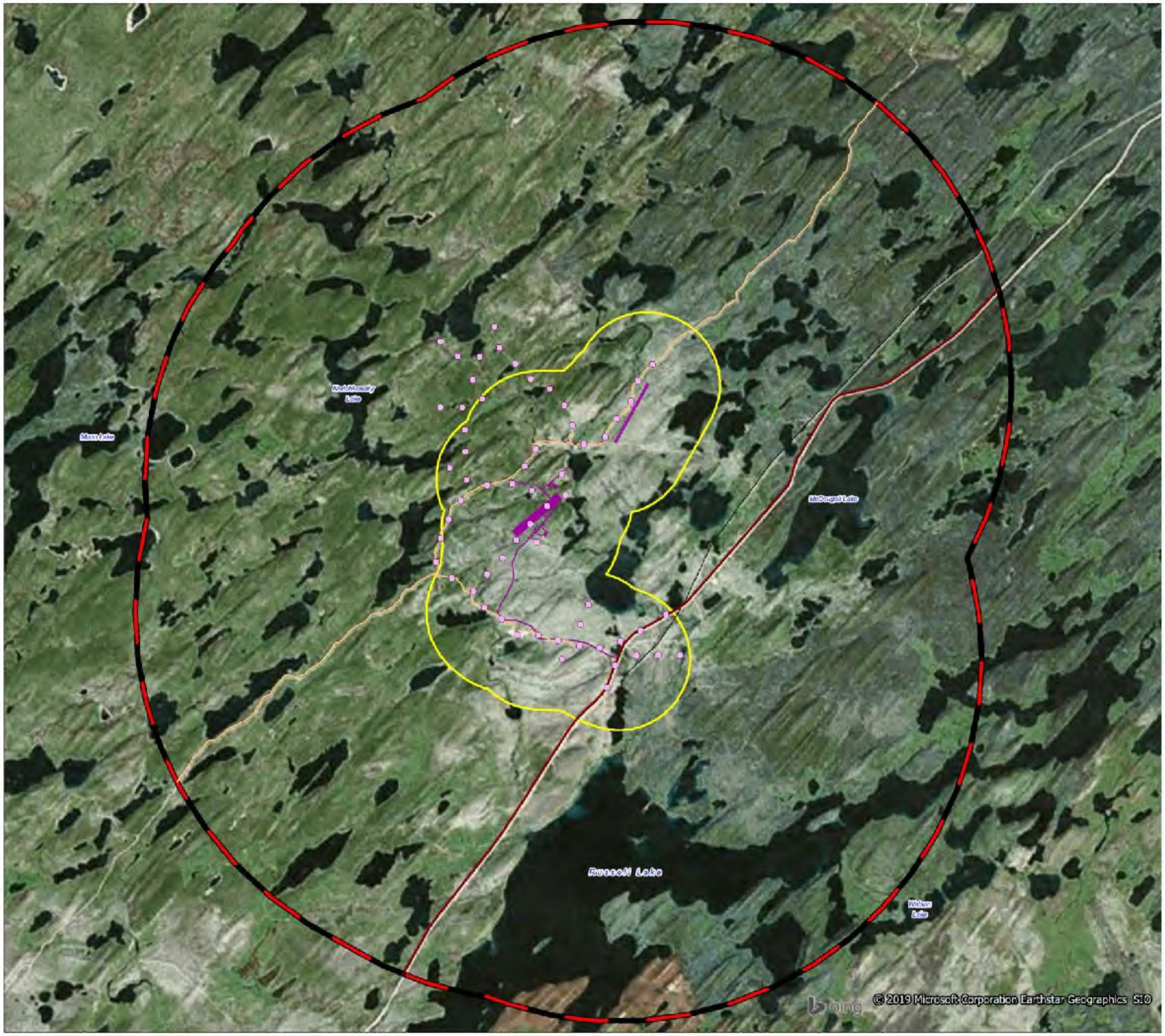

Figure 2.14-1 Acoustic Bat Surveys - Denison Wheeler River Project

Legend

- Bat Survey Location
- Road
- McArthur-Key Haul Road
- Transmission ROW
- Planned Development Footprint
- Local Study Area (LSA)
- Regional Study Area (RSA)

0 5 10

kilometers

Scale = 1 : 90,000

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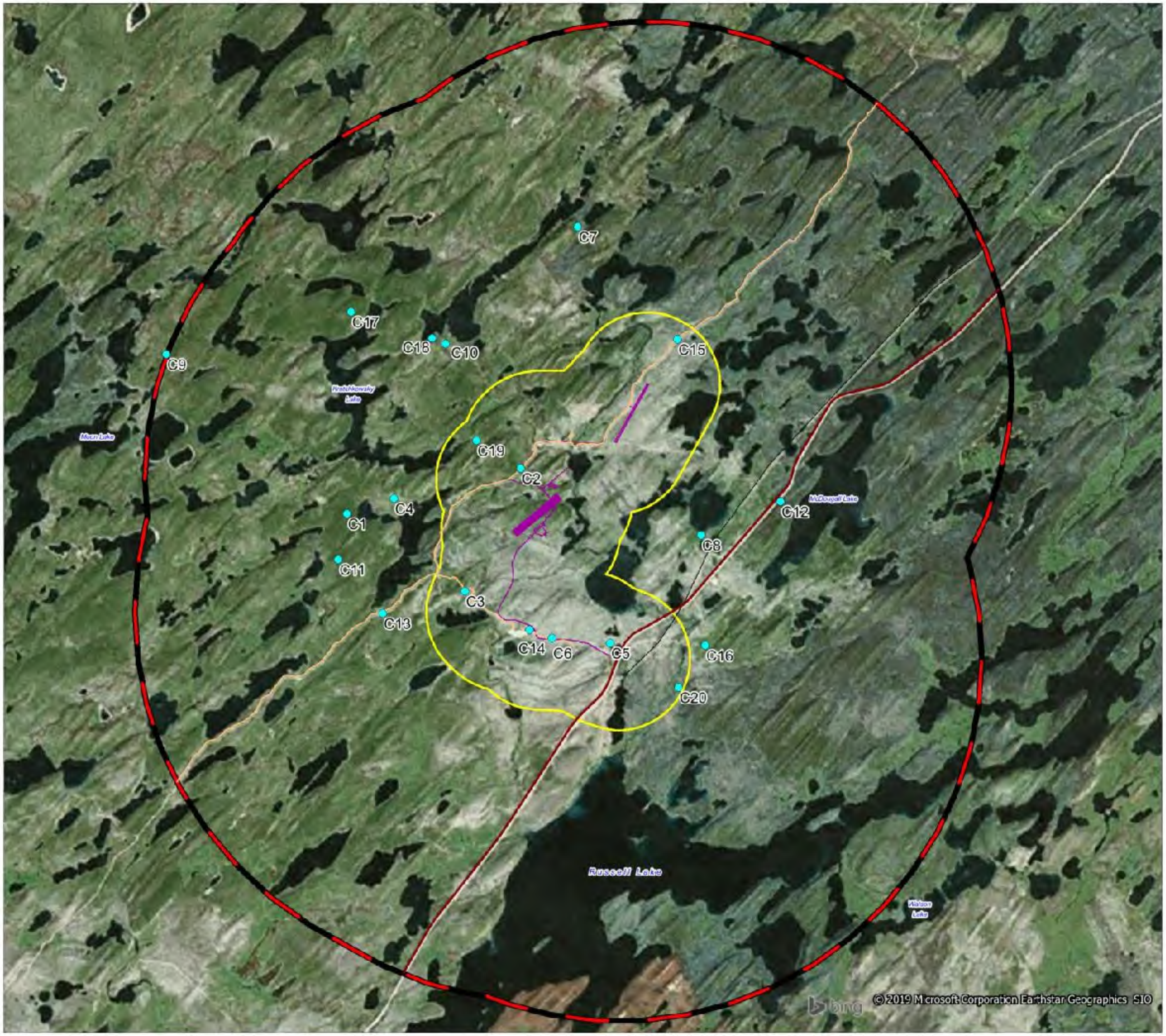

Figure 2.15-1 Covert Camera Surveys - Denison Wheeler River Project

Legend

- Covert Camera Location
- Road
- McArthur-Key Haul Road
- Transmission ROW
- Planned Development Footprint
- Local Study Area (LSA)
- Regional Study Area (RSA)

0 5 10
kilometers
Scale = 1 : 90,000

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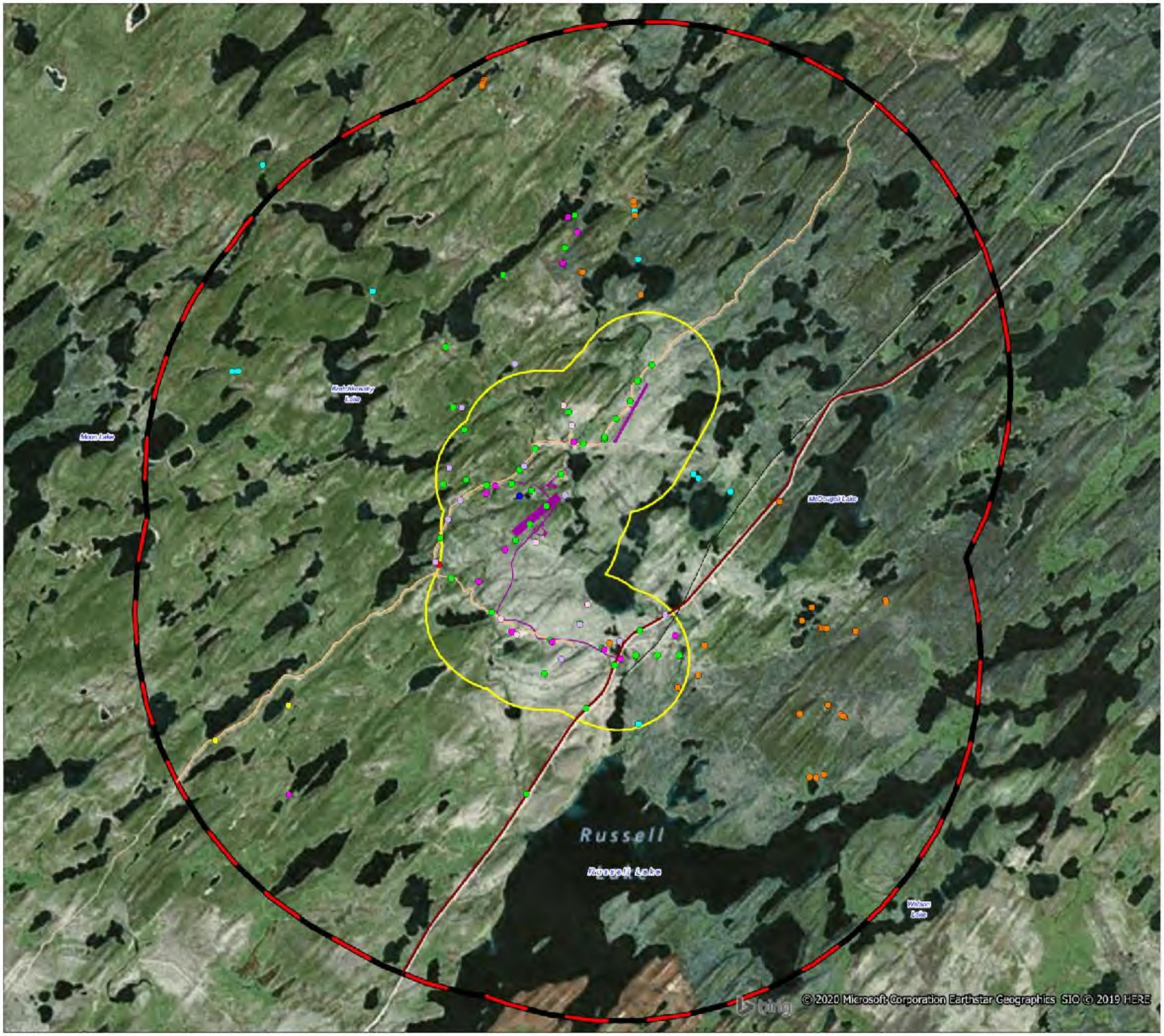
Figure 3-1 Sensitive and Species at Risk Observations - Denison Wheeler River Project



Legend

Species Observed

- Barn Swallow
- Common Nighthawk
- Horned Grebe
- Little Brown Myotis
- Myotis Spp.
- Olive-sided Flycatcher
- Osprey
- River Otter
- Woodland Caribou

- Road
- McArthur-Key Haul Road
- Transmission ROW
- Planned Development Footprint
- Local Study Area (LSA)
- Regional Study Area (RSA)

N
W E
S

0 5 10

kilometers

Scale = 1 : 90,000

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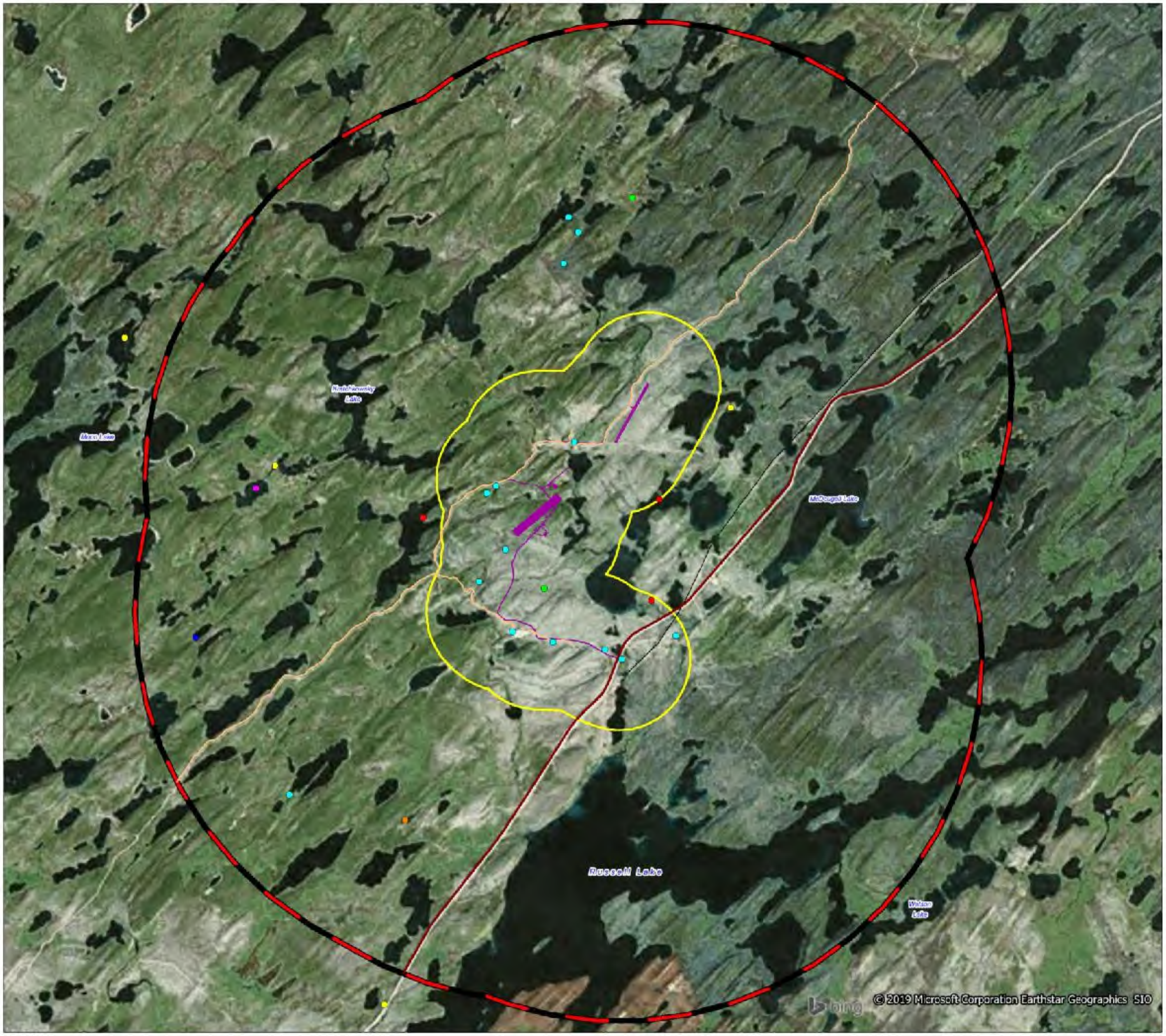
Figure 3-2 Sensitive Species Observations
Requiring Setbacks - Denison Wheeler River Project



Legend

Species Observed

- Bald Eagle Nest
- Common Loon Nest
- Common Nighthawk Nest
- Herring Gull Nest
- Mew Gull Colony
- Olive-sided Flycatcher
- Osprey Nest

- Road
- McArthur-Key Haul Road
- Transmission ROW
- Planned Development Footprint
- Local Study Area (LSA)
- Regional Study Area (RSA)

N W E S

0 5 10

kilometers
Scale = 1 : 90,000

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9.0 APPENDICES

Appendix 1. List of Vertebrates Known or With Potential to Occur in the Denison Wheeler River project area – 2019.

Common Name	Scientific Name	At Risk Designation			Detected/Program[2]
		SKCDC[1]	COSEWIC	SARA	
BIRDS					
Greater White-fronted Goose	*Anser albifrons*				
Snow Goose	*Chen caerulescens*				
Canada Goose	*Branta canadensis*				Aerial Waterfowl, Incidental
Tundra Swan	*Cygnus columbianus*				
American Wigeon	*Anas americana*				Incidental
Mallard	*Anas platyrhynchos*				Aerial Waterfowl
Gadwall	*Anas strepera*				
Canvasback	*Aythya valisineria*				
Ruddy Duck	*Oxyura jamaicensis*				
Blue-winged Teal	*Anas discors*				
Northern Shoveler	*Anas clypeata*				
Northern Pintail	*Anas acuta*				
Green-winged Teal	*Anas crecca*				
Redhead	*Aythya american*				
Ring-necked Duck	*Aythya collaris*				Aerial Waterfowl, Incidental
Greater Scaup	*Aythya marila*				
Lesser Scaup	*Aythya affinis*				Aerial Waterfowl
Surf Scoter	*Melanitta perspicillata*				Aerial Waterfowl, Incidental
White-winged Scoter	*Melanitta fusca*				Aerial Waterfowl
Long-tailed Duck	*Clangula hyemalis*				
Bufflehead	*Bucephala albeola*				Songbird, Aerial Waterfowl, Incidental
Common Goldeneye	*Bucephala clangula*				Aerial Waterfowl
Hooded Merganser	*Lophodytes cullatus*				
Common Merganser	*Mergus merganser*				Songbird, Aerial Waterfowl, Incidental
Red-breasted Merganser	*Mergus serrator*				
Ruffed Grouse	*Bonasa umbellus*				

Appendix 1 cont.

Common Name	Scientific Name	At Risk Designation			Detected/Program[2]
		SKCDC[1]	COSEWIC	SARA	
Spruce Grouse	*Falcipennis canadensis*				Songbird, Incidental
Willow Ptarmigan	*Lagopus lagopus*				Winter Tracking
Sharp-tailed Grouse	*Tympanuchus phasianellus*				
Red-throated Loon	*Gavia stellata*	S1B, S1M			
Pacific Loon	*Gavia pacifica*	S3M			
Common Loon	*Gavia immer*		Not at Risk		Songbird, Aerial Waterfowl, bats Incidental
Red-necked Grebe	*Podiceps grisegena*		Not at Risk		
Horned Grebe	*Podiceps auritus*	S5B, S5M	Special Concern	Special Concern	Incidental
Eared Grebe	*Podiceps nigricollis*				
Pied-billed Grebe	*Podilymbus podiceps*				
American Bittern	*Botaurus lentigenosis*				
American White Pelican	*Pelecanus erythrorhynchos*		Not at Risk		
Double-crested Cormorant	*Phalacrocorax auritus*		Not at Risk		
Osprey	*Pandion haliaetus*	S2B, S2M			Aerial Waterfowl, Incidental
Bald Eagle	*Haliaeetus leucocephalus*		Not at Risk		Aerial Waterfowl, Incidental
Northern Harrier	*Circus cyaneus*		Not at Risk		Aerial Waterfowl, Incidental
Golden Eagle	*Aquila chrysaetos*	S3B,S3N,S4M	Not at Risk		
Sharp-shinned Hawk	*Accipiter striatus*		Not at Risk		
Cooper's Hawk	*Accipiter cooperii*		Not at Risk		
Northern Goshawk	*Accipiter gentilis*		Not at Risk		
Broad-winged Hawk	*Buteo platypterus*				
Swainson's Hawk	*Buteo swainsoni*				
Red-tailed Hawk	*Buteo jamaicensis*		Not at Risk		Aerial Waterfowl Incidental
Rough-legged Hawk	*Buteo lagopus*		Not at Risk		
American Kestrel	*Falco sparverius*				
Merlin	*Falco columbarius*		Not at Risk		
Gyrfalcon	*Falco rusticolus*		Not at Risk		
Peregrine Falcon	*Falco peregrinus*	S1B,SNRM	Special Concern	Special Concern	

Appendix 1 cont.

Common Name	Scientific Name	At Risk Designation			Detected/Program[2]
		SKCDC[1]	COSEWIC	SARA	
Sora	*Porzan carolina*				
Virginia Rail	*Rallus limicola*				
Yellow Rail	*Coturnicops noveboracensis*	S3B, S3M	Special Concern	Special Concern	
American Coot	*Fulica americana*		Not at Risk		
Great Blue Heron	*Ardea herodias*				
Sandhill Crane	*Grus canadensis*				Covert Camera
Whooping Crane	*Grus americana*	SXB, S1M	Endangered	Endangered	
Black-bellied Plover	*Pluvialis squatarola*				
American Golden-Plover	*Pluvialis dominica*				
Piping Plover	*Charadrius melodus*	S3B	Endangered	Endangered	
Semipalmated Plover	*Charadrius sempalmatus*				
Killdeer	*Charadrius vociferus*				Songbird
Spotted Sandpiper	*Actitis macularia*				
Solitary Sandpiper	*Tringa solitaria*				Songbird
Willet	*Tringa semipalmata*				
Greater Yellowlegs	*Tringa melanoleuca*				Songbird, Incidental
Lesser Yellowlegs	*Tringa flavipes*				Incidental
Hudsonian Godwit	*Limosa haemastica*	S4M	Threatened		
Marbled Godwit	*Limosa fedoa*				
Ruddy Turnstone	*Arenaria interpres*				
Red Knot	*Calidris canutus*	S2M	Endangered	Endangered	
Sanderling	*Calidris alba*				
Semipalmated Sandpiper	*Calidris pusilla*				
Least Sandpiper	*Calidris minutilla*				
White-rumped Sandpiper	*Calidris fuscicollis*				
Baird's Sandpiper	*Calidris bairdii*				
Pectoral Sandpiper	*Calidris melanotos*				
Dunlin	*Calidris alpina*				
Stilt Sandpiper	*Calidris himantopus*				

Appendix 1 cont.

Common Name	Scientific Name	At Risk Designation			Detected/Program[2]
		SKCDC[1]	COSEWIC	SARA	
Buff-breasted	*Calidris subruficollis*	S4M	Special Concern	Special Concern	
Short-billed	*Limnodromus griseus*				
Long-billed	*Limnodramus scolopaceus*				
Wilson's Snipe	*Gallinago delicata*				
Wilson's Phalarope	*Phalaropus tricolor*				
Red-necked Phalarope	*Phalaropus lobatus*	S4B, S3M	Special Concern		
Parasitic Jaeger	*Stercorarius parasiticus*				
Franklin's Gull	*Leucophaeus pipixcan*				
Bonaparte's Gull	*Chroicocephalus*				Aerial Waterfowl, Incidental
Mew Gull	*Larus canus*				Songbird, Aerial Waterfowl, Incidental
Ring-billed Gull	*Larus delawarensis*				Songbird, Aerial Waterfowl
California Gull	*Larus californicus*				
Herring Gull	*Larus argentatus*				Songbird, Aerial Waterfowl, Incidental
Glaucus Gull	*Larus hyperboreus*	S2N, S2M			
Forster's Tern	*Sterna forsteri*				
Caspian Tern	*Hydroprogne caspia*	S2B, S2M	Not at Risk		
Black Tern	*Chlidonias niger*		Not at Risk		
Common Tern	*Sterna hirundo*		Not at Risk		Aerial Waterfowl
Arctic Tern	*Sterna paradisaea*	S3B, S3M			
Great Horned Owl	*Bubo virginianus*				
Snowy Owl	*Bubo scandiacus*		Not at Risk		
Northern Hawk Owl	*Surnia ulula*	S3B, S5N	Not at Risk		
Short-eared Owl	*Asio flammeus*	S3B, S2N, S3M	Special Concern	Special Concern	
Long-eared Owl	*Asio otus*				
Barred Owl	*Strix varia*	S3			
Great Gray Owl	*Strix nebulosa*	S3	Not at Risk		
Northern Saw-whet	*Aegolius acadicus*				
Boreal Owl	*Aegolius funereus*	S3	Not at Risk		
Common Nighthawk	*Chordeiles minor*	S4B, S4M	Special Concern	Threatened	Bats, Incidental

Appendix 1 cont.

Common Name	Scientific Name	At Risk Designation			Detected/Program[2]
		SKCDC[1]	COSEWIC	SARA	
Ruby-throated Hummingbird	*Archilochus colubris*				
Belted Kingfisher	*Megaceryle alcyon*				Songbird, Incidental
Yellow-bellied Sapsucker	*Sphyrapicus varius*				
Downy Woodpecker	*Picoides pubescens*				
Hairy Woodpecker	*Picoides villosus*				Covert Camera
Three-toed Woodpecker	*Picoides tridactylus*				
Black-backed Woodpecker	*Picoides arcticus*				
Northern Flicker	*Colaptes auratus*				
Pileated Woodpecker	*Dryocopus pileatus*	S3			
Olive-sided Flycatcher	*Contopus cooperi*	S4B, S4M	Special Concern	Threatened	Songbird, Incidental
Western Wood-Pewee	*Contopus sordidulus*				
Yellow-bellied Flycatcher	*Empidonax*				Songbird, Incidental
Alder Flycatcher	*Empidonax alnorum*				Songbird
Least Flycatcher	*Empidonax minimus*				
Eastern Phoebe	*Sayornis phoebe*				
Eastern Kingbird	*Tyrannus tyrannus*				
Northern Shrike	*Lanius excubitor*	S1B, S4N, S4M			
Blue-headed Vireo	*Vireo solitarius*				Songbird
Warbling Vireo	*Vireo gilvus*				
Philadelphia Vireo	*Vireo philadelphicus*				
Red-eyed Vireo	*Vireo olivaceus*				
Blue Jay	*Cynocitta cristata*				
Gray Jay	*Perisoreus canadensis*				Small Mammal Trapping, Songbird, Covert Camera, Incidental
American Crow	*Corvus*				
Common Raven	*Corvus corax*				Songbird, Aerial Waterfowl, Incidental
Black-billed Magpie	*Pica hudsonia*				
Horned Lark	*Eremophila alpestris*				
Tree Swallow	*Tachycineta bicolor*				Songbird
Bank Swallow	*Riparia riparia*	S4B, S5M	Threatened		
Cliff Swallow	*Petrochelidon*				

Appendix 1 cont.

Common Name	Scientific Name	At Risk Designation			Detected/Program[2]
		SKCDC[1]	COSEWIC	SARA	
Barn Swallow	*Hirundo rustica*	S5B, S5M	Threatened		Songbird
Purple Martin	*Progne subis*				
Black-capped Chickadee	*Poecile atricapillus*				
Boreal Chickadee	*Poecile hudsonicus*				Songbird, Incidental
Red-breasted Nuthatch	*Sitta canadensis*				
White-breasted Nuthatch	*Sitta carolinensis*				
Brown Creeper	*Certhia americana*				
Winter Wren	*Troglodytes troglodytes*				Songbird
Sedge Wren	*Cistothorus platensis*		Not at Risk		
House Wren	*Troglodytes aedon*				
Ruby-crowned Kinglet	*Regulus calendula*				Songbird, Incidental
Golden-crowned Kinglet	*Regulus satrapa*				
Mountain Bluebird	*Sialia currocoides*				
Veery	*Catharus fuscescens*				
Gray-cheeked Thrush	*Catharus minimus*				
Swainson's Thrush	*Catharus ustulatus*				Songbird, Incidental
Hermit Thrush	*Catharus guttatus*				Songbird, Bats, Incidental
American Robin	*Turdus migratorius*				Songbird, Incidental
Gray Catbird	*Dumetella carolinensis*				
European Starling	*Sturnus vulgaris*				
American Pipit	*Anthus rubescens*				
Bohemian Waxwing	*Bombycilla garrulus*				
Cedar Waxwing	*Bombycilla garrulus*				Songbird
Tennessee Warbler	*Oreothlypis peregrina*				Songbird
Orange-crowned Warbler	*Oreothlypis celata*				
Yellow Warbler	*Setophaga petechia*				
Magnolia Warbler	*Setophaga magnolia*				
Chestnut-sided Warbler	*Setophaga pensylvanica*				
Black-and-white Warbler	*Mniotilta varia*				
Black-throated Green Warbler	*Setophaga virens*				

Appendix 1 cont.

Common Name	Scientific Name	At Risk Designation			Detected/Program[2]
		SKCDC[1]	COSEWIC	SARA	
Canada Warbler	*Cardellina canadensis*	S4B, S3M	Threatened	Threatened	
Cape May Warbler	*Setophaga tigrina*				
Yellow-rumped Warbler	*Setophaga coronata*				Songbird, Incidental
Palm Warbler	*Setophaga palmarum*				Songbird
Bay-breasted Warbler	*Setophaga castanea*				
Blackpoll Warbler	*Setophaga striata*				
Connecticut Warbler	*Oporornis agilis*	S2B, S2M			
Mourning Warbler	*Geothlypis philadelphia*				
Nashville Warbler	*Oreothlypis ruficapilla*				
Ovenbird	*Seiurus aurocapillus*				
Northern Waterthrush	*Parkesia noveboracensis*				
Common Yellowthroat	*Geothlypis trichas*				
Wilson's Warbler	*Cardellina pusilla*				Songbird
American Redstart	*Setophaga ruticilla*				
Western Tanager	*Piranga ludoviciana*				
American Tree Sparrow	*Spizella arborea*				
Chipping Sparrow	*Spizella passerina*				Songbird, Incidental
Clay-colored Sparrow	*Spizella pallida*				
Vesper Sparrow	*Pooecetes gramineus*				
Savannah Sparrow	*Passerculus sandwichensis*				Incidental
Le Conte's Sparrow	*Ammodramus leconteii*				
Fox Sparrow	*Passerella iliaca*				Songbird, Incidental
Song Sparrow	*Melospiza melodia*				
Lincoln's Sparrow	*Melospiza lincolnii*				Songbird, Incidental
Swamp Sparrow	*Melospiza georgiana*				Songbird
White-throated Sparrow	*Zonotrichia albicollis*				Songbird, Incidental
Harris' Sparrow	*Zonotrichia querula*	SUB, S5M	Special Concern		
White-crowned Sparrow	*Zonotrichia leucophrys*				
Dark-eyed Junco	*Junco hyemalis*				Songbird, Incidental
Lapland Longspur	*Calcarius lapponicus*				

Appendix 1 cont.

Common Name	Scientific Name	At Risk Designation			Detected/Program[2]
		SKCDC[1]	COSEWIC	SARA	
Smith's Longspur	*Calcarius pictus*				
Snow Bunting	*Plectrophenax nivalis*				
Red-winged Blackbird	*Agelaius phoeniceus*				
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*				
Rusty Blackbird	*Euphagus carolinus*	S3B,SUN,S3M	Special Concern	Special Concern	
Common Grackle	*Quiscalus quiscula*				
Brewer's Blackbird	*Euphagus cyanocephalus*				
Brown-headed Cowbird	*Molothrus ater*				
Pine Grosbeak	*Pinicola enucleator*	S2B, S4N			
Rose-breasted Grosbeak	*Pheucticus ludovicianus*				
Purple Finch	*Haemorhous purpureus*				
Red Crossbill	*Loxia curvirostra*				Incidental
White-winged Crossbill	*Loxia leucoptera*				
Common Redpoll	*Acanthis flammea*				
Hoary Redpoll	*Acanthis hornemanni*				
Pine Siskin	*Spinus pinus*				Incidental
House Sparrow	*Passer domesticus*				
Mammals					
Masked Shrew	*Sorex cinereus*				
Dusky Shrew	*Sorex monticolus*				Small Mammal Trapping
Common Water Shrew	*Sorex palustris*				
Arctic Shrew	*Sorex arcticus*				
Pygmy Shrew	*Sorex hoyi*				
Little Brown Bat	*Myotis lucifugus*	S4B, S4N	Endangered	Endangered	Bats
Northern Myotis	*Myotis septentrionalis*	S3	Endangered	Endangered	Bats
Silver-haired Bat	*Lasionycteris noctivagans*				
Big Brown Bat	*Eptesicus fuscus*				
Eastern Red Bat	*Lasiuris borealis*				
Hoary Bat	*Lasiuris cinereus*				

Appendix 1 cont.

Common Name	Scientific Name	At Risk Designation			Detected/Program[2]
		SKCDC[1]	COSEWIC	SARA	
Snowshoe Hare	*Lepus americanus*				Winter Tracking, Covert Camera
Least Chipmunk	*Tamias minimus*				
Woodchuck	*Marmota monax*				
Red Squirrel	*Tamiasciurus hudsonicus*				Winter Tracking, Covert Camera Incidental
Northern Flying Squirrel	*Glaucomys sabrinus*				
North American Beaver	*Castor canadensis*				Incidental
Deer Mouse	*Peromyscus maniculatus*				
Southern Red-backed Vole	*Myodes gapperi*				Small Mammal Trapping
Western Heather Vole	*Phenacomys intermedias*				
Meadow Vole	*Microtus pennsylvanicus*				Small Mammal Trapping
Yellow-cheecked Vole	*Microtus xanthognathus*				
Muskrat	*Ondatra zibethicus*				Bats, Incidental
Northern Bog Lemming	*Synaptomys borealis*				
Meadow Jumping Mouse	*Zapus hudsonius*				
North American Porcupine	*Erethizon dorsatum*				Bats, Covert Camera, Incidental
Coyote	*Canis latrans*				
Grey Wolf	*Canis lupus occidentalis*		Not at Risk		Covert Camera
Red Fox	*Vulpes vulpes*				Winter Tracking, Covert Camera
Black Bear	*Ursus americanus*		Not at Risk		Covert Camera, Incidental
American Marten	*Martes americana*				Winter Tracking, Covert Camera, Pellet
Fisher	*Pekania pennanti*				Winter Tracking
Short-tailed Weasel	*Mustela erminea*				Winter Tracking
Least Weasel	*Mustela nivalis*				
American Mink	*Neovison vison*				Winter Tracking, Pellet
Wolverine	*Gulo gulo*	S2	Special Concern	Special Concern	
Striped Skunk	*Mephitis mephitis*				
River Otter	*Lontra canadensis*	S3			Winter Tracking, Incidental
Canada Lynx	*Lynx canadensis*		Not at Risk		Winter Tracking, Covert Camera
Moose	*Alces americanus*				Winter Tracking, Covert Camera, Incidental

Appendix 1 cont.

Common Name	Scientific Name	At Risk Designation			Detected/Program[2]
		SKCDC[1]	COSEWIC	SARA	
Woodland Caribou	*Rangifer tarandus caribou*	S3	Threatened	Threatened	Winter Tracking, Pellet, Covert Camera, Incidental
Amphibians					
Canadian Toad	*Anaxyrus hemiophrys*		Not at Risk		
Boreal Chorus Frog	*Pseudacris triseriata*		Not at Risk		Incidental
Wood Frog	*Lithobates sylvaticus*				Amphibian, Bats, Incidental
Northern Leopard Frog	*Lithobates pipiens*	S3	Special Concern	Special Concern	
Red-sided Garter Snake	*Thamnophis sirtalis*				

1 SKCDC rankings presents for species ranked S3 or lower (breeding population for avian species)
2 Species detections included visual/auditory observations, scat/pellet groups, winter tracking trails and general sign

SKCDC Ranking:
B: for a migratory species, applies to the breeding population in the province
N: for a migratory species, applies to the non-breeding population in the province
M: for a migratory species, rank applies to the transient (migrant) population
U: status is uncertain in Saskatchewan because of limited or conflicting information (unrankable)
X: believed to be extinct or extirpated from the province
NR: rank is not yet assigned or species has not yet been assessed (not ranked)
1: Critically Imperiled/ Extremely rare
2: Imperiled/Very rare
3: Vulnerable/Rare to uncommon
4: Apparently Secure
5: Secure/Common
Saskatchewan Conservation Data Centre (SK CDC) go to:
http://www.biodiversity.sk.ca
Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and its recommendations for listing, go to:
http://www.cosewic.gc.ca
Species at Risk Act (SARA) and its registry of protected species go to: http://www.sararegistry.gc.ca

Appendix 2. Species Observations during Plant Structural Diversity, Species Richness Assessment and Ecosite Characterization Survey.

Scientific Name	Common name	SKCDC Rank
Trees		
Abies balsamea	Balsam fir	
Picea mariana	Black spruce	
Pinus banksiana	Jackpine	
Shrubs		
Alnus viridis ssp. crispa	Green alder	
Alnus incana ssp. rugosa	Speckled alder	
Amelanchier alnifolia	Saskatoon	
Andromeda polifolia	Bog rosemary	
Arctostaphylos uva-ursi	Common bearberry	
Betula glandulosa	Dwarf Birch	
Betula occidentalis	River Birch	
Betula papyrifera	Paper birch	
Betula pumila	Swamp Birch	
Chamaedaphne calycaluta	Leatherleaf	
Empetrum nigrum	Crowberry	
Gaultheria hispidula	Creeping-Snowberry	
Kalmia polifolia	Pale Laurel	
Larix laricina	Tamarack	
Rhododendron groenlandicum	Common Labrador tea	
Rhododendron tomentosum	Labrador tea	S3
Linnea borealis	Twinflower	
Myrica gale	Sweet gale	
Vaccinium oxycoccos	Small cranberry	
Ribes glandulosum	Skunk currant	
Ribes lacustre	Bristly black currant	
Ribes triste	Swamp red currant	
Rubus idaeus	Raspberry	
Rubus arcticus ssp. acaulis	Nagoon Berry	
Salix bebbiana	Long-beaked Willow	
Salix discolor	Pussy willow	
Salix famelica	Yellow willow	
Salix maccalliana	Velvet-fruited Willow	
Salix myrtillifolia	Myrtle-leaf Willow	
Salix pedicellaris	Bog willow	
Salix planifolia	Diamondleaf willow	
Salix sp.	Unknown willow	

Appendix 2 cont.

Scientific Name	Common name	SKCDC Rank
Shrubs cont'd		
Salix glauca var. villosa	Gray-leaf Willow	S2
Salix serissima	Autumn willow	
Salix silicicola	Blanket-leaf Willow	S2
Salix pentandra	Bay Willow	
Vaccinium myrtilloides	Blueberry	
Vaccinium uliginosum	Bog Whortleberry	
Vaccinium vitis-idaea ssp. minus	Mountain Cranberry	
Graminoids		
Agrostis scabra	Hair Grass	
Calamagrostis canadensis	Blue-joint Reedgrass	
Calamagrostis stricta	Northern reedgrass	
Carex aquatilis	Water sedge	
Carex brunnescens	Short sedge	
Carex canescens	Hoary sedge	
Carex capitata	Capitate sedge	S3
Carex disperma	Two-seeded sedge	
Carex lasiocarpa var. americana	Slender sedge	
Carex limosa	Mud sedge	
Carex oligosperma	Fewseed sedge	
Carex pauciflora	Fewflower sedge	
Carex sp.	Sedge	
Carex tenuiflora	Thin-flowered Sedge	
Carex utriculata	Northwest territory sedge	
Carex magellanica ssp. irrigua	Boreal bog sedge	
Carex lenticularis	Lens-fruited Sedge	
Carex brevior	Fescue Sedge	
Carex interior	Inland Sedge	
Carex livida	Livid sedge	
Eleocharis palustris	Creeping Spike-rush	
Eleocharis nitida	Neat Spike-rush	S3
Eleocharis quinqueflora	Few-flowered Spikerush	
Eriophorum vaginatum var. spissum	Sheathed cottongrass	
Festuca rubra	Red fescue	
Juncus balticus	Baltic rush	
Juncus filiformis	Thread rush	
Juncus alpinoarticulatus	Northern Green Rush	
Juncus bufonius	Toad rush	
Juncus brevicaudatus	Short-tail Rush	
Juncus dudleyi	Dudley's Rush	

Appendix 2 cont.

Scientific Name	Common name	SKCDC Rank
Graminoids cont'd		
Potamogenton sp.	-	
Puccinellia nuttalliana	Nuttall's Salt-meadow Grass	
Trichophorum cespitosum	Tufted Bulrush	
Forbs		
Aralia nudicaulis	Wild sarsaparilla	
Calla palustris	Water Calla	
Callitriche palustris	Vernal Water-starwort	
Caltha palustris	Yellow Marsh-marigold	
Chenopodium album	Lamb's-Quarters	
Cicuta bulbifera	water hemlock	
Coptis trifolia	Threeleaf goldthread	
Cornus canadensis	Bunchberry	
Drosera anglica	English Sundew	S3
Drosera rotundifolia	Round-leaved sundew	
Dryopteris carthusiana	Spinulose woodfern	
Chamerion angustifolium ssp. angustifolium	Fireweed	
Epilobium palustre	Marsh willowherb	
Equisetum arvense	Common horsetail	
Equisetum fluviatile	Swamp Horsetail	
Equisetum sylvaticum	Woodland horsetail	
Equisetum pratense	Meadow Horsetail	
Galium trifidum	Small Bedstraw	
Platanthera obtusata	Small Northern Bog-orchid	
Lycopodium annotinum	Stiff clubmoss	
Lycopus americanus	Water-horehound	
Lysimachia thyrsiflora	Thufted loosestrife	
Mentha arvensis	Wild mint	
Menyanthes trifoliata	Bog Buckbean	
Mitella nuda	Bishop's-cap	
Polygonum achoreum	Striate Knotweed	
Potentilla norvegica	Rough cinquefoil	
Comarum palustris	Swamp cinquefoil	
Pyro sp.	Unknown Pyrola	
Ranunculus lapponicus	Lapland buttercup	
Ranunculus pensylvanicus	Bristly Buttercup	
Rubus chamaemorus	Cloudberry	
Rubus pubescens	Dewberry	
Rumex britannica	Water dock	
Saxifraga tricuspidata	Three-toothed saxifrage	

Appendix 2 cont.

Scientific Name	Common name	SKCDC Rank
Forbs cont'd		
Scheuchzeria palustris	Scheuchzeria	
Sium suave	Water parsnip	
Smilacina trifolia	Three-leaved Salomon's seal	
Symphyotrichum puniceum	Swamp Aster	
Trientalis borealis	Maystar	
Utricularia intermedia	Flatleaf bladderwort	
Viola adunca	Early Blue Violet	
Viola palustris	Marsh violet	
Viola renifolia	Kidney-leaved white violet	
Mosses		
Aulacomnium palustre	Ribbed Bog Moss	
Bryum pseudotriquetrum	Tall Clustered Thread Moss	
Calliergon giganteum	Giant Water Feather Moss	
Calliergon stramineum	Calliergon moss	
Dicranum bonjeanii	Bonjean's Broom Moss	
Dicranum polysetum	Electric Eels	
Dicranum scoparium	Broom fork moss	
Dicranum undulatum	Wavy Dicranum	
Drepanocladus aduncus	Drepanocladus moss	
Drepanocladus unciatus	Brown moss	
Hylocomium splendens	Stair-step moss	
Hypnum cupressiforme	Cypress Pigtail Moss	
Jungermannia exsertifolia	-	
Lophozia sp.	-	
Marsupella emarginata	Notched Rustwort	
Leiomylia anomala	Anomalous flapwort	S3
Pohlia nutans	Copper Wire Moss	
Plagiomnium ellipticum	Marsh Magnificent Moss	
Pleurozium schreberi	Big Red Stem Feathermoss	
Polytrichum commune	Common hair-cap	
Polytrichum juniperinum	Juniper hair-cap	
Polytrichum piliferum	Awned Hair-cap	
Polytrichum strictum	Bog Hair Cap	
Ptilidium ciliare	Ciliate Fringewort	
Ptilidium pulcherrimum	Tree Fringewort	S3
Ptilium crista castrensis	Knight's plume moss	
Rhizomnium pseudopunctatum	Felt Round Moss	
Sphagnum angustifolium	Poor Fen Peat Moss	
Sphagnum capillifolium	Acute-leaved Peat Moss	

Appendix 2 cont.

Scientific Name	Common name	SKCDC Rank
Mosses cont'd		
Sphagnum fuscum	Rusty Peat Moss	
Sphagnum girgensohnii	Girgensohn's Peat Moss	
Sphagnum magellanicum	Midway Peat Moss	
Sphagnum riparium	Shore-growing Peat Moss	
Sphagnum squarrosum	Squarrose Peat Moss	
Sphagnum majus	Greater peat moss	
Straminergon stramineum	Straw-coloured Water Moss	
Tomenthypnum nitens	Golden moss	
Warnstorfia fluitans	Floating Hook Moss	
Lichens		
Cetraria islandica	True Iceland lichen	S3
Cladina mitis	Green reindeer lichen	
Cladina rangiferina	Gray reindeer lichen	
Cladina stellaris	Star-tipped reindeer lichen	
Cladonia borealis	Boreal pixie-cup	S3
Cladonia botrytes	Wooden soldiers	
Cladonia cariosa	Split-peg lichen	
Cladonia cenotea	Powdered funnel lichen	S3
Cladonia chlorophaea	Mealy pixie-cup	
Cladonia coniocraea	Common powderhorn	
Cladonia cornuta	Bighorn cladonia	
Cladonia crispata	Organ-pipe lichen	S3
Cladonia cristatella	British soldiers	S3
Cladonia deformis	Lesser sulphur-cup	
Cladonia fimbriata	Trumpet lichen	
Cladonia gracilis spp. Turbinata	Smooth cladonia	
Cladonia multiformis	Sieve lichen	
Cladonia phyllophora	Felt cladonia	
Cladonia pleurota	Red-fruited pixie-cup	S2
Cladonia pyxidata	Pebbled pixie-cup	
Cladonia sp.	Cladonia lichen	
Cladonia sulphurina	Greater sulphur-cup	S2
Cladonia uncialis	Thorn cladonia	
Cladonia verruculosa	Western wand lichen	
Cladonia scabriuscula	Mealy forked cladonia	S1
Cetraria nivalis	Crinkled snow lichen	S3
Hypogymnia physodes	Monk's-hood lichen	
Icmadophila ericetorum	Candy lichen	

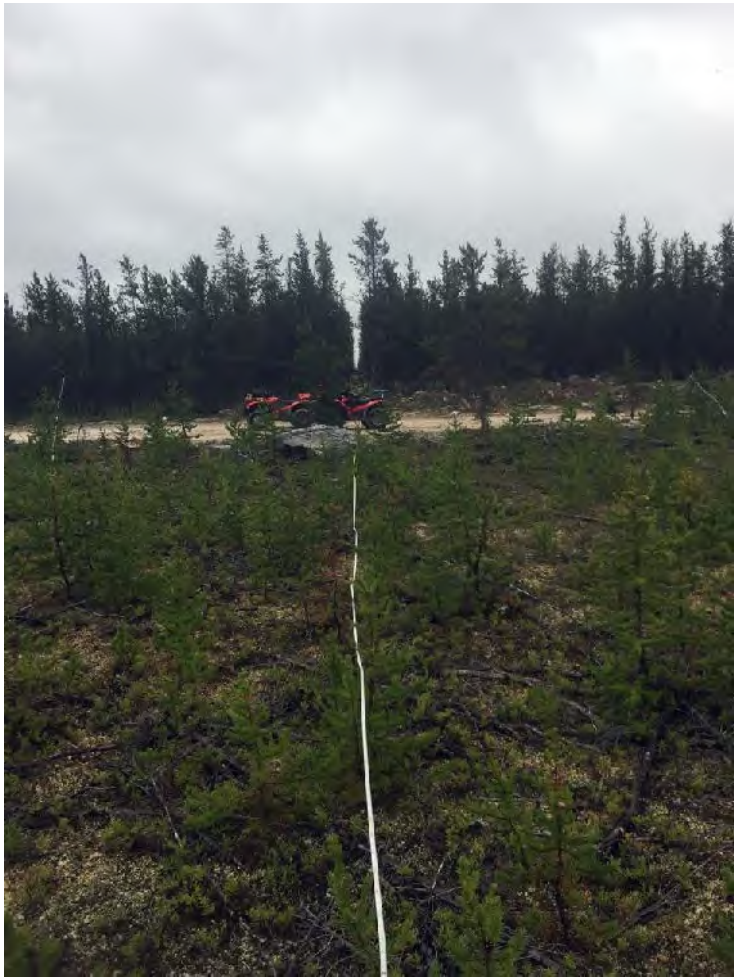
Appendix 2 cont.

Scientific Name	Common name	SKCDC Rank
Lichens cont'd		
Parmeliopsis ambigua	Green starburst lichen	S3
Parmeliopsis hyperopta	Gray starburst lichen	S3
Peltigera aphthosa	Common freckle pelt	S2
Peltigera neopolydactyla	Carpet pelt	
Ramalina pollinaria	Chalky ramalina	S2
Stereocaulon tomentosum	Wolly foam lichen	
Vulpicida pinastri	Powdered sunshine lichen	
Xanthoria fallax	Hooded sunburst lichen	S3

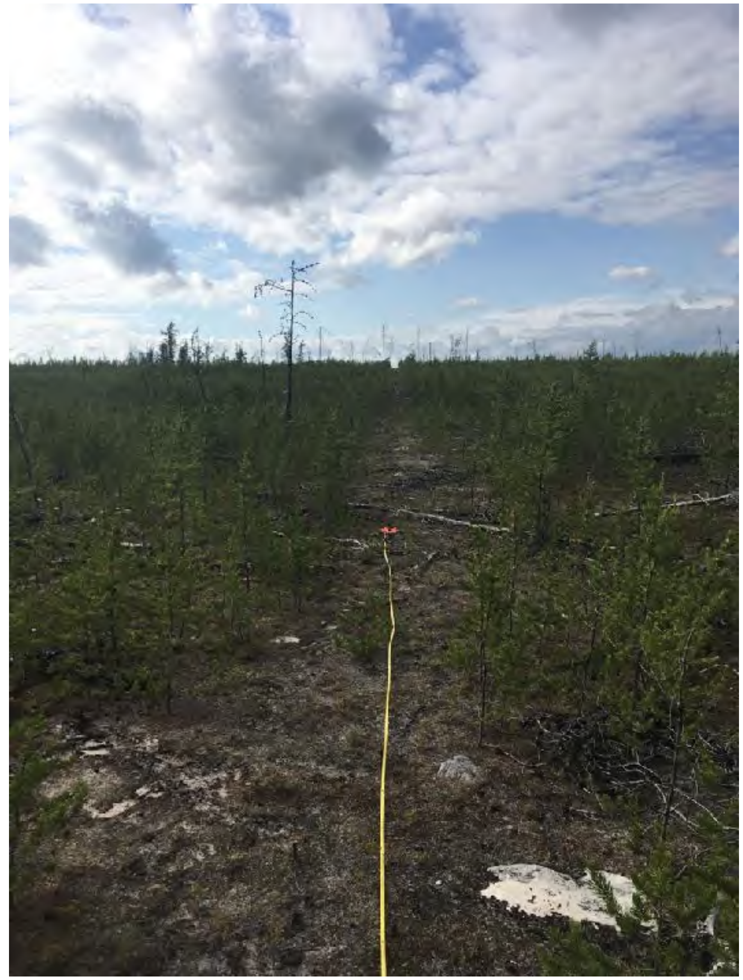
Appendix 3. Transect Details for the Linear Feature Natural Regeneration Assessment.

Transect #	Easting	Northing	Feature Type	Ecosite	Landcover Type	Age Group	Age (years since fire)	Line cut pre or post fire?	Human Use Class
1	476813	6371313	Road	BS3	Upland	Old	71-80	N/A	5
2	474575	6371809	Trail	BS17	Bog	Old	91-100	N/A	1
3	474352	6371768	Handcut	BS18	Bog	Old	71-80	N/A	0
4	477351	6371131	Handcut	RF2	Upland	Young	11-20	Post-fire	0
5	478751	6371016	Road	RF2	Upland	Young	21-30	N/A	5
6	481040	6370932	Handcut	BS17	Bog	Old	91-100	N/A	0
7	480369	6369926	Trail	BS3	Upland	Old	101-110	N/A	3
8	479322	6368607	Trail	BS18	Bog	Young	31-40	N/A	1
9	480949	6373577	Trail	BS3	Upland	Old	61-70	N/A	2
10	482855	6374386	Handcut	BS9	Upland	Old	61-70	N/A	0
11	482103	6375061	Trail	RF1	Upland	Young	31-40	N/A	3
12	479532	6377411	Handcut	RF3	Upland	Young	1-10	Pre-fire	0
13	480400	6378296	Road	BS3	Upland	Old	81-90	N/A	4
14	480794	6379189	Trail	RF2	Upland	Young	1-10	Post-fire	1
15	480251	6378384	Handcut	RF2	Upland	Young	11-20	Post-fire	0
16	475133	6374874	Road	BS17	Bog	Young	31-40	N/A	5
17	473581	6374509	Handcut	RF2	Upland	Young	21-30	Post-fire	0
18	472435	6374145	Trail	RF1	Upland	Young	31-40	N/A	1
19	472233	6373055	Handcut	RF1	Upland	Young	21-30	Post-fire	0
20	471974	6372137	Trail	BS18	Bog	Young	31-40	N/A	1
21	468131	6378012	Trail	RF1	Upland	Young	31-40	N/A	0
22	466904	6377467	Trail	RF3	Upland	Young	1-10	Pre-fire	0
23	471009	6378277	Handcut	BS17	Bog	Old	45-50	N/A	0
24	472575	6378990	Trail	RF1	Upland	Young	31-40	N/A	2
25	474521	6378364	Trail	BS7	Upland	Old	101-110	N/A	4
26	474836	6378215	Handcut	BS3	Upland	Old	51-60	N/A	0
27	476629	6375201	Road	BS9	Upland	Old	71-80	N/A	5
28	477269	6375835	Handcut	RF2	Upland	Young	31-40	N/A	0
29	477820	6375891	Trail	BS3	Upland	Old	51-60	N/A	5
30	477781	6396059	Handcut	BS25	Bog	N/A	N/A	N/A	0
31	478019	6381001	Trail	BS3	Upland	Old	51-60	N/A	5
32	477902	6380689	Handcut	RF2	Upland	Young	1-10	Pre-fire	0
33	475695	6377977	Handcut	BS3	Upland	Old	61-70	N/A	0
34	475645	6376661	Handcut	BS17	Bog	Old	81-90	N/A	0
35	475568	6375893	Handcut	RF2	Upland	Young	31-40	N/A	0
36	474731	6373546	Handcut	BS3	Upland	Old	51-60	N/A	0
37	474454	6372864	Trail	BS17	Bog	Old	51-60	N/A	1
38	471861	6371833	Handcut	BS18	Bog	N/A	N/A	N/A	0
39	473285	6371756	Road	BS9	Upland	Old	61-70	N/A	5
40	473727	6372285	Trail	BS18	Bog	Young	31-40	N/A	2
41	475298	6371828	Handcut	BS3	Upland	Old	61-70	N/A	0
42	477114	6369678	Handcut	BS3	Upland	Old	81-90	N/A	0
43	484881	6373173	Trail	BS3	Upland	Old	51-60	N/A	1
44	481781	6370035	Trail	BS3	Upland	Old	61-70	N/A	2
45	478174	6370968	Handcut	BS3	Upland	Old	71-80	N/A	1
46	475261	6372261	Road	BS3	Upland	Old	61-70	N/A	5

Appendix 4. Example photos from the Linear Feature Natural Regeneration Assessment.



Photograph 2.3-1 Area burned after line creation.



Photograph 2.3-2 Area burned before line creation.


Photograph 2.3-3 Mature upland.


Photograph 2.3-4 Lowland (bog).


Photograph 2.3-5 No human use (0)


Photograph 2.3-6 Low human use (1)


Photograph 2.3-7 Low/Moderate human use (2)


Photograph 2.3-8 Moderate human use (3)


Photograph 2.3-9 Moderate/High human use (4)


Photograph 2.3-10 High human use (5)

Appendix 5. Species Observations during Rare Vascular Plant Survey, July 9 – July 12 2017.

Scientific Name	Common Name	SKCDC
Trees		
Picea mariana	black spruce	
Pinus banksiana	jack pine	
Shrubs		
Alnus viridis ssp. crispa	green Alder	
Arctostaphylos uvi ursi	bearberry	
Betula glandulosa	bog birch	
Chamaedaphne calyculata	leatherleaf	
Myrica gale	sweet gale	
Kalmia polifolia	pale laurel	
Linnaea borealis ssp. americana	twinflower	
Rhododendron groenlandicum	common Labrador Tea	
Salix bebbiana	Bebb's willow	
Salix petiolaris	basket willow	
Vaccinium myrtilloides	blueberry	
Vaccinium oxycoccos	small cranberry	
Vaccinium vitis-idaea	lingonberry	
Grasses		
Agrostis scabra	rough hair grass	
Calamagrostis canadensis	bluejoint	
Deschampsia caespitosa	tufted hair grass	
Sedges, and rushes		
Carex aquatilis	water sedge	
Carex brunnescens ssp. sphaerostachya	brownish sedge	
Carex disperma	two-seeded sedge	
Carex limosa	mud sedge	
Carex oligosperma	few-seeded sedge	
Carex trisperma	**three-fruited sedge**	**S3**
Juncus balticus	baltic rush	
Forbs		
Galium triflorum	sweet-scented bedstraw	
Andromeda polifolia var. polifolia	Bog-rosemary	
Comarum palustre	marsh Cinquefoil	
Coptis trifolia	Goldthread	
Cornus canadensis	bunchberry	
Drosera roundifolia	round-leaved sundew	

Appendix 5 cont.

Scientific Name	Common Name	SKCDC
Forbs		
Equisetum arvense	common horsetail	
Equisetum scirpoides	dwarf scouring rush	
Equisetum sylvaticum	woodland horsetail	
Eriophorum brachyantherum var. brachyantherum	close-sheathed cotton-grass	
Lycopodium annotinum	stiff club-moss	
Maianthemum canadense	two-leaved Solomon's-seal	
Melampyrum lineare var. lineare	American cow-wheat	
Menyanthes trifoliata	bog buckbean	
Rubus chamaemorus	Cloudberry	
Scheuchzeria palustris	American scheuchzeria	
Viola nephrophylla	northern bog violet	
Viola palustris	marsh violet	
Mosses and lichens		
Cladina mitis	green reindeer lichen	
Cladina rangiferina	gray reindeer lichen	
Cladina stellaris	star-tipped reindeer lichen	
Peltigera neopolydactyla	carpet pelt	
Plerozium schreberi	big red stem feathermoss	
Polytrichum juniperinum	juniper hair-cap moss	
Ptilium crista-castrensis	knight's plume	
Sphagnum sp.	peat moss	

Appendix 6. Species Observations during Rare Vascular Plant Survey, July 28 – August 4 2017.

Scientific Name	Common Name	SKCDC Rank
Trees		
Picea mariana	black spruce	
Pinus banksiana	jack pine	
Shrubs		
Alnus viridis ssp. crispa	green Alder	
Arctostaphylos uvi ursi	bearberry	
Betula glandulosa	bog birch	
Chamaedaphne calyculata	leatherleaf	
Myrica gale	sweet gale	
Kalmia polifolia	pale laurel	
Linnaea borealis ssp. americana	twinflower	
Rhododendron groenlandicum	common Labrador Tea	
Salix bebbiana	Bebb's willow	
Salix petiolaris	basket willow	
Salix pyrifolia	balsam willow	
Salix scouleriana	Scouler's willow	
Vaccinium myrtilloides	blueberry	
Vaccinium oxycoccos	small cranberry	
Vaccinium vitis-idaea ssp. minus	mountain Cranberry	
Grasses		
Agrostis scabra	rough hair grass	
Calamagrostis canadensis	bluejoint	
Deschampsia caespitosa	tufted hair grass	
Glyceria grandis	American manna grass	
Sedges, and rushes		
Carex aquatilis	water sedge	
Carex backii	Back's sedge	
Carex brunnescens ssp. sphaerostachya	brownish sedge	
Carex canescens ssp. canescens	hoary sedge	
Carex disperma	two-seeded sedge	
Carex limosa	mud sedge	
Carex oligosperma	few-seeded sedge	
Carex trisperma	**three-fruited sedge**	**S3**
Carex utriculata	small bottle sedge	
Juncus balticus	baltic rush	
Juncus filiformis	thread rush	

Appendix 6 cont.

Scientific Name	Common Name	SKCDC Rank
Forbs		
Galium triflorum	sweet-scented bedstraw	
Andromeda polifolia var. polifolia	Bog-rosemary	
Apocynum androsaemifolium	spreading dogbane	
Campanula rotundifolia	harebell	
Chamerion angustifolium ssp. angustifolium	narrow-leaf Fireweed	
Cicuta maculata	water hemlock	
Comarum palustre	marsh Cinquefoil	
Coptis trifolia	Goldthread	
Cornus canadensis	bunchberry	
Diphasiastrum sitchense	**Alaskan clubmoss**	**S2**
Drosera roundifolia	round-leaved sundew	
Dryopteris carthusiana	spinulose wood-fern	
Equisetum arvense	common horsetail	
Equisetum fluviatile	swamp horsetail	
Equisetum scirpoides	dwarf scouring rush	
Equisetum sylvaticum	woodland horsetail	
Eriophorum brachyantherum var. brachyantherum	close-sheathed cotton-grass	
Eriophorum chamissonis	russet cotton-grass	
Lycopodium annotinum	stiff club-moss	
Lycopodium dendroideum	ground-pine	
Maianthemum canadense	two-leaved Solomon's-seal	
Melampyrum lineare var. lineare	American cow-wheat	
Menyanthes trifoliata	bog buckbean	
Nuphar variegata	yellow cowlily	
Rubus chamaemorus	Cloudberry	
Scheuchzeria palustris	American scheuchzeria	
Sibbaldiopsis tridentata	three-toothed Cinquefoil	
Stuckenia pectinata	Sago Pondweed	
Viola nephrophylla	northern bog violet	
Viola palustris	marsh violet	

Appendix 6 cont.

Scientific Name	Common Name	SKCDC Rank
Mosses and lichens		
Cladina mitis	green reindeer lichen	
Cladina rangiferina	gray reindeer lichen	
Cladina stellaris	star-tipped reindeer lichen	
Peltigera neopolydactyla	carpet pelt	
Plerozium schreberi	big red stem feathermoss	
Polytrichum juniperinum	juniper hair-cap moss	
Ptilium crista-castrensis	knight's plume	
Sphagnum sp.	peat moss	

Appendix 7. Terrestrial and Arboreal Lichen Occurrence by Ecosite Type in the Wheeler River Project Area, 2017/2018.

Ecosite Type	Total Sampling Area (ha)	n	Arboreal Lichen							Terrestrial Lichen		
			% Frequency Occurrence	Frequency by Cover Class								
				1	2	3	4	5	Mean Cover Class	% Frequency Occurrence	Mean % Cover	Importance Value
BS03	9.53	935	96.68	41.04	57.08	1.88	0.00	0.00	1.61	99.36	65.22	6480.26
BS04	0.33	34	88.24	53.33	46.67	0.00	0.00	0.00	1.48	100.00	16.91	1691.00
BS07	0.45	44	97.73	55.81	41.86	2.33	0.00	0.00	1.48	100.00	61.95	6195.00
BS09	0.37	37	89.19	57.58	42.42	0.00	0.00	0.00	1.44	100.00	27.32	2732.00
BS16	0.13	10	100.00	10.00	10.00	50.00	30.00	0.00	3.00	20.00	0.17	3.40
BS17	1.20	115	85.22	60.20	37.76	1.02	1.02	0.00	1.43	95.65	34.83	3331.49
BS18	0.64	63	37.50	70.83	12.50	16.67	0.00	0.00	1.46	89.06	24.92	2219.38
BS19	0.02	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50.00	0.50	25.00
BS21	0.07	7	100.00	85.71	14.29	0.00	0.00	0.00	1.14	71.43	5.71	407.87
BS22	0.17	15	46.67	14.29	42.86	42.86	0.00	0.00	2.29	53.33	4.38	233.59
BS23	0.01	1	100.00	0.00	0.00	0.00	100.00	0.00	4.00	0.00	0.00	0.00
BS24	0.07	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	85.71	4.50	385.70
BS25	0.04	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33	2.00	66.66
BS26	0.09	8	25.00	100.00	0.00	0.00	0.00	0.00	1.00	62.50	4.50	281.25
BS27	0.09	7	28.57	100.00	0.00	0.00	0.00	0.00	1.00	71.43	8.14	581.44
RF03	1.32	131	8.40	90.91	9.09	0.00	0.00	0.00	1.09	74.05	2.51	185.64
RF02	10.44	1042	20.92	95.87	4.13	0.00	0.00	0.00	1.04	98.46	56.74	5586.62
RF01	6.53	646	53.41	93.33	6.09	0.58	0.00	0.00	1.07	98.76	47.26	4667.47
Anthropogenic	0.06	32	21.88	100	0.00	0.00	0.00	0.00	1.00	43.75	8.10	354.38
Recent Burn	0.33	5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**31.88**	**3144**	**55.41**	**61.19**	**36.62**	**1.89**	**0.29**	**0.00**	**1.41**	**96.00**	**52.10**	**5001.60**

Appendix 8. Woody Browse Availability and Use Summary by Ecosite in the Denison Wheeler River Project Area, 2017/2018.

Ecosite	**n**	**Jack Pine (*Pinus banksiana*)**						**Black Spruce (*Picea mariana*)**				
		Frequency %	**Mean PC[1]**	**Importance Value**	**% Browsed[1]**	**Importance Value**		**Frequency %**	**Mean PC[1]**	**Importance Value**	**% Browsed[1]**	**Importance Value**
BS03	935	53.80	6.27	337.38	0.00	0.00		32.09	6.49	208.24	0.00	0.00
BS04	34	8.82	42.50	374.85	0.00	0.00		52.94	9.92	525.16	0.00	0.00
BS07	44	20.45	3.94	80.57	0.00	0.00		95.45	8.76	836.14	0.00	0.00
BS09	37	24.32	7.83	190.43	0.00	0.00		97.30	11.92	1159.82	0.00	0.00
BS16	10	20.00	2.50	50.00	0.00	0.00		60.00	8.33	499.80	0.00	0.00
BS17	115	33.91	8.67	294.00	0.00	0.00		88.70	14.67	1301.23	0.00	0.00
BS18	63	48.44	7.23	350.22	0.00	0.00		81.25	12.60	1023.75	0.00	0.00
BS19	2	100.00	2.50	250.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS21	7	14.29	2.50	35.73	0.00	0.00		71.43	5.10	364.29	0.00	0.00
BS22	15	0.00	0.00	0.00	0.00	0.00		53.33	5.69	303.45	0.00	0.00
BS23	1	100.00	2.50	250.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS24	7	42.86	2.50	107.15	0.00	0.00		28.57	2.50	71.43	0.00	0.00
BS25	3	66.67	2.50	166.68	0.00	0.00		100.00	2.50	250.00	0.00	0.00
BS26	8	37.50	2.50	93.75	0.00	0.00		62.50	2.50	156.25	0.00	0.00
BS27	7	14.29	37.50	535.88	0.00	0.00		100.00	6.07	607.00	0.00	0.00
RF03	131	99.24	46.23	4587.87	0.00	0.00		17.56	5.15	90.43	0.00	0.00
RF02	1042	97.89	58.75	5751.04	0.00	0.00		50.29	13.54	680.93	0.00	0.00
RF01	647	91.96	11.15	1025.35	0.00	0.00		70.79	12.88	911.78	0.00	0.00
Anthropogenic	32	65.63	4.33	284.18	0.00	0.00		9.38	2.50	23.45	0.00	0.00
Recent Burn	5	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
Total	**3145**	**75.12**	**32.29**	**2425.62**	**0.00**	**0.00**		**50.68**	**11.53**	**584.34**	**0.00**	**0.00**

[1] = *Calculated using percent cover/browse only where species/browse is present*

Appendix 8 cont.

Ecosite	n	Alder Spp. (*Alnus spp.*)						Willow Spp. (*Salix spp.*)				
		Frequency %	**Mean PC[1]**	**Importance Value**	**% Browsed[1]**	**Importance Value**		**Frequency %**	**Mean PC[1]**	**Importance Value**	**% Browsed[1]**	**Importance Value**
BS03	935	8.66	8.65	74.94	0.00	0.00		1.93	2.50	4.83	4.17	8.05
BS04	34	35.29	20.67	729.44	0.00	0.00		8.82	2.50	22.05	0.00	0.00
BS07	44	27.27	10.67	290.97	0.00	0.00		6.82	2.50	17.05	0.00	0.00
BS09	37	35.14	6.46	227.00	0.00	0.00		2.70	15.50	41.85	0.00	0.00
BS16	10	0.00	0.00	0.00	0.00	0.00		80.00	16.06	1284.80	11.31	904.80
BS17	115	0.00	0.00	0.00	0.00	0.00		4.35	10.00	43.50	0.00	0.00
BS18	63	0.00	0.00	0.00	0.00	0.00		7.81	2.50	19.53	0.00	0.00
BS19	2	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS21	7	0.00	0.00	0.00	0.00	0.00		57.14	8.88	507.40	0.00	0.00
BS22	15	0.00	0.00	0.00	0.00	0.00		13.33	9.00	119.97	7.75	103.31
BS23	1	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS24	7	0.00	0.00	0.00	0.00	0.00		14.29	2.50	35.73	0.00	0.00
BS25	3	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS26	8	0.00	0.00	0.00	0.00	0.00		75.00	4.58	343.50	0.00	0.00
BS27	7	14.29	2.50	35.73	0.00	0.00		28.57	2.50	71.43	0.00	0.00
RF03	131	24.43	15.39	375.98	0.47	11.48		9.16	4.58	41.95	0.00	0.00
RF02	1042	17.27	11.99	207.07	0.00	0.00		3.26	3.99	13.01	3.75	12.23
RF01	647	28.90	16.75	484.08	0.00	0.00		3.86	4.40	16.98	0.00	0.00
Anthropogenic	32	6.25	2.50	15.63	0.00	0.00		21.88	2.50	54.70	0.00	0.00
Recent Burn	5	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
Total	**3145**	**16.53**	**13.37**	**221.01**	**0.03**	**0.50**		**4.32**	**4.95**	**21.38**	**2.27**	**9.81**

[1] = Calculated using percent cover/browse only where species/browse is present

Appendix 8 cont.

Ecosite	n	Tamarack (*Larix laricina*)						Trembeling Aspen (*Populus tremuloides*)				
		Frequency %	Mean PC[1]	Importance Value	% Browsed[1]	Importance Value		Frequency %	Mean PC[1]	Importance Value	% Browsed[1]	Importance Value
BS03	935	0.00	0.00	0.00	0.00	0.00		0.21	2.50	0.53	0.00	0.00
BS04	34	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS07	44	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS09	37	0.00	0.00	0.00	0.00	0.00		2.70	2.50	6.75	0.00	0.00
BS16	10	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS17	115	10.43	2.50	26.08	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS18	63	7.81	2.50	19.53	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS19	2	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS21	7	71.43	2.50	178.58	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS22	15	26.67	2.50	66.68	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS23	1	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS24	7	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS25	3	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS26	8	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS27	7	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
RF03	131	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
RF02	1042	0.00	0.00	0.00	0.00	0.00		0.10	2.50	0.25	0.00	0.00
RF01	647	0.00	0.00	0.00	0.00	0.00		0.15	2.50	0.38	0.00	0.00
Anthropogenic	32	0.00	0.00	0.00	0.00	0.00		15.63	2.50	39.08	0.00	0.00
Recent Burn	5	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
Total	**3145**	**0.83**	**2.50**	**2.08**	**0.00**	**0.00**		**0.32**	**2.50**	**0.80**	**0.00**	**0.00**

[1] = Calculated using percent cover/browse only where species/browse is present

Appendix 8 cont.

Ecosite	n	Paper Birch (*Betula papyrifera*)						Birch Spp. (*Betula spp.*)				
		Frequency %	Mean PC[1]	Importance Value	% Browsed[1]	Importance Value		Frequency %	Mean PC[1]	Importance Value	% Browsed[1]	Importance Value
BS03	935	0.00	0.00	0.00	0.00	0.00		0.21	2.50	0.53	0.00	0.00
BS04	34	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS07	44	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS09	37	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS16	10	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS17	115	10.43	7.54	78.64	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS18	63	0.00	0.00	0.00	0.00	0.00		17.19	9.14	157.12	0.00	0.00
BS19	2	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS21	7	0.00	0.00	0.00	0.00	0.00		100.00	21.93	2193.00	0.00	0.00
BS22	15	6.67	2.50	16.68	0.00	0.00		33.33	39.00	1299.87	0.00	0.00
BS23	1	0.00	0.00	0.00	0.00	0.00		100.00	37.50	3750.00	0.00	0.00
BS24	7	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS25	3	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS26	8	25.00	2.50	62.50	0.00	0.00		25.00	2.50	62.50	0.00	0.00
BS27	7	0.00	0.00	0.00	0.00	0.00		28.57	2.50	71.43	0.00	0.00
RF03	131	0.00	0.00	0.00	0.00	0.00		0.76	37.50	28.50	0.00	0.00
RF02	1042	0.00	0.00	0.00	0.00	0.00		2.02	4.93	9.96	0.00	0.00
RF01	647	0.46	2.50	1.15	0.00	0.00		1.70	10.36	17.61	0.00	0.00
Anthropogenic	32	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
Recent Burn	5	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
Total	**3145**	**0.19**	**2.50**	**0.48**	**0.00**	**0.00**		**2.38**	**11.29**	**26.87**	**0.00**	**0.00**

[1] = *Calculated using percent cover/browse only where species/browse is present*

Appendix 8 cont.

Ecosite	n	Currant Spp. (*Ribes spp.*) Frequency %	Mean PC[1]	Importance Value	% Browsed[1]	Importance Value		Saskatoon (*Amelanchier alnifolia*) Frequency %	Mean PC[1]	Importance Value	% Browsed[1]	Importance Value
BS03	935	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS04	34	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS07	44	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS09	37	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS16	10	0.00	0.00	0.00	0.00	0.00		10.00	2.50	25.00	0.00	0.00
BS17	115	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS18	63	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS19	2	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS21	7	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS22	15	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS23	1	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS24	7	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS25	3	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS26	8	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS27	7	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
RF03	131	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
RF02	1042	0.10	2.50	0.25	0.00	0.00		0.19	2.50	0.48	0.00	0.00
RF01	647	0.00	0.00	0.00	0.00	0.00		0.15	15.00	2.25	0.00	0.00
Anthropogenic	32	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
Recent Burn	5	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
Total	**3145**	**0.03**	**2.50**	**0.08**	**0.00**	**0.00**		**0.13**	**5.63**	**0.73**	**0.00**	**0.00**

[1] = *Calculated using percent cover/browse only where species/browse is present*

Appendix 8 cont.

Ecosite	n	Sweet Gale (*Myrica gale*)						Cherry Spp. (*Prunus spp.*)				
		Frequency %	Mean PC[1]	Importance Value	% Browsed [1]	Importance Value		Frequency %	Mean PC[1]	Importance Value	% Browsed [1]	Importance Value
BS03	935	1.07	7.60	8.13	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS04	34	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS07	44	4.55	2.50	11.38	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS09	37	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS16	10	70.00	31.07	2174.90	11.31	791.70		0.00	0.00	0.00	0.00	0.00
BS17	115	16.52	9.50	156.94	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS18	63	17.19	11.18	192.18	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS19	2	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS21	7	14.29	2.50	35.73	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS22	15	40.00	15.25	610.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS23	1	100.00	75.00	7500.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS24	7	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS25	3	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS26	8	62.50	10.00	625.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
BS27	7	14.29	2.50	35.73	0.00	0.00		0.00	0.00	0.00	0.00	0.00
RF03	131	1.53	8.75	13.39	0.00	0.00		0.00	0.00	0.00	0.00	0.00
RF02	1042	1.63	6.29	10.25	0.00	0.00		0.00	0.00	0.00	0.00	0.00
RF01	647	2.01	11.73	23.58	0.00	0.00		0.15	2.50	0.38	0.00	0.00
Anthropogenic	32	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
Recent Burn	5	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
Total	**3145**	**3.02**	**11.58**	**34.97**	**0.05**	**0.00**		**0.03**	**2.50**	**0.08**	**0.00**	**0.00**

[1] *= Calculated using percent cover/browse only where species/browse is present*

Appendix 9. Wildlife Covert Camera Photo Captures in the Denison Wheeler River Project Area.

Camera 15 (Road) - Grey Wolf (*Canis lupus*)

Camera 9 (Trail) - Grey Wolf (*Canis lupus*)

Camera 12 (Handcut) - Woodland Caribou (*Rangifer tarandus caribou*)

Camera 16 (Handcut) - Woodland Caribou (*Rangifer tarandus caribou*)

Camera 20 (Trail) - Woodland Caribou (*Rangifer tarandus caribou*)

Camera 10 (Handcut)- Moose (*Alces alces*)

Camera 9 (Trail) - Moose (*Alces alces*)

Camera 15 (Road) - Black Bear (*Ursus americanus*)

Camera 17 (Trail) - Black Bear (*Ursus americanus*)

Camera 19 (Trail) - Lynx (*Lynx canadensis*)

Camera 7 (Trail) - Lynx (*Lynx canadensis*)

Camera 19 (Handcut) - Red Fox (*Vulpes vulpes)*

Camera 3- (Road) Red Fox (*Vulpes vulpes)*

Appendix 10. Local and Indigenous Knowledge.

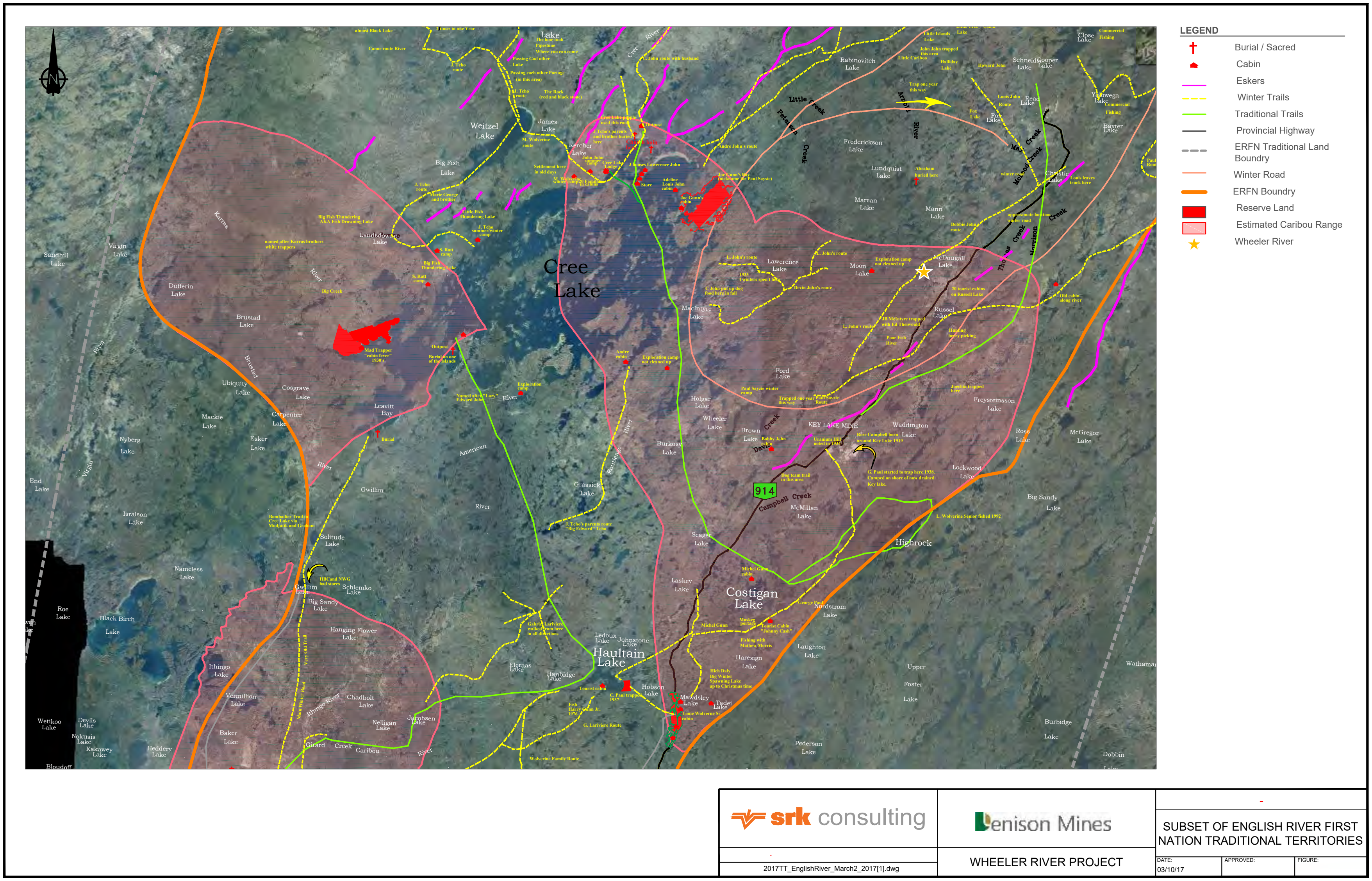


Figure 10-1. Subset of English River First Nation Traditional Territories.

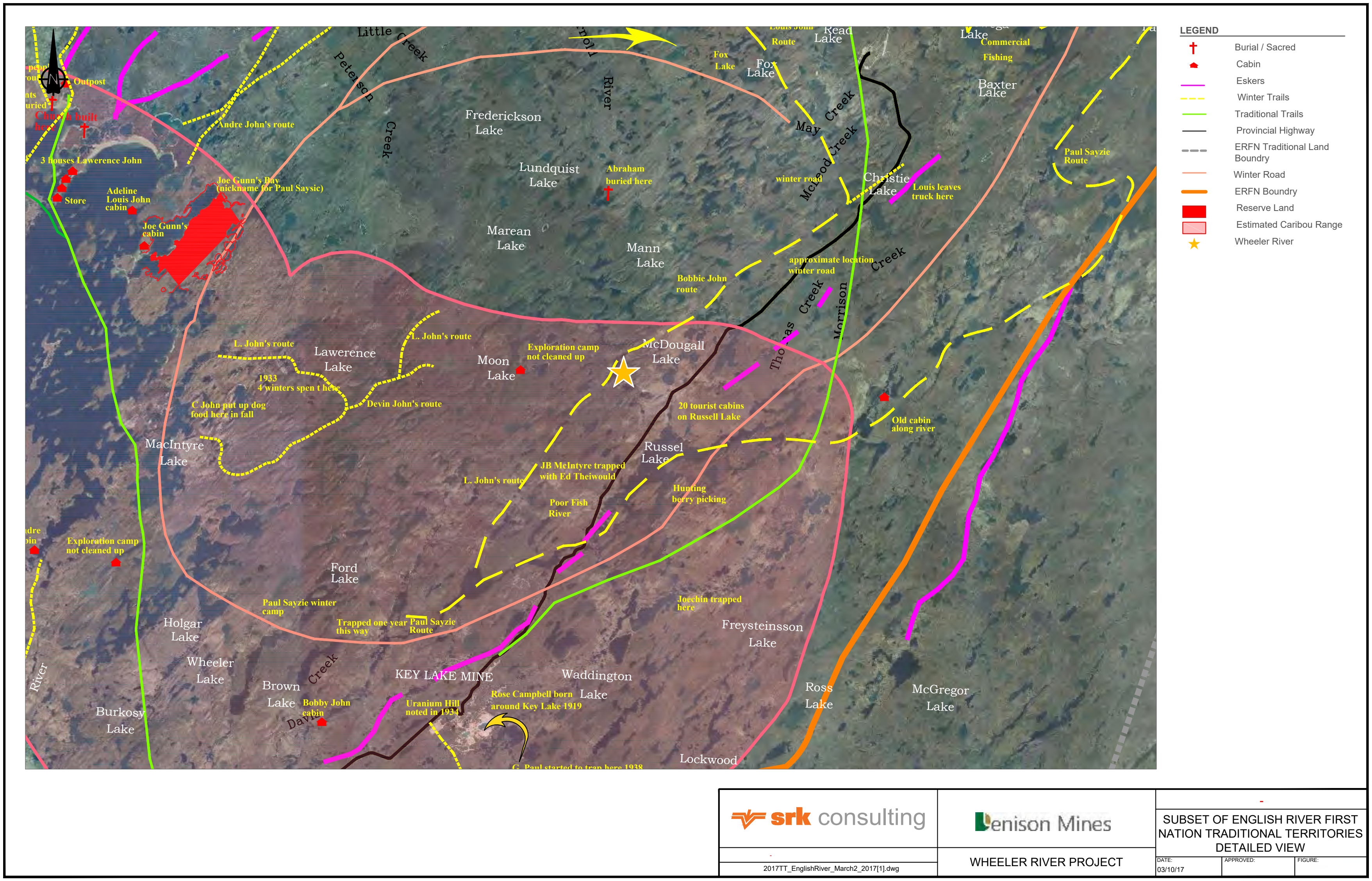


Figure 10-2. Subset of English River First Nation Traditional Territories – Wheeler River Project Area.

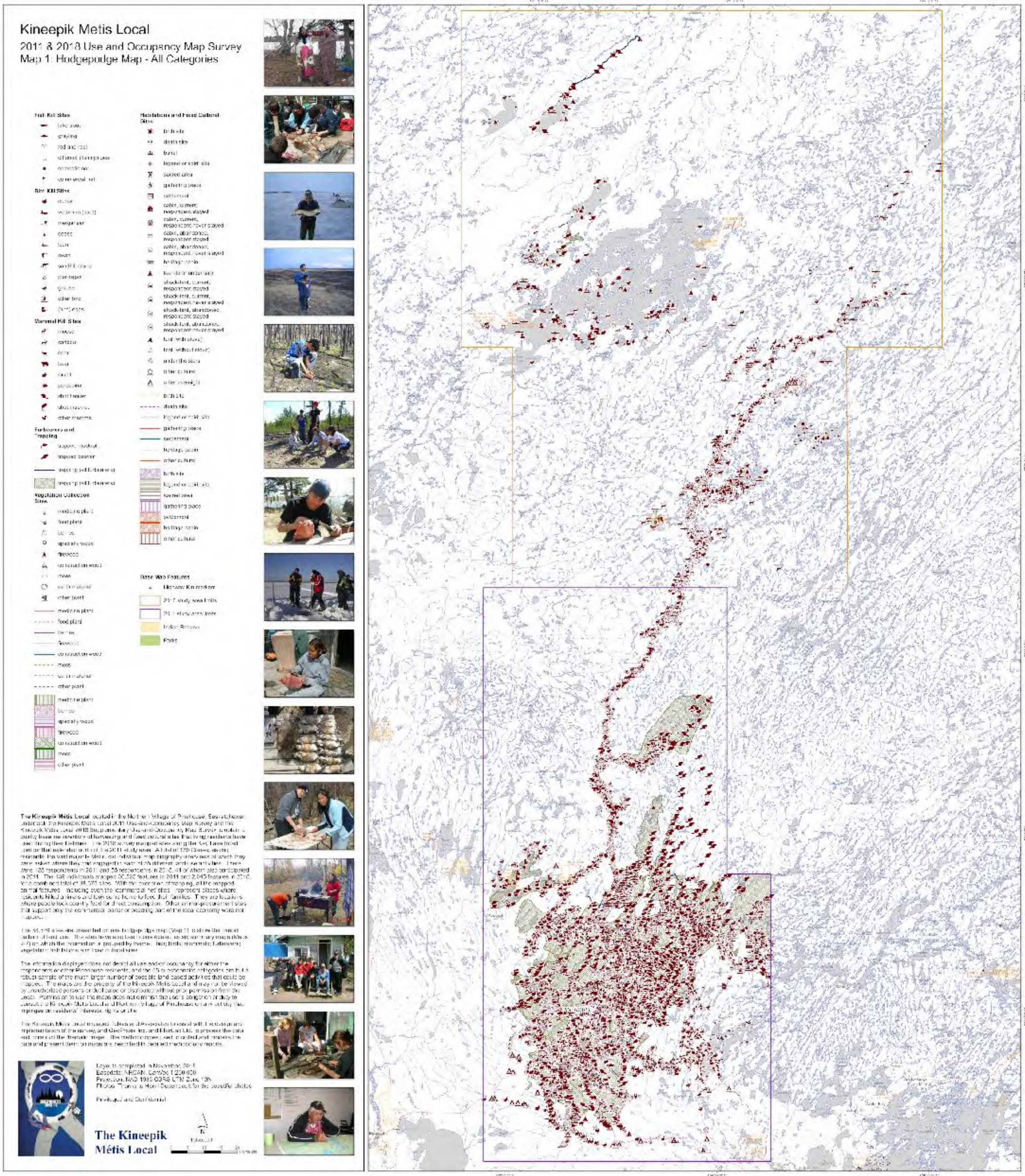


Figure 10-3. Kineepik Metis Local – 2011 & 2018 Use and Occupancy Map Survey.

Denison Mines

Wheeler River Project

Final Environmental Impact Statement

November 2024

Powering
PEOPLE, PARTNERSHIPS
AND PASSION.

Appendix 9-C

WHEELER RIVER PROJECT
Annex Report | Soil, Vegetation and Wildlife

Prepared For

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Down to Earth Biology

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

EDI Environmental Dynamics Inc. (EDI) was contracted by Denison Mining Corp. (Denison) in September 2019 to assist with the environmental effects assessment related to the terrain and soils, vegetation, and wildlife components of the Environmental Impact Statement (EIS) for the Wheeler River Project (the Project). Prior to initiating the effects assessment, the discipline leads reviewed the baseline report that had been prepared by Omnia Ecological Services (Omnia). Upon review of the baseline report, areas that required additional information were identified to adequately complete the environmental assessment (EA) for the EIS that is clear, complete and concise, and to a standard that would be accepted and approved as part of to regulatory review. Identified data gaps in Omnia's 2020 Terrestrial Environment Wildlife and Vegetation Baseline Inventory are summarized in Table 1.

The following annex report uses the same terminology and structure provided in the 2020 Terrestrial Environment Wildlife and Vegetation Baseline Inventory. It provides the methods undertaken to acquire the additional baseline information, along with a summary of the information that was compiled for each of the terrain and soils, vegetation, and wildlife components.

Table 1. Identified data gaps for terrestrial baseline components.

Component	Identified Gaps	Requirements for EA
Terrain and Soil	No detailed assessments of terrain or soil were completed. Consideration for soil and terrain attributes not incorporated into the ecosite mapping component.	A desktop review of available literature and spatial inventories will better capture the predominant environmental setting of the soil component and provide a necessary point-of-reference to determine appropriate mitigation measures and evaluate Project effects to inform the EA and the reclamation and closure planning.
Vegetation	A description of the ecosite classifications for the Regional Study Area (RSA) was presented; however, the resulting categorization of regenerating forest stands as novel disturbed forest classification types does not follow provincial ecosite classification standards. These regenerating forests make up a large proportion of the RSA, and may have implications for the vegetation and wildlife EA.	A revision of the novel ecosite types to better reflect the provincial ecosite classification scheme will support both the vegetation and wildlife EA. This revision will take into consideration existing field data and the interpreted ecosite mapping product, desktop soils data, available predictive ecosystem mapping (PEM), and topographic information.
Wildlife	The baseline report characterizes the wildlife communities found in the RSA based on presence-absence field surveys or other existing data sources. Two wildlife components were inadequately surveyed and/or described: avian species of management concern (SOMC) and ungulates (woodland caribou and moose).	A description of available information on avian SOMC is required by the regulators as part of the EA, this includes information from field surveys and desktop reviews. Ungulates are important for Indigenous harvesters and other land users. In addition, woodland caribou are listed provincially and federally. Current population information (where available) will support the EA through the assessment of potential Project effects, cumulative effects, and the design of efficient mitigation measures.

2 STUDY AREAS

The spatial boundaries or study areas for the description of the environmental setting associated with the terrain and soils, vegetation, and wildlife components include: Project footprint, Local Study Area (LSA), and Regional Study Area (RSA). As defined in Table 2, these study areas were delineated to capture the spatial extent of potential direct and indirect effects of the Project on each Valued Component (VC) and to understand the context in which the effects can occur. The study areas used in this annex report are the same as those used in the 2020 baseline report (Omnia 2020).

Table 2. Description of spatial boundaries and study areas.

Study Area	Descriptors
Project Footprint	– The area in which all Project components will be located. It is expected that all physical disturbances resulting from construction, operation and reclamation activities will occur within this area.
Local Study Area (LSA)	– The area established to assess the potential, largely direct effects of the Project on the environment; delineated based on the area over which direct and indirect effects are most likely to occur on VCs. – Defined as the Project footprint plus a 1.7 km buffer (48 km^2). The buffer provided by the LSA was intended to address provincially and federally mandated activity setback distances required for protected species that may be found within the LSA.
Regional Study Area (RSA)	– The area established to assess the potential, largely indirect effects of the Project in the broader, regional context, and provides the regional context over which cumulative effects may occur. – Defined as a 7 km buffer around the LSA (400 km^2). This RSA was designed to capture regional effects on terrestrial resources including wildlife species with large home ranges (Omnia 2020).

3 TERRAIN AND SOIL

3.1 INFORMATION SOURCES

After review of the original Project-specific Wildlife and Vegetation baseline study (Omnia 2020), information pertaining to terrain and soil was only presented at broad scale and coarse resolution. Additional information was required to conduct the effects assessment. Therefore, desktop investigation of available studies, historic surveys and databases relevant to the Project was conducted to further describe existing conditions and environmental context. Where applicable/appropriate, the desktop review included sources relating to the predominant/regional environment to address information gaps. Table 3 summarizes the information sources consulted for development of the mapping products and data summaries for Terrain and Soil. The following sections describe (to the extent practical) the predominant terrain and soil resources within the study area.

Table 3. Existing information for terrain and soil for the Wheeler River Project.

Information Sources	Descriptors and Resolution
Project-Specific Topographic Survey (Denison Mines Corporation 2019)	– Database; 1 m Contours – Ortho/Aerial Imagery
Saskatchewan Mining and Petroleum GeoAtlas (Simpson 1997)	– Database; 1:1MM Scale – Description of surficial geology in Saskatchewan
Soil Landscapes of Canada (SLC) Version 3.2 Soils of Canada Viewer (Soil Landscapes of Canada Working Group 2010)	– Database; 1:1MM Scale – Compilation of Various Soil Surveys (1:20K to 1:250K Scale) – Coverage includes the entire land mass of Canada – Data includes major soil and landscape attributes
Field Guide to the Ecosites of Saskatchewan's Provincial Forests (McLaughlan et al. 2010)	– Reference Guide; 1:20K to 1:50K Scale – Coverage includes all Saskatchewan Ecosections and Ecosites.
The Ecoregions of Saskatchewan (Acton et al. 1998)	– Description of Saskatchewan's ecoregions and defining features
Terrestrial Ecozones of Canada (Wiken 1986)	– Description of Canada Ecological Framework
National Ecological Framework for Canada: Attribute Data (Marshall et al. 1999)	– Database; 1:7.5MM Scale – Hierarchical description of Canada Ecological Framework (Ecozone > Ecoprovince > Ecoregion > Ecodistrict) – Coverage includes the entire land mass of Canada – Data aligns with major soil and landscape attributes
Canada Land Inventory (CLI) (Agriculture and Agri-Food Canada 1998)	– Database; 1:250K Scale – Coverage includes most agricultural lands in Canada – Data includes capability for Agriculture, Forestry, Wildlife, Recreation, Ungulates (circa 1960's, 1970's and early 1980s)
Glacial landforms of northwest Saskatchewan (Norris et al. 2017)	– Description of predominant landforms and geomorphologic processes in northwestern Saskatchewan.

K = 1,000; MM = 1,000,000

3.2 SUMMARY OF BASELINE INFORMATION ACQUIRED

3.2.1 PROJECT LOCATION AND SETTING

The Project is located near the Wheeler River in north-central Saskatchewan within the uranium-rich Athabasca Basin region in the Canadian Shield (i.e., Laurentian Plateau). It is situated within the administrative boundaries of Division No.18, approximately 5 km west of Saskatchewan Highway 914. Current development includes the Key Lake Uranium Mine (closed) and Key Lake Airport located approximately 35 to 40 km south-southwest of the Project; the McArthur River Uranium Mine (currently under care and maintenance) and Cigar Lake Uranium Mine (operational) located approximately 35 to 40 km and 70 km, respectively, north-northeast of the Project. The landscape is characterized by ridges and drumlins, punctuated by glacial kettle lakes and low-lying wetlands that are interconnected by a network of rivers and creeks. The nearest large/major water body is Cree Lake, located approximately 45 to 50 km west of the Project; however, several named and unnamed waterbodies of various sizes are found in proximity to the Project.

The Project is located in the Athabasca Plain, within the Boreal Shield Ecozone (Ecodistrict 339), that is characterized by short cool summers (12ºC mean temperature) and long cold winters (−20.5ºC mean temperature). This ecoregion is classified as having a subhumid high boreal ecoclimate; the mean annual precipitation ranges from 350 to 450 mm. Predominant land use, vegetation composition and ecological assembly are described in further detail in Section 3 Vegetation. Generally, the landscape is composed of undeveloped coniferous forest and various types of wetlands (bogs, fens and swamps). In dry upland areas, vegetation is generally comprised of black spruce and jack pine-dominated species composition. In wet low-lying areas, vegetation is comprised of treed (black spruce, tamarack), shrubby (Labrador tea) or graminoid (sedges) dominated species composition. As shown in Figure 1, the region has undergone previous disturbance associated with various discrete land use activities, including road development and seismic and geologic/mineral exploration; mining is a common regional land use.

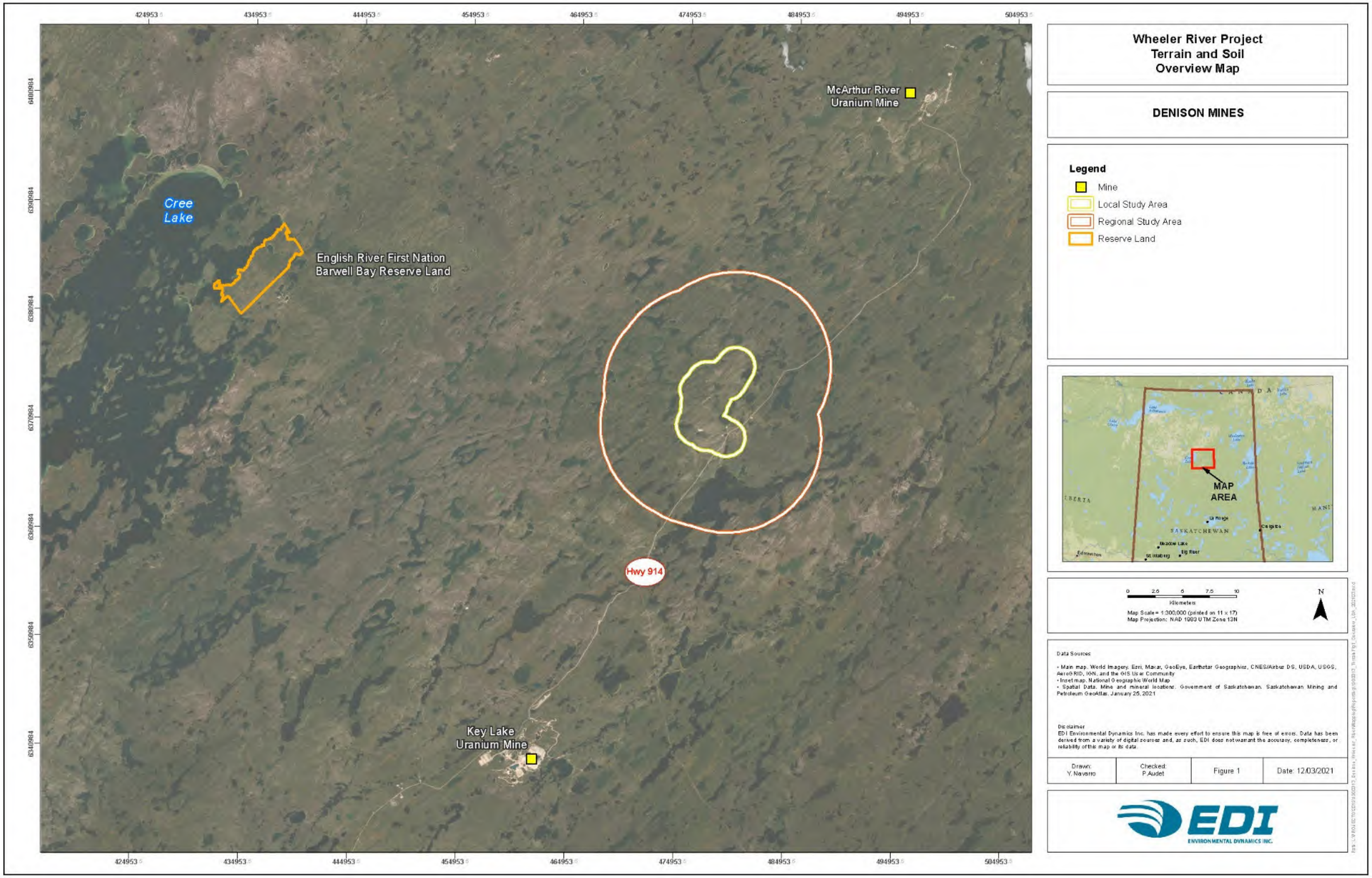

Figure 1. Regional land use map for the Wheeler River Project.

3.2.2 TERRAIN

Terrain morphology within the RSA has been shaped by the last period of glaciation (100,000 to 10,000 years ago) during which the region was covered by the Laurentide Ice Sheet. Geomorphologic processes include deglaciation (glacial retreat) and a combination of erosional and fluvial processes. As shown in Figure 2, landform elements within the RSA are then characterized by eskers (long winding ridges) and drumlins (elongated oval-shaped hills) with only small variations in elevation (ranging 480 to 590 m) resulting in a gently undulating terrain (GeoAtlas ID 7424).

The landscape is punctuated by glacial/proglacial kettle lakes and landscape depressions that are interconnected by a network of rivers and creeks. Based on available ecosite characteristics, the terrain is characterized by slopes ranging from Slope Class A (0 to 3%, little or no slope), Slope Class B (4 to 9% gradient, gentle slopes) and Slope Class C (10 to 15% gradient, moderate slopes). Surface drainage is predominantly rapid or very rapid. The reader should refer to the Project-specific hydrogeological study (Ecometrix 2021) for characterization of surface drainage patterns and processes.

Parent materials are associated with glacio-fluvial and morainal deposits (quartzite) originating from Proterozoic sandstone; surface textures are predominantly sand textured (sand, loam sand/sandy loam and silty sand). Insights on the landscape stability can be gained based on characteristics of terrain, landform elements and surface materials.

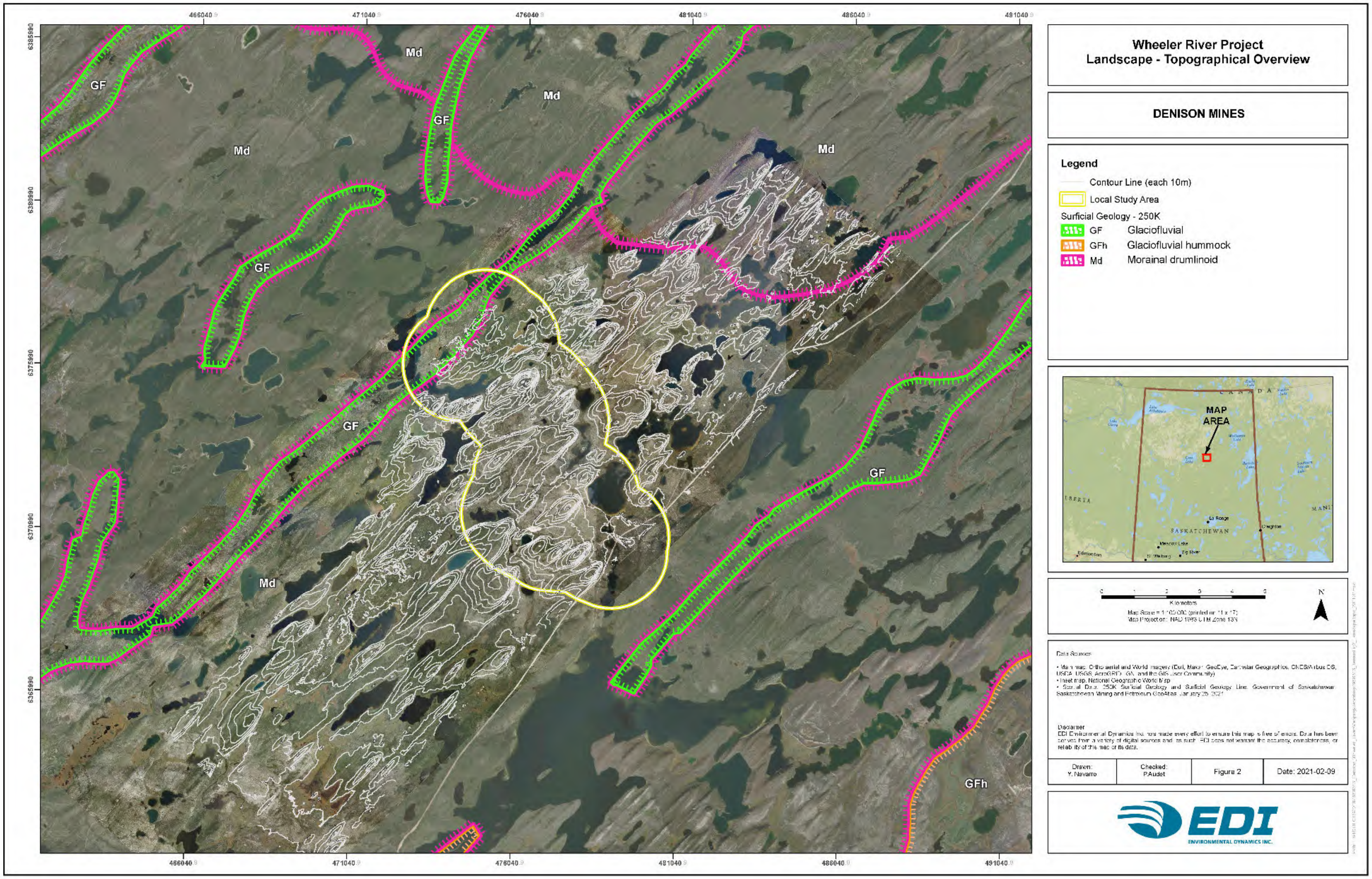

Figure 2. Terrain contours and geomorphology for the Wheeler River Project.

3.2.3 SOIL

As shown in Figure 3, Brunisols predominate the Athabasca Plain Ecozone and are considered the primary soil order within the RSA (Soil Landscapes of Canada, Soil ID 47054022). Regosols and Organic Fibrisols also occur, as well as discrete/sporadic Organic Cryosols.

Brunisols form under forest systems and are characterized by a defined Ae (eluviated) or Aeh (eluviated humic) horizon that is underlain by Bm (modified) and/or Bf (with clay and/or mineral inclusions) horizons that are physico-chemically similar to the parent material. Regosols are characterized by a thin Ah (humic) horizon but hold no recognizable (or only weakly defined) B horizon due to their relatively early/young pedogenic development. Organic Fibrisols are composed largely of organic fibric materials (Of) originated from readily identifiable botanical origin. Organic Cryosols are also composed of organic materials, but necessarily characterized by the presence of permafrost and/or cryoturbation. Based on available ecosite characteristics, mineral soils within the RSA refer to Sandy Dystric Brunisols that are typically acidic, hold low fertility and organic matter content, and lack a well-developed mineral-organic surface horizon. As such, the effective rooting depths (referring to the upper portion of the rooting zone where vegetation mostly access nutrients and water) can be relatively shallow (<30 cm). Topsoil profiles — representing the soil's uppermost and most bioactive portion — are composed of a thin surface organic layer (LFH, Litter-Ferment-Humus) followed by a thin, sand-textured Ae or Aeh. Subsoils are then composed of a characteristically sand-textured Bm and/or Bf horizon of variable depth followed by sand-textured BC or C horizons and/or R horizon (bedrock). Meanwhile, low-lying depressions within the RSA are commonly defined by the presence of wetlands (bogs, fens and swamps) and, therefore, the occurrence of organic soils. Organic soil profiles are likely characterized by a thin LFH followed by Of (fibric), Om (mesic) and/or Oh (humic) horizons of variable depths (depending on the wetland classification). Subsoils are characterized by sand-textured Cg (gleyed) horizon and/or R horizon. Generalized mineral and organic soil profile descriptors are shown in Figure 4.

Insights on soil salvage potential (i.e., the ability to strip and store the material) and soil erosion potential can be gained based on soil profile characteristics and composition, including horizon depths, texture, effective rooting depths, coarse fragment content and organic matter content. Interpretations on the specific soil salvage potential of landscape features within the RSA are speculative in the absence of field data.

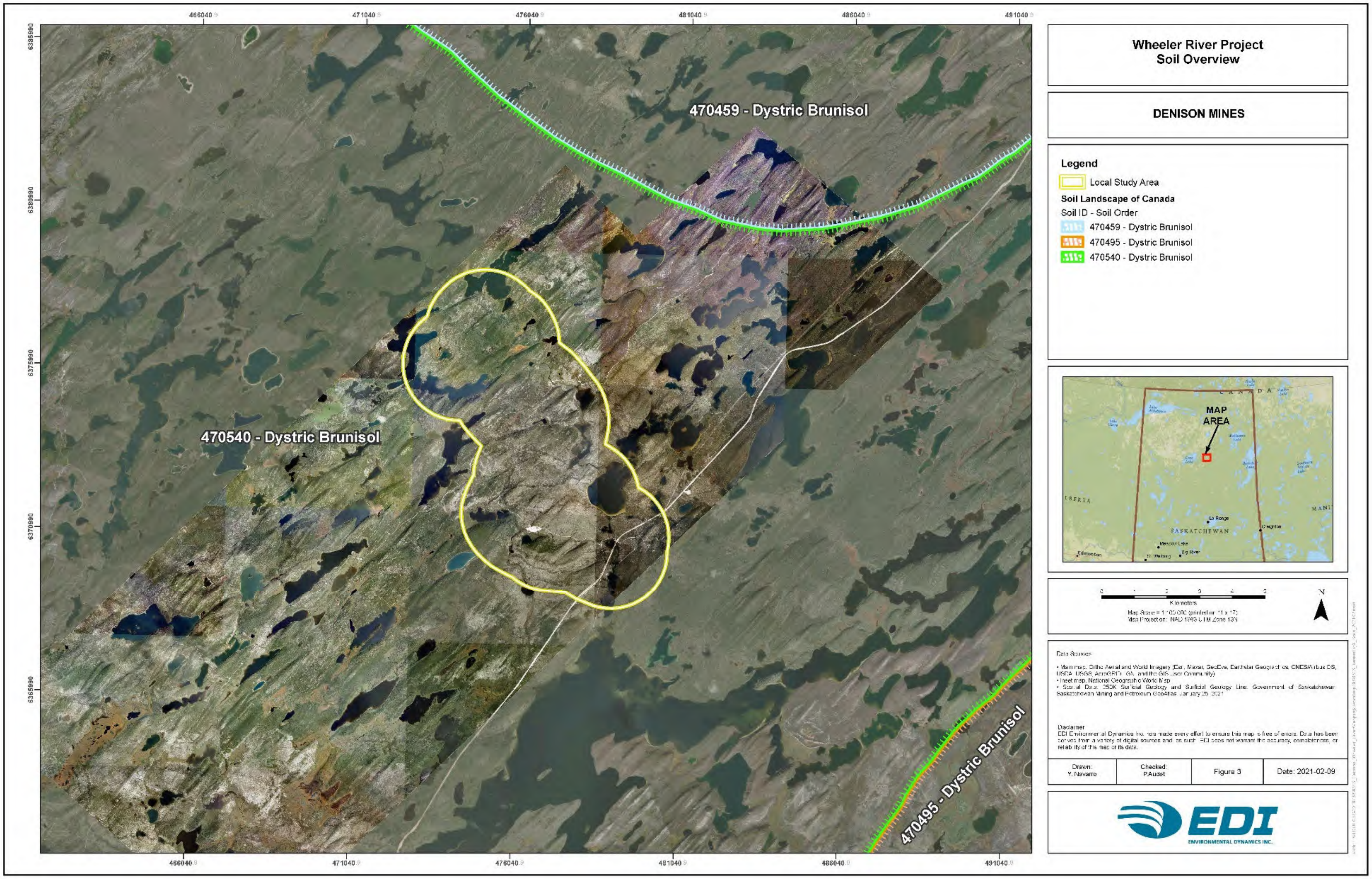

Figure 3. Predominant soil orders for the Wheeler River Project.

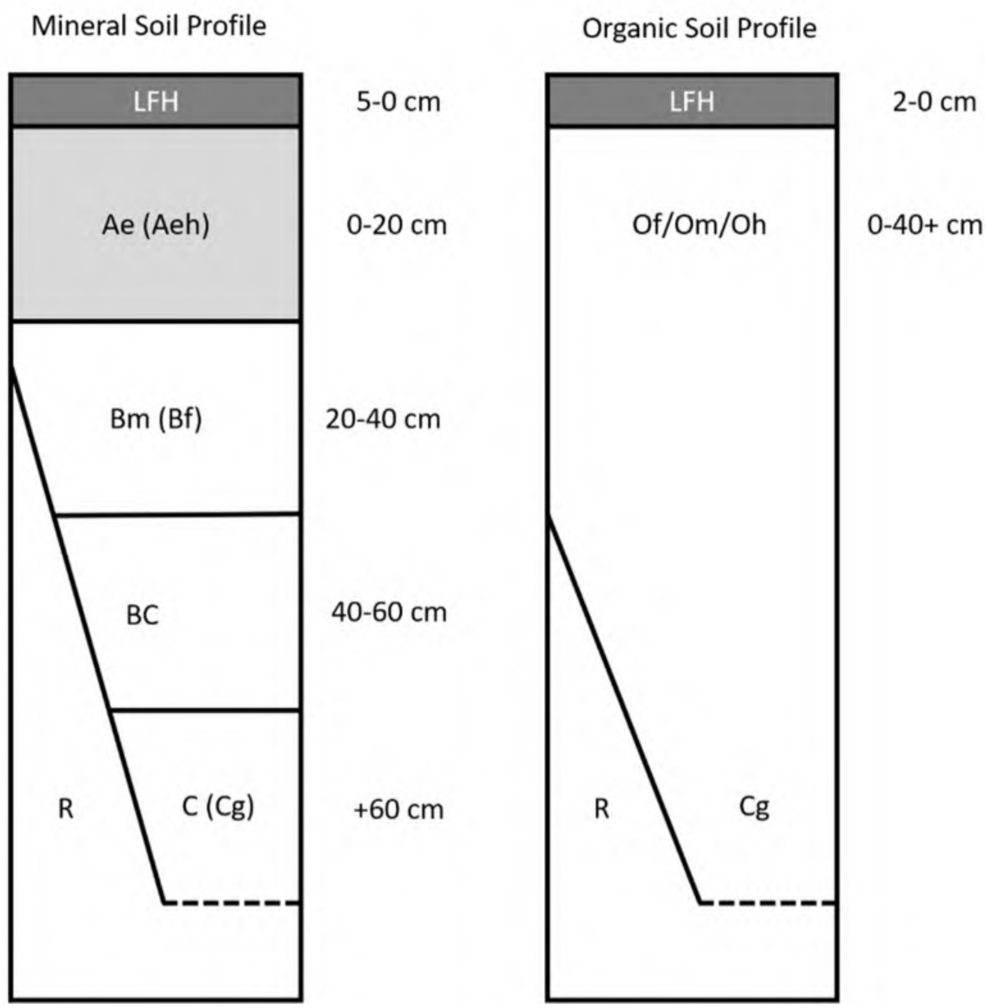

Figure 4. Mineral and organic soil profiles.

Note: Adapted from McLaughlan et al. (2010)

4 VEGETATION

The vegetation component of Project baseline studies presented a description of the ecosite classifications within the RSA. These ecosite classifications were summarized within a 1:20,000 interpreted ecosite mapping product compiled within the RSA with the use of the following inputs:

- 1:5,000 anthropogenic features mapping;
- historical fires data;
- provincial Predicted Ecosite Mapping (PEM);
- current and historical imagery; and,
- field sampling/ground truthing sites (Omnia 2020).

As the Boreal Shield Ecozone experiences a largely natural fire regime that results in the most area burned per unit area and the highest proportion of very large fires (>50,000 ha) in the province (Parisien et al. 2004), much of the vegetation within the RSA (70.6%) is comprised of post-fire regeneration (Omnia 2020). To account for the abundance of regenerating ecosystems within the RSA, the original interpreted ecosite mapping product categorized disturbed forest stands as novel regenerating forest types.

These novel regenerating forest types provide information about forest structure, differentiating among recently disturbed areas dominated by low shrub, tall shrub, and young forest; however, they do not describe dominant biotic (e.g., vegetation species and relative abundance) and abiotic (e.g., moisture and nutrient regimes) processes, or allow for broader ecological interpretation (McLaughlan et al. 2010).

Although these novel regenerating forest types were developed under the assumption that the classification within the *Field Guide to the Ecosites of Saskatchewan's Provincial Forests* does not describe forest types under 40 years of age (Omnia 2020), the guide offers the following advice when working within areas of recent disturbance:

> *"Young (e.g., <40 years old) or modified sites may still be classified according to the guide, but elements or specific features of these sites may vary from the mature natural condition. For both young and modified sites, the reader should anticipate differences in vegetation and are encouraged to supplement their ecosite evaluation with features such as moisture regime and other soil attributes".*

As such, while the provincial ecosite descriptions have been developed to represent the "average natural and mature site condition", they are still valid within disturbed landscapes. Accordingly, to bring this interpreted ecosite mapping product in line with provincial ecosite descriptions, a desktop revision was completed for polygons described with novel regenerating forest types to better reflect the provincial ecosite classification.

4.1 METHODS

Accepted provincial ecosite classification allows for broader ecological interpretation, providing information about soil moisture and nutrient regimes and vegetation community composition and successional trajectories. Thus, novel regenerating forest types within the interpreted ecosite mapping product (Omnia 2020) were reclassified in accordance with accepted provincial ecosites based on available desktop data sources, including:

- Interpreted Ecosite Mapping (Omnia 2020);
- 1 m topographic contours (Denison Mines Corporation 2019);
- soils information (Soil Classification Working Group 1998; Section 3);
- Field Guide to the Ecosites of Saskatchewan's Provincial Forests (McLaughlan et al. 2010); and,
- ecosite descriptions within the Baseline Report (Omnia 2020).

Lower intensity fires are common in the Boreal Shield Ecozone, creating the opportunity for multiple forest age cohorts and diverse structural complexity, which can be important for wildlife habitat (Andison 2013). This diversity of burned and unburned areas was accounted for within the original baseline mapping: in addition to delineating polygon boundaries around burned and unburned areas, Omnia mappers differentiated novel regenerating forest types into low shrub (<1 m tall, 5-20 years old), tall shrub (1–5 m tall, 20–40 years old), and young forest (>5 m tall, 30–50 years old) categories (Omnia 2020).

To retain this level of detail and describe vegetation structure within the RSA, a structure attribute was added to the interpreted ecosite mapping product to match local site conditions and successional trajectories (Table 4). This vegetation structure attribute provides further information about the habitat heterogeneity present within the RSA. It was assumed that all ecosites attributed in accordance with the provincial ecosite guide were present in their "average mature stage", and that any young or modified sites were fully encompassed by polygons described by the novel regenerating forest types (e.g., RF1, RF2, RF3), or anthropogenic features.

Novel regenerating forest types were then reclassified as per provincial ecosite definitions within the Field Guide to the Ecosites of Saskatchewan's Provincial Forests (McLaughlan et al. 2010) based on available spatial datasets and baseline information from Omnia (2020).

Table 4. Vegetation structure definitions used to modify interpreted ecosite mapping for the Wheeler River Project.

Vegetation Structure	Definition
0	Unvegetated – areas that do not support terrestrial vegetation (e.g., paved surfaces, open water).
1	Sparse / bryophyte / lichen – either the initial stages of primary succession, a very early stage of community establishment following a stand-destroying disturbance, or a bryophyte / lichen community maintained by environmental conditions (e.g., bedrock). Bryophytes or lichens can be dominant; time since disturbance is <5 years for normal forest succession; sparse tree, shrub and herb cover: either sparsely vegetated overall, or dominated by bryophytes / lichens.
2	Herb / graminoid – early successional stage or herb community maintained by environmental conditions or disturbance; generally dominated by herbs (forbs, graminoids), although herb cover can be low if sparsely vegetated overall as long as herbs characterize the vegetation; trees and shrubs are usually absent or sparse; time since disturbance is <5 years for normal forest succession; many non-forested communities are perpetually maintained in this stage.
3a	Low shrub – dominated or characterized by shrubby vegetation <1 m tall; time since disturbance 5-20 years for normal forest succession.
3b	Tall shrub – dominated or characterized by shrubby vegetation that is 1-5 m tall; time since disturbance 20-40 years for normal forest succession.
5	Young forest – dominated by trees >5 m tall; forest canopy may have begun to differentiate into distinct layers; time since disturbance estimated between 30-50 years.
6	Mature forest – trees established after the last stand-replacing disturbance have matured; shrub and herb understories well developed; time since disturbance is 50+ years.

Notes:

Modified from the *Field Manual for Describing Terrestrial Ecosystems* (B.C. Ministry of Environment, Lands, and Parks, and B.C. Ministry of Forests 1998).

4.2 RESULTS

Project-specific vegetation structure attributes were assigned in accordance with the definitions in Table 4, based on the "average mature stage" of each ecosite (McLaughlan et al. 2010).

Novel regenerating forest types characterized within the original interpreted ecosite mapping product included three upland types and two wetland types (Table 5). The three novel upland regenerating forest types (RF1-C, RF2-C, RF3-C) were described as structural categories along a natural successional trajectory from a low shrub stage characteristic of recent fire disturbance (RF3-C) toward a young forest stage (RF1-C; Omnia 2020). Vegetation plots within all three novel upland regenerating forest types indicate a dominance of jack pine within the tallest vegetation layer (sometimes co-dominant with black spruce), with blueberry and reindeer lichen dominating the low shrub layer and ground cover, respectively (Omnia 2020; Table 5). Although no soils information was collected during ecosite field verification, vegetation community observations are consistent with the provincial ecosite classification of BS3 (jack pine / blueberry / lichen: moderately fresh sand) and/or BS7 (black spruce / blueberry / lichen: moderately dry sand) (McLaughlan et al. 2010).

Table 5. Novel regenerating forest types, revised ecosites and vegetation structure.

Novel Regenerating Forest Type[1]	Original Ecosite Description[1]	Dominant Tree Species[1]	Revised Ecosite[2]	Vegetation Structure[3]
RF3-C – Regenerating coniferous forest – low shrub <1 m tall (5–20 years)	A pioneer stage following forest fires. Blueberry and jack pine are the most common low shrub species, although cranberry is found in some plots. Scattered tall shrubs include black spruce and jack pine. Commonly encountered in the study area; associated with the hills of eskers and drumlins as well as level plains. Poor in plant and lichen species diversity. The RF3 ecosite is a pioneer stage following forest fires and will succeed towards RF2 in the absence of fire.	Jack pine	BS3 – jack pine / blueberry / lichen or BS7 – black spruce / blueberry / lichen	3a
RF2-C – Regenerating coniferous forest – tall shrub 1–5 m tall (20–40 years)	Usually dominated by a thick cover of tall jack pine stands. Some areas have residual patches of trees. The low shrub layer is dominated by blueberry, with a dominant ground cover of reindeer lichen. RF2 ecosites are relatively poor in vascular species diversity, but lichen diversity is relatively high. Closely resemble the RF1 ecosite but generally younger. Commonly encountered ecosite on the Boreal Shield, associated with the hills of eskers and drumlins as well as level plains. The RF2 ecosite succeeds the RF3 ecosite and will continue to succeed towards RF1 in the absence of fire.	Jack pine	BS3 – jack pine / blueberry / lichen or BS7 – black spruce / blueberry / lichen	3b
RF1-C – Regenerating coniferous forest – treed >5 m tall (30–50 years)	RF1 regeneration stage is usually jack pine dominated. Blueberry and bog cranberry shrubs can be found beneath the tree canopy, along with jack pine and the occasional black spruce and Labrador tea. Bryophytes are sporadically distributed, and the dominant ground cover is reindeer lichen. This phase is on average 40 years old in the study area. RF1 ecosites have a moderate structural diversity and high species richness. They closely resemble the RF2 ecosite but RF1 sites have a greater structural diversity and canopy closure. RF1 can be considered to be a more advanced successional stage than RF2 and will succeed towards a BS3 or BS7 over time.	Jack pine (with components of jack pine, alder and black spruce in shrub layer)	BS3 – jack pine / blueberry / lichen or BS7 – black spruce / blueberry / lichen	5
RF2-B – Regenerating bog – tall shrub 1–5 m tall (20–40 years)	Not described	Not described	BS18 – Labrador tea shrubby bog	3b
RF3-B – Regenerating bog – low shrub <1 m tall (5–20 years)	Not described	Not described	BS18 – Labrador tea shrubby bog	3a

Notes

1 Derived from Omnia 2020.

2 Ecosites as described in McLaughlan et al. 2010.

3 3a — Low Shrub — dominated or characterized by shrubby vegetation <1 m tall; time since disturbance 5 to 20 years for normal forest succession.

3b — Tall shrub — dominated or characterized by shrubby vegetation that is 1-5 m tall; time since disturbance 20 to 40 years for normal forest succession.

5 — Young forest — dominated by trees >5 m tall; forest canopy may have begun to differentiate into distinct layers; time since disturbance estimated between 30 and 50 years.

The jack pine dominated BS3 ecosite is the most common ecosite on the Boreal Shield, occurring in almost every topographic position and slope. It is closely tied with the BS7 ecosite, which can be either dominated by black spruce or a mixture of black spruce and jack pine, and as a result tends to have a greater canopy closure and stem density than the BS3 ecosite. The successional relationship between BS3 and BS7 are interdependent: with sufficient abundance of pine, the BS7 may follow a successional pathway toward BS3, and in the absence of disturbance, BS3 ecosites may transition toward BS7 (McLaughlan et al. 2010).

The two ‘novel wetland regenerating forest’ types (RF2-B and RF3-B) were similarly described as structural categories within fire-disturbed wetland ecosystems. These ‘novel wetland regenerating forest’ types are sparsely distributed, absent from the LSA and representing <0.1% (2.0 ha) and 0.1% (20.2 ha) of the RSA, respectively. Accordingly, little information about these regenerating forest types was provided in the baseline report (Omnia 2020).

The provincial ecosite guide describes four bog ecosites within the Boreal Shield that can represent a successional pathway following disturbance: BS20 (open bog); BS19 (graminoid bog); BS18 (Labrador tea shrubby bog); and BS17 (black spruce treed bog) (McLaughlan et al. 2010). As both ‘novel wetland regenerating forest’ types are defined as different age classes of shrubby bog, both were deemed to fall within the BS18 ecosite. Structural differences associated with the RF2-B (tall shrub) and RF3-B (low shrub) were maintained by assigning structure codes of 3b and 3a, respectively (Table 5).

A summary of the revised ecosite mapping and vegetation structures within the LSA and RSA as is presented in Figure 5 and Figure 6, respectively, as well as summarized in Table 6.

4.3 CONCLUSIONS

These revisions have aligned the Omnia (2020) ecosite mapping product with accepted provincial ecosites (i.e., McLaughlan et al. 2010), while maintaining details about the structural complexity resulting from historic fire disturbance within the RSA. The dominant ecosites within the RSA are upland forested ecosite BS3 (jack pine / blueberry / lichen) and BS7 (black spruce / blueberry / lichen), comprising an estimated 70.1% (Table 6), and the overall composition of ecosites within the RSA appears to be consistent with ecosystems within the Boreal Shield ecozone (McLaughlan et al. 2010).

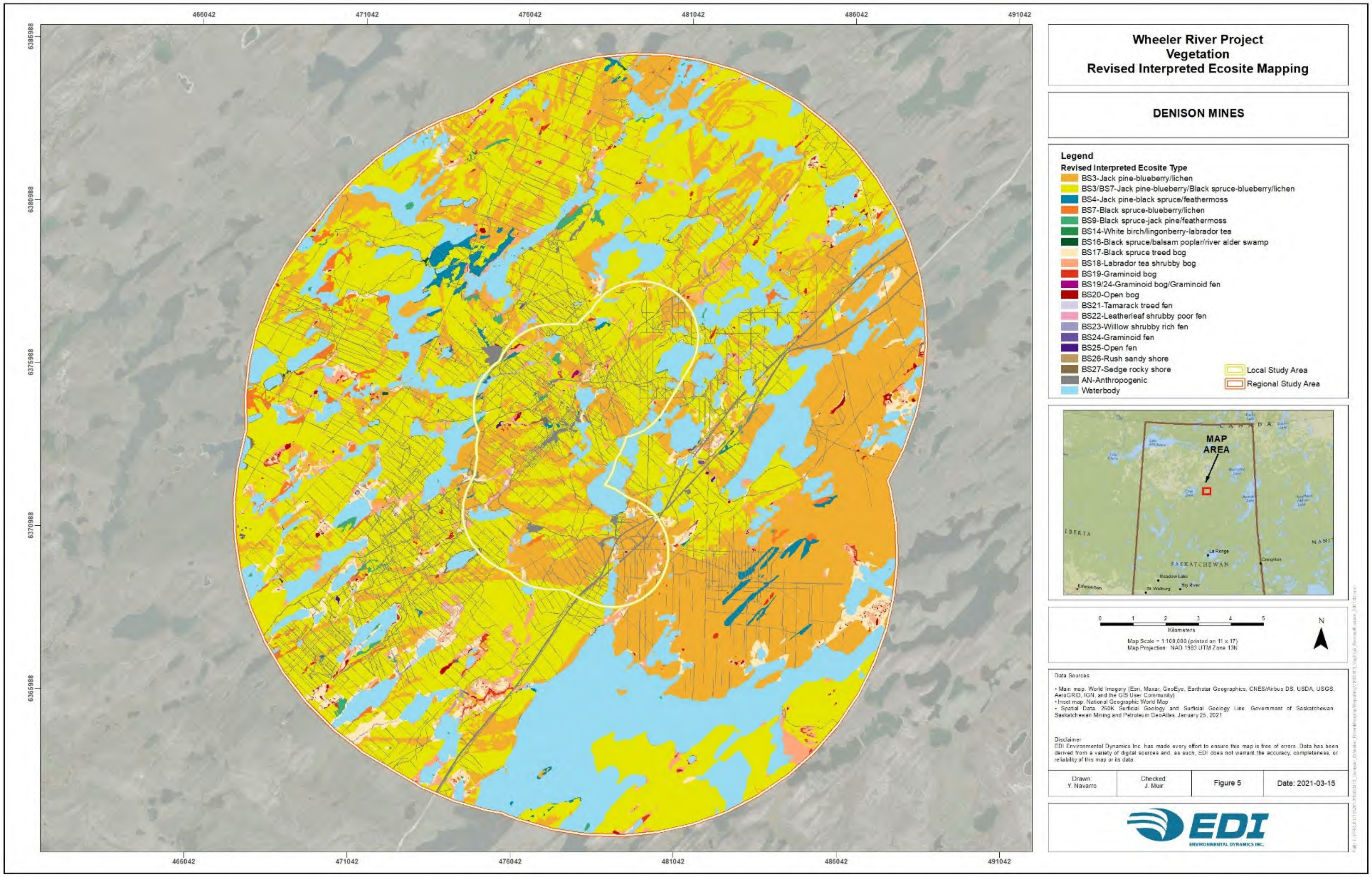

Figure 5. Wheeler River Project - vegetation - revised interpreted ecosite mapping.

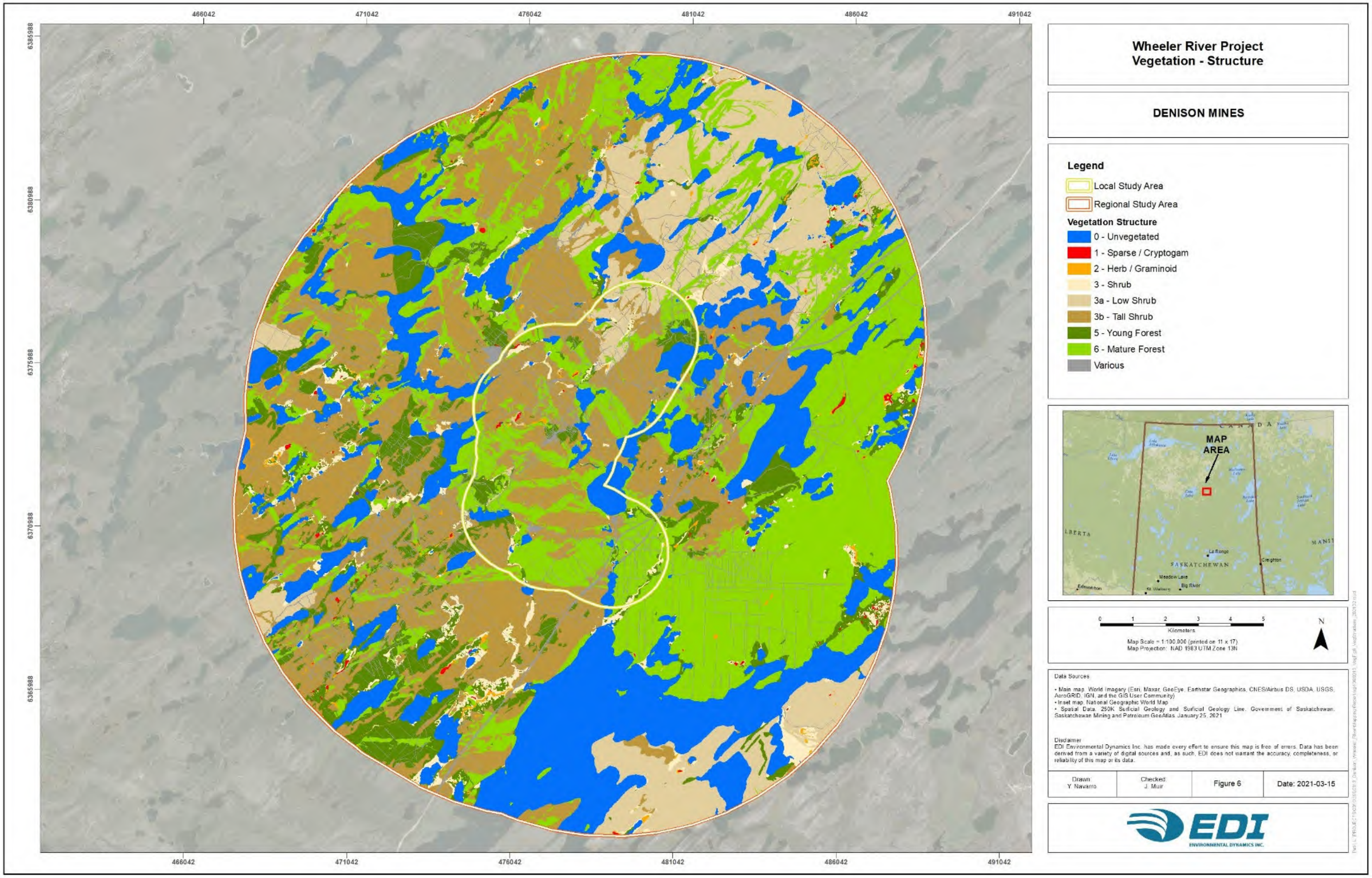

Figure 6. Wheeler River Project vegetation structure.

Table 6. Summary of ecosites and vegetation structure for the Wheeler River Project.

Ecosite Code[1]	Ecosite Description[1]	Structure Code[2]	RSA (ha)	RSA (%)	LSA (ha)	LSA (%)
AN	Anthropogenic	Various[3]	599.0	1.5	166.6	3.5
BS3	Jack pine / blueberry / lichen	6	10,374.8	25.8	1,612.7	33.8
BS3/BS7	Jack pine / blueberry / lichen **or** black spruce / blueberry / lichen	3a	4,556.4	11.3	238.1	5.0
		3b	10,525.5	26.2	1,830.3	38.4
		5	2,412.1	6.0	200.2	4.2
BS4	Jack pine – black spruce / feathermoss	6	332.8	0.8	22.9	0.5
BS7	Black spruce / blueberry / lichen	6	281.0	0.7	9.7	0.2
BS9	Black spruce – jack pine / feathermoss	6	148.5	0.4	15.1	0.3
BS14	White birch / lingonberry – Labrador tea	5	1.8	<0.1	0.3	<0.1
BS16	Black spruce / balsam poplar / river alder swamp	6	8.8	<0.1	--	--
BS17	Black spruce treed bog	5	1,157.1	2.9	82.5	1.7
BS18	Labrador tea shrubby bog	3	967.6	2.4	101.4	2.1
		3a	20.3	0.1	--	--
		3b	2.0	<0.1	--	--
BS19	Graminoid bog	2	160.5	0.4	8.7	0.2
BS19/24	Graminoid bog **or** graminoid fen	2	2.4	<0.1	2.4	0.1
BS20	Open bog	1	65.5	0.2	4.8	0.1
BS21	Tamarack treed fen	5	66.5	0.2	14.8	0.3
BS22	Leatherleaf shrubby poor fen	3a	28.5	0.1	13.2	0.3
BS23	Willow shrubby rich fen	3b	20.9	0.1	3.2	0.1
BS24	Graminoid fen	2	9.0	<0.1	--	--
BS25	Open fen	1	5.7	<0.1	2.1	<0.1
BS26	Rush sandy shore	2	15.1	<0.1	0.9	<0.1
BS27	Sedge sandy shore	2	29.3	0.1	4.2	0.1
Waterbody	--	0	8,381.6	20.9	436.1	9.1
		Total	**40,172.5**	**100.0**	**4,770.2**	**100.0**

Notes:

1 Ecosystems are described in detail in the *Guide to the Ecosites of Saskatchewan's Provincial Forests* (McLaughlan et al. 2010).

2 Modified from the *Field Manual for Describing Terrestrial Ecosystems* (B.C. Ministry of Environment, Lands, and Parks, and B.C. Ministry of Forests 1998). Project-specific structure codes are further described in Table 4.

3 Areas of anthropogenic disturbance have various vegetation structures depending on the intensity and duration of the original disturbance, as well as the time elapsed since disturbance.

5 WILDLIFE

The information presented in the Terrestrial Environment Wildlife and Vegetation Baseline Inventory (Omnia 2020) characterizes the wildlife communities found in the RSA based on several 2017 to 2019 presence-absence field surveys or other existing data sources. However, there were two wildlife components that were subsequently identified as requiring additional information to fully describe the wildlife assemblage in the RSA: avian species of management concern (SOMC) and ungulates (i.e., woodland caribou [*Caribou tarandus caribou*] and moose [*Alces alces*]).

This section describes EDI's approach to acquire the information as part of a desktop exercise and consultations with provincial species specialists for avian SOMC and ungulates, and describes the information obtained through this process that will be used to inform the environmental assessment for the Project.

Avian Species of Management Concern

To detect avian species (including SOMC) in the RSA, Omnia (2020) conducted breeding songbird point count surveys and one aerial waterfowl and raptor stick nest survey. These surveys were designed to capture presence of avian species in the RSA (note that Omnia's report uses the term "Phoenix project area" and the figures depicting the resulting observation locations use the LSA and RSA). The Saskatchewan Ministry of Environment (SK MOE) published Species Detection Survey Protocols (SDSP; available through the Government of Saskatchewan Publication Centre 2021) for a variety of avian species (including avian SOMC), however, these protocols were not implemented for Omnia's surveys. The following list includes avian SOMC mentioned as "known to occur or potentially occurring in the project area" (Appendix 1 of the Terrestrial Environment Wildlife and Vegetation Baseline Inventory [Omnia 2020]):

- Common nighthawk (*Chordeiles minor*): the Omnia (2020) document mentions that there were incidental sightings of common nighthawk, and that the observations of individuals and nest locations were mapped (see Figures 3.1 and 3.2). While the observations were incidental and the SK MOE SDSP for common nighthawk was not used, it is assumed that the available data will satisfy the Environmental Impact Statement (EIS) requirements.
- Short-eared owl (*Asio flammeus*): the Omnia (2020) document does not mention any species-specific surveys or incidental observations of this SOMC.
- Yellow rail (*Coturnicops noveboracensis*): the Omnia (2020) document does not mention any species-specific surveys or incidental observations of this SOMC.
- Rusty blackbird (*Euphagus carolinus*): the Omnia (2020) document does not mention any species-specific surveys or incidental observations of this SOMC.

Ungulates

Two ungulate species were included in the baseline field studies and will be considered in the EIS: boreal woodland caribou and moose.

Omnia (2020) conducted several field surveys to identify seasonal presence and habitat use of woodland caribou and moose (and other terrestrial wildlife species), including the following: winter track count surveys, spring pellet group/browse availability transects, and remote camera surveys. No aerial ungulate surveys were completed as part of the baseline investigation because the SK MOE would not provide permits for these surveys. However, the Terrestrial Environment Wildlife and Vegetation Baseline Inventory (Omnia 2020) summarizes several aerial ungulate surveys that were completed between 2008 and 2014 in the Boreal Shield of Saskatchewan (i.e., in the SK1 Woodland Caribou Management Unit, where the Project is located).

5.1 INFORMATION SOURCES

Additional information regarding the three avian SOMC that were not included in Omnia's (2020) report was gathered from the Hunting, Angling, and Biodiversity Information of Saskatchewan (HABISask) database managed by the Saskatchewan Conservation Data Centre (SKCDC).

In an attempt to gather additional information from more recent aerial surveys conducted by the SK MOE and other entities, EDI reached out to regional SK MOE personnel and University of Saskatchewan researchers took place to acquire the data, where publicly available. Details are provided in Section 5.2.2.

5.2 SUMMARY OF BASELINE INFORMATION ACQUIRED

5.2.1 AVIAN SPECIES OF MANAGEMENT CONCERN

A query was initiated and the HABISask database was searched for the above mentioned four avian SOMC within a 10 km radius around the Project (SK MOE 2021). Table 7 provides the results of the search. Note that common nighthawk is also included in the table, in addition to the incidental sightings of this species recorded and mapped in the baseline report (Omnia 2020).

Table 7. Additional information on avian Species of Management Concern for the Wheeler River Project.

Common Name	Scientific Name	Provincial Rank	COSEWIC[1]	SARA Status[2]	Known Occurrences	Descriptions[3]
Common nighthawk	*Chordeiles minor*	S4B, S4M	Special concern	Threatened	Yes	One observation of one individual.
Short-eared owl	*Asio flammeus*	S3B, S2N, S3M	Special concern	Special concern	No	N/A
Yellow rail	*Coturnicops noveboracensis*	S3B, S3M	Special concern	Special concern	No	N/A
Rusty blackbird	*Euphagus carolinus*	S3B, SUN, S3M	Special concern	Special concern	Yes	Several observations in 2019; between one and three adults per observation.

1 Species listed by the Committee on the Status of Endangered Wildlife in Canada.

2 Species listed under the *Species at Risk Act*.

3 Observations in this database did not provide sighting locations.

In addition to the noted occurrences of common nighthawk, there is evidence that rusty blackbird is using habitat within the RSA. Similar sensitive timing windows (e.g., May 1 to August 31) and setback distances from high disturbance activities (e.g., 200 m) to those outlined for common nighthawk, based on the Saskatchewan Activity Restriction Guidelines (SK MOE 2017), should be considered for rusty blackbird (refer to Table 3.1 of the Terrestrial Environment Wildlife and Vegetation Baseline Inventory [Omnia 2020]).

5.2.2 UNGULATES

To update the Omnia (2020) report with more recent aerial ungulate survey data, EDI contacted SK MOE staff and University of Saskatchewan researchers, once approval from Denison was received. After being informed that the University of Saskatchewan conducted recent aerial surveys, attempts were made to establish a data sharing agreement between Denison and the university or the funding partners but have been unsuccessful to-date. Table 8 summarizes the communications undertaken to obtain additional aerial survey data, and the information received.

Table 8. Communications to obtain additional ungulate data.

Agency	Contact	Data Type / Information	Availability
SK MOE	Gigi Pittoello Habitat Ecologist	No additional aerial ungulate surveys were completed by the government. The 2019 amendment to the federal caribou recovery strategy (Environment and Climate Change Canada [ECCC] 2019) identified that the caribou population in the SK1 Boreal Shield range as the only population assessed as being self-sustaining at a threshold of 40% undisturbed habitat (in a range with predominantly fire disturbance) and that total anthropogenic disturbance should not exceed 5% (while maintaining a minimum of 40% undisturbed habitat in the range).	N/A
University of Saskatchewan	Phil Mcloughlin Department of Biology	Collected GPS telemetry data on caribou, wolves, and black bears in SK1 caribou range. Ninety-four GPS collared caribou were followed from 2014 through 2018; 36 wolves were monitored from 2014 through 2016. In February 2017, a wolf-moose-caribou aerial survey was completed in an area encompassing over 4,500 km^2. In 2015, a helicopter survey was conducted in the Courtney Lake area. In addition, throughout the collaring study area in March of each year (2015, 2016, 2017, and 2018) cow:calf ratios where surveyed when locating collared caribou[1].	Collected data will not be publicly available as they are funded by third parties. It may be possible to access data through data sharing agreements[2].

1 This information was summarized in McLoughlin et al. 2019 and a high-level summary is included in this report.

2 A data sharing agreement between Denison and either with the university or participating (funding) third parties could not be established at the time of this report.

Based on these communications, no additional aerial ungulate survey data were available at this time for inclusion into this baseline annex report and the subsequent EIS.

SK MOE has developed a range plan for woodland caribou in Saskatchewan to facilitate effective landscape management in support of a self-sustaining woodland caribou population (SK MOE 2019). This first range plan was developed for the SK2 Central Caribou Administration Unit (for an area over 200 km south of the Project). To establish a range plan for the SK1 Boreal Shield caribou range (in which the Project is located), initial range planning activities and meetings were scheduled to begin late in 2020. All currently available geospatial woodland caribou information is provided on the Saskatchewan GeoHub (2021). No range information is currently available for the SK1 Boreal Shield range and critical habitat has not yet been identified.

Omnia (2020) cited the document by McLoughlin et al. (2016) entitled "Population Dynamics and Critical Habitat of Woodland Caribou in the Saskatchewan Boreal Shield - Interim Project Report" for a summary of the 2008 to 2014 aerial ungulate surveys. While the 2019 Final Project Report by McLoughlin et al. (which was not included in the Omnia 2020 document) does not provide additional aerial survey results, it does provide some details about the boreal caribou population and other terrestrial wildlife species in the SK 1 Boreal Shield range in which the Wheeler River Project is located. The observations provided in the report are based on the authors' detailed 2014 to 2018 study and are summarized in the following paragraphs.

The Denison Wheeler Project is located in the SK1 Boreal Shield Woodland Caribou Management Unit which has low levels of anthropogenic disturbance (i.e., approximately 3% of habitat occurs within 500 m of any industrial footprint and linear features) and exposed to large fire disturbances in the past 40 years (ECCC 2019). The SK1 management unit contains high-quality conifer-dominated caribou habitat with >40-year-old stands of jack pine and black spruce forests suitable for lichen colonization, black spruce swamps and open muskegs. Surveyed areas support relatively high densities of caribou, at 36.9 caribou/1000 km^2 or approximately 3,380 caribou in McLoughlin et al.'s (2019) study area, translating to approximately 4,000 caribou across the SK1 Boreal Shield Woodland Caribou Management Unit.

Predator surveys were also conducted as part of the study and revealed relatively low population densities (McLoughlin et al. 2019). Wolf (*Canis lupus*) densities in the region were observed to be low, with 3.1 wolves/1000 km^2. Large territories were occupied by established packs (i.e., 2,865 ± 595 km^2 per territory) and pack size averaged at 4.00 ± 0.51 wolves/pack (McLoughlin et al. 2019). Black bear (*Ursus americanus*) densities were also estimated to be low based on large home range sizes (adult males: 316.5 ± 62.1 km^2; adult females: 79.8 ± 13.2 km^2); however, no estimates for bear densities were provided.

In addition to relatively low predator densities, McLoughlin et al. (2019) found that there was some spatial separation between caribou and wolves. Caribou did not seem to avoid existing linear features (such as roads, trails, and transmission lines) in the area, while wolves established their territories away from linear features. Black bears were found to select for linear and anthropogenic features more strongly than did caribou or wolves. Unlike caribou, who preferred mature conifer stands, wolves selected for wetlands and patches of deciduous-mixed forest, avoiding stands of mature conifers (McLoughlin et al. 2019). Black bears used mixed-wood forests similarly to wolves, but, particularly during fall, bears selected for younger stands of jack pine, with high occurrence of berry-producing shrubs. Other prey species, such as moose, also occurred at relatively low densities in the McLoughlin et al. (2019) study area (i.e., 45.7 moose/1000 km^2).

Mortality of adult caribou in this study was observed mostly during the snow-free season, with 76% of observed mortalities occurring between April and October and only 1 of 94 caribou was harvested by a hunter during the four years of the study. McLoughlin et al. (2019) observed that, from 2014 to 2018, the caribou population exhibited a high average adult female survival rate and moderate recruitment (0.192 calves per cow in March), ranging from a low of 0.134 calves/cow in March 2016 to 0.244 calves/cow in March 2018. These demographic parameters lead the authors to assess the SK1 caribou population as being stable over time (McLoughlin et al. 2019).

6 CONCLUSION

Sections 2 through 4 of this annex report describe the additional baseline information compiled for the terrain and soils, vegetation, and wildlife components, respectively. Table 9 summarizes key findings for each component.

Table 9. Summary of additional baseline information for the Wheeler River Project.

Baseline Component	Additional Information Identified to Complete the EA	Information Sources	Summary of Additional Information
Terrain and Soils	Desktop review of available literature and spatial inventories was conducted to situate the Project in the context of Terrain and Soil.	• Interpretation of Project-Specific Topographic Survey Information, (Denison Mines Corporation 2019) and Geology (Simpson 1997), and Soil (Soil Landscapes of Canada Working Group 2010) • Interpretation of Ecosites (McLaughlan et al. 2010), Ecoregions (Acton et al. 1998), and Ecozones (Wiken 1986; Marshall et al. 1999)	General summary of predominant landscape attributes, topography and soil based on available Ecozone, Ecoregion and Ecosite information.
Vegetation	Reclassification of the novel regenerating forest types provided within interpreted ecosite mapping product to the provincial ecosite classification.	• Interpreted Ecosite Mapping (Omnia 2020); • 1 m topographic contours (Denison Mines Corporation 2019); • Soils Information (Soil Classification Working Group 1998). • Field Guide to the Ecosites of Saskatchewan's Provincial Forests (McLaughlan et al. 2010). • Ecosite descriptions within the Baseline Report (Omnia 2020).	Revisions to the interpreted ecosite mapping product aligned regenerating forest areas with accepted provincial ecosite classifications (i.e., McLaughlan et al. 2010), while retaining detail about the structural complexity resulting from historic fire disturbance within the RSA.
Wildlife - Avian Species of Management Concern	Identification of species-specific surveys or literature for avian species of management concern.	Biodiversity Information of Saskatchewan (HABISask) database (SK MOE 2020).	There is evidence that, in addition to common nighthawk, rusty blackbird use the RSA. Mitigation measures (such as setback distances and work outside of sensitive timing windows) need to be included in the EIS.

Baseline Component	Additional Information Identified to Complete the EA	Information Sources	Summary of Additional Information
Wildlife - Ungulates	Survey data and associated information for boreal caribou and moose.	Personal communications with SK MOE staff and University of Saskatchewan researchers; review of recent publication on boreal caribou ecology in northern Saskatchewan (McLoughlin et al. 2019).	No additional aerial ungulate survey data are available for inclusion into the Annex Report. Recent population and habitat studies for boreal caribou in the SK1 Boreal Shield management unit characterize the caribou population in the region as stable, predator densities as low and the habitat currently experiencing low levels of anthropogenic disturbances.

7 REFERENCES

Acton, D.F., Padbury G.A., and Stushnoff, C.T. 1998. The Ecoregions of Saskatchewan. Regina: Canadian Plains Research Center, University of Saskatchewan.

Agriculture and Agri-Food Canada. 1998. Canada Land Inventory, National Soil Database. Ottawa, ON.

Andison, D.W. 2013. Wildfire Patterns in Western Boreal Canada. Healthy Landscapes Research Series Report No. 8. Foothills Research Institute, Hinton, AB. 65 pp.

B.C. Ministry of Environment, Lands, and Parks, and B.C. Ministry of Forests. 1998. Field Manual for Describing Terrestrial Ecosystems. Land Management Handbook No 25. Resource Inventory Branch, B.C. Ministry of Environment, Lands and Parks, and Research Branch, B.C. Ministry of Forests, Victoria, B.C.

Denison Mines Corporation. 2019. 1 m Topographic Contours.

EcoMetrix Incorporated (EcoMetrix). 2021. Wheeler River Project Baseline Hydrogeology Report. Prepared for Denison Mines. March 2021 Draft Report. Mississauga, ON. 257pp.

Environment and Climate Change Canada (ECCC). 2019. Amended Recovery Strategy for the Woodland Caribou (Rangifer tarandus caribou), Boreal population, in Canada [Proposed]. *Species at Risk Act* Recovery Strategy Series. Environment and Climate Change Canada, Ottawa. xiii + 143pp.

Government of Saskatchewan, 2021. Publication Centre. (https://publications.saskatchewan.ca/#/home). Accessed on February 23, 2021.

Marshall, I.B., Schut, P.H., and Ballard, M. 1999. A National Ecological Framework for Canada: Attribute Data. Agriculture and Agri-Food Canada, Research Branch, Centre for Land and Biological Resources Research and Environment Canada, State of the Environment Directorate, Ecozone Analysis Branch. Ottawa/Hull.

McLaughlan, M.S., Wright, R.A., and Jiricka, R.D. 2010. Field Guide to the Ecosites of Saskatchewan's Provincial Forests. Saskachewan Ministry of Environment, Forest Service, Prince Albert, SK. 343 pp.

McLoughlin, P.D., Superbie, C., Stewart, K., Tomchuk, P., Neufeld, B., Barks, D., Perry, T., Greuel, R., Regan, C., Truchon-Savard, A., Hart, S., Henkelman, J., and Johnstone, J.F. 2019. Population and habitat ecology of boreal caribou and their predators in the Saskatchewan Boreal Shield. Final Report. Department of Biology, University of Saskatchewan, Saskatoon. 238 pp.

Norris, S.L., Margol, M., and Froese, D.G. 2017. Glacial landforms of northwest Saskatchewan. Journal of Maps13: 600-607.

Omnia Ecological Services (Omnia). 2020. Terrestrial Environment Wildlife and Vegetation Baseline Inventory. Prepared for Denison Mines. January 2020 Update. Calgary, AB. 265 pp.

Parisien, M.A., Hirsch, K.G., Lavoie, S.G., Todd, J.B., and Kafka, V.G. 2004. Saskatchewan Fire Regime Analysis. Information Report NOR-X-394. Natural Resources Canada, Canadian Forest Service, Northern Forestry Centre, Edmonton, AB.

Saskatchewan GeoHub. 2021. (https://geohub.saskatchewan.ca/search?q=Caribou). Accessed February 23, 2021.

Saskatchewan Ministry of Environment (SK MOE). 2019. Range Plan for Woodland Caribou in Saskatchewan – Boreal Plain Ecozone - SK2 Central Caribou Administration Unit. July 2019. 90pp.

SK MOE. 2020. Hunting, Angling, and Biodiversity in Saskatchewan (HABISask) database. (https://gisappl.saskatchewan.ca/html5ext/?viewer=habisask#). Accessed January 4, 2021.

SK MOE, Fish, Wildlife and Lands Branch. 2017. Saskatchewan Activity Restriction Guidelines. April 2017. 4 pp.

Simpson M.A. (compiler). 1997. Surficial geology map of Saskatchewan; Saskatchewan Energy Mines/Saskatchewan Research Council. Spatial Database.

Soil Classification Working Group. 1998. Canadian System of Soil Classification, Third Edition. National Research Press, Ottawa, Ontario. 187 pp. (http://sis.agr.gc.ca/cansis/publications/manuals/1998-cssc-ed3/cssc3_manual.pdf)

Wiken, E.B. (compiler). 1986. Terrestrial ecozones of Canada. Ecological Land Classification Series No. 19. Environment Canada. Spatial Database.

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Wheeler River Project

Final Environmental Impact Statement

November 2024

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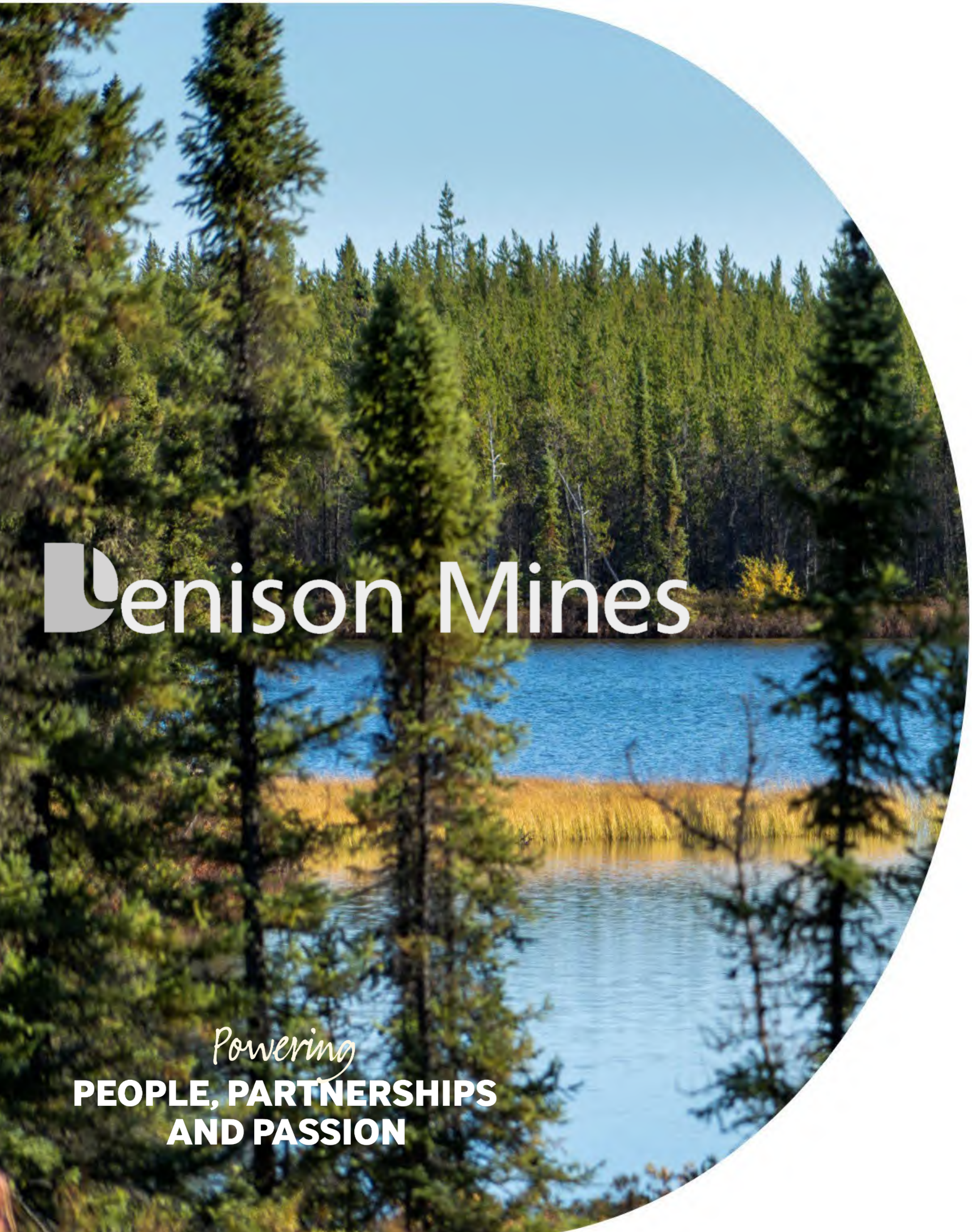
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Appendix 9-D Wildlife Species At Risk

Version 3

October 2024

Table of Contents

Tables

Acronyms and Abbreviations

Term	Definition
BBS	Breeding Bird Survey
BC	British Columbia
CEA	Cumulative effects assessment
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
ECCC	Environment and Climate Change Canada
EIS	Environmental Impact Statement
EMS	Environmental Management System
FIRT	Federal-Indigenous Review Team
IRs	Information requests
ISR	In situ recovery
KI	Key Indicator
LSA	Local Study Area
Project	Wheeler River Project
QP	Qualified Professional
RSA	Regional Study Area
SAR	Species at risk
SARA	*Species at Risk Act*
SARGSS	Saskatchewan Activity Restriction Guidelines for Sensitive Species
SKCDC	Saskatchewan Conservation Data Centre
VC	Valued Component

1 Introduction

1.1 Background

On October 21, 2022, Denison Mines Corp. (Denison) submitted a draft Environmental Impact Statement (EIS) for the proposed Wheeler River Project (the Project). Based on their initial review, the Canadian Nuclear Safety Commission indicated that the submission contained the required information to proceed with the Federal-Indigenous Review Team (FIRT) technical review of the draft EIS. On March 20, 2023, the FIRT provided Denison with a list of information requests (IRs) for Denison to respond to and eventually submit a final EIS document.

This Appendix provides additional information to address several IRs provided by Environment and Climate Change Canada (ECCC) as part of the initial round of Federal Indigenous Review Team (FIRT) comments. These IRs were related to 16 wildlife species at risk (SAR) listed under Schedule 1 of the federal *Species at Risk Act* (SARA). The draft EIS approach was conservative in that it considered appropriate representative species as Valued Components (VCs) and Key Indicators (KIs) in sections 9.3 Ungulates, Furbearers, and Woodland Caribou and 9.4 Raptors, Migratory Breeding Birds, and Bird SAR. Of the 16 wildlife SAR listed in Table 1.1, seven had been included as VCs or KIs in the EIS after a thorough scoping process (refer to Section 1.2 for additional information).

Nine of the sixteen were not included as individual VCs or KIs but are considered important from a regulatory perspective. The SARA-listed species identified by ECCC are listed in Table 1.1. Those noted in bold font indicate those for which further assessment is provided in this appendix.

Table 1-1 Wildlife Species at Risk Listed by Environment and Climate Change Canada

Common Name	Scientific Name	Discussed in Section 9 of the draft EIS
Nine-spotted lady beetle	***Coccinella ovemnotata***	**No**
Transverse lady beetle	***Coccinella transversoguttata***	**No**
Yellow-banded bumble bee	***Bombus terricola***	**No**
Northern leopard frog	***Lithobates pipiens***	**No**
Little brown myotis	***Myotis lucifugus***	**No**
Northern myotis	***Myotis septentrionalis***	**No**
Wolverine	*Gulo gulo*	Yes
Woodland caribou	*Rangifer tarandus caribou*	Yes
Bank Swallow	***Riparia riparia***	**No**
Barn Swallow	***Hirundo rustica***	**No**
Common Nighthawk	*Chordeiles minor*	Yes
Horned Grebe	***Podiceps auritus***	**No**
Olive-sided Flycatcher	*Contopus cooperi*	Yes

Common Name	Scientific Name	Discussed in Section 9 of the draft EIS
Rusty Blackbird	*Euphagus carolinus*	Yes
Short-eared Owl	*Asio flammeus*	Yes
Yellow Rail	*Coturnicops noveboracensis*	Yes

Of the 16 species listed in Table 1.1, seven had been included as VCs or KIs in the EIS after a thorough scoping process, as summarized below.

1.2 Valued Component Selection

The VCs considered in the effects assessment for the Project are aspects of the biophysical and human environments that were considered to be likely to be affected (adversely or positively) by the Project. The VCs reflect identified scientific, local knowledge, and Indigenous Knowledge, and community interests regarding the Project and its potential effects. The potential effects are typically identified early in the environmental assessment process as a result of questions and concerns raised through engagement with Indigenous and community groups, government departments and agencies, and the general public.

Denison reviewed and considered all received input to develop a VC list that reflects the key environmental, socio-economic, heritage, and human health components and interests to appropriately focus the EA.

The initial VCs selected to represent bird SAR in the habitat-based assessment that were provided in the Terms of Reference (Denison 2019) were evaluated, consolidated, and organized to allow for the logical assessment of Project effects, and are presented in Table 1.2 and Table 1.3, which formed the basis for the subsequent VC-specific assessment.

Table 1-2 Wildlife Species at Risk Valued Component and Rationale for their Inclusion in the Habitat-based Environmental Assessment for the Denison Wheeler River Project

Valued Component	Rationale
Biophysical Environment	
Terrestrial Environment	
Furbearers	Project activities and infrastructure may affect local furbearer populations, including species at risk (SAR), resulting in non-compliance with permit conditions (e.g., *Species at Risk Act* [SARA; Government of Canada 2022], *The Wildlife Act 1998* [Government of Saskatchewan 2020]).
Woodland Caribou	Project activities and infrastructure may affect woodland caribou populations, resulting in non-compliance with permit conditions (e.g., SARA [Government of Canada 2022], *The Wildlife Act, 1998* [Government of Saskatchewan 2020]).

Valued Component	Rationale
Bird Species at Risk	Project activities and infrastructure may affect bird SAR (specifically disturbance and/or destruction of eggs, young, and adults) resulting in non-compliance with regulatory requirements (e.g., SARA [Government of Canada 2022], *Migratory Birds Convention Act 1994* [Government of Canada 2017], *Saskatchewan Activity Restriction Guidelines for Sensitive Species* [Government of Saskatchewan 2017], *The Wildlife Act 1998* [Government of Saskatchewan 2020]).

Table 1-3 Valued Components, Key Indicators, and Measurable Parameters for the Wildlife Component included in the Habitat-based Environmental Assessment for Denison Wheeler River Project

Valued Component	Key Indicator	Measurable Parameter
Furbearers	Wolverine	Amount of habitat (km^2) (not necessarily occupied) that may be altered or lost relative to its availability in the Regional Study Area (RSA). The number of wolverine mortalities directly or indirectly attributable to the Project.
Woodland Caribou	Woodland caribou	Amount of habitat (km^2) (not necessarily occupied) that may be altered or lost relative to its availability in the RSA. The number of woodland caribou mortalities directly or indirectly attributable to the Project.
Bird Species at Risk	Common Nighthawk	Percentage of habitat for Common Nighthawk altered/lost directly or indirectly as a result of Project activities. The number of Common Nighthawk mortalities directly or indirectly attributable to the Project.
	Rusty Blackbird	Percentage of habitat for Rusty Blackbird altered/lost directly or indirectly as a result of Project activities. The number of rusty blackbird mortalities directly or indirectly attributable to the Project
	Olive-sided Flycatcher	Percentage of habitat for Olive-sided Flycatcher altered/lost directly or indirectly as a result of Project activities. The number of Olive-sided Flycatcher mortalities directly or indirectly attributable to the Project
	Short-eared Owl	Percentage of habitat for Short-eared Owl altered/lost directly or indirectly as a result of Project activities. The number of Short-eared Owl mortalities directly or indirectly attributable to the Project.

Valued Component	Key Indicator	Measurable Parameter
	Yellow Rail	Percentage of habitat for Yellow Rail altered/lost directly or indirectly as a result of Project activities. The number of Yellow Rail mortalities directly or indirectly attributable to the Project.

The five bird species identified in Table 1.3 were selected as SAR VCs for the habitat-based EA in consideration of information/responses received during extensive Indigenous and community engagement completed by Denison, and they represent wildlife species of local importance. For these five species, additional information is not be provided in this Appendix. Rather, the reader is referred to the applicable sections in the EIS where appropriate information on existing conditions (Section 9.4.3.3), potential project-related effects (Section 9.4.4), mitigation measures (Section 9.4.5), residual effects and their significance (Section 9.4.6), and cumulative effects (Section 9.4.7) is provided.

2 Supplemental Information

As requested by ECCC, the following subsections provide supplemental information for the remaining nine species listed in Table 2.1 that were not included as VCs or KIs in the EIS. For these nine species, a brief overview of life history requirements (existing environment), a discussion on the effects assessment and mitigation measures, and a summary of residual and cumulative effects are included.

Table 2-1 Wildlife Species At Risk Considered in the Wheeler River Project Environmental Impact Statement

Common Name	Scientific Name	Provincial Status	Federal Status[1]	Preferred Habitat	Documented Occurrence in the Local Study Area[2]	Reference in the Environmental Impact Statement (EIS)
Arthropods						
Nine-spotted lady beetle	*Coccinella novemnotata*	S4	Endangered	Habitat generalist – uses a diverse range of habitats and consumes a variety of prey. See Section 2.1.1 for further details.	Local Study Area (LSA) is located within COSEWIC range; no observations in SKCDC and no Project-specific observations to date.	Not included as a Valued Component (VC) in the EIS. A review of life history requirements and discussion on effects assessment are included in this Appendix.
Transverse lady beetle	*Coccinella transversoguttata*	S4	Special Concern	Habitat generalist – uses a diverse range of habitats and consumes a variety of prey. See Section 2.1.2 for further details.	LSA is located within COSEWIC range; no observations in SKCDC and no Project-specific observations to date.	Not included as a VC in the EIS. A review of life history requirements and discussion on effects assessment are included in this Appendix.
Yellow-banded bumble bee	*Bombus terricola*	S4	Special Concern	Habitat generalist – uses a variety of habitats and consumes nectar and pollen from many different flowering plants. See Section 2.1.3 for further details.	LSA is located within COSEWIC range; no observations in SKCDC and no Project-specific observations to date.	Not included as a VC in the EIS. A review of life history requirements and discussion on effects assessment are included in this Appendix.
Amphibians						
Northern leopard frog	*Lithobates pipiens*	S3	Special Concern	Three district habitats: (1) overwintering waterbodies that are cold, well oxygenated, and do not freeze to bottom; (2) breeding and larval waterbodies with shallow, open habitats, neutral pH, and no fish; and (3) summering areas in shallow	LSA is located within COSEWIC range; no observations in SKCDC and no Project-specific observations to date. Amphibian nocturnal call	Not included as a VC in the EIS. A review of life history requirements and discussion on effects assessment are included in this Appendix.

Common Name	Scientific Name	Provincial Status	Federal Status[1]	Preferred Habitat	Documented Occurrence in the Local Study Area[2]	Reference in the Environmental Impact Statement (EIS)
				marshes, moist upland meadows where grass height is less than 1 m. See Section 2.2.1 for further details.	and visual search surveys were completed in the LSA and Regional Study Area (RSA) as part of the baseline program; however, only boreal chorus frogs (*Pseudacris maculata*) were detected (Appendix 9-C).	
Bats						
Little brown myotis	*Myotis lucifugus*	S4B, S4N	Endangered	Seasonal habitat requirements: (1) overwintering hibernacula that are sufficiently cool and humid and (2) summering areas that provide foraging areas and suitable locations for roosting and maternity colonies. See Section 2.3.1 for further details.	Documented during the acoustic bat surveys as part of the baseline field program as present in the LSA and RSA, and previously observed in the RSA (SKCDC 2023).	Not included as a VC in the EIS. A review of life history requirements and discussion on effects assessment are included in this Appendix.
Northern myotis	*Myotis septentrionalis*	S3	Endangered	Seasonal habitat requirements: (1) overwintering hibernacula that are sufficiently cool and humid and (2) summering areas that provide foraging areas and suitable locations for roosting and maternity colonies. See Section 2.3.2 for further details.	Documented during the acoustic bat surveys as part of the baseline field program as present in the LSA and RSA (Appendix 9-C).	Not included as a VC in the EIS. A review of life history requirements and discussion on effects assessment are included in this Appendix.

Common Name	Scientific Name	Provincial Status	Federal Status[1]	Preferred Habitat	Documented Occurrence in the Local Study Area[2]	Reference in the Environmental Impact Statement (EIS)
Terrestrial Wildlife Species						
Wolverine	*Gulo gulo*	S2	Special Concern	See Section 9.3.3.2 of the EIS for details.	LSA is located within COSEWIC range; no observations in SKCDC and no Project-specific observations to date.	Included as a Key Indicator (KI) of the Furbearer VC in the EIS. A review of life history requirements and discussion on effects assessment are included in the EIS (Section 9.3). Additional information for this species is not provided in this Appendix.
Woodland caribou	*Rangifer tarandus caribou*	S3	Threatened	See Section 9.3.3.3 of the EIS for details.	Documented within the RSA during the baseline field program (Appendix 9-C)	Included as a VC in the EIS. A review of life history requirements and discussion on effects assessment are included in the EIS (Section 9.3). Additional information for this species is not provided in this Appendix.
Avian Species						
Bank Swallow	*Riparia riparia*	S4B, S5M	Threatened	Nesting colonies are typically characterized by steep embankments with a sand, silt, or clay substrate that can be easily excavated for burrows. They are often adjacent to slow-moving or still waterbodies and may occur in natural habitats or in anthropogenic features. Bank Swallows are aerial insectivores that forage over a variety of open habitats. See Section 2.4.1 for further details.	LSA is located within COSEWIC range; no historical observations documented by the SKCDC (2023) and no Project-specific observations to date.	Not included as a KI of the Bird Species at Risk (SAR) VC in the EIS (Common Nighthawk was used as a surrogate species). A review of life history requirements and discussion on effects assessment are included in this Appendix. Any new species-specific mitigation measures identified in this appendix will be added to the final EIS (Section 9.4.5).
Barn Swallow	*Hirundo rustica*	S4B	Threatened	Breeding habitat typically requires a suitable nesting site with a vertical or horizontal surface underneath a roof of	Documented during the breeding bird surveys as part of the baseline field	Not included as a KI of the Bird SAR VC in the EIS (Common Nighthawk was used as a surrogate species). A review of life history

Common Name	Scientific Name	Provincial Status	Federal Status[1]	Preferred Habitat	Documented Occurrence in the Local Study Area[2]	Reference in the Environmental Impact Statement (EIS)
				some sort, open areas for foraging, and a waterbody with mud for nest building. Anthropogenic features such as barns, houses, bridges, and culverts are commonly used nesting sites. See Section 2.4.2 for further details.	program as present in the LSA (Appendix 9-C), and previously observed in the RSA (SKCDC 2023)	requirements and discussion on effects assessment are included in this Appendix. Any new species-specific mitigation measures identified in this appendix will be added to the final EIS (Section 9.4.5).
Common Nighthawk	*Chordeiles minor*	S4B	Special Concern	See Section 9.4.3.3 of the EIS for details.	Documented during the baseline field program as present in the LSA (Appendix 9-C), and previously observed in the RSA (SKCDC 2023)	Included as a KI of the Bird SAR VC in the EIS. A review of life history requirements and discussion on effects assessment are included in the EIS (Section 9.3). Additional information for this species is not provided in this Appendix.
Horned Grebe	*Podiceps auritus*	S5B	Special Concern	Breeding habitat consists of small to medium-sized freshwater lakes, ponds, and marshes that are shallow with open water (at least 40%), emergent vegetation, anchorage for nests, and concealment for nests and young. See Section 2.4.3 for further details.	Documented during the baseline field program as present in the LSA (Appendix 9-C).	Not included as a KI of the Bird SAR VC in the EIS (Yellow Rail was used as a surrogate species). A review of life history requirements and discussion on effects assessment are included in this Appendix. Any new species-specific mitigation measures identified in this appendix will be added to the final EIS (Section 9.4.5).
Olive-sided Flycatcher	*Contopus cooperi*	S4B	Special Concern	See Section 9.4.3.3 of the EIS for details.	Documented during the baseline field program as present in the LSA (Appendix 9-C), and previously observed in the RSA (SKCDC 2023)	Included as a KI of the Bird SAR VC in the EIS. A review of life history requirements and discussion on effects assessment are included in the EIS (Section 9.3). Additional information for this species is not provided in this Appendix.

Common Name	Scientific Name	Provincial Status	Federal Status[1]	Preferred Habitat	Documented Occurrence in the Local Study Area[2]	Reference in the Environmental Impact Statement (EIS)
Rusty Blackbird	*Euphagus carolinus*	S3B, SUN	Special Concern	See Section 9.4.3.3 of the EIS for details.	LSA is located within COSEWIC range; no historical observations documented by the SKCDC (2023) and no Project-specific observations to date.	Included as a KI of the Bird SAR VC in the EIS. A review of life history requirements and discussion on effects assessment are included in the EIS (Section 9.3). Additional information for this species is not provided in this Appendix.
Short-eared Owl	*Asio flammeus*	S3B, S2N	Special Concern	See Section 9.4.3.3 of the EIS for details.	LSA is located within COSEWIC range; no historical observations documented by the SKCDC (2023) and no Project-specific observations to date.	Included as a KI of the Bird SAR VC in the EIS. A review of life history requirements and discussion on effects assessment are included in the EIS (Section 9.3). Additional information for this species is not provided in this Appendix.
Yellow Rail	*Coturnicops noveboracensis*	S3B	Special Concern	See Section 9.4.3.3 of the EIS for details.	LSA is located within COSEWIC range; no historical observations documented by the SKCDC (2023) and no Project-specific observations to date.	Included as a KI of the Bird SAR VC in the EIS. A review of life history requirements and discussion on effects assessment are included in the EIS (Section 9.3). Additional information for this species is not provided in this Appendix.

Note: shaded rows indicate SAR was included as a VC or KI in the draft EIS.

1 Schedule 1 under the *Species at Risk Act*.

2 Potential for Occurrence – based on known species occurrence data from Saskatchewan Conservation Data Centre (2023), Omnia (Appendix 9-C), Birds of Saskatchewan (2019), and Atlas of Saskatchewan Birds (Smith 1996) and/or presence of suitable habitat.

2.1 Arthropods

2.1.1 Nine-Spotted Lady Beetle

Source: COSEWIC (2016a).

The nine-spotted lady beetle is a small beetle species found across southern Canada and the continental United States (COSEWIC 2016a). Its northern range limit in Saskatchewan is reported to occur near Lake Athabasca (COSEWIC 2016a). Based on records provided by the Saskatchewan Conservation Data Centre Hunting, Angling and Biodiversity of Saskatchewan (HABISask) database (SKCDC 2023), there are no historical observations of this species documented in the Regional Study Area (RSA).

The nine-spotted lady beetle is a habitat generalist that uses a diverse range of habitats (e.g., open to semi-open forests, grasslands, riparian areas) and consumes a variety of prey (e.g., many species of arthropods [particularly aphids], sap, nectar and pollen) (COSEWIC 2016a). Being a habitat generalist allows the nine-spotted lady beetle to exploit seasonally available prey sources, with prey availability influencing the species' distribution more than habitat availability (COSEWIC 2016a).

The nine-spotted lady beetle has four life stages (i.e., egg, larva, pupa, and adult) and may produce two generations per year (i.e., spring and fall) depending on regional climate conditions (COSEWIC 2016a). Lady beetles, in general, are highly mobile and may undertake short (few hundred metres) and long-distance (18 to 120 km) movements (COSEWIC 2016a). The nine-spotted lady beetle is not migratory nor does it display strong site fidelity (COSEWIC 2016a). The nine-spotted lady beetle overwinters in aggregations in well-ventilated habitats (e.g., in rock crevices, grass tussocks, or leaf litter, or under stones or tree bark), becoming active in the early spring when temperatures start to increase (COSEWIC 2016a).

The nine-spotted lady beetle is federally listed under Schedule 1 of SARA as Endangered (Government of Canada 2023) and is designated as an S4 species in Saskatchewan (i.e., Apparently Secure) (Saskatchewan Conservation Data Centre 2023). The species has undergone significant population declines in Canada since 1975, going from one of the more common lady beetles collected to being rarely collected relative to other lady beetles, despite comprehensive and targeted surveys (COSEWIC 2016a). Reasons for these population declines are currently unknown but are thought to be driven by competition, predation, and introduced diseases from non-native species (including non-native lady beetles), agricultural pesticide use to control aphids, habitat loss via urban expansion, and other human disturbances (COSEWIC 2016a).

2.1.2 Transverse Lady Beetle

Source: COSEWIC (2016b).

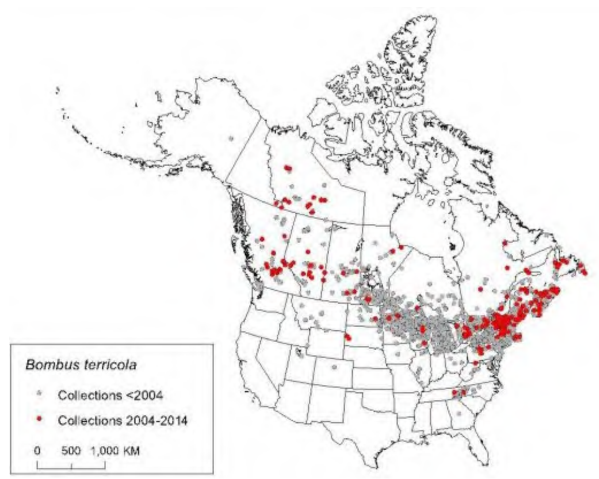
The transverse lady beetle is a small beetle species found across the United States and Canada, including all provinces and territories (COSEWIC 2016b). The species is a habitat generalist and uses similar habitat types and consumes similar prey as the nine-spotted lady beetle, which means it is also able to exploit seasonally available prey sources (COSEWIC 2016b). According to the information from the HABISask database, there are no historical observations of this species documented in the RSA.

The transverse lady beetle has four life stages (i.e., egg, larva, pupa, and adult) and may produce two generations per year (i.e., spring and fall) depending on regional climate conditions (COSEWIC 2016b). Lady beetles in general are highly mobile and may undertake short (few hundred metres) and long-distance (18 to 120 km) movements (COSEWIC 2016b). The transverse lady beetle is not migratory nor does it display strong site fidelity (COSEWIC 2016b). The transverse lady beetle overwinters in aggregations in well-ventilated habitats (e.g., in rock crevices, grass tussocks, or leaf litter, or under stones or tree bark), becoming active in the early spring when temperatures start to increase (COSEWIC 2016b).

The transverse lady beetle is federally listed under Schedule 1 of SARA as Special Concern (Government of Canada 2023) and is designated as an S4 species in Saskatchewan (i.e., Apparently Secure) (Saskatchewan Conservation Data Centre 2023). The species was once abundant across its range in Canada and was one of the most common lady beetles collected; however, since 1986, the species is now absent, below detection limits, or present in low numbers in many parts of its range (COSEWIC 2016b). The transverse lady beetle has not been detected in Saskatchewan since 2001 (COSEWIC 2016b). Reasons for these population declines are currently unknown but are thought to be driven by the same factors listed for the nine-spotted lady beetle in Section 2.1.1.

2.1.3 Yellow-banded Bumble Bee

The yellow-banded bumble bee is a medium-sized bumble bee species found throughout eastern North America, from eastern British Columbia (BC) to Newfoundland and Labrador and from the northern United States up to the southern portion of the territories (COSEWIC 2015). The species is a habitat generalist (e.g., boreal habitats, mixed woodlands, montane meadows) and consumes nectar and pollen from many different flowering plants (COSEWIC 2015). According to the information from the HABISask database, there are no historical observations of this species documented in the RSA.



Source: COSEWIC (2015).

The yellow-banded bumble bee has four life stages (i.e., egg, larva, pupa, and adult) and produces one generation per year, with mated queens establishing new colonies each year (COSEWIC 2015). After overwintering underground in loose soil or decomposing organic material, the mated queens emerge in the spring and search for potential nest sites, which are typically located underground in existing cavities (e.g., abandoned rodent burrows, rotten logs, openings in dead wood, and grassy hummocks) (COSEWIC 2015). Once a queen has found a suitable nest site, she forages for nectar and pollen and then returns to her nest site to lay eggs, which will develop into her future workers (i.e., unmated daughters that do not typically reproduce) (COSEWIC 2015). After the initial eggs hatch and the larva and pupa develop into adult workers, the workers take over nest and brood care, foraging duties, and colony protection while the queen continues to lay eggs (COSEWIC 2015). Males and potential queens are produced by late summer once the colony reaches maximum worker production, at which point they leave the colony and mate (COSEWIC 2015). All males and workers die by fall while the mated queens hibernate through the winter in suitable overwintering sites (COSEWIC 2015).

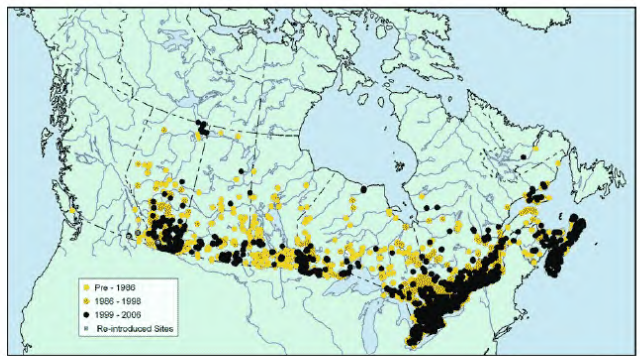
The yellow-banded bumble bee is federally listed under Schedule 1 of SARA as Special Concern (Government of Canada 2023) and is designated as an S4 species in Saskatchewan (i.e., Apparently Secure)

(Saskatchewan Conservation Data Centre 2023). Prior to the 1990s, the yellow-banded bumble bee was one of the more common bumble bees collected in eastern and boreal Canada (COSEWIC 2015, Environment and Climate Change Canada 2022a). Population declines started to occur in the early 1990s, with an average rate of decline of 66.5% in proportional abundance across central and southern Canada between 1992 and 2011 (COSEWIC 2015, Environment and Climate Change Canada 2022a). The species is no longer found at several historical collection sites (COSEWIC 2015).

The status of the yellow-banded bumble bee in boreal habitats and Arctic regions is unknown (COSEWIC 2015, Environment and Climate Change Canada 2022a). Reasons for these population declines are currently unknown but are thought to be driven by introduced diseases from managed bumble bee species, agricultural pesticide use, habitat loss via urban and agricultural expansion, and climate change (COSEWIC 2015).The species' unique type of sex determination, where colonies must reach maximum worker production to produce males and potential queens, has been identified as a limiting factor (COSEWIC 2015, Environment and Climate Change Canada 2022a).

2.2 Amphibians

2.2.1 Northern Leopard Frog



Source: COSEWIC (2009a).

The northern leopard frog is found across most of west-central and northeastern North America (COSEWIC 2009a). The species is widespread in Canada, ranging from southeastern BC to Labrador, and from southcentral Northwest Territories (COSEWIC 2009a, NCC 2023).

Three district habitats are used by the northern leopard frog on an annual basis: (1) overwintering waterbodies that are cold, well oxygenated, and do not freeze to bottom (e.g., rivers, streams, deep lake ponds and creeks, and spillways below dams); (2) breeding and larval waterbodies with shallow, open habitats (e.g., ponds, lakeshores, marshes, and slow-moving streams; may be permanent or semi-permanent), neutral pH, well vegetated, and no fish; and (3) summering areas in shallow marshes, moist upland meadows, forests and grasslands where grass height is less than 1 m (COSEWIC 2009a, NCC 2023). These habitats must be in proximity with suitable dispersal corridors interconnecting them (e.g., riparian areas and waterways) as the species is not capable of long-distance movements (COSEWIC 2009a, Environment Canada 2013).

Northern leopard frogs emerge from their overwintering waterbodies in early spring shortly after ice off (COSEWIC 2009a). The breeding season extends from mid-April to June, with exact timing dependent on location and latitude (COSEWIC 2009a). Females lay several thousand eggs, attaching them to submerged vegetation, which develop into tadpoles within two weeks depending on water temperatures (COSEWIC 2009a). The tadpoles in turn develop into small frogs over a two-to-three-month period, after which they migrate to their summering areas and forage on a variety of arthropods, worms, and snails, sometimes preying on small birds and smaller frogs (COSEWIC 2009a).

Three populations are recognized for the northern leopard frog in Canada: the Rocky Mountain, the Western Boreal/Prairie, and the Eastern (COSEWIC 2009a, NCC 2023). The Western Boreal/Prairie population is found in Alberta, Saskatchewan, Manitoba, and the Northwest Territories (COSEWIC 2009a, NCC 2023). The Western Boreal/Prairie population is federally listed under Schedule 1 of SARA as Special Concern (Government of Canada 2023) and is designated as an S3 species in Saskatchewan (i.e., Vulnerable) (Saskatchewan Conservation Data Centre 2023).

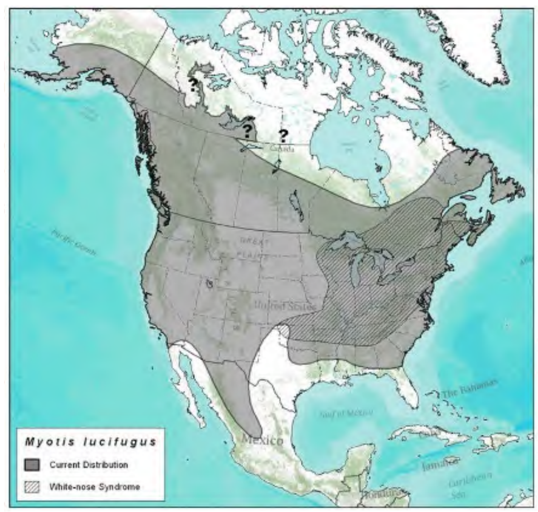
Population data are limited for the northern leopard frog in Canada (COSEWIC 2009a, Environment Canada 2013). Large-scale population declines occurred in the early 1970s, with populations in western Canada (i.e., BC and Alberta) most dramatically affected (COSEWIC 2009a). Information is lacking on the current status of northern leopard frog populations in Saskatchewan (COSEWIC 2009a, Environment Canada 2013).

Threats to the northern leopard frog include emerging diseases (e.g., *Chytridiomycosis*), introduced non-native species, habitat loss and fragmentation, environmental contamination, and increased frequency and severity of droughts (COSEWIC 2009a). The species' specific habitat requirements and vulnerability to diseases and prolonged periods of drought have been identified as limiting factors (Environment Canada 2013).

2.3 Bats

2.3.1 Little Brown Myotis

The little brown myotis is a small bat species found across North America, including across Canada south of the treeline (COSEWIC 2013a). The species is considered a short-distance regional migrant between its summer and winter ranges, with the distance travelled dependent on the location of suitable overwintering hibernacula (COSEWIC 2013a).



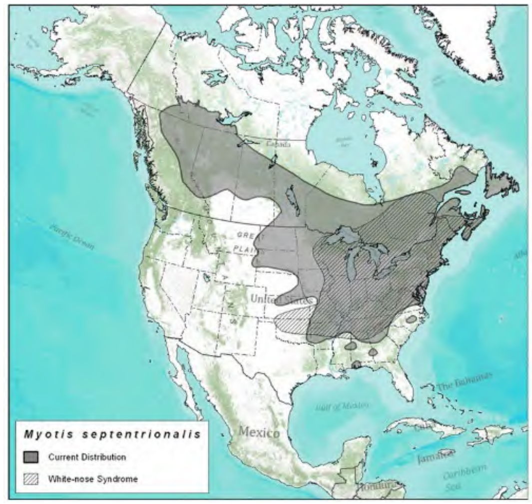
Source: COSEWIC (2013a).

Habitat for the little brown myotis is composed of (1) overwintering hibernacula that are sufficiently cool and humid and (2) summering areas that provide foraging areas and suitable locations for roosting and maternity colonies (COSEWIC 2013a). Hibernacula and maternity sites are the main limiting habitat features for this species (COSEWIC 2013a). Hibernacula occur in parts of caves, mines, and buildings that have stable and specific temperature (-4 to 13°C) and humidity (>80%) conditions (COSEWIC 2013a). Maternity sites occur in large-diameter trees, rock crevices, buildings, and bat houses that offer warm and relatively stable microclimate conditions that allow females to avoid going into torpor so they can focus on caring for their young (COSEWIC 2013a, Slough and Jung 2020). Males are more versatile in their summer roosting requirements and use tree cavities, raised bark, foliage, rock crevices, buildings, and bridges with a broader range of microclimate conditions (COSEWIC 2013a, Johnson et al. 2019). Foraging areas for the little brown myotis include a variety of habitats situated close to roosting and maternity sites, including over water (e.g., wetlands, lakes, ponds, and rivers), along riparian areas and forest edges, and in forest gaps (COSEWIC 2013a).

The little brown myotis is federally listed under Schedule 1 of SARA as Endangered (Government of Canada 2023) and is designated as an S4B, S4N species in Saskatchewan (i.e., Apparently Secure breeding population, Apparently Secure non-breeding population) (Saskatchewan Conservation Data Centre 2023).

The current size of the little brown myotis population in Canada is unknown. Prior to the arrival of White-nose Syndrome in 2010, the population in Canada was estimated to be over one million individuals (COSEWIC 2013a, Environment and Climate Change Canada 2018). White-nose Syndrome is a disease the causes high rates of mortality among hibernating bats, and it has been identified as the main threat for bat populations in Canada (COSEWIC 2013a). Other threats to the little brown myotis include habitat loss, colony eradication, chemical contamination, and wind turbines (COSEWIC 2013a).

2.3.2 Northern Myotis



Source: COSEWIC (2013a).

The northern myotis is a small bat species found across North America, including across Canada south of the treeline (COSEWIC 2013a). The species is considered a short-distance regional migrant between its summer and winter ranges, with the distance travelled dependent on the location of suitable overwintering hibernacula (COSEWIC 2013a).

Habitat for the northern myotis is composed of (1) overwintering hibernacula that are sufficiently cool and humid and (2) summering areas that provide foraging areas and suitable locations for roosting and maternity colonies (COSEWIC 2013a). Hibernacula and maternity sites are the main limiting habitat features for this species (COSEWIC 2013a). Hibernacula occur in parts of caves, mines, and buildings that have stable and specific temperature (0.6 to 14°C) and humidity (>80%) conditions (COSEWIC 2013a). Summer roosting trees are typically found in mature to old-growth forests, swamps, and riparian areas, although retained older trees and snags in younger forests may occasionally provide suitable roosting habitat (Environment and Climate Change Canada 2018). Females strongly prefer tall, large-diameter trees (both living and dead, typically deciduous) with early- to mid-decay for maternity sites (COSEWIC 2013a, Environment and Climate Change Canada 2018). Anthropogenic features (e.g., barns) may occasionally be used as maternity sites in fragmented landscapes with few potential roost trees (Environment and Climate Change Canada 2018). Maternity sites that maintain warm and relatively stable microclimate conditions are important to reproductive females and young as they allow more energy to be directed toward growth and development (Caceres and Barclay 2000, COSEWIC 2013a). Males are more versatile in their summer roosting requirements; they most frequently roost under exfoliating, raised bark but may also roost in the cavities and crevices of trees and snags with early- to mid-decay (Jung et al. 2004, COSEWIC 2013a).

The northern myotis is well adapted to flying in areas of dense or structurally complex vegetation where it catches flying insects on the wing or feeds by gleaning prey from foliage (Caceres and Barclay 2000, Henderson and Broders 2008). The species typically forages within the interior of mature to old-growth deciduous and mixedwood forests, but may also forage in forest gaps, along forest edges and riparian areas, and over rivers (Henderson and Broders 2008, COSEWIC 2013a).

The northern myotis is federally listed under Schedule 1 of SARA as Endangered (Government of Canada 2023) and is designated as an S3 species in Saskatchewan (i.e., Vulnerable) (Saskatchewan Conservation Data Centre 2023). The current size of the northern myotis population in Canada is unknown. Prior to the arrival of White-nose Syndrome in 2010, the population in Canada was estimated to be over one million individuals (COSEWIC 2013a, Environment and Climate Change Canada 2018). White-nose Syndrome has been identified as the main threat for northern myotis populations in Canada (COSEWIC 2013a). . Other threats to the northern myotis include habitat loss, colony eradication, chemical contamination, and wind turbines (COSEWIC 2013a).

2.4 Avian Species

2.4.1 Bank Swallow

Source: COSEWIC (2013b).

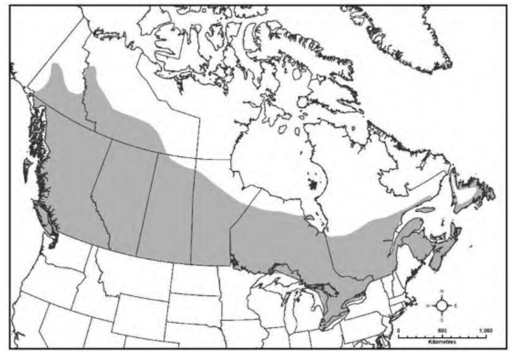
The Bank Swallow is a small songbird that occurs on every continent (except Antarctica and Australia), breeds throughout Canada, and winters primarily in South America (COSEWIC 2013b). Nesting colonies are typically characterized by steep embankments with a sand, silt, or clay substrate that can be easily excavated for burrows (COSEWIC 2013b, Government of Canada 2019a). These steep sand, silt, or clay embankments are frequently subject to erosion or slumping (COSEWIC 2013b, Garrison and Turner 2020).

Nesting colonies are often adjacent to slow-moving or still waterbodies (e.g., low gradient rivers or lakes) and may occur in natural habitats or in anthropogenic features (e.g., quarries or road cuts) (COSEWIC 2013b, Government of Canada 2019a, Garrison and Turner 2020). Colony size can range from less than half a dozen burrows to hundreds or thousands of burrows (COSEWIC 2013b, Government of Canada 2019a). Individual burrows within colonies may be recolonized in subsequent years if the integrity of the colony remains intact (i.e., does not erode and collapse) (Garrison and Turner 2020). Bank Swallows are aerial insectivores that forage over a variety of open habitats such as lakes, ponds, rivers, wetlands, grasslands, and agricultural areas (COSEWIC 2013b, Garrison and Turner 2020).

The Bank Swallow is federally listed under Schedule 1 of SARA as Threatened (Government of Canada 2023) and is designated as an S4B, S5M species in Saskatchewan (i.e., Apparently Secure breeding population, Secure aggregating transient population [migrants]) (Saskatchewan Conservation Data Centre 2023). The most recent breeding population estimate for Canada is 2.4 million individuals (Environment and Climate Change Canada 2022b). Based on Breeding Bird Survey (BBS) data collected between 1970 and 2019, the Bank Swallow population in Canada has declined at a rate of 5.3% per year, for an overall decline of 98.0% (Environment and Climate Change Canada 2022b). The long-term population decline appears to be driven by several threats acting cumulatively, including loss of nesting and foraging habitats, incidental take during anthropogenic activities (e.g., aggregate extraction and erosion control), large-scale declines in aerial insect populations, and climate change (COSEWIC 2013b). Bank Swallows are also particularly vulnerable to collisions with vehicles partly due to the attraction of individuals to intraspecific carcasses; one swallow hit by a vehicle could attract several individuals to a road, potentially resulting in subsequent collisions and large mortality events (COSEWIC 2013b, Garrison and Turner 2020).

Although colonial nesting may provide advantages (e.g., predation protection and assistance with thermoregulation), it has been identified as a limiting factor for the Bank Swallow, potentially making them more vulnerable to natural events or anthropogenic activities, which may result in mass mortality events (Environment and Climate Change Canada 2022b).

2.4.2 Barn Swallow



Source: COSEWIC (2021a).

The Barn Swallow is a medium-sized songbird that occurs on every continent (except Antarctica), breeds throughout Canada, and winters in the southern United States, Mexico, and southwards (COSEWIC 2021a). Breeding habitat typically requires a suitable nesting site with a vertical or horizontal surface underneath a roof of some sort, open areas for foraging (e.g., grasslands, fields, wetlands, and shorelines), and a waterbody with mud for nest building (Government of Canada 2019b, Brown and Brown 2020, COSEWIC 2021a). Historically, suitable nesting sites were likely provided by caves, cliff faces, rock leges, tree branches, and hollow trees (Brown and Brown 2020, COSEWIC 2021a). Today, nesting sites are usually located within agricultural and rural areas, and along roads and highways (Brown and Brown 2020, COSEWIC 2021a). Anthropogenic features such as barns, houses, bridges, and culverts are commonly used for nesting sites (COSEWIC 2021a). Barn Swallows nest in colonies or independently and typically return to the same nesting sites each year and may reuse old nests (Government of Canada 2019b, Brown and Brown 2020, COSEWIC 2021a).

The Barn Swallow is federally listed under Schedule 1 of SARA as Threatened (Government of Canada 2023) and is designated as an S4B species in Saskatchewan (i.e., Apparently Secure breeding population) (Saskatchewan Conservation Data Centre 2023). An estimated 6.4 million individuals currently breed in Canada, with over 60% of the population breeding throughout the prairie provinces (COSEWIC 2021a). Based on BBS data collected between 1970 and 2019, the Barn Swallow population in Canada has declined at a rate of 2.34% per year, for an overall decline of 68.6% (COSEWIC 2021a). Intensification of agriculture, loss of nesting sites, large-scale declines in aerial insect populations, and climate change are cited as the most imminent threats for the Barn Swallow, and its dependence on aerial insects for prey and low post-fledging survival rates are cited as limiting factors for the species (COSEWIC 2021a). The repeated use of anthropogenic features for nesting makes Barn Swallows vulnerable to incidental take, especially if the anthropogenic features require routine maintenance. In addition, their frequent use of anthropogenic features for nesting makes Barn Swallows vulnerable to entrapment (e.g., buildings, pipes, vents, other enclosed spaces) as they search for potential locations to build a nest (COSEWIC 2021a).

2.4.3 Horned Grebe

Source: COSEWIC 2009b.

The Horned Grebe is a small waterbird that occurs in North America and Eurasia (COSEWIC 2009b). Within North America, the species breeds across western Canada from BC and Yukon across to the Magdalen Islands in Quebec and winters along the Pacific and Atlantic coasts (COSEWIC 2009b).

Breeding habitat for the Horned Grebe consists of small to medium-sized freshwater lakes, ponds, and marshes that are shallow with open water (at least 40%), emergent vegetation, anchorage for nests, and concealment for nests and young (COSEWIC 2009b, Stedman 2020). Horned Grebes use a range of waterbody sizes for breeding, but typically prefer waterbodies between 0.3 and 2.0 ha in size (COSEWIC 2009b). Most pairs are solitary, but loose colonies of up to 20 pairs have been found on larger waterbodies with abundant food resources (COSEWIC 2009b, Stedman 2020). Nests are typically located in shallow water near shore on a floating or emerging mass of vegetation (COSEWIC 2009b). Horned Grebes are diving birds that feed on a variety of aquatic arthropods and fish (COSEWIC 2009b, Stedman 2020).

The Western population of the Horned Grebe is federally listed under Schedule 1 of SARA as Special Concern (Government of Canada 2023) and is designated as an S5B species in Saskatchewan (i.e., Secure breeding population) (Saskatchewan Conservation Data Centre 2023). An estimated 200,000 to 500,000 individuals occur in the Western population, with most breeding in southern Alberta and Saskatchewan (COSEWIC 2009b, Environment and Climate Change Canada 2022c). Based on BBS data collected between 1970 and 2019, the Western population of the Horned Grebe in Canada has declined at a rate of 1.7% per year, for an overall decline of 57.0% (Environment and Climate Change Canada 2022c). The reasons for this population decline are unknown. Probable threats include permanent habitat loss, temporary loss of habitat during droughts, eutrophication and degradation of habitat due to fertilizers, predator expansion on the prairies, Type E botulism in the Great Lakes, entanglement in commercial fishing gear, climate change and extreme weather, and oil spills on wintering grounds (COSEWIC 2009b).

3 Mitigation Measures

The Project will require the construction, operation, and decommissioning of several components (as described in Section 2 of the EIS). Expected interactions between these Project components and activities and the wildlife VCs and their associated KIs are summarized by Project phase and activity in Tables 9.3-6 and 9.4-5 of the EIS. Based on the timing and nature of interactions identified in Tables 9.3-6 and 9.4-5 of the EIS, the following adverse effects on the wildlife VCs, including SAR, are likely to occur during the lifetime of the Project:

- alteration and/or loss of habitat; and
- change in mortality.

These potential effects apply to Wildlife SAR as well. The potential effects are described in Sections 9.3.4.2 and 9.4.4.2 of the EIS for each Project phase as they may affect the wildlife VCs and associated KIs.

Mitigation in this EIS is defined as the elimination, reduction, or control of potential adverse effects of the Project on the environment throughout all Project phases. Project-specific mitigation measures include: Project design; implementation of best management practices; development of management plans; implementation of emergency response programs; and provision of training, education and awareness (Denison 2020). Mitigation measures for each potential effect are described in Sections 9.3.5 and 9.4.5 of the EIS. The following subsections summarize mitigation measures that will be implemented to avoid or minimize adverse effects on the Wildlife SAR.

3.1 Project Design Measures

Potential adverse effects on Raptors, Migratory Breeding Birds, and Bird SAR VCs will be avoided or minimized to the extent practical through Project design. All of the Project design measures listed here are consistent with those presented in Section 9 of the EIS (i.e., there are no new Project design measures proposed in this appendix):

- The Project Area (i.e., the area of maximum physical disturbance) has been reduced to the extent practicable resulting in reduced habitat disturbance and noise propagation.
- Much of the proposed footprint will be developed within previously disturbed areas, including roads currently used for exploration activities, thereby minimizing additional habitat disturbance.
- The powerline to the main substation at the site is relatively short (i.e., approximately 7 km) and will be constructed from the existing provincial power line adjacent to Highway 914.
- During Operation, progressive reclamation activities will be completed where possible, and the progress and success of these activities will be assessed annually.
- Cleared brush will be stockpiled when possible, to be used in progressive reclamation.
- Ongoing decommissioning of Project components will be completed when possible.
- Dust deposition on vegetation and waterbodies (including potential deposition of trace metals and radionuclides) will be reduced by:
    - directing processing plant exhaust from drying and packaging areas through a stack prior to release outside of the building;
    - designing the stack height based on results of air dispersion modelling to be an appropriate height for optimal dispersion;

  - controlling access to the property with both a north and south security gate (the north gate is on a decommissioned road and the south gate is manned);
  - making a wash bay available to clean items, equipment and vehicles that may have been in contact with potentially contaminated materials. Contaminated water from the wash bay will be collected in a sump tank and routed to the water treatment plant for treatment and discharge;
  - conducting radiological clearance scanning as required for any items, equipment, and vehicles leaving the Project Area; and
  - watering and traffic controls on roads.

- Battery-powered light vehicles and mobile equipment, and an AC powered dual rotary drill for ISR wellfield development instead of a traditional diesel-powered unit, will be employed, where practical, to reduce air emissions and noise levels and improve energy efficiency.
- The main sources of noise will be related to transport of people and goods, drilling of holes for the freeze wall and wellfield, operation of the batch plant, operation of the processing plant, and operation of the pumphouses. The use of high-quality, low sound emission equipment and regular maintenance will reduce noise associated with Project activities.
- Bulk storage tanks for processing chemicals such as sulphuric and/or hydrochloric acid, sodium hydroxide, and hydrogen peroxide will sit inside appropriately designed and sized secondary containment basins, physically separated from the containment basins for other chemical systems.
- Surface pipelines will be designed to have secondary containment or catchment and have leak detection systems in place at key locations.
- A freeze wall will be established around the uranium deposit to reduce groundwater disturbance.
- Mining solution and process water will be reused throughout the mining process, reducing water use requirements to the extent feasible and reducing the volume of treated effluent requiring discharge. Make-up water will be preferentially sourced from site runoff where possible.
- Double-walled, high-density polyethylene or equivalent piping will be used in the wellfields and will be freeze protected and secured to minimize pipe movement.
- Contaminated wastes (e.g., mineralized drill cuttings, solid impurities removed from mining solution, dewatered reject solids) will be properly contained on a double lined waste pad with leak detection capabilities and an associated monitoring program. An adjacent pond will be used to collect runoff from the pad and water in the waste pond will be piped to the water treatment plant. Such waste will be disposed of either on site or off site at an approved facility.
- The ISR wellfield and processing plant will be designed to re-use most of the solutions inside each circuit; any excess water will be released to a surface water body once acceptable water quality is achieved. All treated effluent released to surface water will meet federal and provincial regulatory discharge limits.
- All contaminated areas, such as waste ponds and pads, and the domestic landfill will be fenced to avoid contact with workers and wildlife. Fences will be monitored and maintained.

3.2 General Mitigation Measures for Wildlife Species at Risk

Mitigation measures specific to the Wildlife SAR, in accordance with the *Migratory Birds Convention Act* and tailored to Project features will be incorporated into various Project management and monitoring plans such as the erosion and sediment controls, soil and vegetation monitoring, wildlife monitoring, the Decommissioning Plan, air quality monitoring, Spill Response Plan, Radiation Protection Plan, surface water and effluent monitoring and Waste Management Plan.

The management plans within the Environmental Management System (EMS) will provide specific mitigation measures based on proven and accepted mitigation measures following standard industry guidelines and best management practices. The EMS will provide guidance to avoid or minimize potential adverse effects of the Project on avian species and their habitat, including monitoring and follow-up programs, as appropriate. It will be in place during all phases of the Project and will be subject to ongoing review and revision as required. If monitoring identifies a need for additional or revised mitigation measures, a process of adaptive management (as described in the plan) will be triggered. The Project management plans provide direction on monitoring and adaptive management so that responses are timely and effective.

The following subsections provide a description of the mitigation measures that will be applicable during all Project phases and expected to be effective immediately following implementation.

3.2.1 Work Timing Windows and Habitat Disturbance

- Site clearing and other works that involve disturbance of vegetation and/or soil will be conducted outside of the nesting season, when practical. The nesting season for many Wildlife SAR in Saskatchewan spans a period from March 15 to August 31; however, the dates differ for certain species. The Wildlife Management Plans within the EMS will provide details on nesting windows for avian species, as well as other sensitive time periods (e.g., caribou calving periods) occurring in the Terrestrial RSA based on the Saskatchewan Activity Restriction Guidelines for Sensitive Species (SARGSS), which were established to support the avoidance of sensitive species' habitats during sensitive periods (SK MOE 2017).
- Prior to commencing any site clearing (i.e., vegetation clearing and/or soil disturbance) during the nesting and breeding season, pre-disturbance wildlife clearance surveys will be conducted a by a Qualified Professional (QP) at that location within the Project Area to identify sensitive species and habitat features (e.g., nests as well as roosts and hibernacula used by bat species).
- Active and/or suspected breeding and roosting locations identified during the pre- disturbance wildlife clearance surveys will be protected with a no-disturbance setback buffer consistent with regulatory guidelines (e.g., the 2017 SARGSS [SK MOE 2017]) in accordance with the level of the disturbance and species until the young have successfully fledged, the nest is confirmed as no longer active (e.g., abandoned or depredated), or the nesting window has passed (for suspected nest locations). If guidelines cannot be met, due to safety or operational concerns, SK MOE will be contacted for advice on the appropriate response to the situation.
- In addition to the species listed under Schedule 1 of SARA, if any features (e.g., nests) of species included on the Saskatchewan Activity Restriction Guidelines for Sensitive Species (SK MOE 2017) are observed during the pre-clearing wildlife surveys, the applicable activity restrictions will be implemented, as appropriate, following discussion with SK MOE.

3.2.2 Wildlife Education and Awareness

- Employees and contractors will be provided with wildlife education and awareness training, including education about potential Wildlife SAR issues on site and training on the mitigation measures to avoid or minimize potential adverse Project effects on Wildlife SAR and their habitats.
- Employees and contractors will be educated on waste management policies that limit human-avian interactions.
- Designated employees will be trained in appropriate avian deterrent techniques to minimize avian interactions with the Project.
- Employees and contractors will be requested to report avian observations on site, injured or dead birds (which will be reported to SK MOE). Avian encounters and outcomes will be monitored, and logbooks will be used to record observations. Logbooks and reports will be available to employees.

3.2.3 Wildlife and Habitat Protection

- Personal firearms will be prohibited for employees and contractors within the Project Area to prevent hunting activities.
- If any individual were seeking access around the Project area to undertake Aboriginal and/or Treaty Rights, Denison staff would facilitate this, provided it were safe to do so given activities in the area.
- Policies will be implemented prohibiting employees and contractors from feeding, approaching, or harassing avian species within the Project Area.
- To support habitat regeneration, progressive reclamation and ecosystem-based revegetation will be conducted on disturbed areas as soon as practicable in accordance with the Reclamation and Closure Plan.

3.2.4 Wildlife Deterrence and Prevention of Wildlife Entrapment

- Buildings and other Project infrastructure will be designed and maintained to exclude birds (e.g., barn swallows) and bats as much as possible. This would include installing solid barriers (e.g., corner slope panels, wooden panels) or flexible barriers (e.g., netting, tarps or geotextiles) under roof eaves or other exterior surfaces.
- Physical, visual, and/or auditory deterrents will be used to discourage bird and bat use of buildings and other Project infrastructure (e.g., water or waste treatment ponds) for refuge, shelter, breeding, and roosting, and to deter birds and bats from potentially becoming entrapped.
- Noise emitting Project activities will be managed to minimize sensory disturbance of wildlife SAR species, especially during sensitive time periods (i.e., breeding and nesting).
- Low sound emission equipment, regular maintenance of equipment, and the use of silencers or mufflers (whenever practical) will be used to reduce noise associated with Project activities, to the extent practical.
- Directed lighting or light shielding, rather than broad lighting, will be implemented to minimize sensory disturbance on the wildlife SAR, and lighting will be focused on work sites and not surrounding areas.

- Dust generation and subsequent deposition on vegetation and in waterbodies (including potential deposition of trace metals and radionuclides) will be limited through dust suppression techniques such as road watering and traffic management.

3.2.5 Road and Traffic Management

- Traffic and access control measures will be implemented will include reducing traffic volume by scheduling truck convoys, using high-volume haul trucks, and restricting public access to the Project site and roads (e.g., private vehicles, snowmobiles, all-terrain vehicles, and foot traffic). It is important to note that if any individual were seeking access around the Project area to undertake Aboriginal and / or Treaty Rights, Denison staff would facilitate this, provided it were safe to do so given activities in the area.
- Appropriate road signage will be installed (e.g., speed limits) along Project roads to raise awareness and minimize the potential for wildlife SAR-vehicle collisions.
- Wildlife will have the right-of-way on Project roads, unless it is unsafe to stop (i.e., if a collision is imminent). Vehicles will not be used to encourage wildlife to move off Project roads.
- Processes will be implemented for employees and contractors to slow down and/or stop vehicles/equipment to allow animals to move away or off the road before resuming normal road speeds for the area.
- Employees and contractors will report and communicate the location and circumstances of any roadkill observed on or alongside Project roads. Large-bodied wildlife carcasses found will be reported to SK MOE and disposed of as directed to discourage avian scavengers.
- Vegetation management, such as mowing and brush cutting, will be implemented along Project roads to reduce site attractiveness for wildlife SAR and maintain appropriate sightlines for drivers to minimize wildlife-vehicle collisions.
- Alternative measures on Project roads for de-icing and winter traction (e.g., sand, gravel) or dust suppression (e.g., water) will be implemented, whenever practicable.
- Appropriately sized gaps in the roadside snowbanks during winter will be maintained to facilitate wildlife crossing and escape thereby reducing the risk of wildlife-vehicle collisions.
- New Project site and access roads will be designed to minimize sightlines for predators, whenever practicable, while still maintaining general road safety.
- Ditches and culverts along Project roads will be designed and maintained to minimize pooling of water. Roadside pools that form may attract wildlife.

3.2.6 Waste and Hazardous Materials Management

- A "no littering policy" for employees and contractors will be implemented within the Project Area.
- Vegetation management will be incorporated in the vicinity of waste ponds to discourage wildlife SAR use of potentially affected vegetation.
- Waste will be collected and temporarily stored in wildlife-proof containers to avoid attracting scavengers and with that increase the risk for human-wildlife interaction.
- The wildlife-proof containers will be inspected regularly for evidence of avian presence (e.g., gull species) or access to waste disposal facilities. If evidence of avian presence or access to waste disposal facilities is detected, modified systems will be implemented and/or off-site waste disposal frequencies will be increased.
- The use of hazardous materials will be limited as much as possible.

- Hazardous materials will be handled, stored, and disposed of appropriately and in accordance with a Waste Management Plan to avoid attracting avian scavengers (e.g., wildlife-proof containers, exclusion fencing).
- Physical deterrents (e.g., fencing) will be employed around contaminated areas (e.g., waste ponds and waste pads), the domestic landfill, or hazardous materials storage areas to discourage wildlife use.
- Appropriate hazardous materials management practices will be implemented in accordance with industry guidelines and a Waste Management Plan to minimize the risk of accidental spills or leakage.
- Appropriate spill response kits will be positioned adjacent to areas where hazardous materials are stored in accordance with the Spill Response Plan.
- A minimum 100 m distance from any waterbody will be maintained for fuel storage, refueling activities, or equipment servicing in accordance with the Spill Response Plan.
- Appropriate fuel, chemical, and materials management practices will be followed in accordance with the Spill Response Plan to minimize the risk of accidental spills or leakage of diesel fuel, other hydrocarbons, and other hazardous materials.
- Air emissions will be reduced to the extent practical through implementation of an air quality monitoring plan within the EMS.
- All vehicles and equipment will be equipped with industry-standard emission control systems; unnecessary idling of vehicles will be prohibited.
- Vehicles and equipment will be maintained in good working condition (e.g., no leaks) and furnished with industry-standard spill response kits.
- Mitigation measures to reduce the potential for dispersion of radiological contaminants of potential concern to vegetation will be implemented in accordance with the Radiation Protection Plan.
- Education on and enforcement of proper waste and hazardous materials management practices will be provided to employees and contractors.

3.3 Species-Specific Mitigation Measures for Wildlife Species at Risk

The following provides a summary of the species-specific mitigation measures that will be implemented during Project activities. Mitigation measures specific to the Wildlife SAR have been added to Section 9 of final EIS as applicable, with species-specific details provided here in the supporting appendix. For further information on methods and timing of SAR pre-clearance sweeps, refer to Section 4 of this appendix.

3.3.1 Arthropod Species

3.3.1.1 Nine-spotted lady beetle

- Mitigation measures designed for the Soil and Organic Matter / Peat (Section 9.1.5) and Vegetation and Ecosystems (Section 9.2.5) VCs are expected to mitigate adverse effects on nine-spotted lady beetle primarily related to limiting the loss and/or disruption of suitable habitat for these species. These include:
  - The Project Area (i.e., the area of maximum physical disturbance) has been reduced to the extent safely practicable resulting in reduced habitat disturbance and noise propagation.

- Much of the proposed Project Footprint will be developed within previously disturbed areas, including roads currently used for exploration activities, thereby minimizing additional habitat disturbance.
- During Operation, progressive reclamation will be completed where possible, and the progress and success of these activities will be assessed annually.

- Herbicide use as part of vegetation management will be limited to the immediate Project Footprint and applied by licensed professional applicators, when necessary, to limit the potential for adverse effects on nine-spotted lady beetle.

3.3.1.2 Transverse lady beetle

- Mitigation measures designed for the Soil and Organic Matter / Peat (Section 9.1.5) and Vegetation and Ecosystems (Section 9.2.5) VCs are expected to mitigate adverse effects on transverse lady beetle primarily related to limiting the loss and/or disruption of suitable habitat for these species. These include:
    - The Project Area (i.e., the area of maximum physical disturbance) has been reduced to the extent safely practicable resulting in reduced habitat disturbance and noise propagation.
    - Much of the proposed Project Footprint will be developed within previously disturbed areas, including roads currently used for exploration activities, thereby minimizing additional habitat disturbance.
    - During Operation, progressive reclamation will be completed where possible, and the progress and success of these activities will be assessed annually.
- Herbicide use as part of vegetation management will be limited to the immediate Project Footprint and applied by licensed professional applicators, when necessary, to limit the potential for adverse effects on transverse lady beetle.

3.3.1.3 Yellow-banded bumble bee

- Mitigation measures designed for the Soil and Organic Matter / Peat (Section 9.1.5) and Vegetation and Ecosystems (Section 9.2.5) VCs are expected to mitigate adverse effects on yellow-banded bumble bee primarily related to limiting the loss and/or disruption of suitable habitat for these species. These include:
    - The Project Area (i.e., the area of maximum physical disturbance) has been reduced to the extent safely practicable resulting in reduced habitat disturbance and noise propagation.
    - Much of the proposed Project Footprint will be developed within previously disturbed areas, including roads currently used for exploration activities, thereby minimizing additional habitat disturbance.
    - During Operation, progressive reclamation will be completed where possible, and the progress and success of these activities will be assessed annually.
- Herbicide use as part of vegetation management will be limited to the immediate Project Footprint and applied by licensed professional applicators, when necessary, to limit the potential for adverse effects on yellow-banded bumble bee.

3.3.2 Amphibian Species

3.3.2.1 Northern leopard frog

- Mitigation measures designed for the Wetlands VC (Section 9.2.5) are expected to mitigate adverse effects on the northern leopard frog primarily related to limiting the loss and/or disruption of suitable habitat for these species. These include:
    - The Project Area (i.e., the area of maximum physical disturbance) has been reduced to the extent safely practicable resulting in reduced habitat disturbance and noise propagation.
    - Much of the proposed Project Footprint will be developed within previously disturbed areas, including roads currently used for exploration activities, thereby minimizing additional habitat disturbance.
    - During Operation, progressive reclamation will be completed where possible, and the progress and success of these activities will be assessed annually.
- Pre-disturbance wildlife clearance surveys will be conducted to identify site-specific habitat features (e.g., northern leopard frog breeding ponds) and implement the setbacks and/or timing windows (that will be defined in the Wildlife Management Plan).
- In addition to the species listed under Schedule 1 of SARA, if any features (e.g., breeding and overwintering habitat) of species included on the Saskatchewan Activity Restriction Guidelines for Sensitive Species (SK MOE 2017) are observed during the pre-clearing wildlife surveys, the applicable activity restrictions will be implemented, as appropriate, following discussion with SK MOE.
- Locations of site-specific habitat features used by northern leopard frog will be communicated to Project personnel and the requirement to limit disturbance in these areas will be implemented.
- Appropriate setback and buffer distances from wetland features where northern leopard frog are known to occur will be implemented and maintained under the direction of a wildlife QP.
- Vehicle traffic and construction activities will be restricted to the approved access routes and work areas and will not cross or enter a watercourse or wetland.

3.3.3 Bat Species

3.3.3.1 Little brown myotis

- Vegetation clearing activities will occur outside of little brown myotis roosting periods, when practical.
- Pre-disturbance wildlife clearance surveys will be completed to identify site-specific habitat features such as little brown myotis maternal rooting sites and hibernacula used by little brown myotis. If features are identified in the Project Footprint, appropriate setbacks and/or timing windows will be implemented (refer to Table 4-1 in final EIS Appendix 9-D which will also be defined in the Wildlife Management Plan).
- In the event a little brown myotis maternal roosting site is identified on the Project Footprint, exclusionary methods (e.g., installing a one-way bat exit) will be implemented following the summer maternity roost season. This installation would allow for little brown myotis to leave but not the ability to re-enter the roosting site.

- Locations of these site-specific habitat features used by little brown myotis will be communicated to the appropriate Project personnel and the requirement to limit disturbance in these areas will be implemented.
- Specific exclusion methods will be added as mitigation measures (Section 9.4.5 of the final EIS) to prevent access to buildings and other infrastructure.

3.3.3.2 Northern myotis

- Vegetation clearing activities will occur outside of northern myotis roosting periods, when practical.
- Pre-disturbance wildlife clearance surveys will be completed to identify site-specific habitat features such as northern myotis maternal rooting sites and hibernacula used by northern myotis. If features are identified in the Project Footprint, appropriate setbacks and/or timing windows will be implemented (refer to Table 4-1 in final EIS Appendix 9-D which will also be defined in the Wildlife Management Plan).
- In the event a northern myotis maternal roosting site is identified on the Project Footprint, exclusionary methods (e.g., installing a one-way bat exit) will be implemented following the summer maternity roost season. This installation would allow for northern myotis to leave but not the ability to re-enter the roosting site.
- Locations of these site-specific habitat features used by northern myotis will be communicated to the appropriate Project personnel and the requirement to limit disturbance in these areas will be implemented.
- Specific exclusion methods will be added as mitigation measures (Section 9.4.5 of the final EIS) to prevent access to buildings and other infrastructure.

3.3.4 Avian Species

3.3.4.1 Bank Swallow

- Site clearing and other works that involve disturbance of vegetation and/or soil will be conducted outside of the bank swallow nesting season, when practical. The breeding and nesting season for bank swallow in Saskatchewan typically spans a period from May 15 to July 31.
- In the event Project activities such as vegetation clearing and/or soil disturbance are required during the bank swallow breeding and nesting season, pre-disturbance wildlife clearance surveys will be conducted by a QP at that location within the Project Area before activities commence to identify the presence of bank swallow nests.
- Active and/or suspected bank swallow nests identified during the pre-disturbance wildlife clearance surveys will be protected with a no-disturbance setback buffer consistent with adopted regulatory guidelines (e.g., Manitoba Conservation [2021] as there is currently no activity restriction guidelines for bank swallow in Saskatchewan) in accordance with the level of the disturbance until the young have successfully fledged, the nest is confirmed as no longer active (e.g., abandoned or depredated), or the nesting window has passed (for suspected nest locations).
- Locations of nesting sites used by bank swallows will be communicated to appropriate Project personnel and the requirement to limit disturbance in these areas will be implemented.

3.3.4.2 Barn Swallow

- Site clearing and other works that involve disturbance of vegetation and/or soil will be conducted outside of the barn swallow nesting season, when practical. The breeding and nesting season for barn swallow in Saskatchewan typically spans a period from May 15 to September 30.
- In the event Project activities such as vegetation clearing and/or soil disturbance are required during the barn swallow breeding and nesting season, pre-disturbance wildlife clearance surveys will be conducted by a QP at that location within the Project Area before activities commence to identify the presence of barn swallow nests.
- Active and/or suspected barn swallow nests identified during the pre-disturbance wildlife clearance surveys will be protected with a no-disturbance setback buffer consistent with adopted regulatory guidelines (e.g., Manitoba Conservation [2021] as there is currently no activity restriction guidelines for barn swallow in Saskatchewan) in accordance with the level of the disturbance until the young have successfully fledged, the nest is confirmed as no longer active (e.g., abandoned or depredated), or the nesting window has passed (for suspected nest locations).
- Locations of nesting sites used by barn swallows will be communicated to appropriate Project personnel and the requirement to limit disturbance in these areas will be implemented.

3.3.4.3 Common Nighthawk

- Site clearing and other works that involve disturbance of vegetation and/or soil will be conducted outside of the common nighthawk nesting season, when practical. The breeding and nesting season for common nighthawk in Saskatchewan typically spans a period from May 1 to August 31.
- In the event Project activities such as vegetation clearing and/or soil disturbance are required during the common nighthawk breeding and nesting season, pre-disturbance wildlife clearance surveys will be conducted by a QP at that location within the Project Area before activities commence to identify the presence of common nighthawk nests.
- Active and/or suspected common nighthawk breeding and roosting locations identified during the pre-disturbance wildlife clearance surveys will be protected with a no-disturbance setback buffer consistent with regulatory guidelines (e.g., the 2017 SARGSS [SK MOE 2017]) in accordance with the level of the disturbance until the young have successfully fledged, the nest is confirmed as no longer active (e.g., abandoned or depredated), or the nesting window has passed (for suspected nest locations).

3.3.4.4 Horned Grebe

- Site clearing and other works that involve disturbance of vegetation and/or soil will be conducted outside of the horned grebe nesting season, when practical. The breeding and nesting season for horned grebe in Saskatchewan typically spans a period from May 1 to September 15.
- In the event Project activities such as vegetation clearing and/or soil disturbance are required during the horned grebe breeding and nesting season, pre-disturbance wildlife clearance surveys will be conducted by a QP at that location within the Project Area before activities commence to identify the presence of horned grebe nests.

- Active and/or suspected horned grebe nests identified during the pre-disturbance wildlife clearance surveys will be protected with a no-disturbance setback buffer consistent with regulatory guidelines (e.g., the 2017 SARGSS [SK MOE 2017]) for other grebe species (as there is currently no activity restriction guidelines for horned grebe in Saskatchewan) in accordance with the level of the disturbance until the young have successfully fledged, the nest is confirmed as no longer active (e.g., abandoned or depredated), or the nesting window has passed (for suspected nest locations).
- Locations of nesting sites used by horned grebe will be communicated to appropriate Project personnel and the requirement to limit disturbance in these areas will be implemented.

3.3.4.5 Olive-sided Flycatcher

- Site clearing and other works that involve disturbance of vegetation and/or soil will be conducted outside of the olive-sided flycatcher nesting season, when practical. The breeding and nesting season for olive-sided flycatcher in Saskatchewan typically spans a period from May 1 to August 31.
- In the event Project activities such as vegetation clearing and/or soil disturbance are required during the olive-sided flycatcher breeding and nesting season, pre-disturbance wildlife clearance surveys will be conducted by a QP at that location within the Project Area before activities commence to identify the presence of olive-sided flycatcher nests.
- Active and/or suspected olive-sided flycatcher nests identified during the pre-disturbance wildlife clearance surveys will be protected with a no-disturbance setback buffer consistent with regulatory guidelines (e.g., the 2017 SARGSS [SK MOE 2017]) in accordance with the level of the disturbance until the young have successfully fledged, the nest is confirmed as no longer active (e.g., abandoned or depredated), or the nesting window has passed (for suspected nest locations).

3.3.4.6 Rusty Blackbird

- Site clearing and other works that involve disturbance of vegetation and/or soil will be conducted outside of the rusty blackbird nesting season, when practical. The breeding and nesting season for rusty blackbird in Saskatchewan typically spans a period from May 1 to July 31.
- In the event Project activities such as vegetation clearing and/or soil disturbance are required during the rusty blackbird breeding and nesting season, pre-disturbance wildlife clearance surveys will be conducted by a QP at that location within the Project Area before activities commence to identify the presence of rusty blackbird nests.
- Active and/or suspected rusty blackbird nests identified during the pre-disturbance wildlife clearance surveys will be protected with a no-disturbance setback buffer consistent with regulatory guidelines (e.g., the 2017 SARGSS [SK MOE 2017]) in accordance with the level of the disturbance until the young have successfully fledged, the nest is confirmed as no longer active (e.g., abandoned or depredated), or the nesting window has passed (for suspected nest locations).

3.3.4.7 Short-eared Owl

- Site clearing and other works that involve disturbance of vegetation and/or soil will be conducted outside of the short-eared owl nesting season, when practical. The breeding and nesting season for short-eared owl in Saskatchewan typically spans a period from March 25 to August 1.
- In the event Project activities such as vegetation clearing and/or soil disturbance are required during the short-eared owl breeding and nesting season, pre-disturbance wildlife clearance surveys will be conducted by a QP at that location within the Project Area before activities commence to identify the presence of short-eared owl nests.
- Active and/or suspected short-eared owl nests identified during the pre-disturbance wildlife clearance surveys will be protected with a no-disturbance setback buffer consistent with regulatory guidelines (e.g., the 2017 SARGSS [SK MOE 2017]) in accordance with the level of the disturbance until the young have successfully fledged, the nest is confirmed as no longer active (e.g., abandoned or depredated), or the nesting window has passed (for suspected nest locations).

3.3.4.8 Yellow Rail

- Site clearing and other works that involve disturbance of vegetation and/or soil will be conducted outside of the yellow rail nesting season, when practical. The breeding and nesting season for yellow rail in Saskatchewan typically spans a period from May 1 to July 15.
- In the event Project activities such as vegetation clearing and/or soil disturbance are required during the yellow rail breeding and nesting season, pre-disturbance wildlife clearance surveys will be conducted by a QP at that location within the Project Area before activities commence to identify the presence of yellow rail nests.
- Active and/or suspected yellow rail nests identified during the pre-disturbance wildlife clearance surveys will be protected with a no-disturbance setback buffer consistent with regulatory guidelines (e.g., the 2017 SARGSS [SK MOE 2017]) in accordance with the level of the disturbance until the young have successfully fledged, the nest is confirmed as no longer active (e.g., abandoned or depredated), or the nesting window has passed (for suspected nest locations).

4 Pre-clearance SAR Survey Methods

The methods and timing of proposed SAR pre-clearance sweep are provided in Table 4-1.

Table 4-1 Wildlife Species at Risk Pre-clearance Sweep Methods and Timing

Species of Concern	Baseline Survey Results	Assessed in the EIS	Important Habitat and Needs	Survey Target Areas	Survey Technique [1]	Timing	Action if Species Detected	Information Source
Northern Leopard Frog	Not observed	Appendix 9-D	From winter sites, adult frogs travel up to 1.6 km to breed.	Wetlands/ water/ riparian / wet/ moist/ scrublands/ bogs/ fens.	Visual searches for egg masses or frogs	Snow/ice-free early spring and spring season	Pond setback; 10m (Low); 200m (Mod) and 500m (High)	MOE (2017)
			They breed in the shallow, warm waters of a variety of wetlands including marshes, springs, flooded ditches, dugouts, borrow pits, beaver ponds, margins of lakes, and slow-moving waters of streams and rivers.		Auditory call surveys	April 20 to June 10		
			After breeding, adults and sub-adults may disperse up to 8 km from breeding ponds.					
			Northern Leopard Frogs usually do not utilize areas that are heavily wooded.		Visual searches for egg masses or frogs	Snow/ice-free early spring and spring season		
			They forage in the summer in riparian or upland habitats. These areas are moist habitats including meadows, pastures, scrublands, riparian corridors, and drainage or irrigation ditches.		Visual searches for egg masses or frogs	Snow/ice-free early spring and spring season		
Little Brown Myotis and Northern Bat	34 ultrasonic detections of little brown/northern myotis	Appendix 9-D	The presence of large snags, tree cavities, is an important attribute in old growth forest stands that provides maternity roosts and day roosts for northern myotis and little brown bats. Buildings are also used.	Treed areas with the largest diameter and/or older trees. Focus on older forest, or areas with large snags in younger forest within the project footprint (majority is regenerating forest 1-5m).	Daytime visual search of trees and potential roost sites. Systematic meandering search of areas to be cleared during active bat season. Focus on searching for roost features (snags, cracks, stumps, cavities, bark peeling) and bat sign (e.g., guano).	May to Sept	Should a roosting bat be discovered the area will be afforded protection from clearing for 24 hours and re-surveyed. The area will only be cleared if no bats are discovered. A 100 m buffer will be given to nursery roots and 50 m to daily roosting bats. If many roosting bats are recorded compensation will be considered (e.g., bat houses).	COSEWIC (2013a); Resources Information Standards Committee (RISC) (2022)

Species of Concern	Baseline Survey Results	Assessed in the EIS	Important Habitat and Needs	Survey Target Areas	Survey Technique [1]	Timing	Action if Species Detected	Information Source
			Foraging habitat in proximity to roosting sites is also an important factor in roost selection.	Treed areas in proximity to clearings, wetlands and open water.		Year Round	Roost/Foraging site; 100m (Low); 500m (Mod) and 500m (High)	MOE (2017)
Wolverine	Not observed	Section 9.3	A wide variety of forested and vegetation associations are used by wolverine. Habitats must have an adequate year-round supply of food, mainly consisting of smaller prey such as rodents and Snowshoe Hares, and the carcasses of large ungulates, like Moose, Caribou, and Muskox. Females den under snow-covered rocks, logs or within snow tunnels. Wolverines reproduce in areas where snow cover persists at least into April.	All areas of project activity.	Winter den searches	Snow cover months	Setback of 250m when occupied and 100m when unoccupied.	COSEWIC (2014); Environmental Protection and Management Guideline (2024)
Woodland Caribou	Observed	Section 9.3	Woodland caribou may occupy all potential project areas but prefer forests greater than 40 years of age.	All areas of project activity.	Visual search to ensure no caribou are in the area. Ongoing vigilance.	Year Round	If caribou are in the area cease operations until they are clear of the area.	SME (2021)
Rusty Blackbird	Not observed	Section 9.4	Rusty blackbird primarily nests in small conifers, predominantly spruce. In Canada, nests have also been found in Balsam Fir, Eastern White Cedar, Paper Birch, Balsam Poplar, Red Maple, Pin Cherry, emergent sedges, cattails, and on the ground on a beaver dam	All habitat with spruce, white birch and balsam poplar. Very limited suitable (spruce) habitat within project footprint.	Visual search for nests	MBCA window	A 75 m buffer around coniferous bogs, fens and other wetlands suitable for Rusty blackbirds (Odsen and Pyper 2019).	Environment Canada. (2015); Odsen and Pyper (2019); Wildlife Division (2020)
			We only have spruce, birch and poplar at Wheeler.			May 1 to July 31	Nest setback of 0-50m (Low activity); 150m (Mod activity) and 300m (High activity)	Manitoba Conservation (2021)
Yellow Rail	Not observed	Section 9.4	Yellow rails inhabit shallow wetlands and other wet areas with grass-like vegetation. They breed in wetlands such as damp hay fields or meadows, floodplains, bogs, upper levels of estuaries, and salt marshes.	Using available mapping conduct daytime Ecosite verification and stratify surveys in appropriate	Mid May to mid to late June. Triplicate nocturnal (23:00-03:00) call-playback surveys spaced at least 4			Environment Canada (2012); SME (2014) Detection surveys per Saskatchewan Species Detection Survey Protocol (SDSP) https://publications.saskatchewan.ca/#/products/79508

Species of Concern	Baseline Survey Results	Assessed in the EIS	Important Habitat and Needs	Survey Target Areas	Survey Technique [1]	Timing	Action if Species Detected	Information Source
			These wetlands are generally dominated by short, fine-stemmed herbaceous vegetation, especially sedges (*Carex* spp.), as well as other graminoid vegetation of the families Cyperaceae, Poaceae, and Juncaceae. Vegetation structure (e.g. short, grass-like, and dense) is likely more important than its taxon.	habitat only. Based on available mapping, no suitable habitat within project footprint.	days apart. Or use Autonomous Recording Units throughout the breeding season.			
			Breeding habitats may have up to 50 cm of standing water, but typically nesting sites are less than 15 cm deep.			May 1 to July 15	Nest site setback; 100m (Low); 150m (Mod) and 350m (High)	MOE (2017)
Bank Swallow	Not observed	Appendix 9-D	The Bank Swallow readily breeds in a wide variety of low elevation (< 900 m), natural and anthropogenic habitats, including: lake and ocean bluffs; stream and river banks; sand and gravel pits; roadcuts; and piles of sand, topsoil, sawdust, coal ash, and other materials.	Survey key habitat features identified as important.	Visual survey during timing window	May 15 to July 31	Nesting Colony Setback; 50m (Low); 150m (Mod) and 300m (High)	Manitoba Conservation (2021)
			Nest burrows are nearly always in a vertical or near-vertical bank (range: 76-105° slope).					COSEWIC (2013b)
			In some cases, Bank Swallows have nested in drain pipes and in structures designed and built specifically for nesting Bank Swallows.					
Barn Swallow	Four visual/auditory detections	Appendix 9-D	Nest on horizontal and vertical structures that include natural sites, such as cliffs and caves, as well as human-made structures, such as barns, bridges, and culverts. The nesting substrate must be rough, or have a ledge or projecting objects, such as bolts or light fixtures, to provide additional structural support to the nest.	Open areas in proximity to water. All buildings and man-made structures.	Visual	May 15 to Sept 30	Nest site setback; 50m (Low); 100m (Mod) and 100m (High)	Manitoba Conservation (2021)
			Nesting sites must provide access to open areas with an abundant supply of aerial insects to feed on; features such as wetlands, waterbodies, watercourses, meadows, grazed grassland, and farmland are preferred. Proximity to a waterbody or moist area with a supply of wet mud is needed to facilitate nest construction.					COSEWIC (2021a)

Species of Concern	Baseline Survey Results	Assessed in the EIS	Important Habitat and Needs	Survey Target Areas	Survey Technique [1]	Timing	Action if Species Detected	Information Source
Common Nighthawk	Two nests, five visuals, and 76 auditory/visual detections	Section 9.4	Nests are typically in open sites with dry, well-drained substrates that will not overheat and that have shade nearby for young to shelter from the sun and predators. Nest sites include forest clearings, bare patches in grassland, gravel pits, outcrops, road or rail sides, and, rarely, fenceposts.	All upland habitat.	Call-playback	May 1 to Aug 31	Nest site setback; 0-50m (Low); 150m (Mod) and 300m (High)	MOE (2017) Detection surveys per Saskatchewan Species Detection Survey Protocol (SDSP) https://publications.saskatchewan.ca/api/v1/products/79502/formats/117104/download
Horned Grebe	One observation	Appendix 9-D	More than 90% of the Horned Grebes in North America breed in ponds and lakes in western and northern Canada.	Water bodies within the project area.	Visual searches	May 1 to Sept 15	Nest site setback; 100m (Low); 200m (Mod) and 400m (High)	Manitoba Conservation (2021)
								COSEWIC (2009b)
Olive-sided Flycatcher	Fourteen observations	Section 9.4	Olive-sided Flycatcher has been widely observed in open coniferous or mixed coniferous forests, often located near water or wetlands with the presence of tall snags or trees.	All conifer and/treed upland areas.	Call-playback	May 1 to Aug 31	Nest setback; 100m (Low); 300m (Mod) and 500m (High)	MOE (2017)
			Data gathered from points across Canada indicate that mature conifer stands within patchy landscapes influenced by natural disturbance (e.g., recent burns) support the highest densities.					Environment Canada (2016)
			Olive-sided Flycatcher prefers post-burn areas or wetlands that create open habitats for the species to forage.					Detection surveys per Saskatchewan Species Detection Survey Protocol (SDSP)
Short-eared Owl	Not observed	Section 9.4	Nesting generally occurs in large open areas.	Open upland and lowland areas with no trees and some shrub cover.	Call-playback	March 25 to Aug 1	100m (Low); 300m (Mod) and 500m (High)	MOE (2017)
			Requires a minimum area of about 50-100 ha, consistent with the mean territory size of 82 ha reported in Manitoba.					COSEWIC (2021b)
			In the north, nests are primarily in tundra (Sinclair et al. 2003), and sometimes beside a small shrub that provides cover.					Detection surveys per Saskatchewan Species Detection Survey Protocol (SDSP) https://publications.saskatchewan.ca/api/v1/products/79506/formats/117101/download

[1] Surveys will be completed by qualified professional biologists; in their capacity as professional biologists, they will refer to available guidance such as the Saskatchewan species detection survey protocols to develop details of the surveys (e.g., selecting the appropriate time of day for the survey).

5 Residual and Cumulative Effects Summary

The approach to assessing residual Project effects on wildlife VCs followed the methodology outlined in Section 5.8 of the EIS, which included a habitat-based approach. For each VC and associated KI, each residual effect was assessed in the context of the Project activities that will occur within each Project phase. Each residual effect was then characterized based on the combined predicted residual effect for all phases. See Sections 9.3.6 and 9.4.6 of the EIS for specific details regarding the residual effects assessment for wildlife VCs (i.e., residual effect characterization and significance determination). A summary of the environmental assessment considerations and determination for predicted residual effects for Wildlife SAR is provided in Table 5-1.

The cumulative effects assessment (CEA) followed standard methodology as per provincial (e.g., Guidelines for an Environmental Assessment under the [Saskatchewan] *Environmental Assessment Act* 1980) and federal (e.g., Assessing Cumulative Environmental Effects under the *Canadian Environmental Assessment Act 2012*) guidance, and is discussed in detail in Section 5.9 of the EIS. Similar to the residual effects assessment, the CEA included a habitat-based approach. See Sections 9.3.7 and 9.4.7 of the EIS for specific details regarding the CEA for wildlife VCs. A summary of the significance determination of the cumulative effects on Wildlife SAR is provided in Table 5-2.

Table 5-1 Summary of the Environmental Assessment Considerations and Determination for Predicted Residual Effects for Wildlife Species At Risk

Component	Wildlife SAR	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Species-Specific Mitigation Measures	Predicted Residual Effect	Significance
Terrestrial Environment	Nine-spotted lady beetle	Amount of habitat that is altered or lost relative to its availability in the Terrestrial Regional Study Area (RSA).	• Development of access roads and airstrip. • Site preparation and earthworks; clearing, levelling, and grading of the Project Area. • Waste management (composting, domestic and industrial landfill operation, recycling). • Water management (including treatment). • Surface water withdrawal. • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Construction	• The proposed mitigation measures outlined in the EIS, particularly those designed for the Valued Components (VCs) Soil and Organic Matter / Peat (Section 9.1.5) and Vegetation and Ecosystems (Section 9.2.5), adequately and appropriately address potential for adverse effects on nine-spotted lady beetle, primarily related to limiting the loss and/or disruption of suitable habitat. These include the following: - The Project Area (i.e., the area of maximum physical disturbance) has been reduced to the extent safely practicable resulting in reduced habitat disturbance and noise propagation. - Much of the proposed Project Footprint will be developed within previously disturbed areas, including roads currently used for	Alteration and/or loss of habitat: predicted to be low magnitude, local geographical extent, long-term duration, frequent, and fully reversible.	Not Significant: the predicted residual effect of alteration and/or loss of habitat is not expected to alter the integrity of the habitat for nine-spotted lady beetle within the Terrestrial RSA to the point where it is not sustainable or available to contribute to ecological functions.
			• Water withdrawal from groundwater or surface water body. • Management of surface water (including seepage and site runoff). • Water release to groundwater and/or surface water body. • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Operation			
			• Site water management, treatment, and release	Decommissioning			

Component	Wildlife SAR	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Species-Specific Mitigation Measures	Predicted Residual Effect	Significance
			• Process water treatment and release. • Demolition and disposal of non-salvageable surface infrastructure and materials. • On-site and off-site operation of vehicles and transport of materials. • Reclamation of disturbed areas.		exploration activities, thereby minimizing additional habitat disturbance. - During Operation, progressive reclamation will be completed where possible, and the progress and success of these activities will be assessed annually.		
		Nine-spotted lady beetle mortalities directly or indirectly attributable to the Project.	• Development of access roads and airstrip. • Site preparation and earthworks; clearing, levelling, and grading of the Project Area. • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Construction	• Herbicide use as part of vegetation management will be limited to the immediate Project Footprint applied by licensed professional applicators when necessary to limit the potential for adverse effects on nine-spotted lady beetle.	Change in mortality: predicted to be low magnitude, local in geographical extent, long-term duration, infrequent, and fully reversible.	The predicted residual effect of change in mortality is not expected to alter the integrity of the regional populations of nine-spotted lady beetle to the point where they are not sustainable or available to contribute to ecological functions.
			• On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Operation			
			• Demolition and disposal of non-salvageable surface infrastructure and materials. • On-site and off-site operation of vehicles and transport of materials. • Reclamation of disturbed areas.	Decommissioning			
			• Development of access roads and airstrip.	Construction			

Component	Wildlife SAR	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Species-Specific Mitigation Measures	Predicted Residual Effect	Significance
Terrestrial Environment	Transverse lady beetle	Amount of habitat that is altered or lost relative to its availability in the Terrestrial Regional Study Area (RSA).	• Site preparation and earthworks; clearing, levelling, and grading of the Project Area. • Waste management (composting, domestic and industrial landfill operation, recycling). • Water management (including treatment). • Surface water withdrawal. • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.		• The proposed mitigation measures outlined in the EIS, particularly those designed for the Valued Components (VCs) Soil and Organic Matter / Peat (Section 9.1.5) and Vegetation and Ecosystems (Section 9.2.5), adequately and appropriately address potential for adverse effects on transverse lady beetle, primarily related to limiting the loss and/or disruption of suitable habitat. These include the following: - The Project Area (i.e., the area of maximum physical disturbance) has been reduced to the extent safely practicable resulting in reduced habitat disturbance and noise propagation. - Much of the proposed Project Footprint will be developed within previously disturbed areas, including roads currently used for	Alteration and/or loss of habitat: predicted to be low magnitude, local geographical extent, long-term duration, frequent, and fully reversible.	Not Significant: the predicted residual effect of alteration and/or loss of habitat is not expected to alter the integrity of the habitat for transverse lady beetle within the Terrestrial RSA to the point where it is not sustainable or available to contribute to ecological functions.
			• Water withdrawal from groundwater or surface water body. • Management of surface water (including seepage and site runoff). • Water release to groundwater and/or surface water body. • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Operation			
			• Site water management, treatment, and release • Process water treatment and release.	Decommissioning			

Component	Wildlife SAR	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Species-Specific Mitigation Measures	Predicted Residual Effect	Significance
			• Demolition and disposal of non-salvageable surface infrastructure and materials. • On-site and off-site operation of vehicles and transport of materials. • Reclamation of disturbed areas.		exploration activities, thereby minimizing additional habitat disturbance. - During Operation, progressive reclamation will be completed where possible, and the progress and success of these activities will be assessed annually. • Herbicide use as part of vegetation management will be limited to the immediate Project Footprint applied by licensed professional applicators when necessary to limit the potential for adverse effects on transverse lady beetle.		
		Transverse lady beetle mortalities directly or indirectly attributable to the Project.	• Development of access roads and airstrip. • Site preparation and earthworks; clearing, levelling, and grading of the Project Area. • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Construction		Change in mortality: predicted to be low magnitude, local in geographical extent, long-term duration, infrequent, and fully reversible.	The predicted residual effect of change in mortality is not expected to alter the integrity of the regional populations of transverse lady beetle to the point where they are not sustainable or available to contribute to ecological functions.
			• On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Operation			
			• Demolition and disposal of non-salvageable surface infrastructure and materials. • On-site and off-site operation of vehicles and transport of materials. • Reclamation of disturbed areas.	Decommissioning			
Terrestrial Environment	Yellow-banded bumble bee	Amount of habitat that is altered or lost relative to its availability in the	• Development of access roads and airstrip. • Site preparation and earthworks; clearing, levelling, and grading of the Project Area.	Construction	• The proposed mitigation measures outlined in the EIS, particularly those designed for the Valued Components (VCs)	Alteration and/or loss of habitat: predicted to be low magnitude, local	Not Significant: the predicted residual effect of alteration and/or loss of

Component	Wildlife SAR	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Species-Specific Mitigation Measures	Predicted Residual Effect	Significance
		Terrestrial Regional Study Area (RSA).	• Waste management (composting, domestic and industrial landfill operation, recycling). • Water management (including treatment). • Surface water withdrawal. • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.		Soil and Organic Matter / Peat (Section 9.1.5) and Vegetation and Ecosystems (Section 9.2.5), adequately and appropriately address potential for adverse effects on yellow-banded bumble bee, primarily related to limiting the loss and/or disruption of suitable habitat. These include the following: - The Project Area (i.e., the area of maximum physical disturbance) has been reduced to the extent safely practicable resulting in reduced habitat disturbance and noise propagation. - Much of the proposed Project Footprint will be developed within previously disturbed areas, including roads currently used for exploration activities, thereby minimizing additional habitat disturbance. - During Operation, progressive reclamation will	geographical extent, long-term duration, frequent, and fully reversible.	habitat is not expected to alter the integrity of the habitat for yellow-banded bumble bee within the Terrestrial RSA to the point where it is not sustainable or available to contribute to ecological functions.
			• Water withdrawal from groundwater or surface water body. • Management of surface water (including seepage and site runoff). • Water release to groundwater and/or surface water body. • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Operation			
			• Site water management, treatment, and release • Process water treatment and release. • Demolition and disposal of non-salvageable surface infrastructure and materials. • On-site and off-site operation of vehicles and transport of materials.	Decommissioning			

Component	Wildlife SAR	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Species-Specific Mitigation Measures	Predicted Residual Effect	Significance
			• Reclamation of disturbed areas.		be completed where possible, and the progress and success of these activities will be assessed annually. • Herbicide use as part of vegetation management will be limited to the immediate Project Footprint applied by licensed professional applicators when necessary to limit the potential for adverse effects on yellow-banded bumble bee.		
		Yellow-banded bumble bee mortalities directly or indirectly attributable to the Project.	• Development of access roads and airstrip. • Site preparation and earthworks; clearing, levelling, and grading of the Project Area. • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Construction		Change in mortality: predicted to be low magnitude, local in geographical extent, long-term duration, infrequent, and fully reversible.	The predicted residual effect of change in mortality is not expected to alter the integrity of the regional populations of yellow-banded bumble bee to the point where they are not sustainable or available to contribute to ecological functions.
			• On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Operation			
			• Demolition and disposal of non-salvageable surface infrastructure and materials. • On-site and off-site operation of vehicles and transport of materials. • Reclamation of disturbed areas.	Decommissioning			
Terrestrial Environment	Northern leopard frog	Amount of habitat that is altered or lost relative to its availability in the Terrestrial RSA.	• Development of access roads and airstrip. • Site preparation and earthworks; clearing, leveling and grading of the Project Area. • Water management (including treatment and site runoff). • Surface water withdrawal.	Construction	• The proposed mitigation measures outlined in the EIS, particularly those designed for the Wetlands VC (Section 9.2.5), adequately and appropriately address potential adverse effects on northern leopard frogs,	Alteration and/or loss of habitat: predicted to be low magnitude, local geographical extent, long-term duration,	Not Significant: the predicted residual effect of alteration and/or loss of habitat is not expected to alter the integrity of the

Component	Wildlife SAR	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Species-Specific Mitigation Measures	Predicted Residual Effect	Significance
			• On-site and off-site operation of vehicles and transport of materials.		primarily related to limiting the loss and/or disruption of suitable habitat for this species. These include the following: - The Project Area (i.e., the area of maximum physical disturbance) has been reduced to the extent safely practicable resulting in reduced habitat disturbance and noise propagation. - Much of the proposed Project Footprint will be developed within previously disturbed areas, including roads currently used for exploration activities, thereby minimizing additional habitat disturbance. - During Operation, progressive reclamation will be completed where possible, and the progress and success of these activities will be assessed annually. • Pre-disturbance wildlife clearance surveys will be conducted to	frequent, fully reversible.	habitat for northern leopard frog within the Terrestrial RSA to the point where it is not sustainable or available to contribute to ecological functions.
			• Water withdrawal from groundwater or surface water body. • Management of surface water (including seepage and site runoff). • Water release to surface water body. • On-site and off-site operation of vehicles and transport of materials.	Operation			
			• Site water management, treatment, and release. • Process water treatment and release. • Demolition and disposal of non-salvageable surface infrastructure and materials. • On-site and off-site operation of vehicles and transport of materials. • Reclamation of disturbed areas.	Decommissioning			
		Northern leopard frog mortalities directly or indirectly attributable to the Project.	• Development of access roads and airstrip. • Site preparation and earthworks; clearing, leveling and grading of the Project Area. • On-site and off-site operation of vehicles and transport of materials.	Construction		Change in mortality: predicted to be low magnitude, local in geographical extent, long-term duration, infrequent, and fully reversible.	The predicted residual effect of change in mortality is not expected to alter the integrity of the regional populations of northern leopard frog to the point
			• Water withdrawal from groundwater or surface water body.	Operation			

Component	Wildlife SAR	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Species-Specific Mitigation Measures	Predicted Residual Effect	Significance
			• Management of surface water (including seepage and site runoff). • Water release to surface water body. • On-site and off-site operation of vehicles and transport of materials		identify site-specific habitat features (e.g., amphibian breeding ponds) and implement the setbacks and/or timing windows (that will be defined in the Wildlife Management Plan). • Locations of site-specific habitat features used by amphibians will be communicated to Project personnel and the requirement to limit disturbance in these areas will be implemented. • Appropriate setback and buffer distances from wetland features where amphibians are known to occur will be implemented and maintained under the direction of a wildlife QP. • Vehicle traffic and construction activities will be restricted to the approved access routes and work areas and will not cross or enter a watercourse or wetland.		where they are not sustainable or available to contribute to ecological functions
			• Site water management, treatment, and release. • Demolition and disposal of non-salvageable surface infrastructure and materials. • Reclamation of disturbed areas). • On-site and off-site operation of vehicles and transport of materials.	Decommissioning			
Terrestrial Environment	Little brown myotis	Amount of habitat that is altered or lost relative to its	• Development of access roads and airstrip. • Site preparation and earthworks; clearing, leveling and grading of the Project Area.	Construction	• Vegetation clearing activities will occur outside of roosting periods, when practical.	Alteration and/or loss of habitat: predicted to be low magnitude, local	Not Significant: the predicted residual effect of alteration and/or loss of

Component	Wildlife SAR	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Species-Specific Mitigation Measures	Predicted Residual Effect	Significance
		availability in the Terrestrial RSA.	• On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.		• Pre-disturbance wildlife clearance surveys will be completed to identify site-specific habitat features such as maternal rooting sites and hibernacula used by little brown myotis. If features are identified in the Project Footprint, appropriate setbacks and/or timing windows will be implemented (refer to Table 4-1 in final EIS Appendix 9-D which will also be defined in the Wildlife Management Plan). • In the event a little brown myotis maternal roosting site is identified on the Project Footprint, exclusionary methods (e.g., installing a one-way bat exit) will be implemented following the summer maternity roost season. This installation would allow for little brown myotis to leave but not the ability to re-enter the roosting site. • Locations of these site-specific habitat features used by little brown myotis will be communicated to appropriate Project personnel and the	geographical extent, long-term duration, frequent, fully reversible.	habitat is not expected to alter the integrity of the habitat for little brown myotis within the Terrestrial RSA to the point where it is not sustainable or available to contribute to ecological functions.
			• On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Operation			
			• Demolition and disposal of non-salvageable surface infrastructure and materials. • On-site and off-site operation of vehicles and transport of materials. • Reclamation of disturbed areas.	Decommissioning			
		Little brown myotis mortalities directly or indirectly attributable to the Project.	• Development of access roads and airstrip. • Site preparation and earthworks; clearing, leveling and grading of the Project Area. • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Construction		Change in mortality: predicted to be low magnitude, local in geographical extent, long-term duration, infrequent, and fully reversible.	The predicted residual effect of change in mortality is not expected to alter the integrity of the regional populations of little brown myotis to the point where they are not sustainable or available to contribute to ecological functions
			• On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Operation			
			• Demolition and disposal of non-salvageable surface infrastructure and materials.	Decommissioning			

Component	Wildlife SAR	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Species-Specific Mitigation Measures	Predicted Residual Effect	Significance
			• On-site and off-site operation of vehicles and transport of materials. • Reclamation of disturbed areas.		requirement to limit disturbance in these areas will be implemented. • Specific exclusion methods will be added as mitigation measures (Section 9.4.5 of the final EIS) to prevent access to buildings and other infrastructure.		
Terrestrial Environment	Northern myotis	Amount of habitat that is altered or lost relative to its availability in the Terrestrial RSA.	• Development of access roads and airstrip. • Site preparation and earthworks; clearing, leveling and grading of the Project Area. • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Construction	• Vegetation clearing activities will occur outside of northern myotis roosting periods, when practical. • Pre-disturbance wildlife clearance surveys will be completed to identify site-specific habitat features such as northern myotis maternal rooting sites and hibernacula used by northern myotis. If features are identified in the Project Footprint, appropriate setbacks and/or timing windows will be implemented (refer to Table 4-1 in final EIS Appendix 9-D which will also be defined in the Wildlife Management Plan). • In the event a northern myotis maternal roosting site is	Alteration and/or loss of habitat: predicted to be low magnitude, local geographical extent, long-term duration, frequent, fully reversible.	Not Significant: the predicted residual effect of alteration and/or loss of habitat is not expected to alter the integrity of the habitat for northern myotis within the Terrestrial RSA to the point where it is not sustainable or available to contribute to ecological functions.
			• On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Operation			
			• Demolition and disposal of non-salvageable surface infrastructure and materials. • On-site and off-site operation of vehicles and transport of materials. • Reclamation of disturbed areas.	Decommissioning			
			• Development of access roads and airstrip.	Construction			

Component	Wildlife SAR	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Species-Specific Mitigation Measures	Predicted Residual Effect	Significance
		Northern myotis mortalities directly or indirectly attributable to the Project.	• Site preparation and earthworks; clearing, leveling and grading of the Project Area. • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.		identified on the Project Footprint, exclusionary methods (e.g., installing a one-way bat exit) will be implemented following the summer maternity roost season. This installation would allow for northern myotis to leave but not the ability to re-enter the roosting site. • Locations of these site-specific habitat features used by northern myotis will be communicated to appropriate Project personnel and the requirement to limit disturbance in these areas will be implemented. • Specific exclusion methods will be added as mitigation measures (Section 9.4.5 of the final EIS) to prevent access to buildings and other infrastructure.	Change in mortality: predicted to be low magnitude, local in geographical extent, long-term duration, infrequent, and fully reversible.	The predicted residual effect of change in mortality is not expected to alter the integrity of the regional populations of northern myotis to the point where they are not sustainable or available to contribute to ecological functions
			• On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Operation			
			• Demolition and disposal of non-salvageable surface infrastructure and materials. • On-site and off-site operation of vehicles and transport of materials. • Reclamation of disturbed areas.	Decommissioning			
Terrestrial Environment	Bank Swallow	Amount of habitat that is altered or lost relative to its availability in the Terrestrial RSA.	• Development of access roads and airstrip. • Site preparation and earthworks; clearing, leveling and grading of the Project Area. • Water management (including treatment and site runoff). • Surface water withdrawal.	Construction	• Site clearing and other works that involve disturbance of vegetation and/or soil will be conducted outside of the bank swallow nesting season, when practical. The breeding and nesting season for most bank swallows in	Alteration and/or loss of habitat: predicted to be low magnitude, local geographical extent, long-term duration,	Not Significant: the predicted residual effect of alteration and/or loss of habitat is not expected to alter the integrity of the

Component	Wildlife SAR	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Species-Specific Mitigation Measures	Predicted Residual Effect	Significance
			• On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.		Saskatchewan typically spans a period from May 15 to July 31. • In the event Project activities such as vegetation clearing and/or soil disturbance are required during the bank swallow breeding and nesting season, pre-disturbance wildlife clearance surveys will be conducted a by a QP at that location within the Project Area before activities commence to identify the presence of bank swallow nests. • Active and/or suspected bank swallow nests identified during the pre- disturbance wildlife clearance surveys will be protected with a no-disturbance setback buffer consistent with adopted regulatory guidelines (e.g., Manitoba Conservation [2021] as there is currently no activity restriction guidelines for bank swallow in Saskatchewan) in accordance with the level of the disturbance until the young have successfully fledged, the nest is	frequent, fully reversible.	habitat for bank swallow within the Terrestrial RSA to the point where it is not sustainable or available to contribute to ecological functions.
			• Management of surface water (including seepage and site runoff). • Water release to surface water body. • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Operation			
			• Site water management, treatment, and release. • Process water treatment and release. • Demolition and disposal of non-salvageable surface infrastructure and materials. • On-site and off-site operation of vehicles and transport of materials. • Reclamation of disturbed areas.	Decommissioning			
		Bank Swallow mortalities directly or indirectly attributable to the Project.	• Development of access roads and airstrip. • Site preparation and earthworks; clearing, leveling and grading of the Project Area. • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Construction		Change in mortality: predicted to be low magnitude, regional in geographical extent, long-term duration, infrequent, and fully reversible.	The predicted residual effect of change in mortality is not expected to alter the integrity of the regional populations of bank swallow to the point where they are not

Component	Wildlife SAR	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Species-Specific Mitigation Measures	Predicted Residual Effect	Significance
			• On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Operation	confirmed as no longer active (e.g., abandoned or depredated), or the nesting window has passed (for suspected nest locations). • Locations of nesting sites used by bank swallows will be communicated to appropriate Project personnel and the requirement to limit disturbance in these areas will be implemented. • Minimize height of salvaged soil stockpiles and avoid vertical slopes to deter bank swallows from creating nesting cavities.		sustainable or available to contribute to ecological functions.
			• Demolition and disposal of non-salvageable surface infrastructure and materials. • On-site and off-site operation of vehicles and transport of materials. • Reclamation of disturbed areas.	Decommissioning			
Terrestrial Environment	Barn Swallow	Amount of habitat that is altered or lost relative to its availability in the Terrestrial RSA.	• Development of access roads and airstrip. • Site preparation and earthworks; clearing, leveling and grading of the Project Area. • Water management (including treatment and site runoff). • Surface water withdrawal. • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Construction	• Site clearing and other works that involve disturbance of vegetation and/or soil will be conducted outside of the barn swallow nesting season, when practical. The breeding and nesting season for barn swallow in Saskatchewan typically spans a period from May 15 to September 30. • In the event Project activities such as vegetation clearing	Alteration and/or loss of habitat: predicted to be low magnitude, local geographical extent, long-term duration, frequent, fully reversible.	Not Significant: the predicted residual effect of alteration and/or loss of habitat is not expected to alter the integrity of the habitat for barn swallow within the Terrestrial RSA to the point where it is not

Component	Wildlife SAR	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Species-Specific Mitigation Measures	Predicted Residual Effect	Significance
			• Management of surface water (including seepage and site runoff). • Water release to surface water body. • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Operation	and/or soil disturbance are required during the barn swallow breeding and nesting season, pre-disturbance wildlife clearance surveys will be conducted by a QP at that location within the Project Area before activities commence to identify the presence of barn swallow nests. • Active and/or suspected barn swallow nests identified during the pre-disturbance wildlife clearance surveys will be protected with a no-disturbance setback buffer consistent with adopted regulatory guidelines (e.g., Manitoba Conservation [2021] as there is currently no activity restriction guidelines for barn swallow in Saskatchewan) in accordance with the level of the disturbance until the young have successfully fledged, the nest is confirmed as no longer active (e.g., abandoned or depredated), or the nesting window has		sustainable or available to contribute to ecological functions.
			• Site water management, treatment, and release. • Process water treatment and release. • Demolition and disposal of non-salvageable surface infrastructure and materials. • On-site and off-site operation of vehicles and transport of materials. • Reclamation of disturbed areas.	Decommissioning			
		Barn Swallow mortalities directly or indirectly attributable to the Project.	• Development of access roads and airstrip. • Site preparation and earthworks; clearing, leveling and grading of the Project Area. • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Construction		Change in mortality: predicted to be low magnitude, regional in geographical extent, long-term duration, infrequent, and fully reversible.	The predicted residual effect of change in mortality is not expected to alter the integrity of the regional populations of barn swallow to the point where they are not sustainable or available to contribute to ecological functions.
			• On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Operation			

Component	Wildlife SAR	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Species-Specific Mitigation Measures	Predicted Residual Effect	Significance
			• Demolition and disposal of non-salvageable surface infrastructure and materials. • On-site and off-site operation of vehicles and transport of materials. • Reclamation of disturbed areas.	Decommissioning	passed (for suspected nest locations). • Locations of nesting sites used by barn swallows will be communicated to appropriate Project personnel and the requirement to limit disturbance in these areas will be implemented.		
Terrestrial Environment	Common Nighthawk	Amount of habitat that is altered or lost relative to its availability in the Terrestrial RSA.	• Development of access roads and airstrip. • Site preparation and earthworks; clearing, leveling and grading of the Project Area. • Water management (including treatment and site runoff). • Surface water withdrawal. • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Construction	• Site clearing and other works that involve disturbance of vegetation and/or soil will be conducted outside of the common nighthawk nesting season, when practical. The breeding and nesting season for common nighthawk in Saskatchewan typically spans a period from May 1 to August 31. • In the event Project activities such as vegetation clearing and/or soil disturbance are required during the common nighthawk breeding and nesting season, pre-disturbance wildlife clearance surveys will be conducted by a QP at that	Alteration and/or loss of habitat: predicted to be low magnitude, local geographical extent, long-term duration, frequent, fully reversible.	Not Significant: the predicted residual effect of alteration and/or loss of habitat is not expected to alter the integrity of the habitat for common nighthawk within the Terrestrial RSA to the point where it is not sustainable or available to contribute to ecological functions.
			• Management of surface water (including seepage and site runoff). • Water release to surface water body. • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Operation			

Component	Wildlife SAR	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Species-Specific Mitigation Measures	Predicted Residual Effect	Significance
			• Site water management, treatment, and release. • Process water treatment and release. • Demolition and disposal of non-salvageable surface infrastructure and materials. • On-site and off-site operation of vehicles and transport of materials. • Reclamation of disturbed areas.	Decommissioning	location within the Project Area before activities commence to identify the presence of common nighthawk nests. • Active and/or suspected common nighthawk nests identified during the pre-disturbance wildlife clearance surveys will be protected with a no-disturbance setback buffer consistent with regulatory guidelines (e.g., the 2017 SARGSS [SK MOE 2017]) in accordance with the level of the disturbance until the young have successfully fledged, the nest is confirmed as no longer active (e.g., abandoned or depredated), or the nesting window has passed (for suspected nest locations).		
		Common Nighthawk mortalities directly or indirectly attributable to the Project.	• Development of access roads and airstrip. • Site preparation and earthworks; clearing, leveling and grading of the Project Area. • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Construction		Change in mortality: predicted to be low magnitude, regional in geographical extent, long-term duration, infrequent, and fully reversible.	The predicted residual effect of change in mortality is not expected to alter the integrity of the regional populations of common nighthawk to the point where they are not sustainable or available to contribute to ecological functions.
			• On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Operation			
			• Demolition and disposal of non-salvageable surface infrastructure and materials. • On-site and off-site operation of vehicles and transport of materials. • Reclamation of disturbed areas.	Decommissioning			

Component	Wildlife SAR	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Species-Specific Mitigation Measures	Predicted Residual Effect	Significance
Terrestrial Environment	Horned Grebe	Amount of habitat that is altered or lost relative to its availability in the Terrestrial RSA.	• Development of access roads and airstrip. • Site preparation and earthworks; clearing, leveling and grading of the Project Area. • Water management (including treatment and site runoff). • Surface water withdrawal. • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Construction	• Site clearing and other works that involve disturbance of vegetation and/or soil will be conducted outside of the horned grebe nesting season, when practical. The breeding and nesting season for horned grebe in Saskatchewan typically spans a period from May 1 to September 15. • In the event Project activities such as vegetation clearing and/or soil disturbance are required during the horned grebe breeding and nesting season, pre-disturbance wildlife clearance surveys will be conducted by a QP at that location within the Project Area before activities commence to identify the presence of horned grebe nests. • Active and/or suspected horned grebe nests identified during the pre-disturbance wildlife clearance surveys will be protected with a no-disturbance setback buffer consistent with	Alteration and/or loss of habitat: predicted to be low magnitude, local geographical extent, long-term duration, frequent, fully reversible.	Not Significant: the predicted residual effect of alteration and/or loss of habitat is not expected to alter the integrity of the habitat for horned grebe within the Terrestrial RSA to the point where it is not sustainable or available to contribute to ecological functions.
			• Management of surface water (including seepage and site runoff). • Water release to surface water body. • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Operation			
			• Site water management, treatment, and release. • Process water treatment and release. • Demolition and disposal of non-salvageable surface infrastructure and materials. • On-site and off-site operation of vehicles and transport of materials. • Reclamation of disturbed areas.	Decommissioning			

Component	Wildlife SAR	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Species-Specific Mitigation Measures	Predicted Residual Effect	Significance
		Horned Grebe mortalities directly or indirectly attributable to the Project.	• Development of access roads and airstrip. • Site preparation and earthworks; clearing, leveling and grading of the Project Area. • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Construction	regulatory guidelines (e.g., the 2017 SARGSS [SK MOE 2017]) for other grebe species (as there is currently no activity restriction guidelines for horned grebe in Saskatchewan) in accordance with the level of the disturbance until the young have successfully fledged, the nest is confirmed as no longer active (e.g., abandoned or depredated), or the nesting window has passed (for suspected nest locations). • Locations of nesting sites used by horned grebe will be communicated to appropriate Project personnel and the requirement to limit disturbance in these areas will be implemented.	Change in mortality: predicted to be low magnitude, regional in geographical extent, long-term duration, infrequent, and fully reversible.	The predicted residual effect of change in mortality is not expected to alter the integrity of the regional populations of horned grebe to the point where they are not sustainable or available to contribute to ecological functions.
			• On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Operation			
			• Demolition and disposal of non-salvageable surface infrastructure and materials. • On-site and off-site operation of vehicles and transport of materials. • Reclamation of disturbed areas.	Decommissioning			
Terrestrial Environment	Olive-Sided Flycatcher	Amount of habitat that is altered or lost relative to its availability in the Terrestrial RSA.	• Development of access roads and airstrip. • Site preparation and earthworks; clearing, leveling and grading of the Project Area. • Water management (including treatment and site runoff). • Surface water withdrawal.	Construction	• Site clearing and other works that involve disturbance of vegetation and/or soil will be conducted outside of the olive-sided flycatcher nesting season, when practical. The breeding and nesting season for olive-sided	Alteration and/or loss of habitat: predicted to be low magnitude, local geographical extent, long-term duration,	Not Significant: the predicted residual effect of alteration and/or loss of habitat is not expected to alter the integrity of the

Component	Wildlife SAR	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Species-Specific Mitigation Measures	Predicted Residual Effect	Significance
			• On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.		flycatcher in Saskatchewan typically spans a period from May 1 to August 31. • In the event Project activities such as vegetation clearing and/or soil disturbance are required during the olive-sided flycatcher breeding and nesting season, pre-disturbance wildlife clearance surveys will be conducted by a QP at that location within the Project Area before activities commence to identify the presence of olive-sided flycatcher nests. • Active and/or suspected olive-sided flycatcher nests identified during the pre-disturbance wildlife clearance surveys will be protected with a no-disturbance setback buffer consistent with regulatory guidelines (e.g., the 2017 SARGSS [SK MOE 2017]) in accordance with the level of the disturbance until the young have successfully fledged, the nest is confirmed as no longer active (e.g., abandoned or depredated),	frequent, fully reversible.	habitat for olive-sided flycatcher within the Terrestrial RSA to the point where it is not sustainable or available to contribute to ecological functions.
			• Management of surface water (including seepage and site runoff). • Water release to surface water body. • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Operation			
			• Site water management, treatment, and release. • Process water treatment and release. • Demolition and disposal of non-salvageable surface infrastructure and materials. • On-site and off-site operation of vehicles and transport of materials. • Reclamation of disturbed areas.	Decommissioning			
		Olive-Sided Flycatcher mortalities directly or indirectly attributable to the Project.	• Development of access roads and airstrip. • Site preparation and earthworks; clearing, leveling and grading of the Project Area. • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Construction		Change in mortality: predicted to be low magnitude, regional in geographical extent, long-term duration, infrequent, and fully reversible.	The predicted residual effect of change in mortality is not expected to alter the integrity of the regional populations of olive-sided flycatcher to the point where they

Component	Wildlife SAR	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Species-Specific Mitigation Measures	Predicted Residual Effect	Significance
			• On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Operation	or the nesting window has passed (for suspected nest locations).		are not sustainable or available to contribute to ecological functions.
			• Demolition and disposal of non-salvageable surface infrastructure and materials. • On-site and off-site operation of vehicles and transport of materials. • Reclamation of disturbed areas.	Decommissioning			
Terrestrial Environment	Rusty Blackbird	Amount of habitat that is altered or lost relative to its availability in the Terrestrial RSA.	• Development of access roads and airstrip. • Site preparation and earthworks; clearing, leveling and grading of the Project Area. • Water management (including treatment and site runoff). • Surface water withdrawal. • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Construction	• Site clearing and other works that involve disturbance of vegetation and/or soil will be conducted outside of the rusty blackbird nesting season, when practical. The breeding and nesting season for rusty blackbird in Saskatchewan typically spans a period from May 1 to July 31. • In the event Project activities such as vegetation clearing and/or soil disturbance are required during the rusty blackbird breeding and nesting season, pre-disturbance wildlife clearance surveys will be conducted by a QP at that location within the Project Area	Alteration and/or loss of habitat: predicted to be low magnitude, local geographical extent, long-term duration, frequent, fully reversible.	Not Significant: the predicted residual effect of alteration and/or loss of habitat is not expected to alter the integrity of the habitat for rusty blackbird within the Terrestrial RSA to the point where it is not sustainable or available to contribute to ecological functions.
			• Management of surface water (including seepage and site runoff). • Water release to surface water body. • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Operation			

Component	Wildlife SAR	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Species-Specific Mitigation Measures	Predicted Residual Effect	Significance
			• Site water management, treatment, and release. • Process water treatment and release. • Demolition and disposal of non-salvageable surface infrastructure and materials. • On-site and off-site operation of vehicles and transport of materials. • Reclamation of disturbed areas.	Decommissioning	before activities commence to identify the presence of rusty blackbird nests. • Active and/or suspected rusty blackbird nests identified during the pre-disturbance wildlife clearance surveys will be protected with a no-disturbance setback buffer consistent with regulatory guidelines (e.g., the 2017 SARGSS [SK MOE 2017]) in accordance with the level of the disturbance until the young have successfully fledged, the nest is confirmed as no longer active (e.g., abandoned or depredated), or the nesting window has passed (for suspected nest locations).		
		Rusty Blackbird mortalities directly or indirectly attributable to the Project.	• Development of access roads and airstrip. • Site preparation and earthworks; clearing, leveling and grading of the Project Area. • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Construction		Change in mortality: predicted to be low magnitude, regional in geographical extent, long-term duration, infrequent, and fully reversible.	The predicted residual effect of change in mortality is not expected to alter the integrity of the regional populations of rusty blackbird to the point where they are not sustainable or available to contribute to ecological functions.
			• On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Operation			
			• Demolition and disposal of non-salvageable surface infrastructure and materials. • On-site and off-site operation of vehicles and transport of materials. • Reclamation of disturbed areas.	Decommissioning			

Component	Wildlife SAR	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Species-Specific Mitigation Measures	Predicted Residual Effect	Significance
Terrestrial Environment	Short-eared Owl	Amount of habitat that is altered or lost relative to its availability in the Terrestrial RSA.	• Development of access roads and airstrip. • Site preparation and earthworks; clearing, leveling and grading of the Project Area. • Water management (including treatment and site runoff). • Surface water withdrawal. • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Construction	• Site clearing and other works that involve disturbance of vegetation and/or soil will be conducted outside of the short-eared owl nesting season, when practical. The breeding and nesting season for short-eared owl in Saskatchewan typically spans a period from March 25 to August 1. • In the event Project activities such as vegetation clearing and/or soil disturbance are required during the short-eared owl breeding and nesting season, pre-disturbance wildlife clearance surveys will be conducted by a QP at that location within the Project Area before activities commence to identify the presence of short-eared owl nests. • Active and/or suspected short-eared owl nests identified during the pre-disturbance wildlife clearance surveys will be protected with a no-disturbance setback buffer consistent with	Alteration and/or loss of habitat: predicted to be low magnitude, local geographical extent, long-term duration, frequent, fully reversible.	Not Significant: the predicted residual effect of alteration and/or loss of habitat is not expected to alter the integrity of the habitat for short-eared owl within the Terrestrial RSA to the point where it is not sustainable or available to contribute to ecological functions.
			• Management of surface water (including seepage and site runoff). • Water release to surface water body. • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Operation			
			• Site water management, treatment, and release. • Process water treatment and release. • Demolition and disposal of non-salvageable surface infrastructure and materials. • On-site and off-site operation of vehicles and transport of materials. • Reclamation of disturbed areas.	Decommissioning			

Component	Wildlife SAR	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Species-Specific Mitigation Measures	Predicted Residual Effect	Significance
		Short-eared Owl mortalities directly or indirectly attributable to the Project.	• Development of access roads and airstrip. • Site preparation and earthworks; clearing, leveling and grading of the Project Area. • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Construction	regulatory guidelines (e.g., the 2017 SARGSS [SK MOE 2017]) in accordance with the level of the disturbance until the young have successfully fledged, the nest is confirmed as no longer active (e.g., abandoned or depredated), or the nesting window has passed (for suspected nest locations).	Change in mortality: predicted to be low magnitude, regional in geographical extent, long-term duration, infrequent, and fully reversible.	The predicted residual effect of change in mortality is not expected to alter the integrity of the regional populations short-eared owl to the point where they are not sustainable or available to contribute to ecological functions.
			• On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Operation			
			• Demolition and disposal of non-salvageable surface infrastructure and materials. • On-site and off-site operation of vehicles and transport of materials. • Reclamation of disturbed areas.	Decommissioning			
Terrestrial Environment	Yellow Rail	Amount of habitat that is altered or lost relative to its availability in the Terrestrial RSA.	• Development of access roads and airstrip. • Site preparation and earthworks; clearing, leveling and grading of the Project Area. • Water management (including treatment and site runoff). • Surface water withdrawal. • On-site and off-site operation of vehicles and transport of materials.	Construction	• Site clearing and other works that involve disturbance of vegetation and/or soil will be conducted outside of the yellow rail nesting season, when practical. The breeding and nesting season for yellow rail in Saskatchewan typically spans a period from May 1 to July 15.	Alteration and/or loss of habitat: predicted to be low magnitude, local geographical extent, long-term duration, frequent, fully reversible.	Not Significant: the predicted residual effect of alteration and/or loss of habitat is not expected to alter the integrity of the habitat for yellow rail within the Terrestrial RSA to the

Component	Wildlife SAR	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Species-Specific Mitigation Measures	Predicted Residual Effect	Significance
			• Air transportation for workers.		• In the event Project activities such as vegetation clearing and/or soil disturbance are required during the yellow rail breeding and nesting season, pre-disturbance wildlife clearance surveys will be conducted by a QP at that location within the Project Area before activities commence to identify the presence of yellow rail nests. • Active and/or suspected yellow rail nests identified during the pre-disturbance wildlife clearance surveys will be protected with a no-disturbance setback buffer consistent with regulatory guidelines (e.g., the 2017 SARGSS [SK MOE 2017]) in accordance with the level of the disturbance until the young have successfully fledged, the nest is confirmed as no longer active (e.g., abandoned or depredated), or the nesting window has passed (for suspected nest locations).		point where it is not sustainable or available to contribute to ecological functions.
			• Management of surface water (including seepage and site runoff). • Water release to surface water body. • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Operation			
			• Site water management, treatment, and release. • Process water treatment and release. • Demolition and disposal of non-salvageable surface infrastructure and materials. • On-site and off-site operation of vehicles and transport of materials. • Reclamation of disturbed areas.	Decommissioning			
		Yellow Rail mortalities directly or indirectly attributable to the Project.	• Development of access roads and airstrip. • Site preparation and earthworks; clearing, leveling and grading of the Project Area. • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Construction		Change in mortality: predicted to be low magnitude, regional in geographical extent, long-term duration, infrequent, and fully reversible.	The predicted residual effect of change in mortality is not expected to alter the integrity of the regional populations of yellow rail to the point where they are not sustainable or available to
			• On-site and off-site operation of vehicles and transport of materials.	Operation			

Component	Wildlife SAR	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Species-Specific Mitigation Measures	Predicted Residual Effect	Significance
			• Air transportation for workers.				contribute to ecological functions.
			• Demolition and disposal of non-salvageable surface infrastructure and materials. • On-site and off-site operation of vehicles and transport of materials. • Reclamation of disturbed areas.	Decommissioning			

Table 5-2 Summary of Significance of the Cumulative Effects on Wildlife Species At Risk

Component	Valued Component	Key Indicator	Cumulative Effects	Summary of Significance of the Cumulative Effects
Terrestrial Environment	Wildlife Species at Risk	• Nine-spotted lady beetle • Transverse lady beetle • Yellow-banded bumble bee • Northern leopard frog • Little brown myotis • Northern myotis • Bank Swallow • Barn Swallow • Common Nighthawk • Horned Grebe • Olive-sided Flycatcher • Rusty Blackbird • Short-eared Owl • Yellow Rail	Alteration and/or loss of habitat.	**Not significant:** The cumulative effect of alteration and/or loss of habitat is not expected to alter the integrity of the Wildlife Species at Risk habitat within the Terrestrial RSA to the point where it is not sustainable or available to contribute to ecological functions.
			Change in mortality.	**Not significant:** The cumulative effect of change in mortality is not expected to alter the integrity of the regional populations to the point where they are not sustainable or available to contribute to ecological functions.

6 References

Brown, M.B. and Brown, C.R. 2020. Barn Swallow (*Hirundo rustica*), version 1.0. In Birds of the World (P. G. Rodewald, Editor). Cornell Lab of Ornithology, Ithaca, NY, USA. (https://birdsoftheworld.org/bow/species/barswa/cur/introduction). Accessed May 30, 2023.

Caceres, M.C. and Barclay, R.M.R. 2000. *Myotis septentrionalis*. Mammalian Species (634):1–4. DOI: 10.2307/0.634.1

COSEWIC. 2009a. COSEWIC assessment and update status report on the Northern Leopard Frog *Lithobates pipiens*, Rocky Mountain population, Western Boreal/Prairie populations, and Eastern populations, in Canada. Committee on the Status of Endangered Widllife in Canada, Ottawa. vii + 69 pp.

COSEWIC. 2009b. COSEWIC assessment and status report on the Horned Grebe, *Podiceps auritus*, Western population and Magdalen Islands population, in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa. vii + 42 pp.

COSEWIC. 2013a. COSEWIC assessment and status report on the Little Brown Myotis *Myotis lucifugus*, Northern Myotis *Myotis septentrionalis*, and Tri-colored Bat *Perimyotis subflavus* in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa. xxiv + 93 pp.

COSEWIC. 2013b. COSEWIC assessment and status report on the Bank Swallow *Riparia riparia* in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa. xi + 48 pp.

COSEWIC. 2014. COSEWIC assessment and status report on the Wolverine *Gulo gulo* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xi + 76 pp.

COSEWIC. 2015. COSEWIC assessment and status report on the Yellow-banded Bumble Bee *Bombus terricola* in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa. ix + 60 pp.

COSEWIC. 2016a. COSEWIC assessment and status report on the Nine-spotted Lady Beetle *Coccinella novemnotata* in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa. x + 57 pp.

COSEWIC. 2016b. COSEWIC assessment and status report on the Transverse Lady Beetle *Coccinella transversoguttata* in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa. xi + 57 pp.

COSEWIC. 2021a. COSEWIC assessment and status report on the Barn Swallow *Hirundo rustica* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xii + 60 pp.

COSEWIC 2021b. COSEWIC Assessment and Status Report on the Short-eared Owl *Asio flammeus* in Canada. Committee on the status of Endangered Wildlife in Canada (COSEWIC). Threatened 2021Environment and Climate Change Canada. 2018. Recovery Strategy for the Little Brown Myotis (*Myotis lucifugus*), the Northern Myotis (*Myotis septentrionalis*), and the Tri-colored Bat (*Perimyotis subflavus*) in Canada. Environment and Climate Change Canada, Ottawa. ix + 172 pp.

Environment and Climate Change Canada. 2022a. Management Plan for the Yellow-banded Bumble Bee (*Bombus terricola*) in Canada [Proposed]. Species at Risk Act Management Plan Series. Environment and Climate Change Canada, Ottawa. iv + 46 pp.

Environment and Climate Change Canada. 2022b. Recovery Strategy for the Bank Swallow (*Riparia riparia*) in Canada. Species at Risk Act Recovery Strategy Series. Environment and Climate Change Canada, Ottawa. ix + 125 pp.

Environment and Climate Change Canada. 2022c. Management Plan for the Horned Grebe (*Podiceps auritus*), Western population, in Canada. Species at Risk Act Management Plan Series. Environment and Climate Change Canada, Ottawa. v + 49 pp.

Environment Canada. 2013. Management Plan for the Northern Leopard Frog (*Lithobates pipiens*), Western Boreal/Prairie Populations, in Canada. Species at Risk Act Management Plan Series. Environment Canada, Ottawa. iii + 28 pp.

Environment Canada. 2012. Management Plan for the Yellow Rail (*Coturnicops noveboracensis*) in Canada [Proposed]. Species at Risk Act Management Plan Series. Environment Canada, Ottawa. iv + 23 pp.

Environment Canada. 2015. Management Plan for the Rusty Blackbird (*Euphagus carolinus*) in Canada. Species at Risk Act Management Plan Series. Environment Canada, Ottawa. iv + 26 pp.

Environment Canada. 2016. Recovery Strategy for the Olive-sided Flycatcher (*Contopus cooperi*) in Canada. Species at Risk Act Recovery Strategy Series. Environment Canada, Ottawa. vii + 52 pp.

Environmental Protection and Management Guideline. 2024. VERSION 3.1: July 2024. British Columbia Energy Regulator. 104pp.Garrison, B.A. and Turner, A. 2020. Bank Swallow (*Riparia riparia*), version 1.0. In Birds of the World (S. M. Billerman, Editor). Cornell Lab of Ornithology, Ithaca, NY, USA. (https://birdsoftheworld.org/bow/species/banswa/cur/introduction). Accessed May 30, 2023.

Government of Canada. 2019a. Description of Residence for Bank Swallow (*Riparia riparia*) in Canada. (https://species-registry.canada.ca/index-en.html#/species/1233-894#residence_description)

Government of Canada. 2019b. Description of Residence for Barn Swallow (*Hirundo rustica*) in Canada. (https://species-registry.canada.ca/index-en.html#/species/1147-790#residence_description)

Government of Canada. 2023. Species at risk public registry. (https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry.html). Accessed May 31, 2023.

Henderson, L.E. and Broders, H.G. 2008. Movements and Resource Selection of the Northern Long-Eared Myotis (*Myotis septentrionalis*) in a Forest - Agriculture Landscape. Journal of Mammalogy 89(4):952–963. DOI: 10.1644/07-MAMM-A-214.1

Johnson, J.S., Treanor, J.J., Slusher, A.C., and Lacki, M.J. 2019. Buildings provide vital habitat for little brown myotis (*Myotis lucifugus*) in a high-elevation landscape. Ecosphere 10(11):e02925. DOI: 10.1002/ecs2.2925

Jung, T.S., Thompson, I., and Titman, R.D. 2004. Roost site selection by forest-dwelling male Myotis in central Ontario, Canada. Forest Ecology and Management (202):325–335.

Manitoba Conservation. 2021. Recommended Development Setback Distances and Restricted Activity Periods for Birds by Wildlife Feature Type Manitoba Conservation Data Centre 2021 November

Ministry of Environment (MOE 2017), Fish, Wildlife and Lands Branch. April 2017. Activity Restriction Guidelines for Sensitive Species. Regina, Saskatchewan. 4pp.

Nature Conservancy Canada (NCC). 2023. Northern Leopard Frog. (https://www.natureconservancy.ca/en/what-we-do/resource-centre/featured-species/reptiles-and-amphibians/northern-leopard-frog.html).

Odsen, S. and M. Pyper. 2019. Rusty blackbird forestry fact sheet. Foothills Research Institute. Summaries and Communications Fact Sheets.

Resources Information Standards Committee (RISC). 2022. Inventory Methods for Bats, Standards for Components of British Columbia's Biodiversity No. 20. Version 3.0. B.C. Ministry of Land, Water and Resource Stewardship, Ecosystems Branch, Victoria, B.C.

Saskatchewan Conservation Data Centre. 2023. Saskatchewan Conservation Data Centre. (http://biodiversity.sk.ca/). Accessed May 30, 2023.

Saskatchewan Ministry of the Environment (SME) 2014. Yellow Rail Survey Protocol. Fish and Wildlife Branch Report No. 2014-14.0. 3211 Alberta Street, Regina, Saskatchewan. 8pp.

Saskatchewan Ministry Environment (SME). 2021. Saskatchewan Ministry of the Environment Crown Land Work Authorization (2021). Denison Wheeler Project Area.Slough, B.G. and Jung, T.S. 2020. Little Brown Bats Utilize Multiple Maternity Roosts Within Foraging Areas: Implications for Identifying Summer Habitat. Journal of Fish and Wildlife Management 11(1):311–320.

Smith, A.R. 1996. Atlas of Saskatchewan Birds. Special Publication No. 22. Saskatchewan Natural History Society (Nature Saskatchewan). Regina, Saskatchewan. 456 pp.

Smith, A.R., C.S. Houston, and J.F. Roy. 2019. Birds of Saskatchewan. Special Publication No. 38. Nature Saskatchewan. Regina, Saskatchewan. 765 pp.

Stedman, S.J. 2020. Horned Grebe (Podiceps auritus), version 1.0. In Birds of the World (S. M. Billerman, Editor). Cornell Lab of Ornithology, Ithaca, NY, USA. (https://birdsoftheworld.org/bow/species/horgre/cur/introduction). Accessed May 30, 2023.

Wildlife Division. 2020. Management Plan for the Rusty Blackbird (*Euphagus carolinus*) in Newfoundland and Labrador. Department of Fisheries, Forestry and Agriculture, Government of Newfoundland and Labrador, Corner Brook, Canada. v + 23 pp.

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Wheeler River Project

Final Environmental Impact Statement

November 2024

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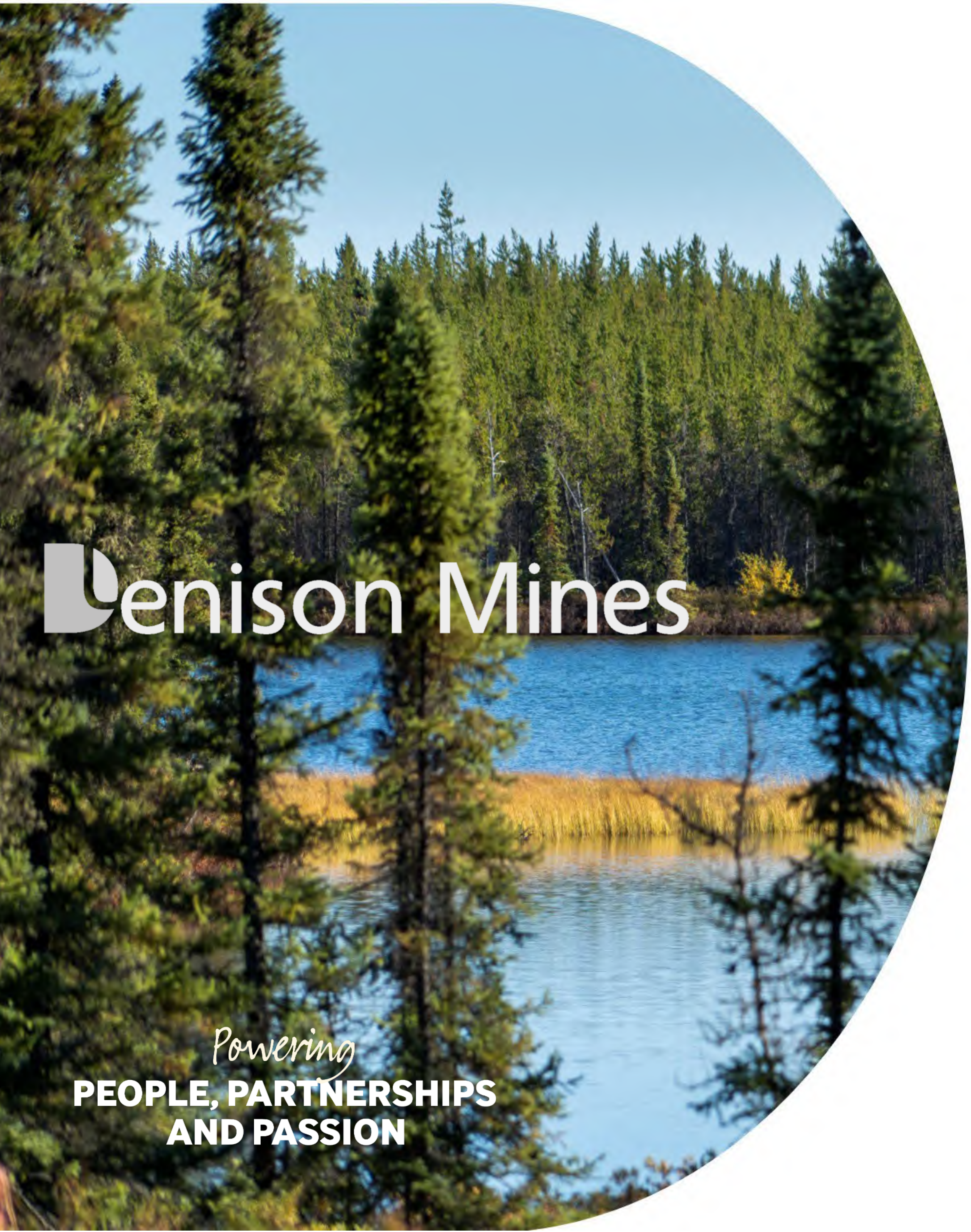
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Wheeler River Project Caribou Management Framework

Version 3

October 2024

Revision History

Version	Date	Description of Revision
1	June 30, 2023	Conceptual plan to support provincial and federal review of the draft environmental impact statement
2	January 28, 2024	Title updated from Conceptual Caribou Mitigation Plan to Wheeler River Project Caribou Management Framework to reflect the current status and intent of the report. Revisions to incorporate 1. advances in Saskatchewan Ministry of Environment boreal caribou habitat offset calculator; 2. additional local and Indigenous knowledge related to woodland caribou; and, 3. discussions with Saskatchewan Ministry of Environment on Version 1 of the document.
3	September 19, 2024	Updated to incorporate airstrip information and mitigation measures provided as part of federal EIS review comment (IR-149-R1B [round 4]).

Table of Contents

Figures

Acronyms and Abbreviations

Term	Definition
Anthropogenic	Caused or produced by humans
Boreal Caribou	The boreal ecotype of woodland caribou occurs within the boreal forest of Canada. These non-migratory caribou form small aggregations throughout the year and disperse for solitary calving.
CDP	Conceptual Decommissioning Plan
Critical Habitat	The habitat that is necessary for the survival of a listed wildlife species and is identified as the species critical habitat in the recovery strategy or action plans for the species.
Disturbed habitat (per ECCC 2020)	Habitat showing: i) anthropogenic disturbance visible on Landsat at a scale of 1:50,000, including habitat within a 500 m buffer of the anthropogenic disturbance; and/or ii) fire disturbance in the last 40 years, as identified in data from each provincial and territorial jurisdiction (without buffer).
ERFN	English River First Nation
ECCC	Environment and Climate Change Canada
EA	environmental assessment
EIS	environmental impact statement
EMS	Environmental Management System
ENV	Saskatchewan Ministry of Environment
Framework	Caribou Management Framework
ha	hectare
IK	Indigenous knowledge
ISR	in-situ recovery
KML	Kineepik Métis Local
Project	Wheeler River Project

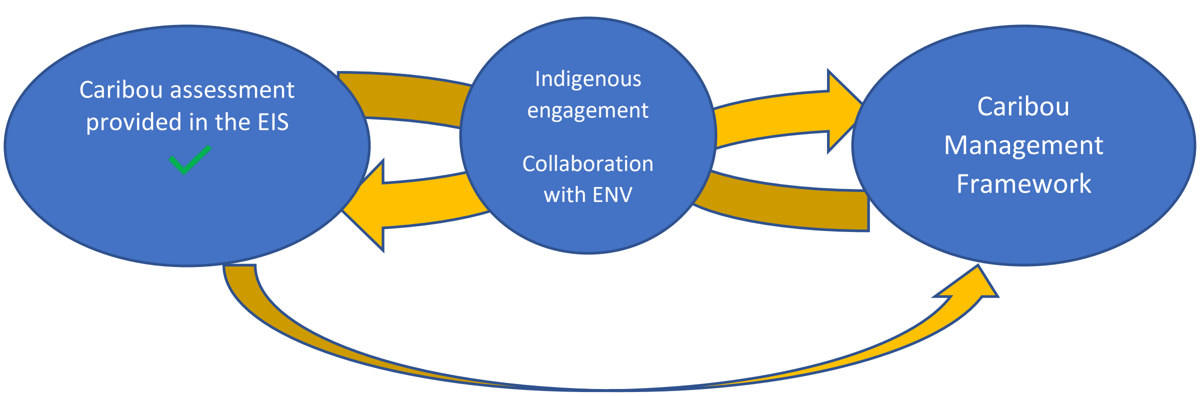
Term	Definition
Recovery strategy	A planning document that identifies what needs to be done to stop or reverse the decline of a species.
Threatened species	A wildlife species that is likely to become endangered if nothing is done to reverse the factors leading to its extirpation or extinction.

1 Introduction

The Wheeler River Project (the Project) environmental impact statement (EIS; Denison 2024) evaluated and assessed potential effects on the boreal population of woodland caribou (*Rangifer tarandus caribou*; referred to herein as caribou or boreal caribou) following standard environmental assessment (EA) methodology. The assessment of potential effects, including the assessment of Project-related and cumulative effects, considered both direct (e.g., habitat loss) and indirect effects (e.g., habitat alteration) on caribou and their habitat, while assuming that caribou were present year-round and during all of their life stages (i.e., calving, rearing, mating, over wintering). In this way, the EIS took a precautionary or conservative approach to understanding / addressing the potential residual effects (i.e., effects remaining after mitigation measures were considered) of the Project on caribou and their habitat. Moreover, this precautionary approach provides the basis for planning to inform/support future Project-related regulatory approvals processes and follow-up monitoring. The EIS concluded that in consideration of proposed measures to avoid and minimize potential effects, as well as in consideration of proposed conceptual site restoration, residual Project-related and cumulative effects on caribou and their habitat were not significant.

This Caribou Management Framework (the Framework), developed by Denison for the Project, follows from the environmental assessment (EA) process, though its objective differs from that of related EA / EIS documentation. The Framework builds on the assessment of potential Project effects, including cumulative effects, and commitments to avoid and minimize such effects described in the EIS and provides a further Project-specific management tool to be employed in relation to caribou and their habitat. The Framework is expected to be advanced through ongoing consultation with the Saskatchewan Ministry of Environment (ENV) as ENV finalizes the caribou range plan for the SK1 conservation unit, the caribou conservation unit in which the Project is located. The EIS is a conservative planning tool, whereas the Framework is a practical, living document intended to contribute to the province's overall caribou conservation strategy. The Framework is not a requirement for EA determination but is provided as a guidance document to help Denison proactively describe and inform the development and implementation of appropriate management measures related to caribou and their habitat.

The Framework is an evergreen document but has been developed based on Denison's current understanding of range plan development for SK1 to date. As needed, the Framework will be updated to be consistent with the management goals defined by ENV for SK1 (once established) and will be developed / refined in consultation with local communities including English River First Nation (ERFN), Kineepik Métis Local (KML) in Pinehouse, and regulators (e.g., ENV) as depicted graphically below.



As noted above, the boreal caribou range plan for SK1 is under development, and it is understood that this Framework will be updated as more range plan details become available. Developing the Framework at this early stage is consistent with and reflects Denison's commitment to continue to work with the province to meet the management objectives and management strategies for the SK1 range. It is envisioned that this Framework will be included as a component of the provincial environmental impact statement and should it be accepted through the issuance of a Ministerial Approval, form the basis of a condition of approval pursuant to *The Environmental Assessment Act*.

2 Regulatory Setting and Indigenous Perspectives Related to Boreal Caribou

A brief review highlighting provincial and federal governments, and Indigenous nations and communities considerations of boreal caribou is provided below for reference. Briefly, in 2002, boreal woodland caribou were recommended for “threatened” status by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and were listed as “threatened” under the Species at Risk Act (SARA) when it was proclaimed in 2003. As required under SARA, the Government of Canada developed a Recovery Strategy for the Woodland Caribou Boreal Population in Canada (the Recovery Strategy) which was released in October 2012. Saskatchewan is responsible for managing woodland caribou on provincial and private lands, and as signatory to the Accord for the Protection of Species at Risk in Canada, has a responsibility to prepare a provincial range plan for woodland caribou. Range plans, which involve close collaboration between the provincial government and Indigenous nations and communities, provide a path forward for effective landscape management. They provide the federal government with clear information on the measures, tools and targets for woodland caribou habitat management being deployed, and that they effectively protect woodland caribou habitat.

2.1 Provincial Government

The responsibility for woodland caribou management lies with the Province of Saskatchewan. As noted above, the province is responsible for developing range plans or management plans which build on the federal recovery strategy by setting goals and objectives for maintaining sustainable population levels.

The Saskatchewan Conservation Data Centre is responsible for evaluating and assigning a conservation rank to each taxon, resident or transient, found in the province. Woodland caribou’s subnational or S-rank conservation rank is S3. This ranking indicates that, provincially, the species is vulnerable/rare to uncommon which is associated with a moderate risk of extinction or extirpation due to a restricted range, relatively few populations, recent and widespread declines, threats, or other factors.

Based on work completed by McLoughlin et al. (2019), which was confirmed by ENV in November 2023 (SK ENV 2023b), the caribou populations in SK1 are stable. The amended federal recovery strategy identifies 40% undisturbed habitat in the SK1 conservation unit as the disturbance management threshold as well as the maintenance of total anthropogenic disturbance in the range at or below 5% while maintaining the minimum 40% undisturbed habitat (ECCC 2020). The SK1 conservation unit has high levels of natural disturbance (fire), but very low levels of human-caused disturbance. At present, the habitat disturbance level in SK1 is 53% (that is, 47% undisturbed habitat) (SK ENV 2023b). Approximately 50% of SK1 is disturbed by wildfires and 3% by anthropogenic features such as roads, communities, power transmission lines, forestry, mineral exploration, and mining (3%).

The provincial goal is to sustain and enhance woodland caribou populations, and maintain the ecosystems they require, throughout their current range (ENV 2013). Through the woodland caribou range assessment and range planning program, the province is:

- Gaining a better understanding of woodland caribou ecology;
- Working toward meeting objectives identified in provincial and federal strategies; and
- Improving how the province manages the species and related habitat.

The province's woodland caribou range assessment and range planning program incorporates two key components:

- Woodland caribou range assessment, which enhances the understanding of woodland caribou populations and their interactions with the environment; and
- Woodland caribou range planning, which provides a framework, strategies and objectives that allow for better decisions involving habitat management and self-sustaining caribou populations.

Additionally, the province has identified that engagement is a key component of the range plan process and will be completed with representatives from First Nation, Métis, industry, non-governmental organizations, and communities[1].

Although the management objectives and management strategies for caribou in SK1 are not yet defined, Denison is committed to working with ENV as the range plan is developed to ensure this project-specific management framework aligns with the conservation objectives as determined by the province as the primary steward of caribou in the province.

2.2 Federal Government

Boreal caribou have been designated as *threatened* under the federal *Species at Risk Act*. Environment and Climate Change Canada (ECCC) released amended recovery strategy for woodland caribou in 2020 (ECCC 2020). A recovery strategy is a planning document that identifies what should be done to stop or reverse the decline of a species.

The Project is located in the Boreal Shield West ecoregion of the Boreal Shield ecozone. The Boreal Shield West ecoregion stretches from Alberta to Ontario (Figure 2-1).

[1] Woodland Caribou Conservation | Woodland Caribou Program | Government of Saskatchewan

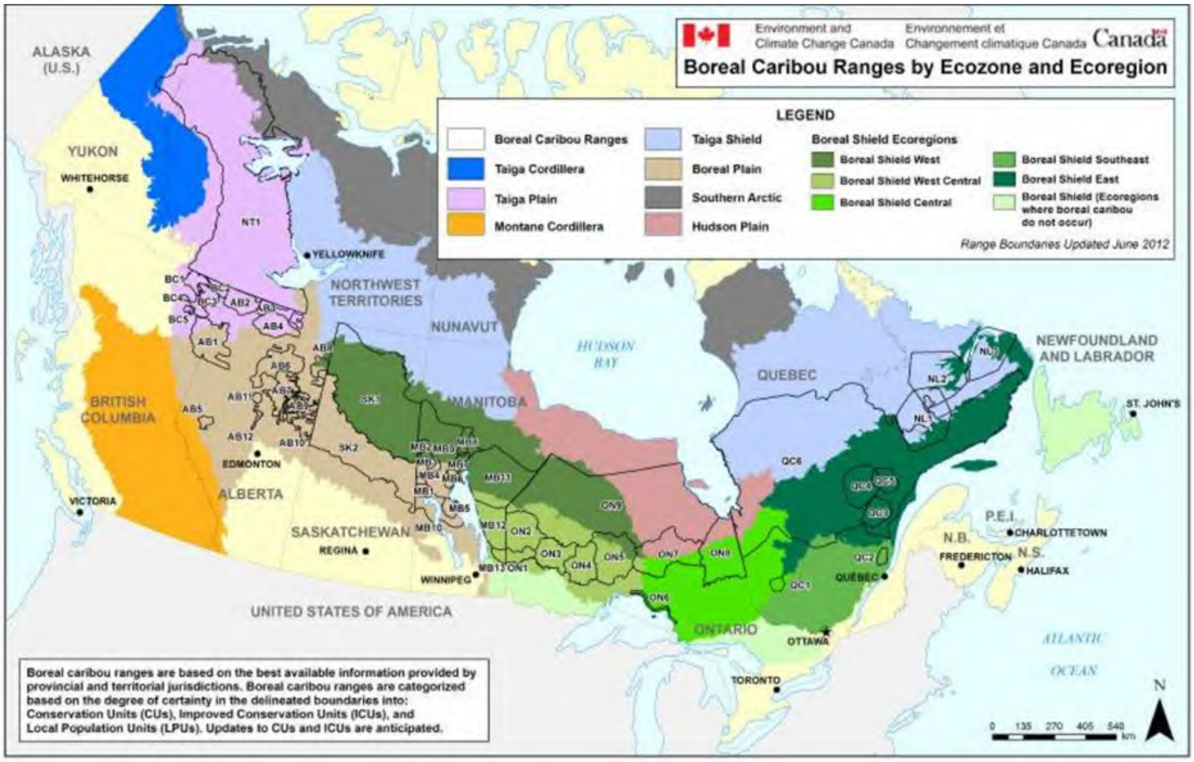


Figure 2-1: Boreal Caribou Distribution Across Ecozones and Ecoregions in Canada (source: ECCC 2020)

The SK1 range comprises more than 18,000,000 hectares (ha) and is characterized by high fire disturbance and low anthropogenic disturbance (ECCC 2020). The likelihood of caribou self-sustainability in the boreal shield range in SK1 is "likely" (ECCC 2020). For SK1, the amended recovery strategy (ECCC 2020) identifies 40% undisturbed habitat in the range as the disturbance management threshold, which provides a measurable probability (71%) for the local population to be self-sustaining. This threshold is considered a minimum threshold because at 40% undisturbed habitat there remains a risk (29%) that the SK1 local population cannot be self-sustaining. Disturbed habitat (ECCC 2020) is habitat showing: i) anthropogenic disturbance visible on Landsat at a scale of 1:50,000, including habitat within a 500 m buffer of the anthropogenic disturbance; and/or ii) fire disturbance in the last 40 years, as identified in data from each provincial and territorial jurisdiction (without buffer). Undisturbed habitat (ECCC 2020) is habitat not showing any: i) anthropogenic disturbance visible on Landsat at a scale of 1:50,000, including habitat within a 500 m buffer of the anthropogenic disturbance; and/or ii) fire disturbance in the last 40 years, as identified in data from each provincial and territorial jurisdiction (without buffer). Disturbance within the 500 m buffer would result in a reduction of the undisturbed habitat.

Studies (e.g., McLoughlin et al. 2019) indicate that the SK1 local caribou population is likely self-sustaining at current levels of disturbance (60% total disturbance), with a 71% probability of persistence. Environment and Climate Change Canada's analyses also indicate that the SK1 local population is sensitive to small increases anthropogenic disturbance and sensitive to small decreases in adult survival. For these reasons, a higher probability of persistence was selected for critical habitat identification in SK1 (71%) than was selected for the other 50 ranges across Canada (60%) (ECCC 2019).

The precise location of the 40% undisturbed habitat within the range is expected to vary over time. The habitat within the SK1 range should exist in an appropriate spatial configuration such that boreal caribou can move throughout the range and access required habitat when needed. The key to this habitat delineation is achieving and maintaining an overall, ongoing range condition that allows for the dynamic habitat supply system, containing the biophysical attributes upon which caribou depend, to remain sustainable. It is this dynamic habitat supply system within the SK1 range that is the habitat condition considered to be necessary for the caribou.

2.3 Indigenous Nations and Communities

Woodland caribou has historically been and continue to be an important part of the culture and diet of Indigenous people in northern Saskatchewan and identified as part of the subsistence harvest by EFRN, and KML. Athabasca Denesųłiné have also described hunting woodland caribou along with Barren-ground caribou and identify deeply with caribou and define their territorial extent with that of the Beverly and Qamanirjuaq caribou ranges. Elders from ERFN have shared that their people have always respected the land and animals and that the tradition to take only what is needed has been passed on through generations (EFRN 2011).

Forest fires are considered the main threat to woodland caribou in the ERFN Traditional Territory. Predators pose a threat as well, but their presence never seemed to have affected the caribou population in the past. In addition, it was pointed out that industry (such as mining and exploration), tourism (in the summer), and hunting by other Indigenous groups may pose additional threats to the caribou population (ERFN 2011).

Knowledge from Indigenous nations and communities will be used to support the management and conservation of caribou in SK1 through the province's range planning process.

3 SK 1 Caribou Population – Background Information

Background information concerning the condition of caribou populations in the SK1 conservation unit is provided below.

3.1 SK1 Conservation Unit

Saskatchewan's boreal woodland caribou range is divided into two woodland caribou conservation units that are based on the boundaries of the boreal ecozones - the Boreal Shield Woodland Caribou Conservation Unit (SK1) and the Boreal Plain Woodland Caribou Conservation Unit (SK2). Per ECCC (2020) information available to delineate boreal caribou ranges varies in certainty and therefore caribou ranges are categorized into three types: conservation units (low certainty), improved conservation units (medium certainty) and local population units (high certainty). ECCC (2020) also recognizes that there will be changes to conservation units and improved conservation units as more information becomes available, which is aligned with the province's range planning work to date in SK2.

While the two conservation units represent important differences in ecological conditions (e.g., habitat types, fire regimes, landforms, etc.) and human land use and management (e.g., overall levels and types of land use, fire management, etc.), the boundary between SK1 and SK2 does not represent a population boundary, as caribou move freely between the two areas, as well as within the individual units.

The Project is located in SK1, with SK1 encompassing the rocky shield, sandy plains and many lakes of northern Saskatchewan. Despite its relatively large size (~176,000 km^2 or 18 million ha), at present the SK1 unit has not been sub-divided into administrative units, as has been the case with SK2 through its range planning process. The province has noted that SK1 is an area with considerable fire disturbance, ecological differences from west to east, and different levels of development.

3.2 Population Trends

3.2.1 Western Science

The SK1 Boreal Shield management unit contains high-quality conifer-dominated caribou habitat with greater than 40-year-old stands of jack pine and black spruce forests suitable for lichen colonization, black spruce swamps, and open muskegs supporting relatively high densities of caribou, at 36.9 caribou/1,000 km^2 or approximately 4,000 caribou across the SK1 Boreal Shield Woodland Caribou Management Unit (McLoughlin et al. 2019).

Research has shown that up to 70% of the year-round diet of caribou may consist of ground and arboreal lichens. If the quantity of available lichen forage is low, caribou can exist without relying entirely on lichens (McLoughlin et al. 2019). Due to their physiology, lichens are resilient to periods of drought and cold temperatures, but because of their slow growth rate, exhibit a slow recovery time after depletion and fire events. In the SK1 range, McLoughlin et al. (2019) found that stand types with the highest potential for adequate lichen biomass for caribou are jack pine and poorly drained black spruce sites.

McLoughlin et al. (2019) observed that, from 2014 to 2018, the caribou population exhibited a high average adult female survival rate and moderate recruitment (0.192 calves per cow in March), ranging from a low of 0.134 calves/cow in March 2016 to 0.244 calves/cow in March 2018. These demographic parameters led the authors to assess the SK1 boreal shield caribou population as being stable at the time of their study (McLoughlin et al. 2019).

While calving areas have not been documented within the SK1 range, it is recognized that caribou may use open fen and treed bog habitat types for calving during the spring/summer period. In Saskatchewan, caribou habitat used during the calving season in the SK2 range demonstrated a strong selection for treed muskegs, but avoidance of jack pine, mixed hardwood stands, and roads (Dyke 2008).

Neufeld et al. (2021) summarized results from aerial surveys over a period of eight years in an 87,193 km^2 study area in the Athabasca Plain and Churchill River Upland ecoregions in the north, that are inclusive of the Terrestrial Regional Study Areas that were used in the EIS. During 11 of 16 aerial caribou surveys conducted between 2008 and 2015, woodland caribou were detected in the surveyed areas. The average density of the 16 surveys was estimated at 36.9 caribou/1,000 km^2) (95% CI = 26.7 to 47.2 caribou/1,000 km^2). Across the Neufeld et al. (2021) study area and all years, estimated caribou densities were higher in comparison to averages reported for most other boreal woodland caribou ranges in Canada (i.e., caribou density reported in other areas ranged 4.3 to 18.7/1,000 km^2) indicating that caribou can tolerate natural disturbance. One exception to the relatively high caribou densities in northern Saskatchewan was noted: the 2,285 km aerial the Millennium Project in March 2014, 10 km west of the Terrestrial Regional Study Area, resulted in lower woodland caribou densities at 5 caribou/1,000 km2 (Neufeld et al. 2021).

Eight of the sixteen caribou surveys reported the ratios of male to female and calf to female in their results with the average male:female ratio calculated at 0.571 (95% CI = 0.444 to 0.699) and calf:female at 0.195 (0.158 to 0.232). Again, the 2014 Millennium survey reported a different male:female ratio, outside the reported range (1.6), concurring with the reported low caribou densities.

3.2.2 Indigenous and Local Knowledge

Information provided by Indigenous knowledge (IK) holders to Denison as part of the Wheeler River Project EA process generally agrees with the science-based findings that show the population of woodland caribou in northern Saskatchewan is stable; however, some IK perspectives differ from the narrative that holds that caribou populations are stable. The difference in perspectives may stem from changes in distribution, as opposed to density, as caribou alter their movements in response to landscape disturbances.

The ERFN trapper, fisher, and resource harvester (ERFN Trapper), whose ancestral lands overlap with the Wheeler River terrestrial RSA and SK1, shared that they have not observed any changes in woodland caribou numbers (i.e., densities); woodland caribou numbers have remained stable over the years (19 - LK-ERFN Trap-134.156; Denison 2024). The ERFN trapper, fisher, and resource harvester (ERFN Trapper) have also shared that caribou are the most frequently sighted big game between Russell and McDougall lakes, which lie immediately to the east and south of the Wheeler River Project (19-LK-ERFNTrap-134.174; Denison 2024).

Some EFRN Elders have shown concern over woodland caribou populations, worrying that future generations will not experience the same abundance of wildlife that they themselves experienced (EFRN 2011). These concerns partly stem from EFRN observations of changing woodland caribou distribution, which is believed to be influenced by wildfire. According to EFRN Elders, wildfires play a role in calving success and impact caribou distribution and population by disturbing habitat and travel routes. Some Elders have also suggested a decline in caribou populations as a result of these wildfire disturbances (EFRN 2011). Participants in an EFRN traditional knowledge study also shared concerns over the potential decline of caribou and moose as an effect from increased access leading to more hunting pressure (EFRN and SVS 2022).

3.3 Predation

3.3.1 Western Science

In addition to relatively low predator densities in their study area, McLoughlin et al. (2019) found some spatial separation between caribou and wolves. Caribou did not seem to avoid existing linear features (such as roads, trails, and transmission lines) in the area, while wolves established their territories away from linear features. Unlike caribou, who preferred mature conifer stands, wolves selected for wetlands and patches of deciduous-mixed forest, avoiding stands of mature conifers. Other prey species, such as moose, also occurred at relatively low densities (i.e., 45.7 moose/1,000 km^2) (McLoughlin et al. 2019).

McLoughlin et al. (2019) observed that mortality of adult caribou occurred mostly during the snow-free season and only 1 of 94 collared caribou was harvested by a hunter during the four years of the study.

While predation is believed to be a key limiting factor for woodland caribou (Bergerud 1974; Stuart-Smith et al. 1997, DeMars et al. 2011 from ECCC 2020), Neufeld et al. (2021) suggested that habitat- or disturbance-mediated apparent competition only plays a minor role in the Saskatchewan woodland caribou population. Habitat- or disturbance-mediated apparent competition occurs when natural (e.g., forest fires) and anthropogenic (e.g., human development or activities) disturbances increase the abundance of other ungulates, which in turn may increase predator densities, which then increases predation risk to caribou. Neufeld et al. (2021) concluded that Northern Shield and Taiga ecoregions are of low productivity where caribou may compete with only one ungulate species (i.e., moose) and therefore, caribou and wolf dynamics do not follow general habitat- or disturbance-mediated apparent competition models.

3.3.2 Indigenous and Local Knowledge

The perspective of Indigenous knowledge holders is generally consistent with western-scientific findings that show low impacts of wolf predation on woodland caribou; for instance, EFRN knowledge holders have stated that wolves do act as a predation threat to caribou, but their presence has never caused population declines in the past (EFRN 2011). However, the experiences of some knowledge holders contradict the findings that relate to spatial separation of the two species. The ERFN Trapper has described an increase in trails and roads as more cabins are built in the areas where they typically hunt and trap. According to the ERFN Trapper, trails and roads are used by wolves and caribou alike. As the ERFN Trapper recounts, “wolves travel on bush roads. [I] saw a pack of about 18 wolves recently” (19-LK-ERFNTrap-134.159; Denison 2024). On the other hand, local trappers often see caribou tracks on roads, trails, and hand-cut lines (19-LK-ERFNTrap-134.153; Denison 2024).

The ERFN Trapper believes that wolf populations are increasing, and steps should be taken to curb this growth (21-LK-ERFNTrap-506.2; 21-LK-ERFNTrap-506.3; Denison 2024). One solution put forward was to remediate the extensive network of trails, roads, and cut-lines by blocking access to them (21-LK-ERFNTrap-506.4; Denison 2024). Other IK indicates that wolves are a natural presence on the landscape and not a serious threat to the long-term stability of woodland caribou populations; however, the growing presence of roads, trails, and cut lines poses a potential issue as both caribou and wolves utilize these landscape features, increasing the likelihood of predation opportunities, especially if the wolf population is on an upward trend.

3.4 Harvest

Indigenous peoples in Saskatchewan have an inherent right to harvest woodland caribou for subsistence purposes (ENV 2013). No other harvest of woodland caribou is currently permitted.

Under provincial and federal recovery planning and effective species management, self-sustaining caribou populations will support long-term subsistence use of the species and protect treaty rights. Subsistence harvest levels are assumed to be low but actual numbers are not available because most communities or Indigenous groups are not collecting and/or publishing this information.

The ERFN Country Foods Study (2017), highlights the importance of caribou in the diet of the people of this community. Of the traditional meats harvested by ERFN study participants, woodland caribou was the third most consumed mammal species. The Wheeler River EFRN Traditional Knowledge Study (2022), documented woodland caribou harvesting locations in the study area. Three areas that had been used for woodland caribou hunting in the last ten years were recorded (codes: 1003-10, 1004, 09, 1016-09).

3.5 Overall Status

As noted previously, based on work completed by McLoughlin et al. (2019), which was confirmed by ENV in November 2023 (SK ENV 2023b), the caribou populations in SK1 are stable. The amended federal recovery strategy specifies a unique disturbance threshold of 40% undisturbed habitat for SK1. Habitat disturbance is assessed by the combination of human-caused disturbance (e.g. roads, industrial infrastructure) with a 500 m buffer and wildfire perimeters (less than 40 years old). Based on the federal assessment and recent preliminary disturbance assessment from ENV, an estimated 53% of SK1 is considered disturbed, with 47% undisturbed (ENV 2023b), indicating that the land use and overall disturbance in the conservation unit remains below the recovery strategy disturbance threshold.

4 Mitigation Hierarchy

A generic biodiversity mitigation hierarchy is provided in Figure 4-1. As shown in the hierarchy, an offset can be used to address any residual effects following efforts to avoid, minimize, and restore potential project effects. This generic hierarchy is generally consistent with the approach of ENV to manage effects on caribou and their habitat.

The balance of Section 4 of this Plan outlines Denison's approach to avoid, minimize, and restore caribou habitat per commitments made in the EIS associated with the Project. The discussion of additional management measures through offsetting is provided in Section 5.

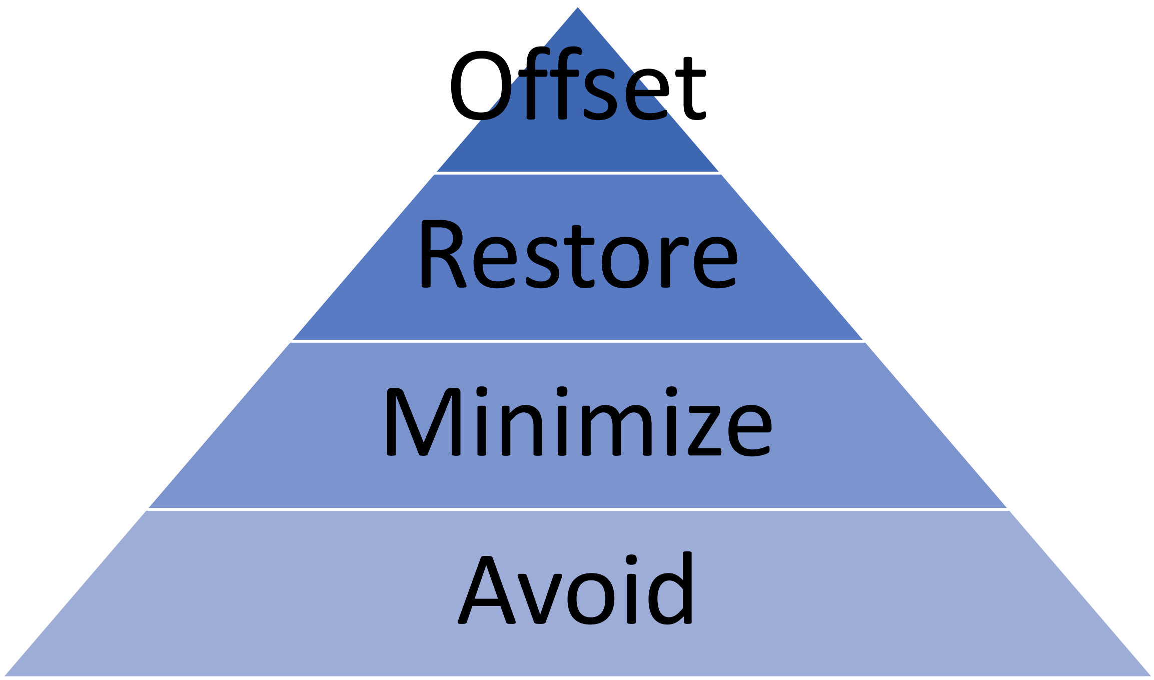


Figure 4-1: Mitigation Hierarchy

4.1 Avoid

Potential adverse effects on the caribou have been avoided to the extent possible through Project design, including:

- Selection of in-situ recovery (ISR) mining avoids some direct and indirect effects compared to conventional underground or open-pit mining methods. In-situ recovery mining avoids the need for spatially expansive infrastructure such as waste rock piles and tailings management facilities reducing the Project footprint (i.e., avoids direct effects on caribou and their habitat). In-situ recovery mining also reduces the potential for interactions between caribou and Project components / activities as it concerns sensory disturbance as it is inherently a less intensive form of mining with reduced noise/light/vibration generation (i.e., avoids indirect effects on caribou and their habitat).
- Site clearing and other works that involve disturbance of vegetation and/or soil will be completed during least-risk timing windows for caribou (for example, outside of

wintering/calving period from April 1-July 31, per ENV 2013), where practical, to avoid disturbance during sensitive time periods.
- Pre-disturbance wildlife surveys will be completed to identify caribou presence and work will be postponed if caribou are present.

4.2 Minimize

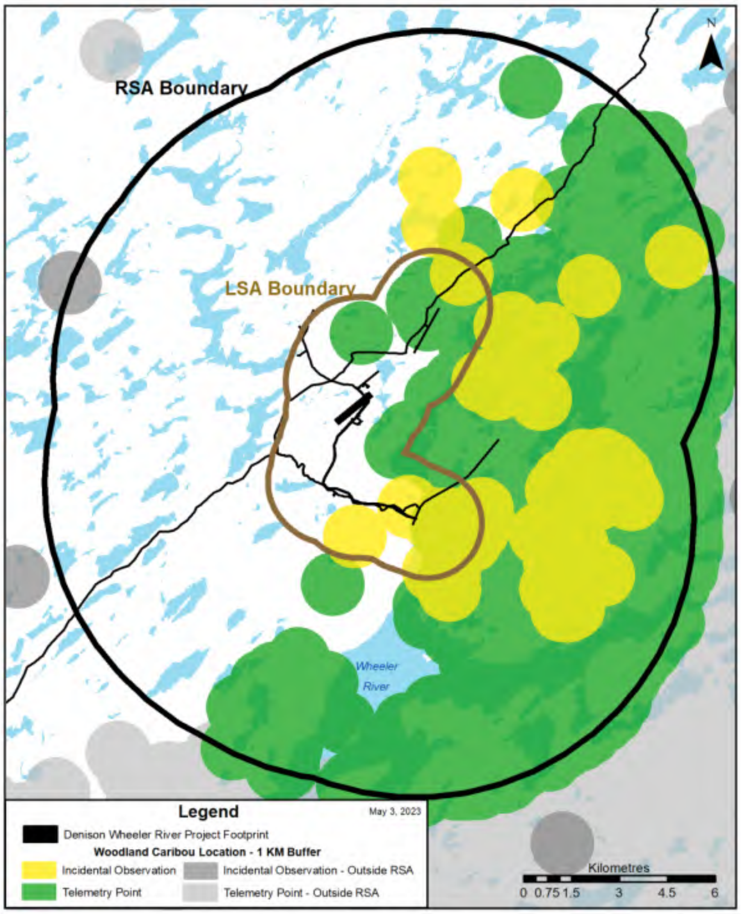
Additional mitigation measures to minimize effects on caribou and their habitat and tailored to Project features have been incorporated into the various Project management and monitoring plans within the Environmental Management System (EMS) including but limited to erosion and sediment controls, soil and vegetation monitoring, Decommissioning Plan, air quality monitoring, fuel spill control and response, Radiation Protection Plan, surface water and effluent monitoring, and Waste Management Plan.

The Project's EMS plans provide direction on monitoring and adaptive management so that if issues are identified, mitigation measures can be developed and implemented in a timely and effective manner. Mitigation measures specific to caribou are applicable during all Project phases, within all seasons and expected to be effective following appropriate implementation. Examples of the measures to minimize Project effects on wildlife in general, and caribou in particular, are highlighted below.

1.1.1 Disturbance Footprint

- Siting Project components in close proximity to the ISR mining area minimizes indirect effects on caribou and their habitat. The Project components are also west of woodland caribou observations from a large-scale caribou collaring program based on tracking data received by the Ministry of Environment (Figure 4-2), although the absence of data does not necessarily mean the absence of caribou and Denison has observed caribou in the area. Appropriate siting is anticipated to minimize the potential for interactions with woodland caribou and Project activities.
- The Project footprint (i.e., the area of maximum physical disturbance) has been reduced to the extent safely practicable, resulting in limited/minimal habitat loss/disturbance and noise propagation.
- Portions of the proposed Project footprint will be developed within previously disturbed areas, including roads currently used for exploration activities, thereby minimizing additional habitat disturbance.

Denison-Wheeler Study Area - Woodland Caribou Location Data



RSA Boundary		
Data Type	**Years**	**Number of Locations**
Incidental Observation	1987, 2017 – 2022	89
Telemetry Point*	2013 – 2016	3,848

*Data from 15 individual woodland caribou cows

LSA Boundary		
Data Type	**Years**	**Number of Locations**
Incidental Observation	2017 – 2022	19
Telemetry Point*	2013, 2015 – 2016	62

*Data from 4 individual woodland caribou cows

NOTE: Absence of data does not mean absence of woodland caribou.

Figure 4-2 Saskatchewan Ministry of Environment Woodland Caribou Location Data Provided to Denison

4.2.1 Wildlife and Habitat Protection

- Project activities have been assessed for their potential to disturb or remove wildlife and/or wildlife habitat (e.g., site clearing, soil disturbance) to determine potential effects on wildlife and wildlife habitat and the assessment, including proposed mitigation measures, for the Project will guide Project activities.
- Pre-disturbance wildlife clearance surveys will be conducted within the Project Area; results of the clearance surveys will inform the development and implementation of appropriate mitigation (e.g., delay of work) to address the identified issue (e.g., presence of caribou).
- Personal firearms for employees and contractors will be prohibited within the Project Area to prevent hunting activities.
- Policies will be implemented prohibiting employees and contractors from feeding, approaching, or harassing wildlife species within the Project Area.
- To support wildlife habitat regeneration, progressive restoration including ecosystem-based revegetation will be conducted on disturbed areas as soon as practicable in accordance with the Decommissioning Plan.

4.2.2 Wildlife Deterrence and Prevention of Wildlife Entrapment

- In addition to installing secure fencing around all contaminated areas to prevent accidental contaminant exposure, buildings and other Project components will be designed and maintained to exclude wildlife from using buildings for refuge or shelter, and to deter wildlife from potentially becoming entrapped.

4.2.3 Sensory Disturbance

- Noise emitting Project activities will be managed to minimize sensory disturbance of wildlife, especially during sensitive time periods, such as calving. This would include:
  - locating excessive noise generating activities such as the concrete batching operation as far away from sensitive wildlife locations as possible;
  - directing the generator discharge openings away from sensitive locations; and
  - making use of available on-site obstructions to control sound exposure at sensitive areas (i.e., locate sources behind buildings).
- The main sources of noise will be related to transport of people and goods, drilling of holes for the freeze wall and wellfield, operation of the batch plant, operation of the processing plant, and operation of the pumphouses. Low sound emission equipment and the use of silencers or mufflers (whenever practical) will be used to reduce noise associated with Project activities. There will be regular maintenance of equipment to ensure it is in proper working order and not emitting noise unduly.
- Lighting will be focused on work sites and not surrounding areas, to minimize light trespass and other light-related pollution sources.
- Facilities will be illuminated only to meet standards set for the protection of workers to avoid over-illumination.
- Battery-powered, light vehicles and mobile equipment, and an AC powered dual rotary drill will be used for ISR wellfield development instead of a traditional diesel-powered unit, where practical, to reduce air emissions and noise levels and improve energy efficiency.

- Fugitive dust sources that could lead to deposition of dust on vegetation and waterbodies (including potential deposition of trace metals and radionuclides) will be reduced by:
  - dust suppression techniques on site roadways, such as road watering and traffic management;
  - directing processing plant exhaust from drying and packaging areas through a stack prior to release outside of the building;
  - designing the stack height based on results of air dispersion modelling to be an appropriate height for optimal dispersion;
  - making a wash bay available to clean items, equipment, and vehicles that may have been in contact with potentially contaminated materials. Contaminated water from the wash bay will be collected in a sump tank and routed to the water treatment plant for treatment and discharge; and,
  - conducting radiological clearance scanning as required for any items, equipment, and vehicles leaving the Project Area.

4.2.4 Transportation Management

- Traffic and access control measures will be implemented, including managing traffic volume by scheduling truck convoys, using high-volume haul trucks, and restricting public access (e.g., private vehicles, snowmobiles, all-terrain vehicles, and foot traffic) to the Project site and roads with both north and south security access gates. It is important to note that if any individual were seeking access around the Project area to undertake Aboriginal and / or Treaty Rights, Denison staff would facilitate this, provided it was safe to do so given Project activities in the area.
- For Project air traffic, as safety allows, planes will be encouraged to use the most direct approach and departure flight paths in order to leave the terrestrial LSA and RSA in an expedient manner.
- The anticipated aircraft traffic at the Project airstrip is expected to include approximately five flights per week during Operation (this was the assumption used in the EIS) and opportunities to optimize the flight schedule will be completed by Denison as the Project advances.
- Denison will operate the airstrip and flights in a safe manner and will also seek to minimize interactions with wildlife by following guidance and best practice from Saskatchewan and other jurisdictions. Mitigation measures likely to be incorporated into the operation of the airstrip, with respect to air traffic, would include, as safety allows, maintaining as direct approach and departure flight paths as possible, and obtaining appropriate altitudes, and leaving the LSA and RSA, as quickly as is safely reasonable. Flight paths can be adjusted based on the location of caribou observations or known important areas during sensitive periods, as is safe and practical to do so. Details related to airstrip and flight management will be developed as part of Project licensing and permitting.
- Appropriate road signage will be installed (e.g., speed limits, identification of wildlife crossings and areas of high activity) along Project roads to minimize the risk of wildlife-vehicle collisions.
- Speed limits will be implemented to reduce the risk of wildlife-vehicle collisions.
- Wildlife will have the right-of-way on Project roads, unless it is unsafe to stop (i.e., if a collision is imminent). Vehicles will not be used to encourage caribou to move off Project roads and processes will be implemented for employees and contractors to slow down and/or stop

vehicles/equipment to allow caribou to move away or off the road before resuming normal road speeds for the area.

- Road watering and regular road maintenance to limit dust dispersion.
- Employees and contractors will report and communicate the location and circumstances of any roadkill observed on or alongside Project roads. Large-bodied wildlife carcasses found will be promptly reported to ENV and disposed of as directed to prevent scavenging.
- Vegetation along Project roads will be managed to reduce attractiveness to wildlife (e.g., forage plants) and maintain appropriate sightlines for drivers to minimize wildlife-vehicle collisions.
- Alternative measures on Project roads for de-icing and winter traction (e.g., sand, gravel) or dust suppression (e.g., water) will be implemented, whenever practicable, to limit the use of specialty chemicals and potential exposure of wildlife including caribou to them.
- Appropriately sized gaps in the roadside snowbanks during winter will be maintained to facilitate caribou crossing and escape and, with that, reducing their risk of vehicle collisions.
- New Project site and access roads will be designed to minimize sightlines for predators, whenever practicable, while still maintaining general road safety.
- Ditches and culverts along Project roads will be designed and maintained to minimize pooling of water as roadside pools may attract caribou.

4.2.5 Water Management, Waste Management, Emissions, and Hazardous Materials Management

- Education on and enforcement of proper water, waste, emissions and hazardous materials management practices will be provided to employees and contractors.
- A freeze wall will be established around the uranium deposit to reduce potential for groundwater disturbance or contamination mitigating the likelihood of exposure of caribou to contaminants in local areas of groundwater discharge to surface.
- The ISR wellfield and processing plant will be designed to re-use most of the solutions inside each circuit, reducing water use requirements to the extent feasible. Make-up water will be preferentially sourced from site runoff (instead of freshwater) where possible.
- Contaminated wastes (e.g., mineralized drill cuttings, process precipitates) will be temporarily stored on double lined pads with leak detection capabilities and an associated monitoring program until final disposal at an approved facility. An adjacent pond will be used to collect contact water from these pads.
- All contact water will be routed to the Industrial Wastewater Treatment Plant for treatment and eventual release to the environment. All treated effluent released to surface water will meet federal and provincial regulatory discharge limits. This will mitigate exposure of caribou to Project-related contaminants released to the environment.
- Surface pipelines will be designed to have secondary containment or catchment and have leak detection systems in place at key locations to mitigate the likelihood of the release of such chemicals to the environment that could result in exposure of caribou to the chemicals.
- Double-walled high-density polyethylene or equivalent piping will be used in the wellfields and will be freeze protected and secured to minimize pipe movement to mitigate the likelihood of the piping failure and the associated release of wellfield chemicals to the environment that could result in exposure of caribou to the chemicals.

- Denison is proposing to segregate and compost organic wastes on site in a composting system, reducing the volume of material in the domestic landfill generating odours and thereby minimizing wildlife attractants.
- Domestic waste will be collected and temporarily stored in wildlife-proof containers to avoid attracting wildlife and reduce the risk for human-wildlife interactions. The wildlife-proof containers will be inspected regularly for evidence of wildlife presence or access to waste disposal facilities. If evidence of wildlife presence or access to waste disposal facilities is detected, modified systems will be implemented and/or off-site waste disposal/incineration frequencies will be increased.
- A "no littering policy" for employees and contractors will be implemented within the Project Area.
- Air emissions will be reduced to the extent practical through implementation of the development of air emissions management and monitoring plans within the EMS.
- All vehicles and equipment will be equipped with industry-standard emission control systems; unnecessary idling of vehicles will be prohibited to reduce emissions.
- The use of hazardous materials will be limited as much as possible.
- Appropriate hazardous materials management practices will be implemented in accordance with industry guidelines to minimize the risk of accidental spills or leakage. This will mitigate the likelihood of release to the environment that could result in exposure of caribou to the hazardous materials.
- Hazardous materials will be handled, stored, and disposed of appropriately and in accordance to avoid attracting wildlife (e.g., wildlife-proof containers, exclusion fencing) to mitigate the likelihood of exposure of caribou to hazardous materials.
- Physical deterrents (e.g., fencing) will be employed around contaminated areas (e.g., waste ponds and waste pads), the domestic landfill, or hazardous materials storage areas to discourage wildlife use / interaction. The deterrents will be monitored and maintained .
- Appropriate spill response kits will be positioned adjacent to areas where hazardous materials are stored in accordance with the Spill Response Plan to mitigate the likelihood of the release of hazardous material to the environment that could result in exposure of caribou to the material.
- A minimum 100 m distance from any waterbody will be maintained for fuel storage, refueling activities, or equipment servicing in accordance with the Spill Response Plan. This will mitigate the likelihood of a fuel spill to water that could result in exposure of caribou to fuel.
- Appropriate fuel, chemical, and materials management practices will be followed in accordance with the Spill Response Plan to minimize the risk of accidental spills or leakage of diesel fuel, other hydrocarbons, and other hazardous materials and mitigate the likelihood of exposure of caribou to such chemicals.
- All vehicles and equipment will be maintained in good working condition (e.g., no leaks) and furnished with industry-standard spill response kits.

1.1.2 Wildlife Education

- Employees and contractors will be provided with wildlife education and awareness training, including education about potential caribou issues on site and training on the mitigation measures summarized with the EMS and specifically in this Plan to avoid or minimize potential Project effects on caribou and caribou habitat.

- Employees and contractors will be educated on waste and hazardous waste management practices / policies that limit human-wildlife interactions and the potential exposure of wildlife to those wastes.
- Designated employees will be trained in appropriate wildlife deterrent techniques to minimize wildlife interactions with the Project.
- Employees and contractors will be requested to report wildlife observations, including prompt reporting of caribou observations and immediate communication to on-site staff. Wildlife encounters and outcomes will be monitored, and logbooks will be used to record wildlife observations. Logbooks and reports will be available to employees. Incidental observations recorded by staff will be entered into Species Detection Loadforms and submitted to the Saskatchewan Conservation Data Centre annually.

4.3 Restore

The temporal bounds for the Project as stated in the EIS are years 1 to 3 for construction, years 3 to 18 for operation, years 18 to 23 for decommissioning, and fifteen years of post-decommissioning monitoring and inspections from years 23 to 38. Importantly, during physical decommissioning (years 18 to 23) the majority of Project components are scheduled to be removed from site which is expected to facilitate restoration activities. Also, because of the selected ISR mining method, there are no large, permanent Project components, such as waste rock piles or tailings management facilities, for which large scale and potentially complex restoration strategies are needed.

Denison's decommissioning commitment is to return the land back to the Province of Saskatchewan for unrestricted surface land use post-closure. The Project's Conceptual Decommissioning Plan (CDP) is included in the final EIS. The details of decommissioning and restoration will be refined over time as the Project proceeds. A Preliminary Decommissioning Plan will be developed by Denison to support licensing and permitting applications. Prior to executing decommissioning activities, Denison will prepare and submit a Detailed Decommissioning Plan to regulators for their review and acceptance, which builds on the Preliminary Decommissioning Plan.

The CDP outlines plans for physical decommissioning (mining area remediation; asset removal; and decontamination, demolition, and disposal), followed by restoration. A summary of the CDP is provided here.

- Ongoing decommissioning of Project components will be completed when possible.
- Denison has committed to progressively restore areas no longer necessary to support/facilitate Operations to limit the amount of disturbance at any given time. Restoration of inactive areas will take place when/as these areas become available. The progress and success of these activities will be assessed regularly at a schedule commensurate with the expectations of the activities per the decommissioning plan. Progressive restoration including ecosystem-based revegetation will be conducted on disturbed areas as soon as safely and logistically practicable with the use of suitable/appropriate native species and in accordance with the decommissioning plan.
- Once the asset removal, decontamination, demolition, and disposal are completed, and the site has been cleared and leveled, restoration activities, including planting, will take place. Currently this would largely be with jack pine seedlings, but the mix of plants will depend on location and available species. Restoration activities monitored until it is deemed self-sustaining and viable wildlife habitat.

- Future discussions will be held with Indigenous and general public Interested Parties to determine the amount of access to the area they wish to maintain in the future (post-decommissioning). Based on results of these discussions, transportation corridors including roads or trails associated with the Project site that are no longer needed will be graded, scarified, and vegetated with native, self-sustaining species as required. Access to facilitate safe post-closure monitoring or requested by appropriate Interested Parties (e.g., to facilitate land use) may be left in place. Access to the site may be restricted by gates and/or berms.
- Laydown areas will be scarified, covered with 0.5 to 1.0 m of stockpiled overburden, and vegetated with native, self-sustaining species. The footprints of other infrastructure, such as the camp, will be scarified and vegetated with native, self-sustaining species as required. The goal of revegetation would be to restore the site to former state, or something similar including tree cover, to the extent possible. The topsoil and brush stockpiled during pre-construction activities will be used during restoration.
- Lessons learned from progressive decommissioning and any site-specific restoration studies will be incorporated into the Detailed Decommissioning Plan. Additionally, information from other northern Saskatchewan mine sites will be examined to help Denison select the restoration tools, including revegetation options, which will contribute towards decommissioning success.

Closure of the entire Project will be completed in accordance with provincial and federal regulations and guidance documents with the fundamental considerations being to confirm physical and chemical stability of the site to protect human health and the environment.

Progressive decommissioning and restoration will be completed throughout the life of the Project, whenever feasible, and reported to the regulatory agencies as part of the annual reporting requirements throughout Operation. Associated activities will focus on the decontamination, demolition, and disposal of unused buildings and infrastructure, as well as the removal of unused equipment and machinery. Progressive decommissioning and restoration are expected to continue and result in positive effects as revegetation is continued and regeneration occurs. Following decommissioning and restoration, wildlife habitat is expected to recover to baseline conditions.

5 Additional Caribou Management Measures

As part of its boreal caribou management efforts, the province is working with industry to develop effective and practical approaches to mitigate potential effects of activities on woodland caribou. To this end, the province describes a hierarchy of controls for caribou habitat management. The final element of this hierarchy of controls is termed offset, whereby restoration of habitats outside the project footprint are used to “offset” for project footprint effects where such footprint effects render a given area as unavailable to be functional habitat for an extended time period.

The ENV is developing a boreal caribou habitat offset calculator to address the above-referenced situation. The calculator’s objective is to consistently estimate and calculate appropriate offset requirements for applicable developments. The calculator recognizes that there are a number of key variables influencing both habitat loss and habitat gain calculations. As such, the following key concepts have been integrated into the calculator:

1. **Not all projects are created equal**

   Different types of projects/activities/footprints on the landscape have different potential effects on caribou habitat.

2. **Reach of effects**

   A project’s total effect on caribou habitat and associated habitat offset needs to integrate both direct and indirect (zone of influence) concepts. The total project effect includes the area of direct disturbance plus the surrounding indirect effects (Zone of Influence). Similarly, the total offset includes direct habitat gain or restoration plus indirect habitat benefits.

3. **Location matters**

   The location of the project/activity/footprint has different effects on caribou, based on habitat value. Similarly, the location of the offset has different benefits for caribou when habitat value is factored in.

In consideration of these key concepts, the calculator aims to balance functional habitat that is disturbed or removed with restored functional habitat. Through habitat loss and gain calculations, the calculator estimates habitat offset requirements for a project footprint, expressed as an equivalent length/area of linear features. In SK1 and SK2, legacy roads and trails are expected to be the primary candidate features for habitat offsets and restoration activities. It is also noted that the estimated cost to deliver the required offset is calculated. As an optional mechanism for proponents, Saskatchewan is working to establish a mechanism for in-lieu mitigation payments such that the province can allocate resources based on its caribou habitat restoration priorities.

Through refinements to our final project design, Denison is committed to continue working with the province to finalize our habitat offset requirement using the province’s habitat offset calculator.

6 References

Denison Mines Corp. (Denison). 2024. Wheeler River Project. Final Environmental Impact Statement. July 2024.

English River First Nation (ERFN). 2011. English River First Nation: English River First Nation, ATK (Aboriginal Traditional Knowledge) Summary Report. Compiled by Environment Canada.

English River First Nation (ERFN) and Shared Value Solutions (SVS). 2022. Wheeler River Project – Summary of Traditional Knowledge Study Results – English River First Nation. Prepared for English River First Nation. March 2022.

Environment Canada. 2011. Scientific Assessment to Inform the Identification of Critical Habitat for Woodland Caribou (Rangifer tarandus caribou), Boreal Population, in Canada: 2011 Update. Ottawa, ON. 102pp. plus appendices.

Environment and Climate Change Canada (ECCC). 2019. Boreal Caribou Science to Inform Recovery: Science Summary Sheet #1. Ottawa, Ontario, Canada. 10p.

Environment and Climate Change Canada (ECCC). 2020. Amended Recovery Strategy for the Woodland Caribou (Rangifer tarandus caribou), Boreal Population, in Canada. *Species at Risk Act* Recovery Strategy Series. Environment and Climate Change Canada, Ottawa. xiii + 143pp.

McLoughlin, P. D., C. Superbie, K. Stewart, P. Tomchuk, B. Neufeld, D. Barks, T. Perry, R. Greuel, C. Regan, A. Truchon-Savard, S. Hart, J. Henkelman, and J. F. Johnstone. 2019. *Population and habitat ecology of boreal caribou and their predators in the Saskatchewan Boreal Shield*. Final Report. Department of Biology, University of Saskatchewan, Saskatoon. 238 pp.

Neufeld, B., C. Superbie, R. J. Greuel, T. Perry, P. A. Tomchuk, D. Fortin, and P. D. McLoughlin. 2021. Disturbance-Mediated Apparent Competition Decouples in a Northern Boreal Caribou Range. *The Journal of Wildlife Management* 85(2): 254–270.

OECD. 2016. Biodiversity Offsets: Effective Design and Implementation. OECD Publishing, Paris. https://doi.org/10.1787/9789264222519-en

Saskatchewan Ministry of Environment (ENV). 2013. Conservation Strategy For Boreal Woodland Caribou (Rangifer tarandus caribou) in Saskatchewan. Saskatchewan Ministry of Environment. Fish and Wildlife Technical Report 2014.

Saskatchewan Ministry of Environment (ENV). 2021. Range Plan for Woodland Caribou in Saskatchewan. Boreal Plain Ecozone – SK2 West Caribou Administration Unit. October 2021.

Saskatchewan Ministry of Environment (ENV). 2023a. Wildlife Species At Risk – Woodland Caribou. https://www.saskatchewan.ca/business/environmental-protection-and-sustainability/wildlife-and-conservation/wildlife-species-at-risk/woodland-caribou (accessed May 2023).

Saskatchewan Ministry of Environment (ENV). 2023b. Woodland Caribou in the Boreal Shield (SK1): Background Information.

Denison Mines

Wheeler River Project

Final Environmental Impact Statement

November 2024

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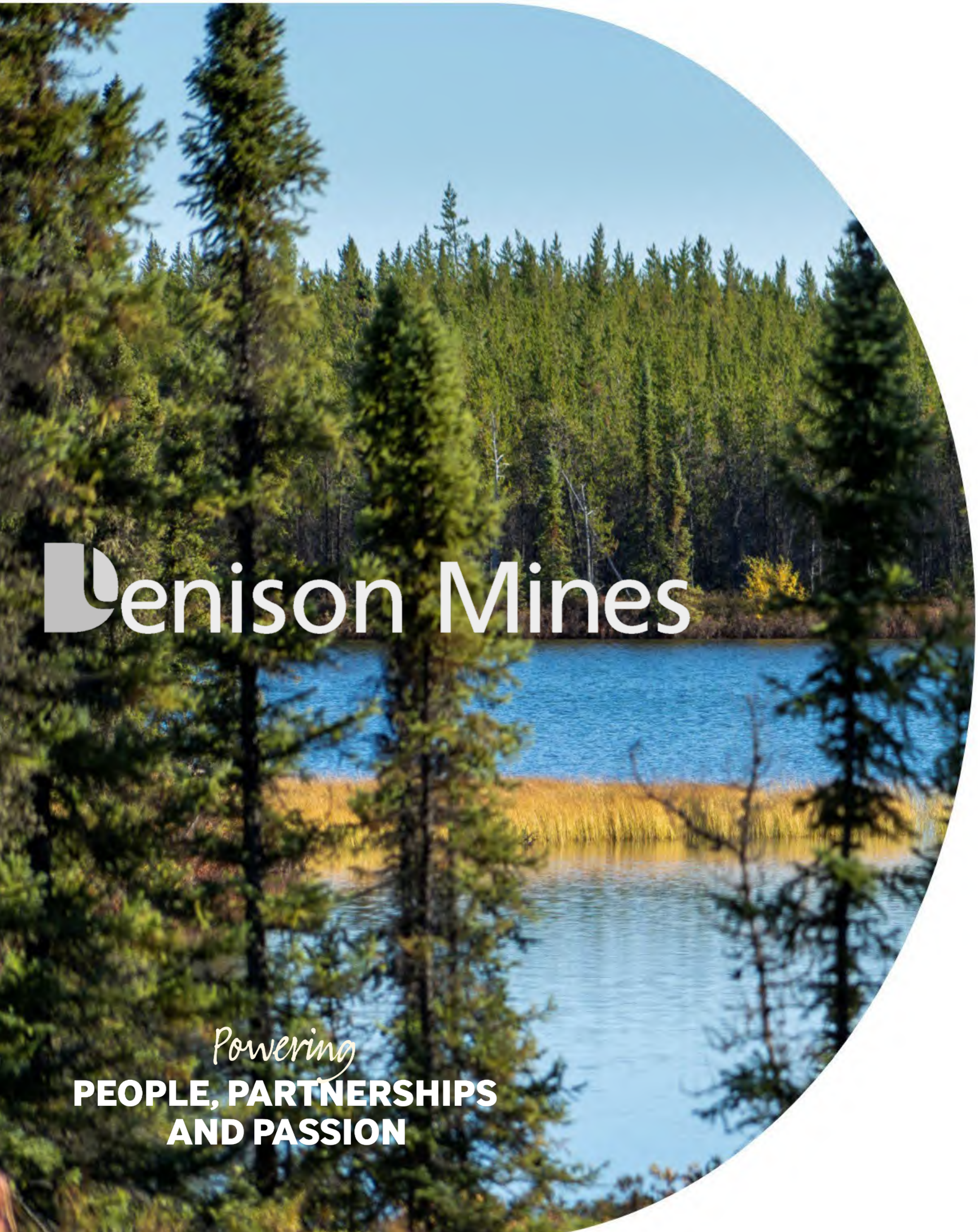

Denison Mines

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Denison Mines Corp.

Appendix 9-F Supplemental Information

Version 3

October 2024

Table of Contents

List of Figures

1 Introduction

On October 21, 2022, Denison Mines Corp. (Denison) submitted a draft Environmental Impact Statement (EIS) for the proposed Wheeler River Project (the Project). Based on their initial review, the Canadian Nuclear Safety Commission indicated that the submission contained the required information to proceed with the Federal-Indigenous Review Team (FIRT) technical review of the draft EIS. On March 20, 2023, the FIRT provided Denison with an initial list of information requests (IRs) for Denison to respond to and eventually submit a final EIS document. Denison compiled a list of responses to these initial IRs and provided the FIRT with a revised draft on August 18, 2023. Following the review of these documents, the FIRT provided Denison with a subsequent list of IRs on November 27, 2023. This Appendix provides additional information to address several IRs provided by Environment and Climate Change Canada (ECCC) related to woodland caribou, migratory songbird species, and species at risk (SAR) listed under Schedule 1 of the federal *Species at Risk Act* (SARA).

2 Supplemental Information

2.1 Woodland Caribou

The following information is intended to provide additional context to the responses provided in the IR tracking sheet, particularly in regard to the following: IR-137, IR-143, IR 144, IR 145, IR-143/144R1, IR-143/145R1, IR-149, IR-149-R1A and R1B, IR-151, IR-155, and IR-156.

Figure 2-1 illustrates the location of woodland caribou observed during the baseline field program in association with the ecosite types as classified by the Saskatchewan Ministry of Environment as having the potential to develop into low, moderate, or high-quality habitat to support woodland caribou in relation to the SK1 range. These habitat potential categories are based on the overall habitat suitability ranking for the life history requirements, including forage, refuge, and calving habitat for caribou (Saskatchewan Ministry of Environment 2019). Figure 2-2 provides further insight as to the woodland caribou observed during the baseline field program in association with the ecosite types as classified by the Saskatchewan Ministry of Environment but in context with the Wildlife Study Areas.

To provide further context on the biophysical attributes for woodland caribou, as referenced in the 2020 Amended Recovery Strategy for the Woodland Caribou (*Rangifer tarandus caribou*), Boreal Population, in Canada (ECCC 2020), Figure 2-3 to Figure 2-8 illustrate the location of caribou observations from the baseline field program in relation to calving, foraging, and refuge habitat, based on information received from the Saskatchewan Ministry of Environment (2023). These figures present the information at two different scales: (1) in context with the Wildlife Study Areas, and (2) in relation to the Project Footprint.

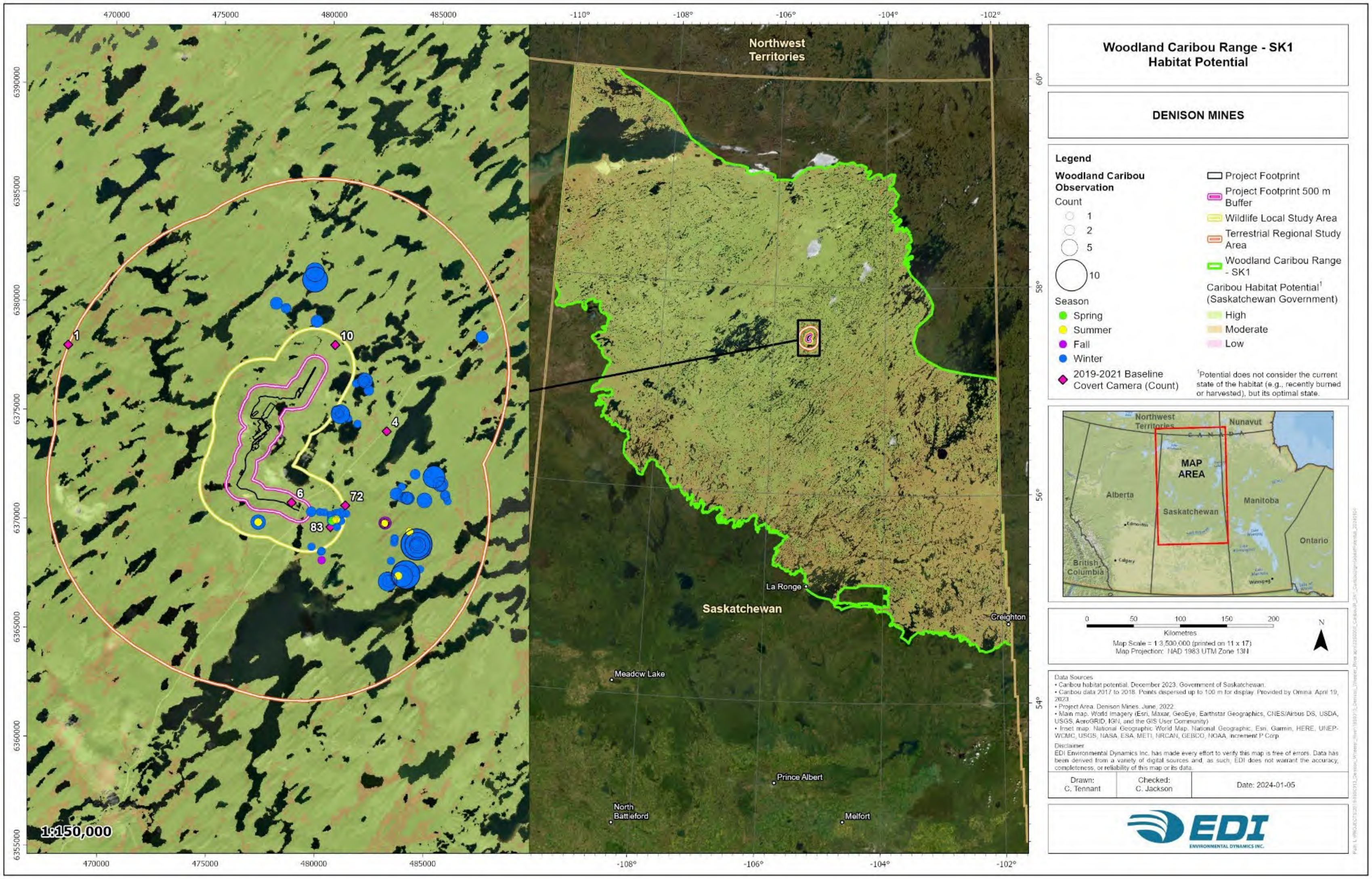

Figure 2-1: Woodland Caribou Range – SK1, Habitat Potential

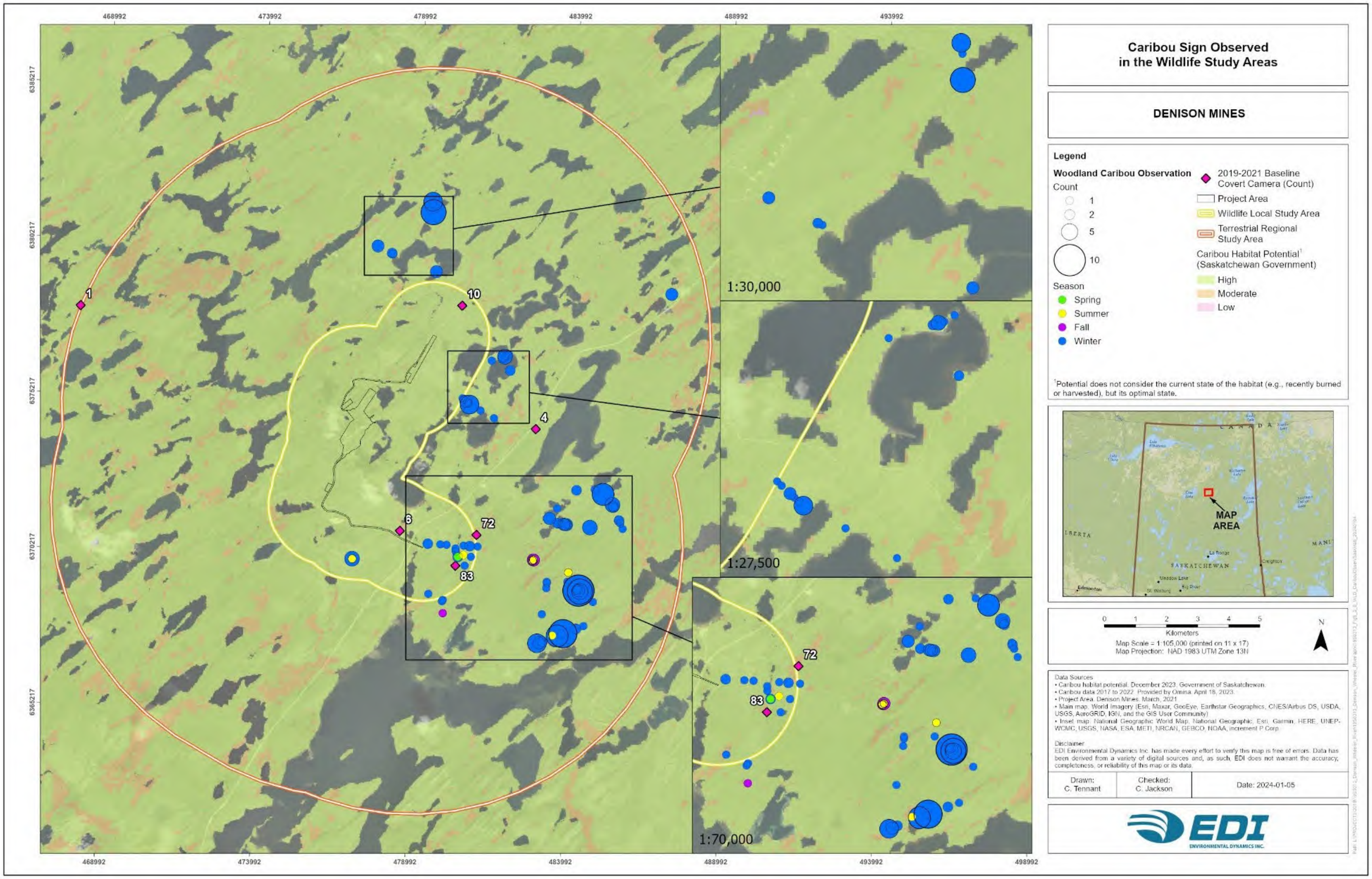

Figure 2-2: Caribou Sign Observed in the Wildlife Study Areas

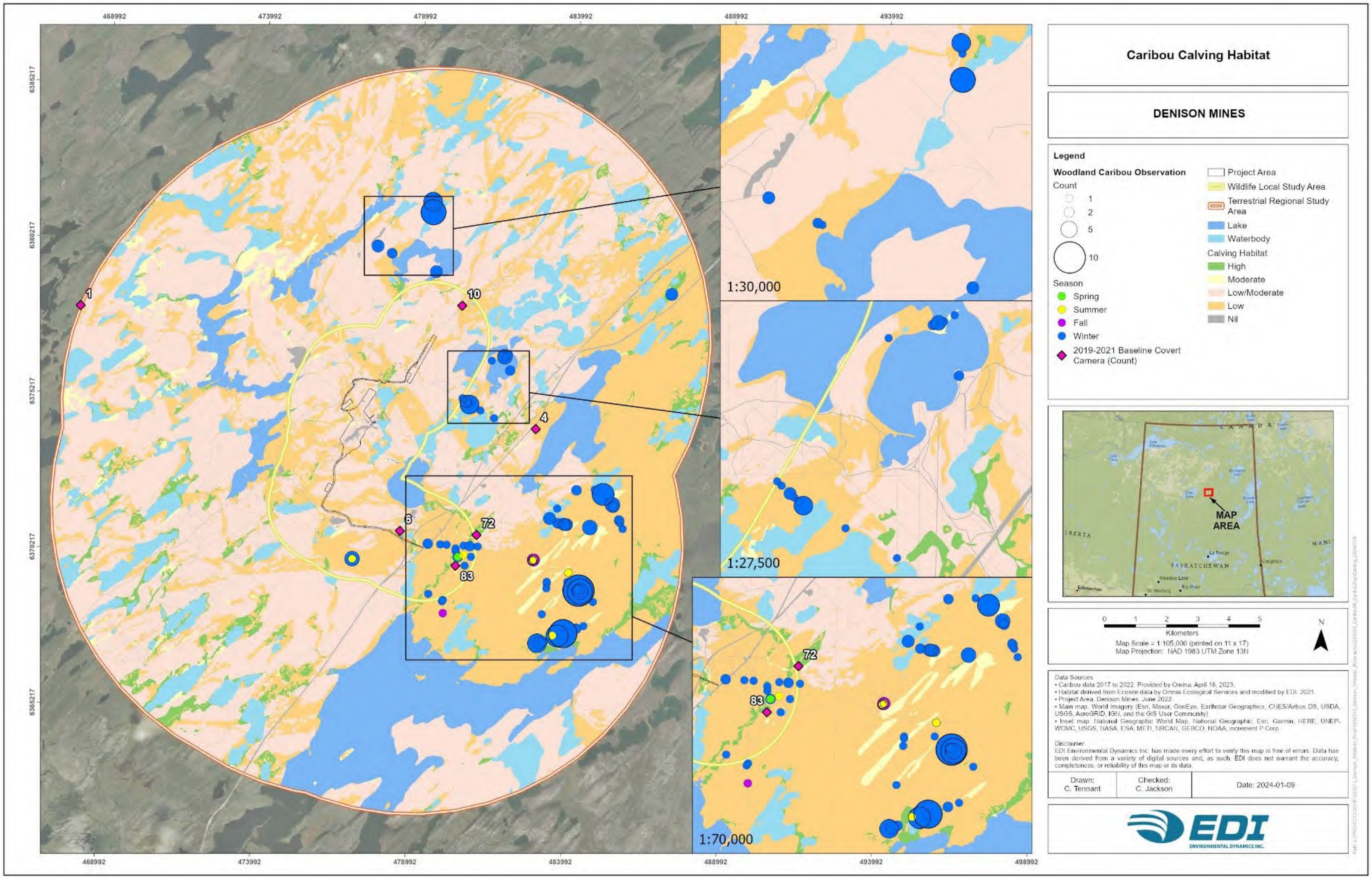

Figure 2-3: Caribou Calving Habitat Potential within the Wildlife Study Areas

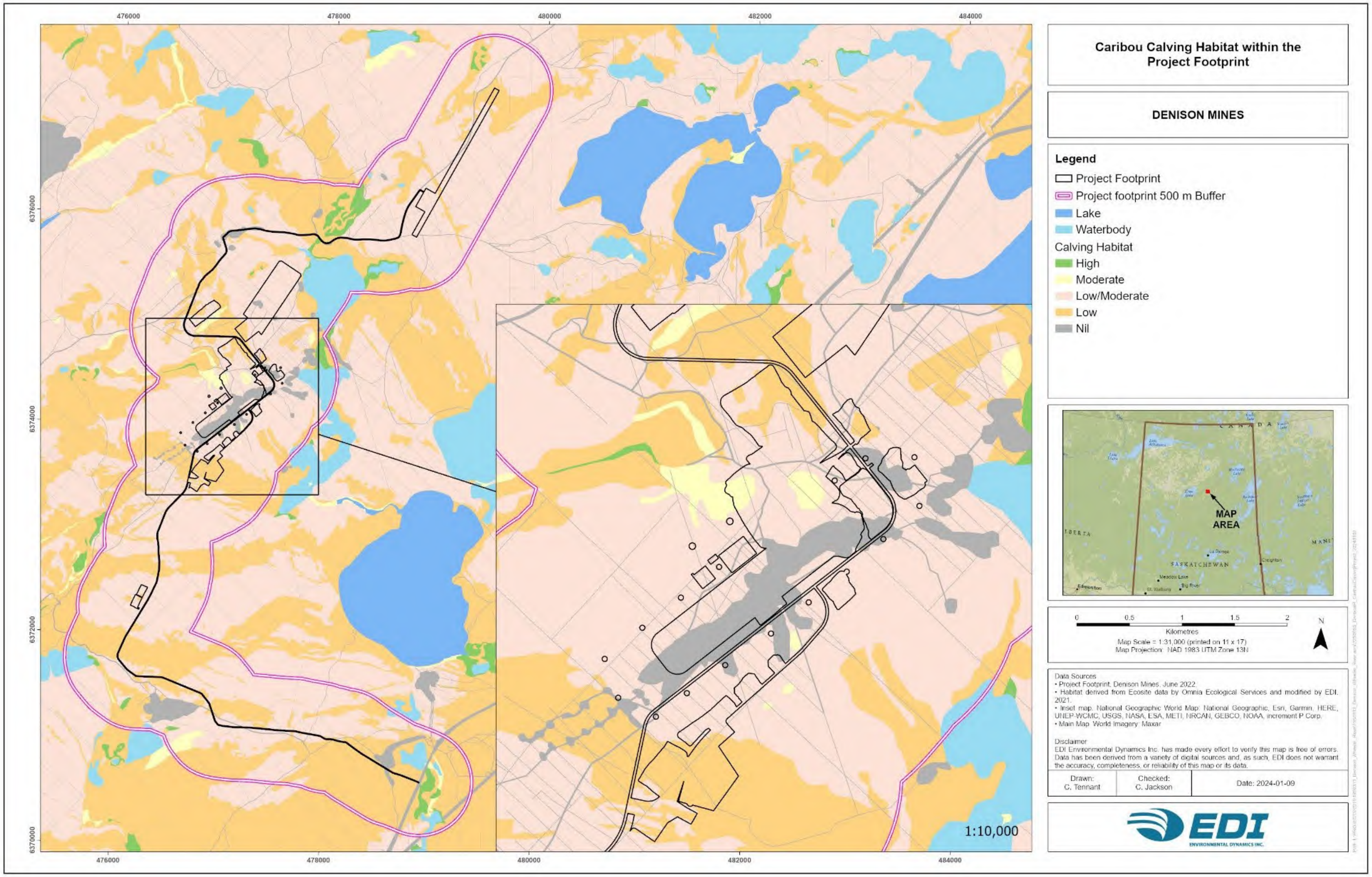

Figure 2-4: Caribou Calving Habitat Potential within the Project Footprint

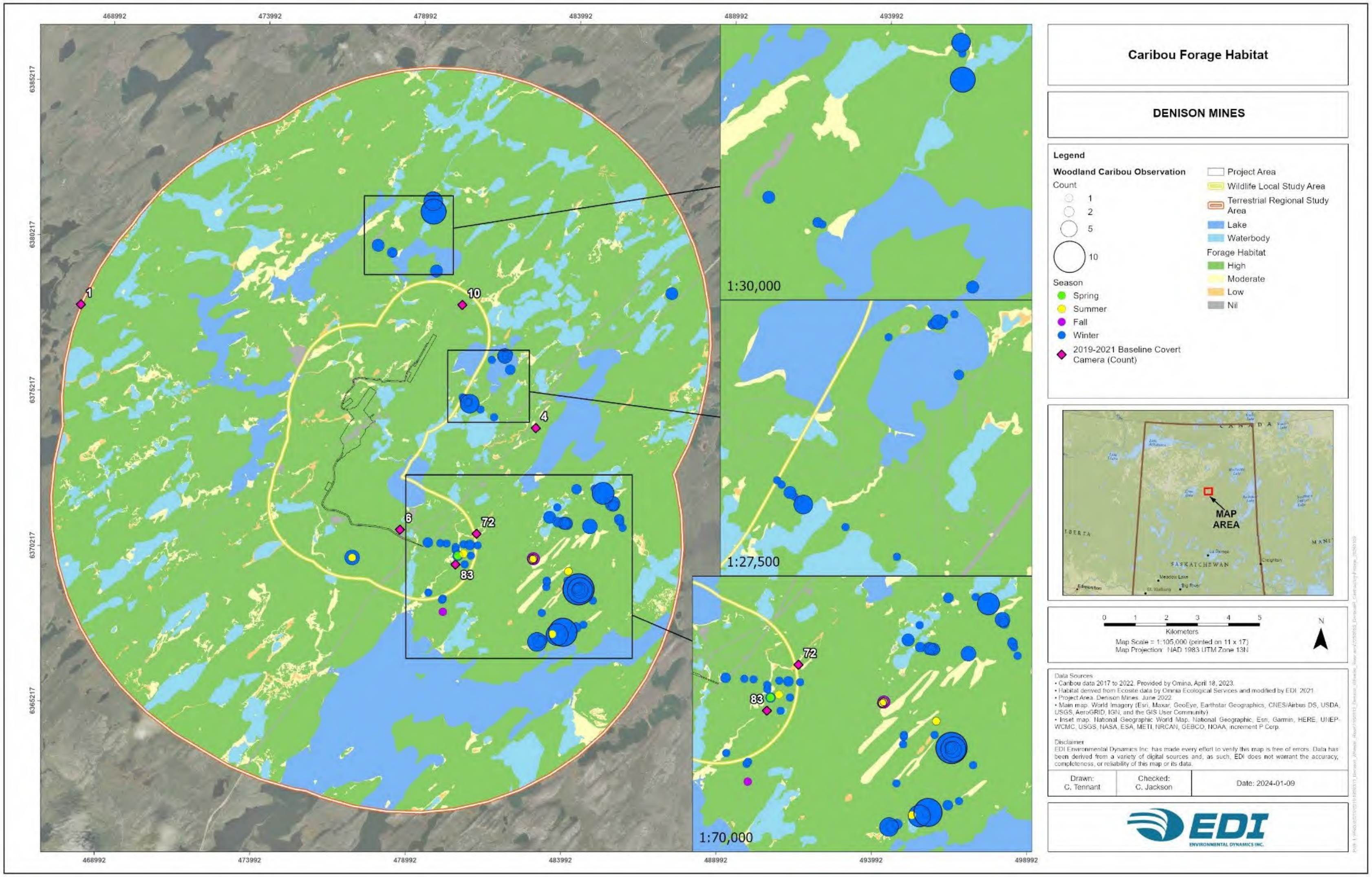

Figure 2-5: Caribou Forage Habitat Potential within the Wildlife Study Areas

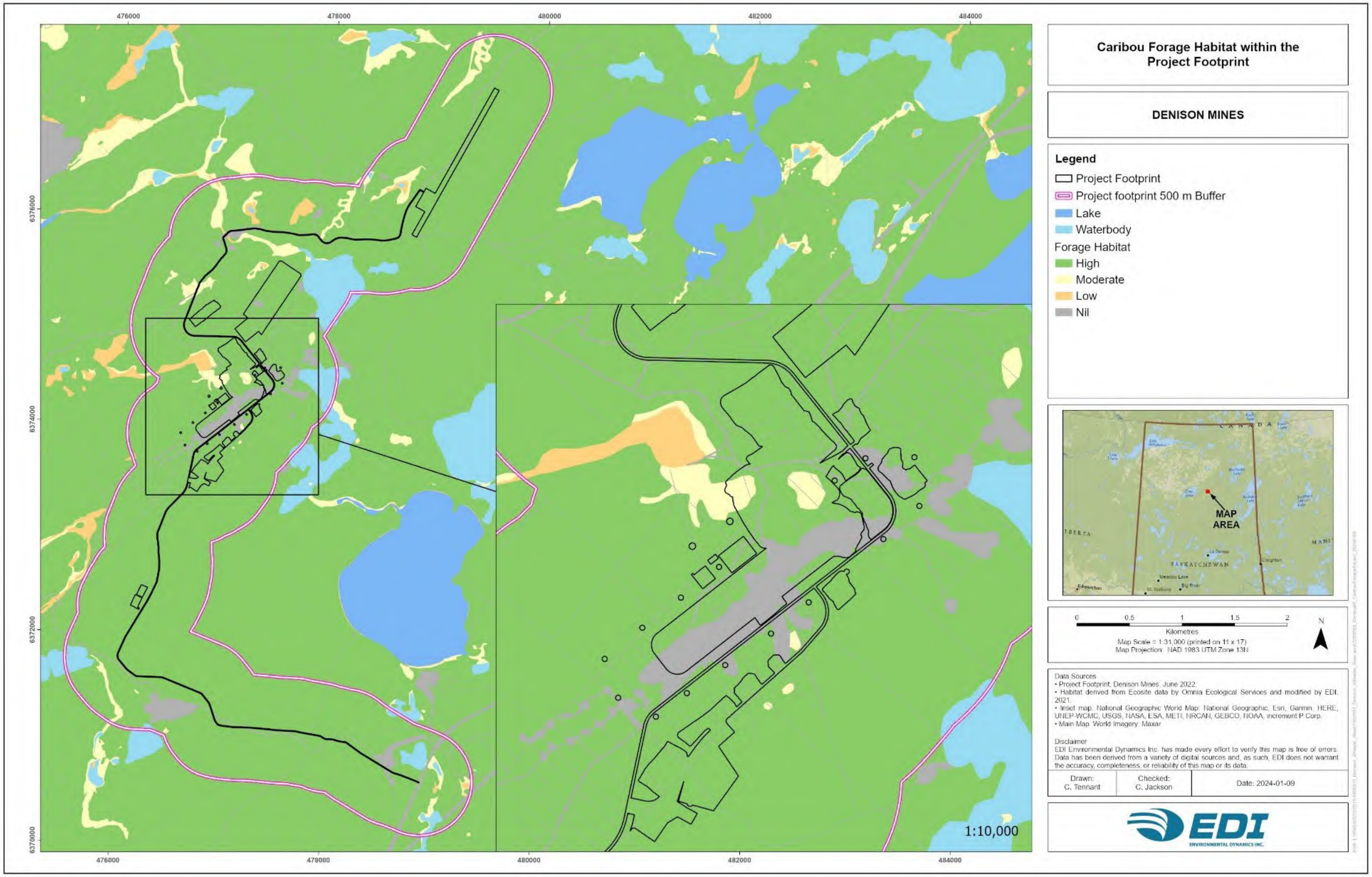

Figure 2-6: Caribou Forage Habitat Potential within the Project Footprint

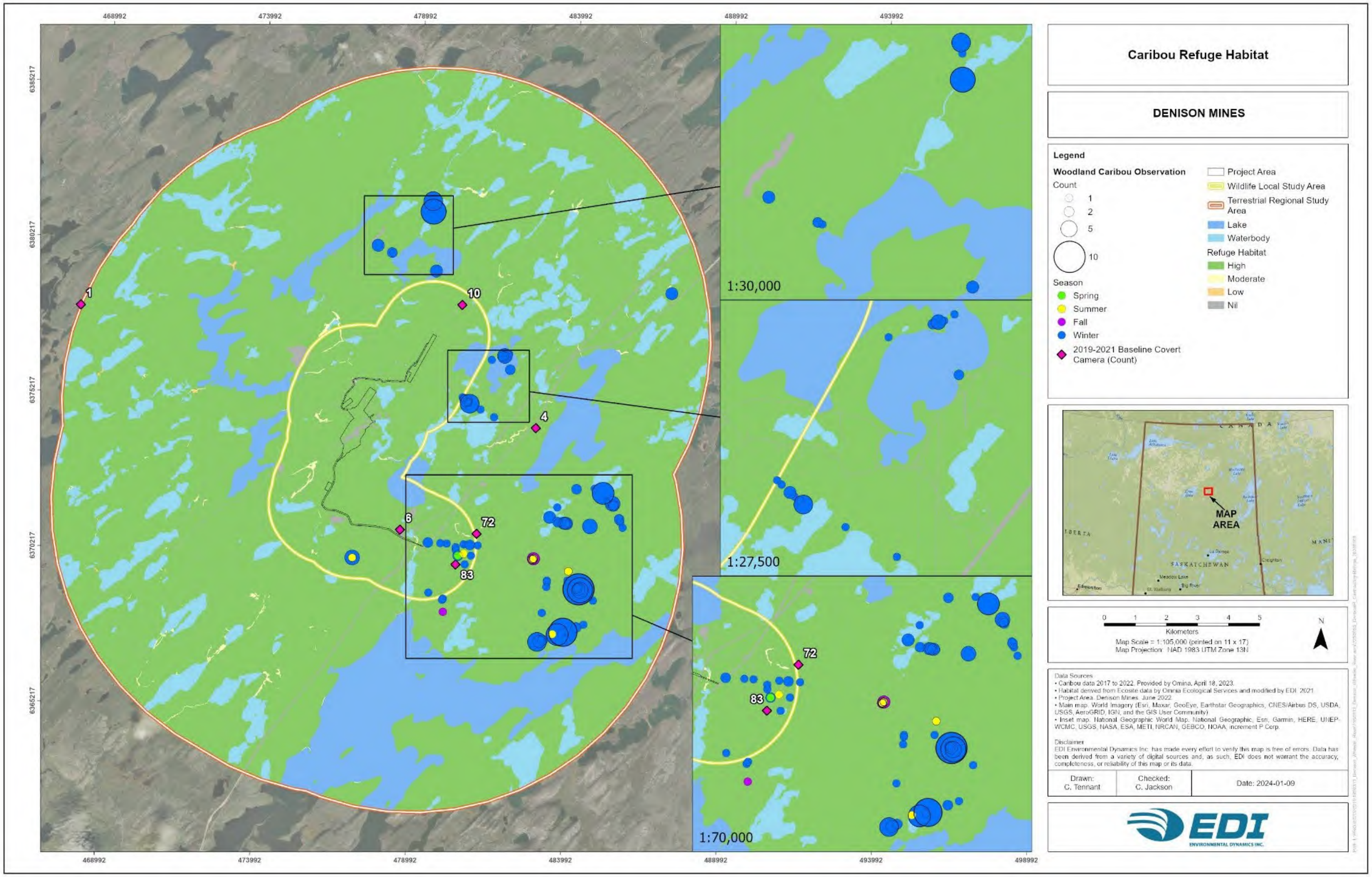

Figure 2-7: Caribou Refuge Habitat Potential within the Wildlife Study Areas

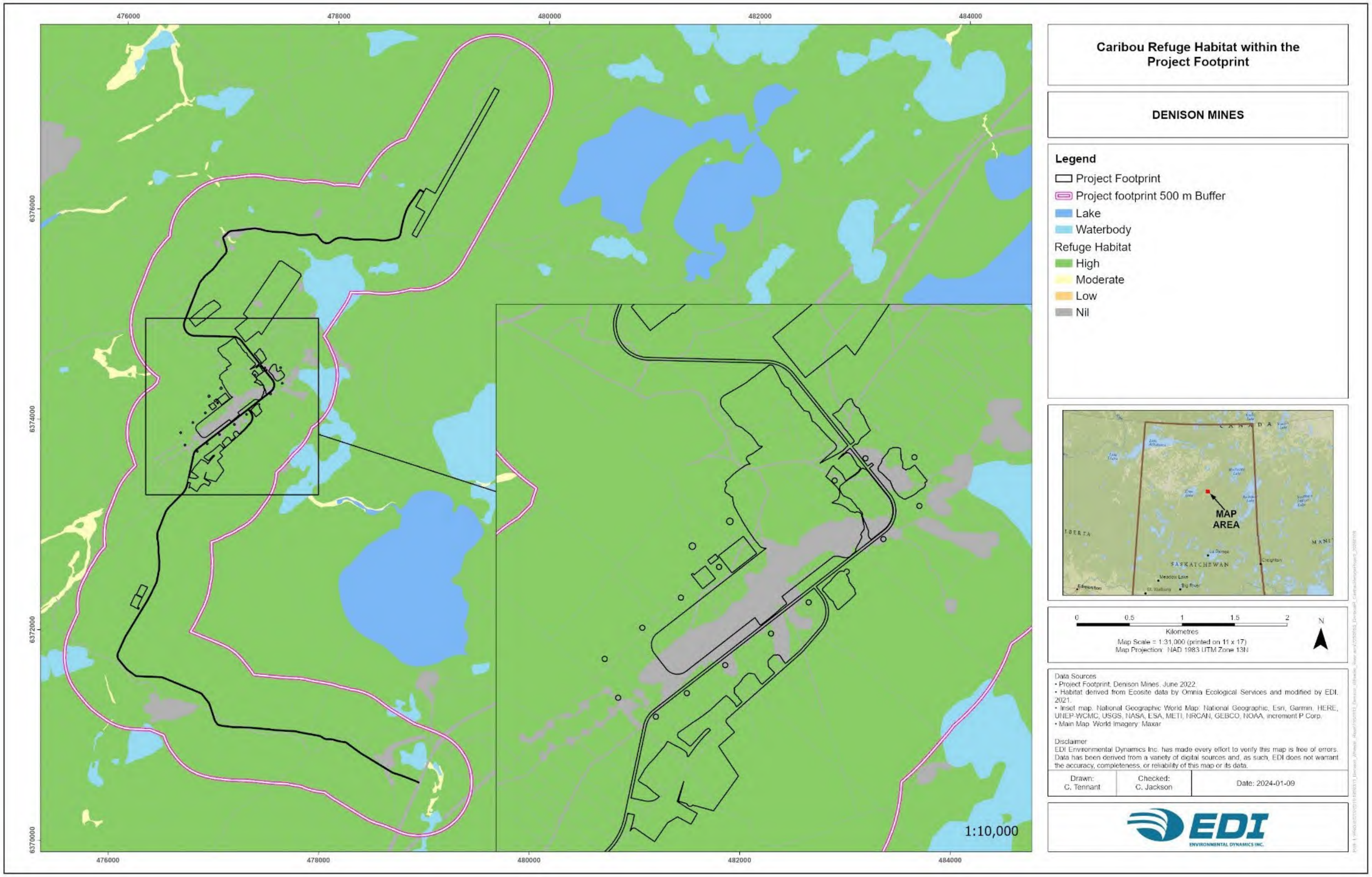

Figure 2-8: Caribou Refuge Habitat Potential within the Project Footprint

2.2 Migratory Birds

The following information is intended to provide additional context to the responses provided in the IR tracking sheet, particularly in regard to the following: IR-159 and IR-162. For IR-160, IR-164, IR-169, and IR-170, the updates were made in Section 9 of the EIS.

Number	IR-159_WRP
Dept.	ECCC
Project effects link	Migratory Birds
Reference to EIS, appendices, or supporting documentation	9.4.3.2.3 Baseline Studies – Migratory Songbirds Appendix 9-B, Section 2.10.2, Results
Context and Rationale	**Context and Rationale:** Information presented in the draft EIS is insufficient to accurately predict Project impacts to breeding birds. The Proponent collected a single year of breeding songbird point counts and aerial waterfowl surveys (including avian species at risk). A single year of surveys in which birds may be unusually scarce or abundant could severely compromise interpretation of post- construction monitoring data. Additionally, data presented in the draft EIS is from 2017 and ECCC advises that more recent data is needed for a comprehensive baseline to verify Project impacts. Data from the Saskatchewan Conservation Data Centre (HABISask), the Saskatchewan Breeding Bird Atlas and the Boreal avian Modelling project contain information on avian densities and avian species at risk that could supplement field data. The national standard for major projects recommends a minimum of two years of field surveys to be provided, so that temporal variability can be considered when comparing post-construction against baseline records and other available data. **Updated Rationale:** ECCC recommends that for major projects, a minimum of two years of field surveys should be provided so that temporal variability can be considered when comparing post-construction against baseline records and other available data. More recent data is needed. due to landscape changes that may have occurred since 2017 as well as cumulative effects that have occurred in that time. Additionally, if there was an unusually high population density of birds in 2017 due to extraneous circumstances, Project effects may be attributed to a non-existent decline in the population when the discrepancy can be due to natural variability. A more recent baseline will account for interannual variation and any regional effects and will allow for a more accurate review of mitigation and follow-up measures. Data from the Saskatchewan Conservation Data Centre (HABISask), the Saskatchewan Breeding Bird Atlas and the Boreal Avian Modelling project contain information on avian densities and avian species at risk that could supplement field data.
Information Requirement	Supplement breeding bird point count data and aerial waterfowl data collected during 2017 with additional pre-construction field data or existing post-2017 data/modelling to provide a comprehensive baseline that can be used to verify Project impacts during construction and operational phases.

Response:

The EA used an accepted, proven habitat-based EA approach to address the variability of population surveys. Further, the EA used all available, recent/relevant survey data collected in appropriately timed and executed methodologies, including TK. However, supplemental surveys would not be expected to provide any information/data that would affect or alter the findings of the habitat-based EA.

The supplemental avian data received from records from the Saskatchewan Breeding Bird Atlas downloaded through the NatureCounts web portal (Saskatchewan Breeding Bird Atlas 2017), which also includes data received as part of the Saskatchewan Boreal Monitoring Strategy program. These data represent bird observations from 24-point counts conducted on June 7 and June 9, 2019. Nine point-counts are located approximately 6.5 km east of the Project footprint, the majority of which are located in the BS3 ecosite type; 15 point-counts are located approximately 7.7 km south of the Project footprint, the majority of which are located in the BS3/BS7 ecosite type. During this survey effort, 24 migratory songbird species were documented. A summary of the total number of individuals observed for each species across all plots are presented below.

Common Name	Scientific Name	Number of Individuals Observed
American Robin	*Turdus migratorius*	8
Bald Eagle	*Haliaeetus leucocephalus*	1
Canada Goose	*Branta canadensis*	50
Canada Jay	*Perisoreus canadensis*	10
Chipping Sparrow	*Spizella passerina*	19
Common Loon	*Gavia immer*	2
Common Tern	*Sterna hirundo*	1
Dark-eyed Junco	*Junco hyemalis*	10
Greater Yellowlegs	*Tringa melanoleuca*	1
Hermit Thrush	*Catharus guttatus*	11
Lincoln's Sparrow	*Melospiza lincolnii*	8
Orange-crowned Warbler	*Leiothlypis celata*	2
Palm Warbler	*Setophaga palmarum*	10
Red-breasted Merganser	*Mergus serrator*	2
Ruby-crowned Kinglet	*Corthylio calendula*	14
Savannah Sparrow	*Passerculus sandwichensis*	1
Solitary Sandpiper	*Tringa solitaria*	0
Song Sparrow	*Melospiza melodia*	2
Spotted Sandpiper	*Actitis macularius*	1

Common Name	Scientific Name	Number of Individuals Observed
White-crowned Sparrow	*Zonotrichia leucophrys*	6
White-throated Sparrow	*Zonotrichia albicollis*	24
White-winged Crossbill	*Loxia leucoptera*	40
Yellow Warbler	*Setophaga petechia*	3
Yellow-rumped Warbler	*Setophaga coronata*	12

Number	IR-162_WRP
Dept.	ECCC
Project effects link	Migratory birds
Reference to EIS, appendices, or supporting documentation	Section 9.4.3.3, Bird Species at Risk
Context and Rationale	**Context and Rationale:** Not all avian species at risk present in the study area were included as Key Indicators in the avian species at risk (SAR) valued component (VC). Barn swallow and horned grebe were recorded in the study area, but not included as VCs. Additionally, bank swallow may inhabit the Project area. Impacts to Species at Risk Act Schedule 1 listed species need to be identified, avoided, lessened and monitored. In Section 9.4.3.3. the Proponent states: "It is acknowledged that the listed Barn Swallow (*Hirundo rustica*) and Horned Grebe (Podiceps auratus) could potentially occur in the Terrestrial RSA. Incidental observations occurred during the baseline studies (Appendix 9-B). To focus the effects assessment on a few key species (described in the following) it was decided to use Olive-sided Flycatcher and Common Nighthawk to represent Barn Swallow as well, and to use Yellow Rail and Rusty Blackbird as a substitute for Horned Grebe. Unlike Horned Grebe, Yellow Rail and Rusty Blackbird are also listed provincially." Barn swallow, bank swallow and horned grebe may have different nesting habitat requirements than the representative species discussed in the draft EIS. An explanation of how differing species are representative of one another is required, or if an explanation cannot be provided, the species should be assessed individually. **Updated Rationale:** The management plans for these three species demonstrate the variability in their habitat selection. The Management Plan for the Yellow Rail (*Coturnicops noveboracensis*) in Canada (Environment Canada, 2013) states "Yellow Rails inhabit shallow wetlands and other wet areas with grass-like vegetation. They breed in wetlands such as damp hay fields or meadows, floodplains, bogs, upper levels of estuaries, salt marshes (Bookhout 1995, Alvo and Robert

	1999, COSEWIC 2009), shallow prairie wetlands, and wet montane meadows (Peabody 1922, Sherrington 1994, Popper and Stern 2000). “ The Management Plan for the Rusty blackbird (*Euphagus carolinus*) in Canada (Environment Canada 2015), states: “Rusty Blackbirds tend to select breeding sites with a combination of freshwater bodies with shallow water and emergent vegetation for foraging that are adjacent to wetlands with conifers or tall shrubs with cover for nesting (Matsuoka et al. 2010a, Matsuoka et al. 2010b, Greenberg et al. 2011).” The Management Plan for the Horned Grebe (*Podiceps auritus*), Western population, in Canada (ECCC, 2022) states: “The Horned Grebe breeds in small (generally 0.5 to 2 ha, but ranging from 0.24 to 18.2 ha), shallow (at least 20 cm deep, but on average 40 cm), and usually fishless, perennial wetlands, but they can also nest on larger lakes with shallow edges and sufficient emergent vegetation. Breeding sites usually contain at least 40% open water with beds of emergent vegetation, such as sedges (Carex spp.), rushes (Juncus spp.) and cattails (Typha spp.) (Faaborg 1976, Kuczynski et al. 2012, Routhier 2012, Stedman 2018).” Due to differing habitat selection and use, ECCC recommends that each selected VC is given an individual assessment with specific mitigation measures. This will allow for a more accurate review of the chosen mitigation measures.
Information Requirement	Explain how nesting habitat requirements of barn swallow is represented by common nighthawk and olive-sided flycatcher as a VC or assess individually each SAR that overlaps with the Project and is likely to be affected. Explain how nesting habitat requirements of horned grebe are represented by yellow rail and rusty blackbird as a VC, or assess individually each SAR that overlaps with the Project and is likely to be affected. Assess individually each SAR that overlaps with the Project and is likely to be affected. See also related IRs: IR-160 and IR-161.

<u>Response</u>:

As per accepted, proven EA methodology, Denison used a habitat-based methodology to determine the Project’s effects on VCs, using an accepted Key Indicator methodology, and not every species, to focus and inform the EA.

Nesting habitat requirements of the horned grebe are similar at a landscape level to those represented by yellow rail and rusty blackbird in that they are typically found associated with northern waterbodies and watercourses with various forms of emergent vegetation. At a site-specific scale, there are subtle differences in nesting habitat requirements, as summarized previously by ECCC in the Context and Rationale response.

Given the nesting habitat requirements of these species, the available habitat types within the Denison study areas (e.g., Project Area, Wildlife Local Study Area, and the Terrestrial Regional Study Area) for use by these species include the following ecosite types: Labrador tea shrubby bog (BS18), graminoid bog (BS 19), graminoid bog/graminoid fen (BS19/BS24), open bog (BS 20), leatherleaf shrubby poor fen (BS22), willow shrubby rich fen (BS23), graminoid fen (BS24), open fen (BS25), and waterbodies and lakes. The habitat-based methodology of the environmental assessment adequately and appropriately addresses effects on these habitat types and the associated migratory bird species that could potentially use these habitat types. Further assessment of each species would not be expected to affect or alter the findings of the habitat-based environmental assessment.

The characterization of the alteration and/or habitat loss residual effect considers the Project effects on available habitat used by these three migratory breeding birds within the Wildlife LSA and Terrestrial RSA. As outlined in Table 9.3-18, 0.05% of the Project Area, 11.5% of the Wildlife LSA, and 24.2% of the Terrestrial RSA provide habitat types that are potentially available to these three migratory breeding bird species.

Direct habitat loss is calculated as the area of available habitat lost due to site clearing within the Project Area. Direct habitat loss has been mitigated by reducing the size of the Project Area to the extent practicable during Project design; however, available habitat is still predicted to be cleared during Construction. In the Project Area, 0.09 ha or 100% of available habitat is assumed to be removed and will not be available to these species for the duration of the Project (Table 9.3-19). This considers that the Project Area has previously been disturbed (i.e., almost 15% of the Project Area is disturbed by anthropogenic activities) and includes only 0.02 ha (0.01%) of landscape covered by waterbodies. This relates to a removal of 0.02% of available habitat within the Wildlife LSA and 0.001% in the Terrestrial RSA.

An additional 93.9 ha (17.0%) of available habitat in the Wildlife LSA may experience habitat alteration resulting from indirect Project effects, such as sensory disturbance (Table 9.3-19). This area of indirect effect represents 1.0% of available habitat in the Terrestrial RSA that may experience habitat alteration.

2.3 Species At Risk – *Myotis* Species

The following information is intended to provide additional context to the responses provided in the IR responses to for IR-174 associated with both the Round 2 and Round 3 responses.

Acoustic bat surveys were completed between July 22 and 23, 2019 with 61 survey points sampled across five ecosite types (refer to Appendix 9-B). The location of the survey points, species detected, and frequency of detections are included in Figure 2-9.

As noted in Appendix 9-D, habitat for the little brown myotis is composed of (1) overwintering hibernacula that are sufficiently cool and humid and (2) summering areas that provide foraging areas and suitable locations for roosting and maternity colonies (COSEWIC 2013). Hibernacula and maternity sites are reported as being the main limiting habitat features for this species (COSEWIC 2013), and this, as described below, is consistent with conditions at the Project site and surrounding area.

Hibernacula occur in parts of caves, mines (openings to surface for ramps and raises for example), and buildings that have stable and specific temperature (-4 to 13°C) and humidity (>80%) conditions (COSEWIC 2013). Based on existing environment information presented in the EIS including the terrain and vegetation and ecosystem existing environment sections, there are no hibernacula anticipated in the Project Area (i.e., caves, mines, buildings with stable and specific temperatures per COSEWIC 2013). Terrain is low relief due to flat-lying sandstone and almost continuous cover of sandy glacial deposits (i.e., surface is predominately sand textured and there are no rocky outcrops or bedrock at surface for cave habitats); there are no man-made structures (e.g., mine openings or buildings) in the Project Area. As noted in the EIS, the terrain and vegetation communities are fairly uniform throughout the study areas and the habitat considerations in the Project Area are considered representative of the landscape in the wildlife LSA and RSA.

Maternity sites can occur in large-diameter trees, rock crevices, buildings, and bat houses that offer warm and relatively stable microclimate conditions that allow females to avoid going into torpor so they can focus on caring for their young (COSEWIC 2013a, Slough and Jung 2020). As highlighted above, since there are no rock crevices, buildings, or bat houses in the Project Area, a consideration for maternal roost potential was focused on the areas where larger diameter trees may be present.

Existing ecosite information was reviewed and ecosites with higher potential for maternity roosts (i.e., larger diameter trees) were selected. The ecosites with the potential for larger diameter trees are shown in Figure 2-10 below, and include ecosites RF1 (regenerating forest >5m tall; per Appendix 9-B), BS3 jack pine/blueberry/lichen, BS4 jack pine – black spruce/feathermoss, BS7 black spruce/blueberry/lichen, BS9 black spruce – jack pine/feathermoss, BS14 white birch/lingonberry – labrador tea, BS16 black spruce/ balsam poplar/river alder swamp, BS17 black spruce treed bog, and BS21 tamarack treed fen. While these ecosites were selected for the *potential* to have larger diameter trees, it is important to note that the majority of these ecosites have trees with diameter at breast height <10 cm. Refer to Appendix 9-B for representative photos of the selected ecosites.

Based on this conservative mapping exercise, the Project Area contains small areas of suitable potential maternal roost habitat. The total Project Area is around 170 ha and potential bat maternal roost ecosites represent less than 49 ha, when as noted above it is assumed that the ecosites identified above provide trees suitable for maternity roosts across their entirety. As noted in the EIS, the terrain and vegetation communities are fairly uniform throughout the study areas and the habitat considerations in the Project Area are considered representative of the landscape in the wildlife LSA and RSA.

Denison Mines

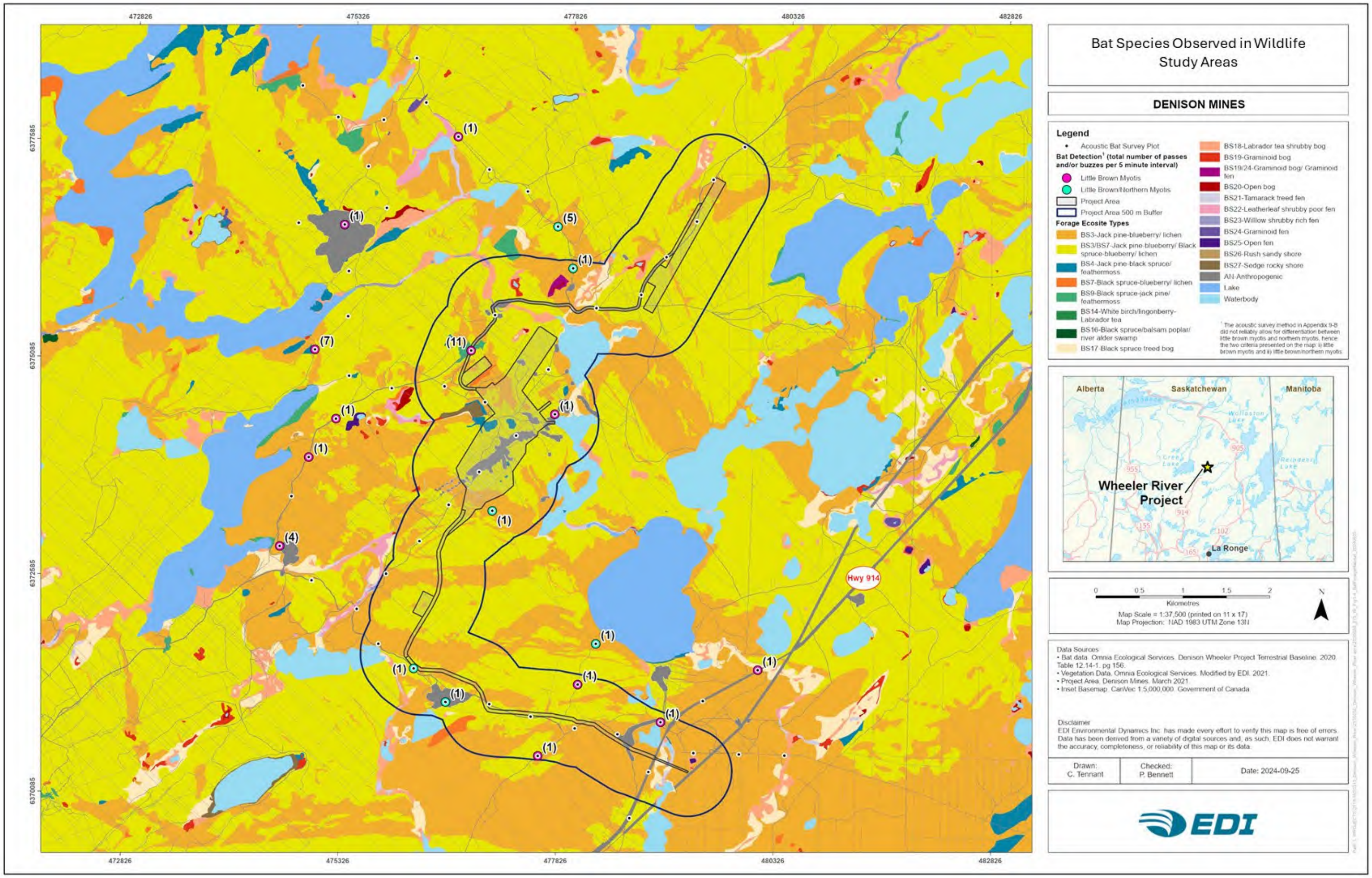

Figure 2-9: Bat Species Observed within the Wildlife Study Areas

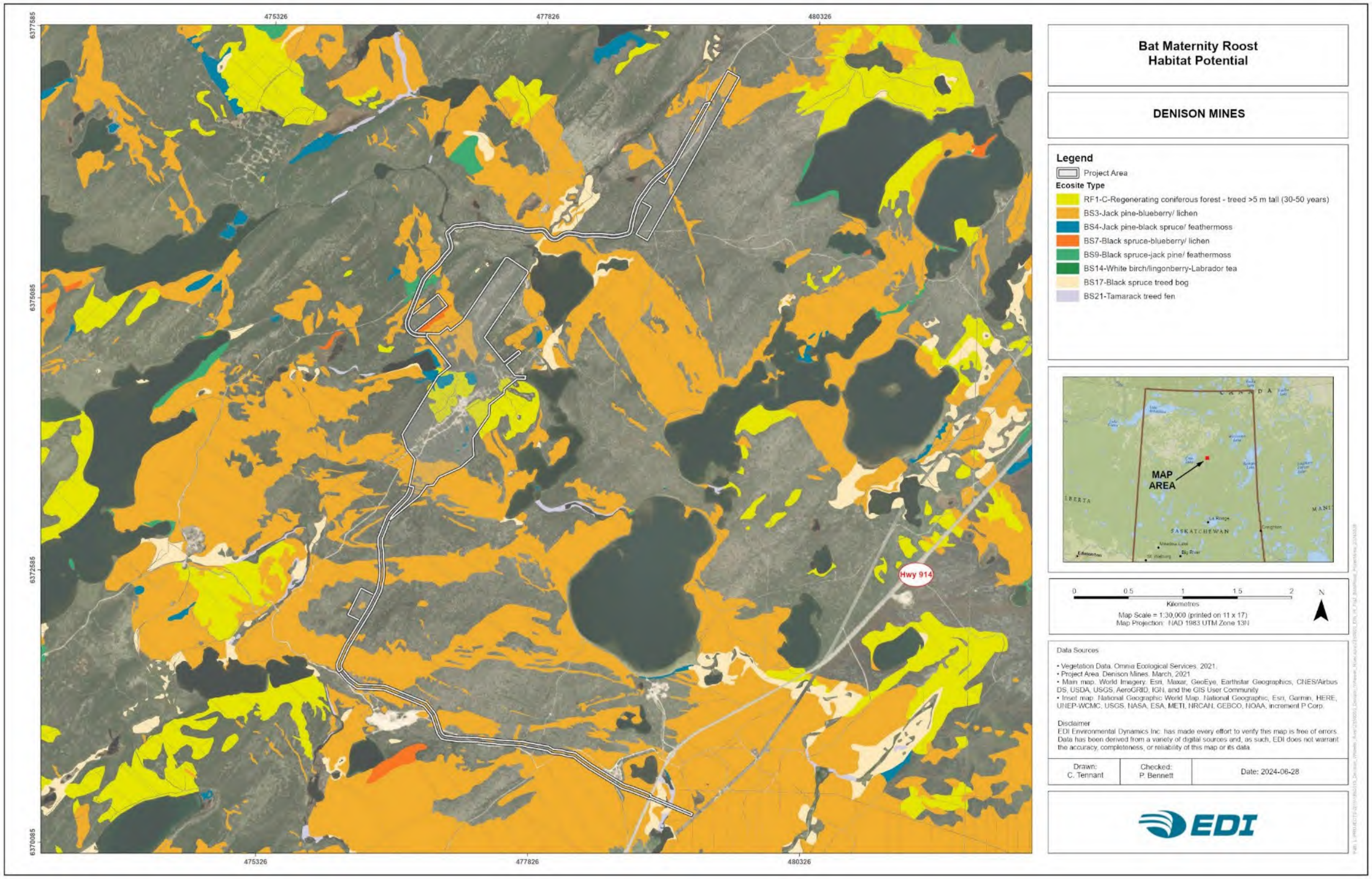

Figure 2-10: Bat Maternity Roost Habitat Potential

3 References

COSEWIC. 2013. COSEWIC assessment and status report on the Little Brown Myotis *Myotis lucifugus*, Northern Myotis *Myotis septentrionalis*, and Tri-colored Bat *Perimyotis subflavus* in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa. xxiv + 93 pp.

Environment and Climate Change Canada (ECCC). 2020*. Amended Recovery Strategy for the Woodland Caribou (Rangifer tarandus caribou), Boreal Population, in Canada. Species at Risk Act* Recovery Strategy Series. Environment and Climate Change Canada, Ottawa. xiii + 143pp.

Saskatchewan Breeding Bird Atlas. 2017. Data accessed from NatureCounts, a node of the Avian Knowledge Network, Birds Canada. (http://www.naturecounts.ca/). Accessed January 15, 2024.

Saskatchewan Ministry of Environment (SK MOE). 2019c. *Range Plan for Woodland Caribou in Saskatchewan – Boreal Plain Ecozone - SK2 Central Caribou Administration Unit*. July 2019. 90 pp.

Saskatchewan Ministry of Environment (SK MOE). 2023. *SK1 habitat potential raster data for woodland caribou in Saskatchewan*. Email from Lisa Stuart, GIS analyst, Saskatchewan Ministry of Environment. December 8, 2023 email.

Slough, B.G. and Jung, T.S. 2020. Little Brown Bats Utilize Multiple Maternity Roosts Within Foraging Areas: Implications for Identifying Summer Habitat. Journal of Fish and Wildlife Management 11(1):311–320.

APPENDIX 10-A: ENVIRONMENTAL RISK ASSESSMENT FOR WHEELER RIVER

TECHNICAL SUPPORT DOCUMENT

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Ref. 19-2638
20 December 2024

APPENDIX 10-A: ENVIRONMENTAL RISK ASSESSMENT FOR WHEELER RIVER

TECHNICAL SUPPORT DOCUMENT

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EXECUTIVE SUMMARY

The Wheeler River Project (the Project) proposes the development of the high-grade Phoenix uranium deposit as an in-situ recovery (ISR) mining operation with on-site processing. The Project is located approximately 35 km north-northeast of Cameco's Key Lake Operation and 35 km southwest of Cameco's McArthur River Operation in the eastern portion of the Athabasca Basin region in northern Saskatchewan.

The proposed Project is subject to both federal and provincial Environmental Assessment (EA) processes, and the Environmental Impact Statement (EIS) was prepared to support the EA. This environmental risk assessment (ERA) encompasses a human health risk assessment (HHRA) and an ecological risk assessment (EcoRA), which have been prepared to be compliant with Canadian Standards Association Group (CSA) N288.6-22 *Environmental Risk Assessments at Nuclear Facilities and Uranium Mines and Mills* (CSA, 2022). It also meets the requirements for an ERA outlined in Section 4.1 of Regulatory Document-2.9.1, *Environmental Principles, Assessments and Protection Measures* (CNSC, 2020).

The ERA focused on constituents of potential concern (COPCs) that exceeded screening values in air and water based on predicted atmospheric releases and aqueous releases (e.g., treated effluent and groundwater solute releases) from the Project. Based on the screening of atmospheric releases, no COPCs in air were advanced for further quantitative assessment in the ERA. Based on the screening of aqueous releases, arsenic, cadmium, chromium, cobalt, copper, molybdenum, selenium, uranium, vanadium, zinc, sulphate, and chloride were advanced for further quantitative assessment in the ERA. Radionuclides, including the uranium-238 series and radon, were included as COPCs because these constituents are of public interest.

An environmental transport and pathways model (IMPACT) was used to evaluate the effects of COPCs on the local environment including human and ecological receptors.

The ERA estimated dose and risk to human and ecological receptors during all Project phases and in the future centuries. The future centuries reflect the time period over which the highest constituent concentrations in groundwater are predicted to migrate towards and interact with surface water post-restoration (i.e. beyond the Project timeline of 0-38 years).

The selection of human and ecological receptors was informed by Indigenous and Local Knowledge.

The HHRA focused on members of the public potentially exposed to low levels of airborne or waterborne constituents. The selected human health receptor groups included a camp worker, seasonal resident, recreational fisher/hunter, and fisher/trapper. In the future centuries a hypothetical permanent resident was assessed at the former mine site instead of a camp worker.

The ecological receptors selected for the EcoRA were a subset of valued components identified for the EA so that the results from the ERA could be used in the effects assessments for fish, vegetation, wildlife, human health, Indigenous land and resource use, and other land and resource uses.

Non-radiological Human Health Risk Assessment

The potential effects on human receptors were evaluated by comparing the non-radiological exposures of receptors to recognized benchmarks, a dose-based toxicity reference value in the same units, for each COPC.

For assessment of non-carcinogens, risk was estimated based on Project total HQs (includes the Project risk in addition to the baseline risk) and Project incremental HQs (includes the Project risk only with baseline component removed). Project incremental HQs were compared to a benchmark HQ value of 0.2 because total background exposures (e.g., store-bought foods) were not included in the incremental HQ. This approach is consistent with Health Canada's guidance on human health preliminary quantitative risk assessment (Health Canada, 2021a).

The Project incremental HQ was predicted to remain below 0.2 for human receptors for all non-carcinogens and all pathways during all phases of the Project, with the exception of selenium for fisher/trapper at Russell Lake from the fish ingestion pathway. The traditional foods diet for the fisher/trapper is conservative as it assumes a high annual fish consumption rate of 183 kg/yr (approximately 1 to 2 servings per day) and assumes that all fish consumed in the diet is obtained from Russell Lake, whereas it is likely that someone would fish from many different lakes including those outside of the RSA. The diet of the fisher/trapper is representative of one person, who consumes a unique composition and quantity of traditional foods. Most people fishing, hunting, and trapping in the LSA and RSA would consume traditional foods more consistent with the average traditional foods consumer diet which was developed from the ERFN country foods study (CanNorth, 2017). However, it is recognized that the ERFN considers the fisher/trapper's use of the area as representative of current and future land users and expects that their relationship to the Project Area will be continued and strengthened through generations of future use.

During the future centuries there are no predicted exceedances of the HQ benchmark (HQ<0.2) for any human receptors, including the permanent resident, for any non-carcinogens.

For the assessment of carcinogens (arsenic), the incremental risk of developing cancer over a lifetime (ILCR) was estimated and compared against the cancer risk level of 1 in 100,000 recommended by Health Canada (Health Canada, 2021a). The ILCR was predicted to remain below the negligible cancer risk level of 1 in 100,000 for the camp worker, recreational fisher/hunter, and seasonal resident during the Project phases. The ILCR was predicted to be essentially equal to the negligible cancer risk level of 1 in 100,000 for the adult fisher/trapper at Russell Lake. These findings for the fisher/trapper are based on the conservative assumption of high consumption of traditional foods including fish and caribou in the LSA and RSA. As indicated above, the diet of the fisher/trapper is representative of one person, who consumes a unique composition and quantity of traditional foods. During the future centuries, the cancer risk was not predicted to exceed the negligible cancer risk level of 1 in 100,000 for any human receptor, including the permanent resident.

Radiological Human Health Risk Assessment

The incremental radiation dose to all human receptors during all Project phases is predicted to be below the regulatory public dose limit of 1 mSv/yr and the dose constraint of 0.3 mSv/yr during all Project phases and in the future centuries. The maximum incremental radiological dose is predicted to be 0.06 mSv/yr to the fisher/trapper at Russell Lake. The total incremental dose to the camp worker from all radionuclides in the U-238 decay chain including radon would be 0.16 mSv/year, which is below the dose limit for a non-NEW of 1 mSv/yr.

Overall, since the radiation dose estimates were predicted to be below the public dose limit, no discernable health effects would be anticipated due to exposure of human receptors to radioactive releases from the Project.

Non-radiological Ecological Risk Assessment

The potential for ecological effects was assessed by comparing exposure levels to toxicological benchmarks and characterized quantitatively in terms of HQs. An HQ greater than 1 indicates adverse effects may be possible for a given ecological receptor and further investigation would be warranted. Species at risk were either assessed directly or were represented by other more common species that have similar diets and exposure pathways.

No significant adverse effect on either aquatic or terrestrial populations or communities, as a result of releases from the Project, are predicted during the Project phases or during the future centuries. Estimated total HQs for the COPCs arsenic, cadmium, chromium, cobalt, molybdenum, selenium, uranium, vanadium, zinc, chloride and sulphate, for all ecological receptors are predicted to remain below the HQ benchmark of 1. Under baseline conditions as well as the future centuries, copper HQs for all aquatic organisms are less than 1 with the exception of predator fish in Whitefish Lake, and benthic invertebrates at all locations where HQs are above 1.

Using predicted operational site conditions for hardness and pH, copper HQs for all aquatic organisms are less than 1 at all downstream locations, indicating no adverse effects to aquatic organisms from facility related copper.

Species at risk were assessed using surrogate species. Since there are no total HQs above 1 for birds and mammals, individual species at risk would also be considered protected.

Radiological Ecological Risk Assessment

Radiation dose benchmarks of 9.6 milligrays per day (mGy/d) and 2.4 mGy/d (UNSCEAR, 2008) were selected for the assessment of effects on aquatic biota and terrestrial biota, respectively, as recommended in CSA N288.6-22.

There were no predicted exceedances of the 9.6 mGy/d radiation dose benchmark for aquatic biota, or the 2.4 mGy/d radiation dose benchmark for terrestrial and riparian biota during any Project phase or during the future centuries.

Since there were no predicted exceedances of the respective dose benchmarks for any of the aquatic or terrestrial receptors, individual species at risk would also be considered protected.

Monitoring and Follow-up

The ERA was developed based on the best available information for the Project, including baseline monitoring data, assumptions on source-terms, and Traditional Foods diet (intake rates and food types).

Monitoring would focus on collecting data to verify ERA model predictions as well as providing data to improve model predictions as the Project begins. Recommended monitoring would support Denison's environmental protection framework with the goal of reducing uncertainty over time through an iterative process.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

AAAQO	Alberta Ambient Air Quality Objectives
AAQC	ambient air quality criteria
ATSDR	Agency for Toxic Substances and Disease Registry
BAF	bioaccumulation factor
BC MECCS	British Columbia Ministry of Environment and Climate Change Strategy
BC MOE	British Columbia Ministry of Environment
BLM	biotic ligand model
CAAQS	Canadian Ambient Air Quality Standards
CAC	criteria air contaminant
Cal OEHHA	California Office of Environmental Health Hazard Assessment
CCC	criterion continuous concentration
CCME	Canadian Council of Ministers of the Environment
CF	conversion factor
CNSC	Canadian Nuclear Safety Commission
COPC	constituent of potential concern
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CSA	Canadian Standards Association
CSM	conceptual site model
DCF	dose coefficient
DWWTP	domestic wastewater treatment plant
EA	Environmental Assessment
EC	effect concentration
EcoRA	ecological risk assessment
Eco-SSL	ecological soil screening level
ECOTOX	Ecotoxicology database
EIS	Environmental Impact Statement
ERA	environmental risk assessment
ERFN	English River First Nation
ESL	effects screening level
ESOD	erythrocyte superoxide dismutase
FEQG	federal environmental quality guidelines
FNFNES	First Nations Food, Nutrition and Environment Study
HC	Health Canada
HHRA	human health risk assessment
HQ	hazard quotient
IAEA	International Atomic Energy Agency
IC	inhibition concentration
ICRP	International Commission on Radiological Protection
ILCR	incremental lifetime cancer risk
IMPACT	Integrated Model for the Probabilistic Assessment of Contaminant Transport
ISQG	interim sediment quality guideline

ISR	in-situ recovery
IWWTP	industrial wastewater treatment plant
LC	lethal concentration
LEL	lowest effect level
LOAEL	lowest observed adverse effect level
LOEC	lowest observed effect concentration
LSA	local study area
MECP	Ministry of the Environment, Conservation and Parks
MOE	Ministry of Environment
MATC	maximum acceptable toxicant concentration
NCRP	National Council on Radiation Protection and Measurements
NOAEL	No-observed adverse effect level
OAAQC	Ontario Ambient Air Quality Criteria
OF	occupancy factor
ORNL	Oak Ridge National Laboratory
PEL	probable effect level
PESC	Pacific Environmental Science Centre
PM	particulate matter
PM_{10}	particulate matter with a diameter of 10 microns or less
$PM_{2.5}$	particulate matter with a diameter of 2.5 microns or less
RAF	relative absorption factors
Rec F/H	Recreational Fisher/Hunter
REF	reference
RSA	regional study area
SAAQS	Saskatchewan Ambient Air Quality Standards
SAR	Species at Risk
SARA	Species at Risk Act
SEL	severe effect level
SEQG	Saskatchewan environmental quality guidelines
SKCDC	Saskatchewan Conservation Data Centre
TDI	tolerable daily intake
TF	transfer factor
TRV	toxicity reference value
TSP	total suspended particulates
UL	upper intake level
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
USEPA	United States Environmental Protection Agency
VC	valued component
WHO	World Health Organization
WQO	water quality objective
YNLR	Ya'thi Néné Lands and Resources

Units of Measure

%	percent
µg/L	Micrograms per litre
µg/m^3	micrograms per cubic metre
µg/kg/d	micrograms per kilogram per day
Bq/g	becquerels per gram
Bq/kg	becquerels per kilogram
Bq/L	becquerels per litre
Bq/m^3	becquerels per cubic metre
dw	dry weight
fw	fresh weight
g/d	grams per day
g/m^2/yr	grams per square metre per year
h/yr	hours per year
kg/yr	kilograms per year
km	kilometre
km^2	square kilometre
L/d	Litre per day
m	metre
min	minute
m^3/h	cubic metre per hour
m/min	metres per minute
mg $CaCO_3$/L	milligrams of calcium carbonate per litre
mg/cm^2/30 days	milligrams per square centimetre per 30 days
mg/d	milligrams per day
mg/kg	milligrams per kilogram
mg/kg/d	milligrams per kilogram per day
mg/L	milligrams per litre
mGy/d	milligrays per day
mGy/h	milligrays per hour
mSv/yr	millisieverts per year

1.0 Introduction

1.1 Background and Regulatory Context

The Wheeler River Project (the Project) proposes the development of the high-grade Phoenix uranium deposit as an in-situ recovery (ISR) mining operation with on-site processing. Denison Mines Corp. (Denison) is the operator of the Wheeler River Joint Venture and holds a 90% interest (directly or through its subsidiaries). JCU (Canada) Exploration Company Ltd. owns the remaining 10% of the joint venture. The Project is located approximately 35 km north-northeast of Cameco's Key Lake Operation and 35 km southwest of Cameco's McArthur River Operation in the eastern portion of the Athabasca Basin region in northern Saskatchewan.

The proposed Project is subject to both federal and provincial Environmental Assessment (EA) processes, and the Environmental Impact Statement (EIS) was prepared to support the EA. This environmental risk assessment (ERA) encompasses a human health risk assessment (HHRA) and an ecological risk assessment (EcoRA), which have been prepared to be compliant with Canadian Standards Association Group (CSA) N288.6-22 *Environmental Risk Assessments at Nuclear Facilities and Uranium Mines and Mills* (CSA, 2022). It also meets the requirements for an ERA outlined in Section 4.1 of Regulatory Document-2.9.1, *Environmental Principles, Assessments and Protection Measures* (CNSC, 2020). The ERA has been developed with current science and current regulatory attitudes in mind.

The ERA is used to inform other EA disciplines and to support the conclusions made in the EIS. The regulatory and guidance documents applicable to the EIS are discussed in the EIS.

1.2 Objectives

The objectives of this ERA are to:

- Predict and assess the risk to representative human and ecological receptors resulting from exposure to radiological and non-radiological substances expected to be released throughout the Project Phases;
- Inform decision-making in the EIS; and
- Inform prioritization of monitoring and mitigation measures.

1.3 Scope

The scope of the ERA encompassed both human and ecological health risks, and radiological and non-radiological constituents of potential concern (COPCs).

The ERA used the expected sources of atmospheric and liquid releases to predict the transport of these constituents through the environment, exposure and dose to the public, and exposure and effects on representative ecological receptors.

1.3.1 Spatial Boundaries

The spatial boundaries of the ERA are generally consistent with the boundaries defined for the EIS for the aquatic and terrestrial environment. The study areas include the Project area, the local study area (LSA), and the regional study area (RSA). The spatial boundaries include the Icelander River drainage and major waterbodies along its course including Kratchkowsky Lake, Whitefish Lake, McGowan Lake, and parts of Russell Lake. The spatial boundaries for the ERA are shown on Figure 1-1.

The study areas for the ERA are defined as follows:

- **Project Area:** the area within which the Project and all components/activities are located (i.e., the Project footprint; the area of maximum physical disturbance).
- **Local Study Area (LSA):** the area that surrounds the Project Area where both direct and indirect effects resulting from Project activities can be reasonably measured. The LSA is established to assess the potential, largely direct effects of the Project and represents the extent to which there is a reasonable potential for the Project or Project-related activities to interact with and potentially adversely effect the valued components (VCs).
    - The LSA for the ERA represents the area where direct Project-related changes in air quality, sediment and water quality, and soil quality would likely occur. The LSA includes parts of the Icelander River drainage to its confluence with Russell Lake in the Wheeler River.
- **Regional Study Area (RSA):** the area that surrounds and includes the LSA, established to assess the potential, largely indirect effects of the Project in a regional context. The RSA is large enough to capture the extent of potential effects (i.e., zone of influence) on a VC and defines the area within which cumulative effects may occur (i.e., cumulative effects assessment boundary).
    - The RSA for the ERA includes parts of Russell Lake and the Wheeler River downstream of the Project.

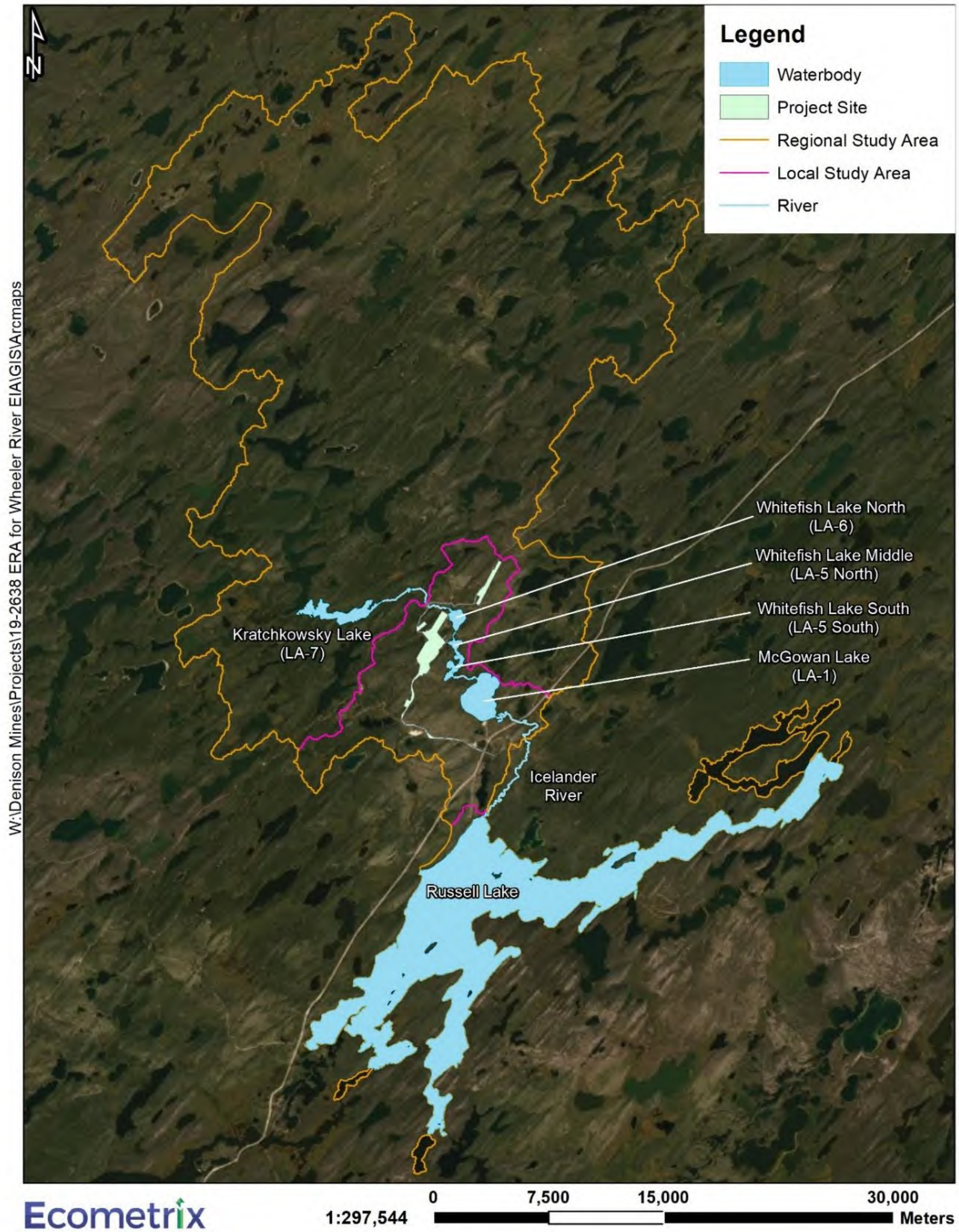


Figure 1-1: Spatial Boundaries of the ERA

1.3.2 Temporal Boundaries

Consistent with the Wheeler River Project EIS, the temporal boundaries of the assessment include the following Project phases: construction (which includes site preparation), operation, decommissioning, and post-decommissioning (Table 1-1). After post-decommissioning, the objective is to transfer the property to the province through the institutional control program or to direct the release of the land back to the Crown.

The temporal boundaries also include the "future centuries" period to assess the potential effects post-restoration (i.e. beyond the Project timeline of 0-38 years) and to reflect the time period over which the highest constituent concentrations in groundwater are predicted to migrate towards and interact with surface water.

This period represents the time where the highest constituent concentrations in groundwater are predicted to interact with surface water based on groundwater modelling. In this context, the future centuries scenario is considered with respect to the interaction of groundwater migration from the Project site and its potential influence on surface water in local water bodies. The future centuries projection encompasses the long-term period during which slow migration of groundwater from the Phoenix Ore Zone area to the surface water environment is anticipated, and it constitutes a bounding scenario of maximum concentrations of constituents of potential concern.

Table 1-1: Project Phases of the Wheeler River Environmental Risk Assessment

Phase and Year	Description of Activities	
Construction Year 1 to 3	• Development of access roads and air strip • Site preparation and earthworks; clearing, leveling and grading of the project area • Power generation – generators • Installation of main substation and distribution of power around site • Wellfield and freeze hole drilling; ground freezing • Batch plant operation (concrete); crusher at borrow area • Development of surface infrastructure (camp, operations centre, plants, ponds, pads and support facilities)	• Waste management (composting, domestic and industrial landfill operation, recycling) • Water management (including treatment and site run-off) • Groundwater supply • Surface water supply and release • Fuel management (e.g., propane for comfort heating; vehicle and aircraft fuel) • On-site and off-site operation of vehicles and transport of materials • Air transportation for workers • Regulatory site inspections • Engagement - site visit from Interested Parties
Operation Year 3 to 18	• Operation of the ISR wellfield • Wellfield and freeze wall drilling • Operation and expansion of freeze wall	• Storage and disposal of drill waste rock, process precipitates and industrial wastewater treatment plant precipitates

Phase and Year	Description of Activities	
	• Batch plant operation (grout and cement); crusher at borrow area • Expansion of pond and pads • Operation of the processing plant and production of uranium concentrate • Water withdrawal from groundwater or surface water body • Management of surface water (including seepage and site run-off) • Water treatment, both domestic and industrial • Water release to surface water body • Waste management (composting, domestic and industrial landfill operation, recycling) • Hazardous waste management (temporary storage, handling, and off-site transportation)	• On-site and off-site operation of vehicles and transport of materials • Power supply – primarily power from the grid, also generators and back-up generators • Package and transport of nuclear substances • Fuel management (e.g., propane for comfort heating; vehicle and aircraft fuel) • Air transportation for workers • Progressive decommissioning and reclamation • Regulatory site inspections • Engagement - site visit from Interested Parties
Decommissioning Year 18 to 23	• Site water management, treatment and release • Mining horizon remediation and thawing of freeze wall • Process water treatment and release • Closure of ISR and freeze wells and related infrastructure • Decontamination of surface facilities and injection, recovery and monitoring wells • Asset removal (including site power transmission lines and electrical infrastructure) • Demolition and disposal of non-salvageable surface infrastructure and materials • Remediation of contaminated areas (wellfield, pads, ponds, domestic wastewater treatment location, and process plant area)	• Power generation – generators • Waste management (composting and landfill operation) • Decommissioning of landfills; hazardous materials management (temporary storage and off-site disposal) • On-site and off-site operation of vehicles and transport of materials • Reclamation of disturbed areas • Regulatory site inspections • Engagement - site visit from Interested Parties
Post-Decommissioning Year 23 to 38	• Environmental monitoring • Regulatory site inspections	• Engagement - site visit from Interested Parties

2.0 Site Description

2.1 Project Description

The mining method proposed for the Project is in-situ recovery, and the process is shown on Figure 2-1.

A mining solution will be used to leach the uranium ore, similar to that used at other Athabasca Basin uranium mills: an acidic or low pH solution. The mining solution will be pumped underground to the uranium deposit via an injection well and recovered as uranium rich mining solution (i.e., mining solution now containing uranium) through a series of recovery wells. Once uranium rich mining solution is recovered to surface, it will be pumped from the pumphouses into the processing plant where uranium will be removed from the uranium rich solution. The mining solution will be refortified with reagents as required and pumped back into the mining horizon via an injection well. In this way, it is expected that the mining solution will be reused over and over again throughout the mining process. A small volume of make-up water will be added to the mining solution to replace moisture removed during the yellowcake precipitation and drying processes. This make-up water will be preferentially sourced from site runoff where possible; however, to be conservative, the assessment has included options for obtaining make-up water from either a shallow groundwater well or a nearby lake.

At the Project, the very low permeability basement rock below the uranium deposit serves as a natural aquitard; however, the sandstone hosting the uranium deposit is permeable and groundwater can flow horizontally through the deposit. To achieve containment at the Project, the uranium deposit will be surrounded by an engineered freeze wall that extends from the basement rock to surface, isolating the mining area from regional groundwater movement.

Processing or milling of the uranium rich solution and final processing to yellowcake will take place in the processing plant. Additionally, in the processing plant, the mining solution will be refortified for continued use in the ISR wellfield. An overview of the processing plant is shown in Figure 2-2. The anticipated production capacity of the Project is up to 12 Mlbs U_3O_8/year with a mine life of up to 15 years.

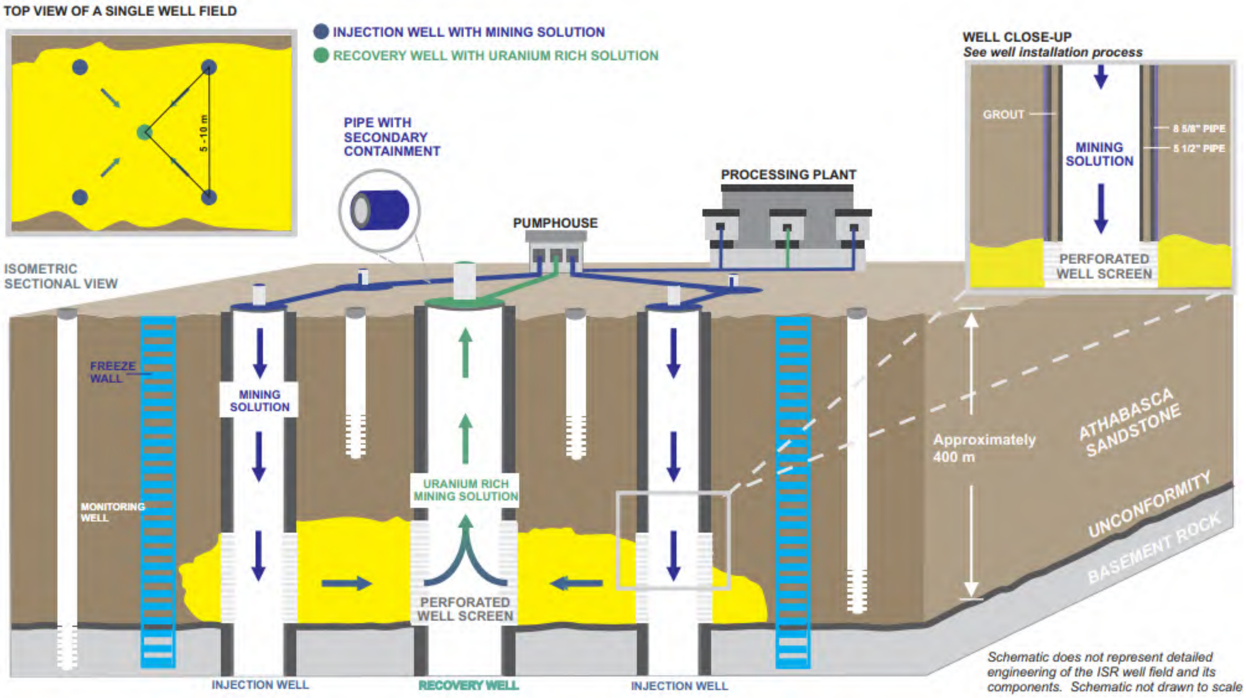


Figure 2-1: Overview of the ISR Process

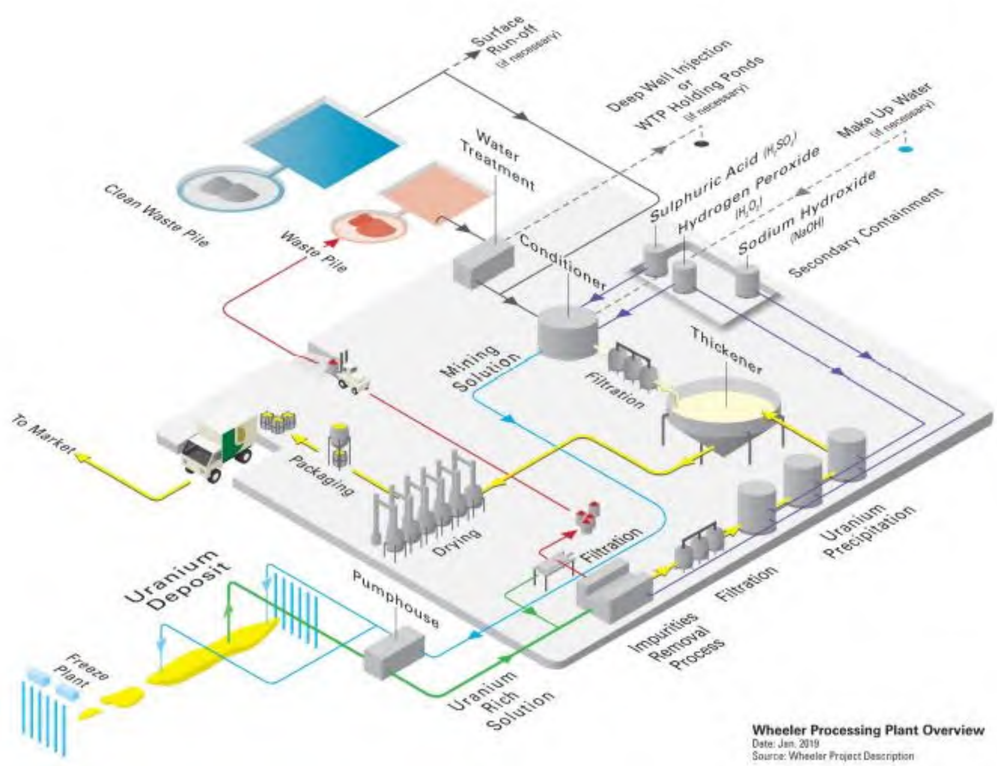


Figure 2-2: Overview of the Processing Plant Process

2.2 Description of the Natural and Physical Environment

The natural and physical environment is presented in the EIS and not reproduced in the ERA. Overall, the site is well characterized with regards to biophysical data and no residual uncertainties in the site characterization have been identified.

3.0 Source Term Characterization

3.1 Aqueous Sources

During construction, no effluent is expected to be released to the aquatic environment. Water management of runoff during construction will follow industry best management practices.

The following describes Denison's water management plan during operation.

Denison's approach to sustainable mining for the Project includes recycling as much process water as possible to reduce the need for fresh water supply.

When freshwater is needed, it would be obtained from a shallow groundwater well and/or from surface water, for a total maximum freshwater withdrawal of 81 m^3/h. Freshwater would be sent to the potable water treatment plant for treatment and distribution.

Domestic wastewater (which includes greywater and sewage) will be generated at the camp, processing plant, airstrip terminal, and the operations centre. Domestic wastewater from the central facilities will be piped directly to the on-site domestic wastewater treatment plant (DWWTP). Other sewage will be collected in septic tanks and transported via a vacuum truck to the DWWTP for treatment. Treated effluent from the DWWTP will be stored in a 5,000 m^3 pond prior to routing to the effluent monitoring and release ponds. Any reject solids from the DWWTP will be collected, dewatered, and disposed of at the site composting system, domestic landfill, or an approved off-site facility.

Contaminated water from the ISR process (e.g., backwash of sand filters, bleed solution) and various sources (e.g., wash bay sump water, leachate from the industrial landfill, wellfield runoff pond) will be treated in a three-stage industrial wastewater treatment plant (IWWTP). Water will be routed to the IWWTP via the process water pond. Treated water in the IWWTP will be routed back into the mining process, any excess treated water will be pumped to the effluent monitoring and release ponds. Any precipitates generated through the treatment process will be primarily comprised of gypsum and will be routed to the IWWTP precipitate pond.

There will be two effluent monitoring and release ponds, each with a composite liner and a capacity for 5,000 m^3 of water. The effluent monitoring and release ponds will primarily receive treated water from the DWWTP and IWWTP, but may also receive water from the process water pond, IWWTP precipitate pond, and wellfield runoff pond.

Effluent will be released to Whitefish Lake Middle (LA-5) via a discharge line with a diffuser at the end to promote effluent mixing within the lake. Effluent will be released at a discharge rate of 36.5 m^3/h as the EA case. The maximum upper bound discharge rate is 81 m^3/hr.

Surface runoff will generally be managed through collection in ponds. The wellfield runoff pond will capture runoff from the wellfield and the special waste pad. Any runoff from the process precipitate pond will be directed to the process water pond. A pond may be constructed beside the clean waste rock pad to collect runoff if required. Any runoff from the clean waste rock pad will be directed to the process water pond or to effluent monitoring and release ponds.

During decommissioning, mining area remediation will be initiated which will involve injecting water into the mining horizon via the injection wells and then recovering the water via the recovery wells. Water would be processed in the processing plant. This process would continue until the recovered water meets acceptable groundwater quality decommissioning objectives. After mining area remediation is complete, the freeze wall would be turned off, which would allow for gradual re-establishment of the pre-operational groundwater flow regime.

As such, during decommissioning effluent may be released to Whitefish Lake, but effluent is not expected to be released during post-decommissioning.

In summary, the main source of aquatic release to Whitefish Lake will be from the effluent monitoring and release ponds during operation and decommissioning. Effluent will undergo monitoring prior to discharge to ensure it meets federal and provincial regulatory discharge limits.

After all Project phases, in the future centuries, there is potential for leaching of post mining and residual mass into groundwater as part of natural groundwater evolution which can result in potential migration of constituents in groundwater into Whitefish Lake (LA-5) (see Section 3.1.2.2 for further details).

3.1.1 Screening for Constituents of Potential Concern

The list of constituents in liquid effluent started with a longer list, and this became more focused as more information became available. The larger list of constituents was based on constituents that:

- are known to be present in the treated effluent; and
- have existing water quality guidelines; or
- are identified in the Metal and Diamond Mining Effluent Regulations, SOR/2002-222, with the exception of cyanide which is considered not applicable.

The longer list of constituents was then reduced to those constituents expected to potentially be operational issues or result in changes to water quality in Whitefish Lake (LA-5) and the downstream environment.

3.1.1.1 Screening Value Selection

Screening values were selected based on the process shown in Figure 3-1. The most restrictive federal or provincial guideline for surface water quality, based on the Canadian Council of Ministers of the Environment (CCME) Canadian water quality guidelines for the protection of fresh water aquatic life, the federal environmental quality guidelines (FEQG), and the

Saskatchewan environmental quality guidelines (SEQG), was selected as the screening value for most surface water COPCs. Guidelines were adjusted for pre-operational hardness and pH, where applicable.

For molybdenum, the Saskatchewan Water Security Agency published an updated water quality objective for the protection of aquatic life based on current understanding of aquatic toxicity of molybdenum to fresh water aquatic organisms (WSA, 2017). This water quality objective of 31 mg/L is based on the 5th percentile of the species sensitivity distribution, and follows the CCME protocol (CCME, 2007). The British Columbia MOE has also published a water quality guideline for molybdenum of 7.6 mg/L (BC MOE, 2021). It was adopted for the Project for protection of aquatic life in preference over the CCME water quality objective of 0.073 mg/L. For protection of human health through the drinking water pathway, a value of 0.07 mg/L was used from the World Heath Organization (WHO, 2017).

Canadian drinking water quality guidelines were included for protection of human health (Health Canada, 2020). These guidelines are based on current, published scientific research related to human health effects, aesthetic effects, and operational considerations. Health-based guidelines are established on the basis of a comprehensive review of the known health effects associated with each constituent, on exposure levels, and on the availability of treatment and analytical technologies. Aesthetic effects (e.g., taste or odour) were taken into account when these play a role in determining whether consumers will consider the water drinkable, as is the case with copper. Where no Canadian drinking water quality guidelines were available, guidelines were obtained from the World Health Organization (WHO, 2017) or British Columbia Ministry of Environment and Climate Change Strategy (BC MECCS, 2020).

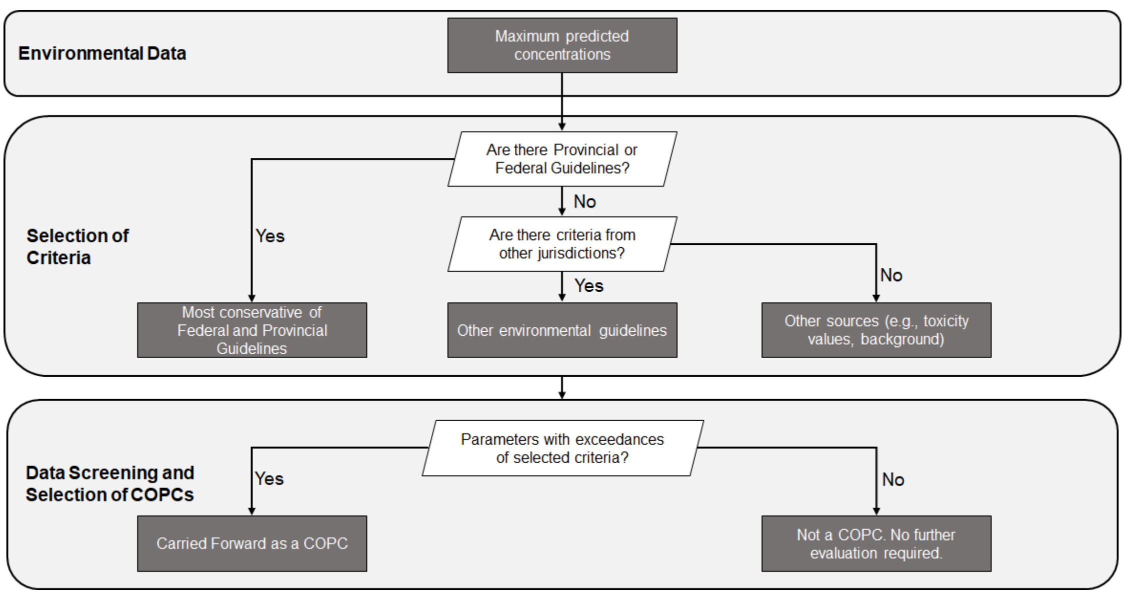


Figure 3-1: Selection of Surface Water Screening Values for the ERA

3.1.1.2 Constituents of Potential Concern in Surface Water

The screening involved a conservative process of comparing the reasonable upper bound treated effluent quality against the selected water quality guidelines protective of human and ecological health (Table 3-1). The reasonable upper bound treated effluent was derived using a combination of information available from lab tests conducted by Denison as well as derived effluent quality based on not exceeding water and sediment quality guidelines in the middle part of Whitefish Lake. Effluent treatment feed solution was prepared by leaching drill core material from the Phoenix deposit, and further processing that solution through two steps (process precipitate removal and yellowcake precipitation) prior to effluent treatment testing. Effluent treatment tests incorporated three stages: low pH, high pH, and neutralization. A combination of reagents (iron sulphate, barium chloride, lime, and sulphuric acid) was used to facilitate precipitation of constituents. After each stage, solid-liquid separation was conducted by mixing flocculant with solution to settle solids to the bottom of the test vessel. The supernatant liquid was used for the following stage. The solids were washed, filtered, and dried to determine solids mass generation for mass balance purposes. For each stage, the liquids and solids were assayed for various COPCs. The reasonable upper bound effluent was usually an expected effluent quality from Denison multiplied by a safety factor of three. The derived effluent quality was used for a handful of constituents including cadmium, chromium, and selenium.

Phosphorus was not considered a COPC for the ERA. Phosphorus is present in the aquatic environment as phosphate, where it acts as a nutrient rather than a toxicant. The water quality guideline selected for screening is the interim Ontario Provincial Water Quality Objective, which was set to avoid nuisance concentrations of algae in lakes and is not relevant to ecological health. Therefore, phosphorus was not considered a COPC for further quantitative assessment.

While the ERA focuses on chronic effects, it is acknowledged that Denison will not be allowed to release effluent above acute guidelines.

No formal screening was conducted for radionuclides. However, since radiation dose to human and ecological receptors is of great public and regulatory interest, the radionuclides in the U-238 decay series (U-238, U-234, thorium-230 [Th-230], radium-226 [Ra-226], Pb-210, polonium-210 [Po-210]) were considered COPCs for further modelling.

Radon-222 was not considered a COPC in surface water. Radon is expected to volatilize rapidly to air. Health Canada considers that the health risk from ingesting radon-contaminated drinking water is negligible (Health Canada, 2020). Radon is expected to escape at the faucet or water outlet, leaving only minimal amounts in the water itself. This assumption is consistent with Clause 5.1.8 of CSA N288.1-20, *Guidelines for calculating derived release limits for radioactive material in airborne or liquid effluents for normal operation of nuclear facilities*, which indicates that noble gases, including radon-222, are not considered relevant for release to water because they do not enter environmental compartments other than air (CSA, 2020).

Based on the screening (see Table 3-1), the following COPCs were included in the surface water modelling for the ERA.

- General Chemistry: chloride, sulphate, and total dissolved solids
- Metals and metalloids: arsenic, cadmium, chromium, cobalt, copper, molybdenum, selenium, uranium, zinc
- Radionuclides: uranium-238, uranium-234, thorium-230, radium-226, lead-210, polonium-210.

Table 3-1: Screening of Effluent Quality against Surface Water Quality Guidelines for the Wheeler River ERA

Constituent	Unit	Reasonable Upper Bound Effluent Quality	CCME Protection of Aquatic Life		Federal Environmental Quality Guideline		Saskatchewan Environmental Quality Guidelines (SEQG Online) (1)		Other		Drinking Water Guidelines			Selected Screening Value	Source	Is Effluent Quality Greater than Screening Value?
			Long Term	Note	Long Term	Note	Long Term	Note	Long Term	Note	Health Canada (15)	Other Source	Note			
Total suspended solids	mg/L	6.00E+00	background + 5 mg/L													N/A
Aluminum	mg/L	5.10E-02	1.00E-01	(6)			1.00E-01				1.00E-01			1.00E-01	SEQG/CCME	No
Arsenic	**mg/L**	**6.00E-03**	**5.00E-03**				**5.00E-03**				**1.00E-02**			**5.00E-03**	**SEQG/CCME**	**Yes**
Cadmium	**mg/L**	**1.80E-03**	**4.00E-05**				**4.00E-05**				**7.00E-03**			**4.00E-05**	**SEQG/CCME**	**Yes**
Chromium	**mg/L**	**2.50E-02**	**1.00E-03**				**1.00E-03**				**5.00E-02**			**1.00E-03**	**SEQG/CCME**	**Yes**
Cobalt	**mg/L**	**2.70E-03**			**7.80E-04**	**(11)**						**1.00E-03**	**(16)**	**7.80E-04**	**FEQG**	**Yes**
Copper	**mg/L**	**2.22E-02**	**2.00E-03**	**(8)**	**2.00E-04**	**(12)**					**2.00E+00**			**2.00E-04**	**FEQG**	**Yes**
Iron	mg/L	3.90E-03	3.00E-01								3.00E-01			3.00E-01	CCME	No
Lead	mg/L	3.00E-04	1.00E-03	(9)			1.00E-03	(2)			5.00E-03			1.00E-03	SEQG/CCME	No
Manganese	mg/L	3.00E-02	2.10E-01	(3)							1.20E-01			1.20E-01	Health Canada	No
Mercury	mg/L	1.00E-05	2.60E-05				2.60E-05				1.00E-03			2.60E-05	SEQG/CCME	No
Molybdenum	**mg/L**	**2.50E+00**	**7.30E-02**	-	-	-	**3.10E+01**	-	**7.60E+00**	-	-	**7.00E-02**	**(17)**	**7.00E-02** **7.60E+00**	**WHO (drinking water)** **BC MOE (eco)**	**Yes (human health)** **No (eco health)**
Nickel	mg/L	1.38E-02	2.50E-02	(9)	-	-	2.50E-02	(2)	-	-	-	7.00E-02	(17)	2.50E-02	SEQG/CCME	No
Phosphorous	mg/L	1.00E-02	-	-	-	-	-	-	0.004-0.01	(18)	-	1.00E-02	(16)	0.004-0.01	Ontario PWQO	No
Selenium	**mg/L**	**4.19E-02**	**1.00E-03**				**1.00E-03**				**5.00E-02**			**1.00E-03**	**SEQG/CCME**	**Yes**
Thallium	mg/L	6.00E-04	0.0008	-	-	-	-	-	-	-	-	-	-	0.0008	CCME	No
Uranium	**mg/L**	**5.70E-02**	**1.50E-02**	-	-	-	**1.50E-02**	-	-	-	**2.00E-02**	-	-	**1.50E-02**	**SEQG/CCME**	**Yes**
Vanadium	mg/L	5.90E-02	-	-	1.20E-01	(14)	-	-	-	-	-	-	-	1.20E-01	FEQG	No
Zinc	**mg/L**	**4.20E-02**	**1.30E-02**	**(10)**	-	-	**3.00E-02**	-	-	-	**5.00E+00**	-	-	**1.30E-02**	**CCME**	**Yes**
Total Ammonia as nitrogen	mg/L	3.90E+00	5.74E+00	(4)	-	-	5.74E+00	(4)	-	-	none required	-	-	5.74E+00	SEQG/CCME	No
Un-ionized ammonia as nitrogen (5)	mg/L	1.06E-02	1.56E-02	-	-	-	1.56E-02	-	-	-	none required	-	-	1.56E-02	SEQG/CCME	No
Chloride	**mg/L**	**6.00E+02**	**1.20E+02**	**(7)**	-	-	**1.20E+02**	-	-	-	**none required**	-	-	**1.20E+02**	**SEQG/CCME**	**Yes**
Total dissolved solids	**mg/L**	**6.42E+03**	-	-	-	-	**5.00E+02**	-	-	-	**5.00E+02**	-	-	**5.00E+02**	**SEQG**	**Yes (addressed in Section 10.2 of EIS)**

Constituent	Unit	Reasonable Upper Bound Effluent Quality	CCME Protection of Aquatic Life		Federal Environmental Quality Guideline		Saskatchewan Environmental Quality Guidelines (SEQG Online) (1)		Other		Drinking Water Guidelines			Selected Screening Value	Source	Is Effluent Quality Greater than Screening Value?
			Long Term	Note	Long Term	Note	Long Term	Note	Long Term	Note	Health Canada (15)	Other Source	Note			
Sulphate	**mg/L**	**3.92E+03**	-	-	-	-	-	-	**1.28E+02**	**(13)**	**5.00E+02**	-	-	**1.28E+02**	**BC MOE**	**Yes**
Radium-226	**Bq/L**	**1.50E-01**	-	-	-	-	**0.11**	-	-	-	-	-	-	**0.11**	**SEQG**	**Yes**
Thorium-230	Bq/L	9.00E-01	-	-	-	-	-	-	-	-	-	-	-	N/A	-	N/A
Lead-210	Bq/L	4.19E-01	-	-	-	-	-	-	-	-	-	-	-	N/A	-	N/A
Polonium-210	Bq/L	1.50E-01	-	-	-	-	-	-	-	-	-	-	-	N/A	-	N/A
Uranium-238	Bq/L	7.04E-01	-	-	-	-	-	-	-	-	-	-	-	N/A	-	N/A
Uranium-234	Bq/L	7.04E-01	-	-	-	-	-	-	-	-	-	-	-	N/A	-	N/A

Notes:

(1) Saskatchewan Water Quality Objectives, SEQG on-line (https://envrbrportal.crmp.saskatchewan.ca/seqg-search/), SEQG for the protection of aquatic life were selected, based on total concentrations, a temperature of 15°C and a pH of 7.0.

(2) Hardness dependent WQOs are for very soft water (hardness <25 mg $CaCO_3$/L). Site-specific hardness is 5.26 mg/L (95th percentile of LA-5 and LA-6).

(3) Scientific Criteria Document for the Development of the Canadian Water Quality Guidelines for the Protection of Aquatic Life - Manganese, Appendix B - Canadian Water Quality Guidelines Calculator (pH = 6.6, hardness = 5.6 mg/L). Guideline is based on dissolved manganese.

(4) Total ammonia-N calculated from the total ammonia guideline for a temperature of 15°C and a pH of 7.0.

(5) A pH of 7 and a temperature of 15^{0}C were assumed to convert total ammonia to un-ionized ammonia in accordance with CCME (2002)

(6) Based on a pH of >6.5.

(7) Based on water hardness >0 to <17 mg/L.

(8) Based on water hardness >0 to <82 mg/L.

(9) Based on water hardness >0 to ≤60 mg/L.

(10) Guideline is based on dissolved zinc. Long term guideline is based on CWQG = exp(0.947[ln(hardness mg·L-1)] - 0.815[pH] + 0.398[ln(DOC mg·L-1)] + 4.625). (Site-specific background hardness is 5.26 mg/L, DOC is 2.24 mg/L, pH is 6.61 (95th percentile of LA-5 and LA-6). Note – extrapolated for value outside the hardness range.

(11) Environment Canada 2017. Federal Environmental Quality Guidelines, Cobalt, May. Based on equation and lowest hardness for equation of 52 mg/L.

(12) The Biotic Ligand Model was used. The calculated HC_5 is below 0.2 µg/L, however, 0.2 µg/L is considered to be the lowest concentration routinely measured and therefore replaces the calculated HC_5 value for this water chemistry.

(13) BC MECCS 2021. British Columbia Approved Water Quality Guidelines: Aquatic Life, Wildlife & Agriculture. https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/water-quality-guidelines/approved-wqgs/wqg_summary_aquaticlife_wildlife_agri.pdf

(14) Environment Canada 2016. Federal Environmental Quality Guidelines, Vanadium. May.

(15) Health Canada 2020. Guidelines for Canadian Drinking Water Quality Summary Table. September. https://www.canada.ca/content/dam/hc-sc/migration/hc-sc/ewh-semt/alt_formats/pdf/pubs/water-eau/sum_guide-res_recom/summary-table-EN-2020-02-11.pdf

(16) BC MECCS 2020. Source Drinking Water Quality Guidelines, Guideline Summary Ministry of Environment & Climate Change Strategy Water Protection & Sustainability Branch.

(17) WHO 2017. Guidelines for Drinking Water Quality. Fourth Edition Incorporating The First Addendum.

(18) Ontario Ministry of Environment and Energy: Water management: policies, guidelines, provincial water quality objectives (1994).

(19) BC MOE (B.C. Ministry of Environment and Climate Change Strategy). 2021. Molybdenum Water Quality Guidelines for the Protection of Freshwater Aquatic Life, Livestock, Wildlife and Irrigation. Water Quality Guideline Series, WQG-07. Prov. B.C., Victoria B.C.

3.1.2 Surface Water Quality Modelling

3.1.2.1 Project Phases

Surface water quality modeling was completed using IMPACT version 5.6.0. IMPACT is consistent with the COPC transport equations outlined in CSA N288.1-20. The modeling is discussed in detail in the IMPACT Model Report for the Project (Appendix A). Waterbodies from Whitefish Lake to the Russell Lake inlet were modelled in IMPACT to assess the effects of the Project on the downstream environment – this included the following distinct water polygons: Whitefish Lake Middle, Whitefish Lake South, McGowan Lake, and Russell Lake. Kratchkowsky Lake and Whitefish Lake North were modelled as reference locations.

Treated effluent will be released to Whitefish Lake Middle at an expected discharge rate of 36.5 m^3/h during the operation and decommissioning phases of the Project. The reasonable upper bound effluent quality during the phases where effluent will be released is summarized in Table 3-2 – effluent quality is assumed to be constant over that time period. Receiving water flow varies seasonally, resulting in seasonal fluctuations in receiving water quality. No effluent is expected to be released during construction or post-decommissioning.

Surface water quality modelling included predicting water and sediment concentrations in Whitefish Lake, the lake to which treated effluent will be released, as well as locations farther downstream. The geometric mean of measured water concentrations from baseline studies performed between 2011 and 2019 (Ecometrix, 2020) was selected as the water baseline concentration for constituents that had measured data over the detection limit. Sediment baseline concentrations were predicted from surface water concentrations using the partitioning coefficients (Kd) which consist of regional published values that have been calibrated on similar sites in northern Saskatchewan and have been checked against Wheeler River measurement data. In the case of constituents for which most or all measured concentrations in water were under the detection limit, but sediment concentration measurements were over the detection limit, the baseline water concentration was calculated from the geometric mean of the sediment measurements using the Kds (Section 3.3.2 in Appendix A).

When the treated effluent is released to Whitefish Lake (LA-5), water and sediment concentrations were predicted using IMPACT according to the equations outlined in the IMPACT model (Section 2.2.2 in Appendix A). The predicted maximum concentrations of COPCs in water and sediment are shown in Table 3-3. There are no predicted exceedances of water quality guidelines for any of the COPCs, except for copper where baseline concentrations exceed the federal environmental quality guideline (FEQG). A detailed comparison of sediment concentrations against sediment quality guidelines is discussed in Section 3.1.2.3.

Figure 3-2 and Figure 3-3 show the predicted concentrations of selected COPCs in water and sediment over time at the exposed locations (Whitefish Lake Middle, Whitefish Lake South, McGowan Lake, and Russell Lake) and reference locations (Kratchkowsky Lake and Whitefish Lake North) during project phases. The modelled maximum COPC concentrations in water during decommissioning phase were the same as those during operations (Table 3-3). The peak concentrations of arsenic and polonium-210 appear annually in June, and the peak concentrations of all other COPCs appear annually in March due to the variation of the monthly local inflow during the effluent discharge period (Figure 3-2). It is noted that the maximum predicted concentrations of COPCs in water occurred over short periods of effluent discharge and subsequently decrease relatively quickly during periods when there is no effluent discharge. This is related to the short retention time of the modelled lakes. As shown in Table 3-1 in Appendix A, the modelled lakes (excluding the reference lake) are small, with lake area ranging from 0.10 to 1.49 km^2 and with average depths ranging from 1.0 to 5.5 m. Based on the area, depth and outflow, the calculated retention times ranged from 0.88 to 51.61 days. As noted, the short retention times result in rapid increases and decreases of concentrations of COPCs in response to effluent discharge and then its cessation. Since COPCs accumulate in sediment, the peak concentrations of all COPCs in sediment appear at the end of each individual Project phase, which are year 20 for the operations and year 25 for the decommissioning phase, as shown in Figure 3-3.

Based on the screening methodology in Table 3-1, the effluent quality for TDS is expected to exceed its water quality guideline of 500 mg/L. The water quality guideline for TDS is an aesthetic drinking water objective from Health Canada (1991). No health effects associated with ingestion of TDS have been identified (Health Canada, 1991). Modelling of TDS was not included in the IMPACT model; however, TDS concentrations were predicted in the near-field water quality model in Section 10.2 (see Table 10.2-10) of the EIS, Surface Water Quality. Predicted TDS concentrations are expected to range from approximately 74 mg/L to 131 mg/L under various flow conditions and are well below the drinking water quality objective. Since TDS is not considered a health risk, and concentrations in LA-5 are predicted to be below the aesthetic objective, TDS is not considered further in the ERA.

Table 3-2: Summary of Effluent Quality for the Wheeler River Project

Constituent of Potential Concern	Unit	Effluent Quality
General Chemistry		
Chloride	mg/L	600
Sulphate	mg/L	3915
Total Dissolved Solids	mg/L	6420
Metals and Metalloids		
Arsenic	mg/L	0.006
Cadmium	mg/L	0.0018
Chromium	mg/L	0.025
Cobalt	mg/L	0.003
Copper	mg/L	0.022
Molybdenum	mg/L	2.5
Selenium	mg/L	0.042
Uranium	mg/L	0.057
Vanadium	mg/L	0.059
Zinc	mg/L	0.042
Radionuclides		

Constituent of Potential Concern	Unit	Effluent Quality
Uranium-238	Bq/L	0.7[(a)]
Uranium-234	Bq/L	0.7[(a)]
Thorium-230	Bq/L	0.9
Radium-226	Bq/L	0.15
Lead-210	Bq/L	0.419
Polonium-210	Bq/L	0.15

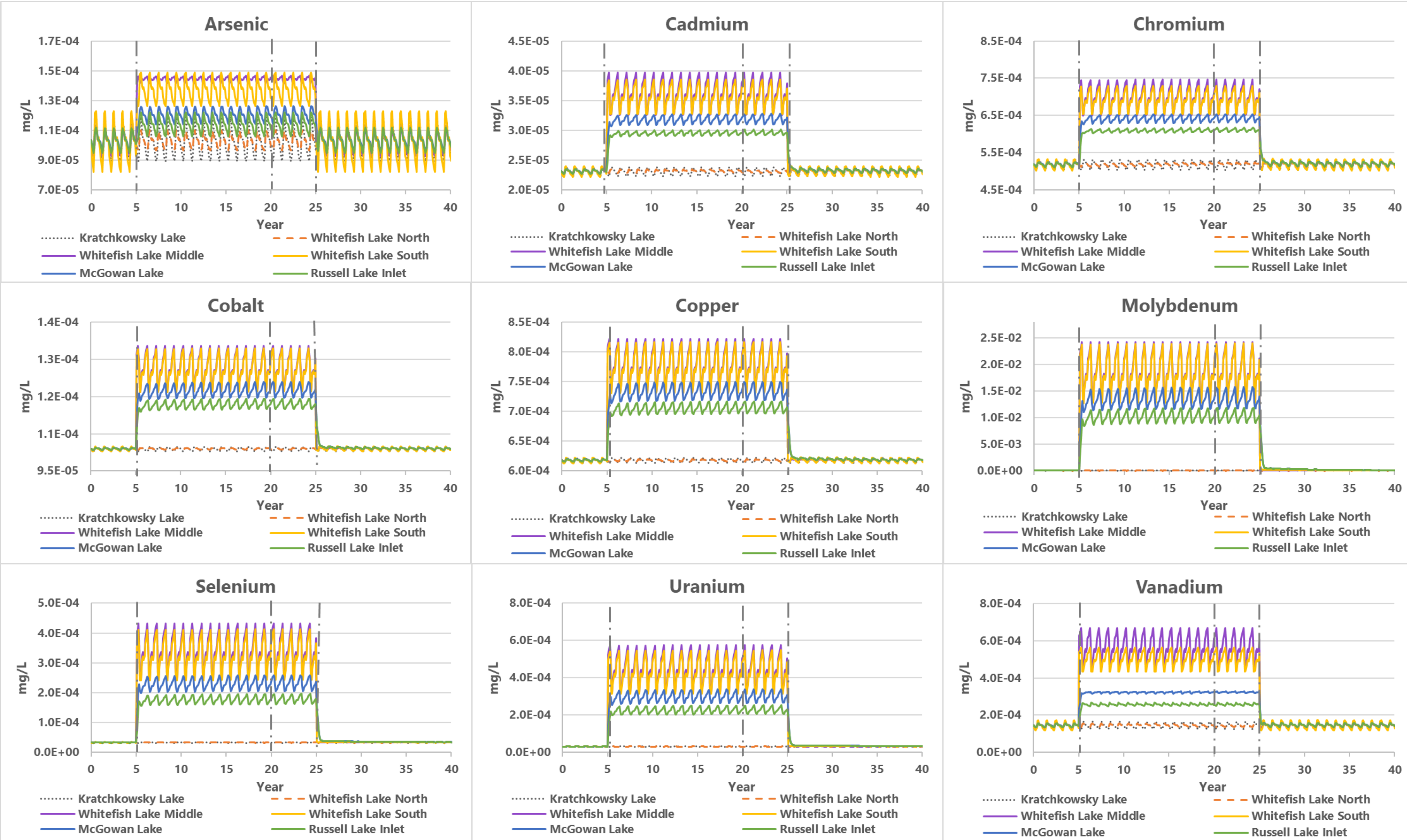
Note:
(a) Estimated from uranium using the specific activity of 12,356 Bq/g and assuming secular equilibrium between uranium-238 and uranium-234 (**https://www.wise-uranium.org/rup.html**)

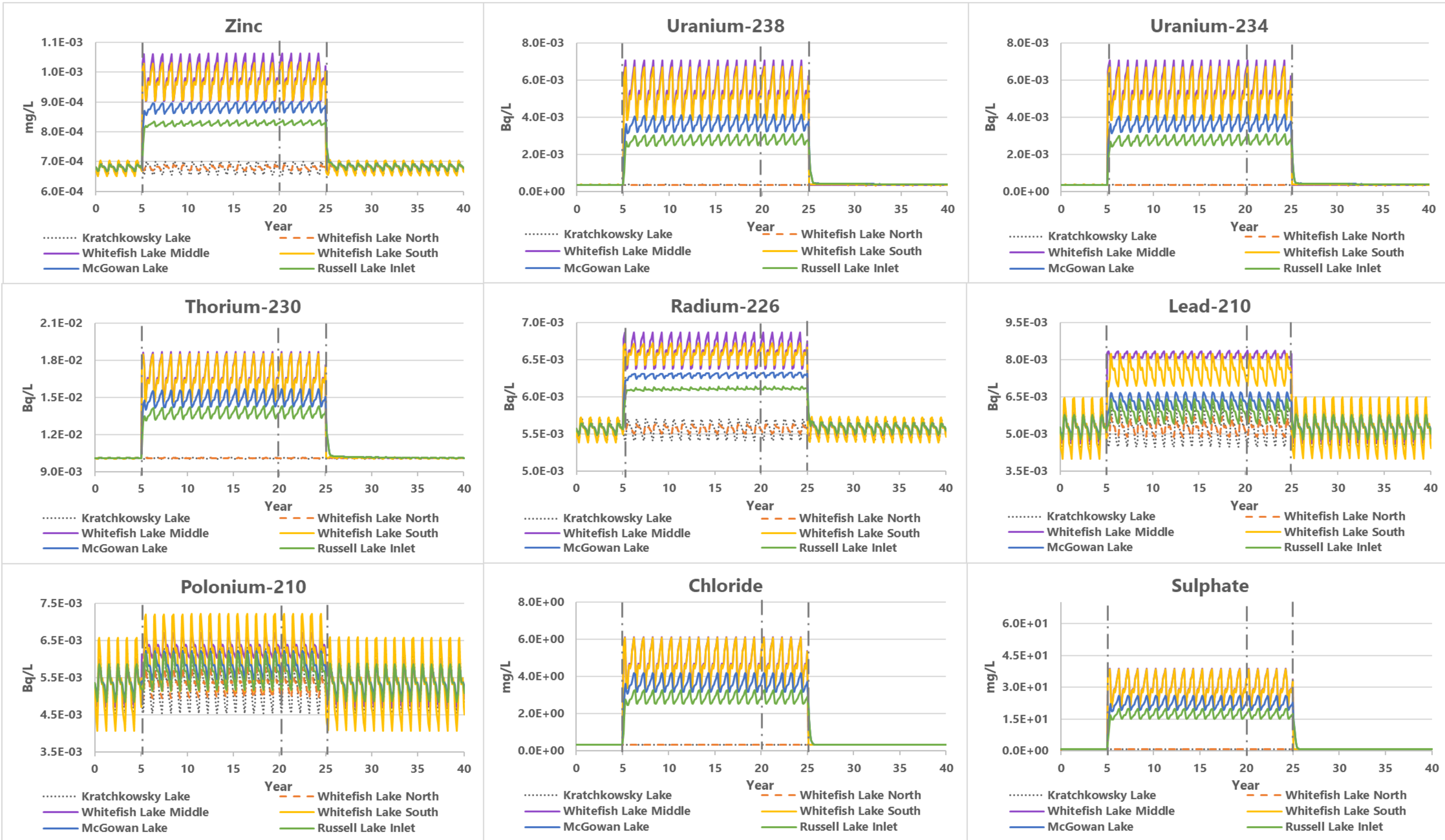
Table 3-3: Maximum Concentration of COPCs in Water and Sediment during Project Phases

Environmental Media	Location	Maximum Concentration of Non-radionuclides during Project Phases											
		Arsenic	Cadmium	Chloride	Cobalt	Chromium	Copper	Molybdenum	Sulphate	Selenium	Uranium	Vanadium	Zinc
Water (mg/L)	Quality Guideline	5.00E-03	4.00E-05	1.20E+02	2.95E-04	1.00E-03	2.00E-04	7.6E+00	1.28E+02	1.00E-03	1.50E-02	1.20E-01	1.30E-02
	Kratchkowsky Lake	1.19E-04	2.38E-05	3.22E-01	1.01E-04	5.30E-04	6.22E-04	1.07E-04	6.87E-01	3.35E-05	3.12E-05	1.67E-04	7.00E-04
	Whitefish Lake North	1.10E-04	2.34E-05	3.22E-01	1.01E-04	5.24E-04	6.20E-04	1.07E-04	6.87E-01	3.28E-05	3.05E-05	1.55E-04	6.89E-04
	Whitefish Lake Middle	1.46E-04	3.97E-05	6.14E+00	1.29E-04	7.46E-04	8.22E-04	2.43E-02	3.87E+01	4.33E-04	5.74E-04	6.70E-04	1.06E-03
	Whitefish Lake South	1.49E-04	3.86E-05	6.11E+00	1.28E-04	7.30E-04	8.17E-04	2.40E-02	3.85E+01	4.12E-04	5.47E-04	5.64E-04	1.03E-03
	McGowan Lake	1.26E-04	3.28E-05	4.20E+00	1.19E-04	6.54E-04	7.50E-04	1.58E-02	2.60E+01	2.59E-04	3.38E-04	3.28E-04	9.01E-04
	Icelander River	1.26E-04	3.26E-05	4.16E+00	1.19E-04	6.52E-04	7.49E-04	1.56E-02	2.57E+01	2.56E-04	3.34E-04	3.26E-04	8.99E-04
	Russell Lake Inlet	1.22E-04	3.01E-05	3.26E+00	1.14E-04	6.17E-04	7.17E-04	1.18E-02	1.99E+01	1.95E-04	2.52E-04	2.69E-04	8.40E-04
Sediment (mg/kg dw)	Quality Guideline	2.10E+01	6.00E-01	n/a	n/a	3.15E+01	9.10E+01	2.30E+01	n/a	3.60E+00	9.70E+01	3.51E+01	1.23E+02
	Kratchkowsky Lake	8.35E+00	3.38E-01	n/a	2.52E-01	5.86E+00	1.85E+00	3.37E-01	n/a	6.22E-01	5.78E-01	1.12E+01	9.93E+00
	Whitefish Lake North	8.35E+00	3.38E-01	n/a	2.52E-01	5.86E+00	1.85E+00	3.37E-01	n/a	6.22E-01	5.78E-01	1.12E+01	9.93E+00
	Whitefish Lake Middle	1.10E+01	4.97E-01	n/a	3.05E-01	7.59E+00	2.31E+00	5.72E+01	n/a	5.48E+00	7.18E+00	3.72E+01	1.36E+01
	Whitefish Lake South	1.05E+01	4.90E-01	n/a	3.04E-01	7.53E+00	2.30E+00	5.62E+01	n/a	5.26E+00	6.87E+00	3.33E+01	1.35E+01
	McGowan Lake	9.47E+00	4.43E-01	n/a	2.90E-01	7.03E+00	2.18E+00	4.11E+01	n/a	3.71E+00	4.78E+00	2.22E+01	1.24E+01
	Russell Lake Inlet	9.04E+00	4.15E-01	n/a	2.81E-01	6.73E+00	2.10E+00	3.13E+01	n/a	2.88E+00	3.64E+00	1.82E+01	1.17E+01

Environmental Media	Location	Maximum Concentration of Radionuclides during Project Phases					
		Uranium-238	Uranium-234	Thorium-230	Radium-226	Lead-210	Polonium-210
Water (Bq/L)	Quality Guideline	n/a	n/a	n/a	1.10E-01	n/a	n/a
	Kratchkowsky Lake	3.85E-04	3.85E-04	1.01E-02	5.70E-03	6.22E-03	6.33E-03
	Whitefish Lake North	3.77E-04	3.77E-04	1.01E-02	5.63E-03	5.68E-03	5.78E-03
	Whitefish Lake Middle	7.05E-03	7.05E-03	1.87E-02	6.87E-03	8.36E-03	6.71E-03
	Whitefish Lake South	6.72E-03	6.72E-03	1.85E-02	6.73E-03	8.25E-03	7.22E-03
	McGowan Lake	4.15E-03	4.15E-03	1.57E-02	6.33E-03	6.68E-03	6.23E-03
	Icelander River	4.11E-03	4.11E-03	1.56E-02	6.32E-03	6.66E-03	6.20E-03
	Russell Lake Inlet	3.09E-03	3.09E-03	1.43E-02	6.14E-03	6.41E-03	6.16E-03
Sediment (Bq/kg dw)	Quality Guideline	n/a	n/a	n/a	6.00E+02	9.00E+02	8.00E+02
	Kratchkowsky Lake	7.14E+00	7.14E+00	2.32E+01	6.51E+01	3.74E+02	3.80E+02
	Whitefish Lake North	7.14E+00	7.14E+00	2.32E+01	6.51E+01	3.74E+02	3.80E+02
	Whitefish Lake Middle	8.82E+01	8.82E+01	3.83E+01	7.57E+01	5.57E+02	5.58E+02
	Whitefish Lake South	8.44E+01	8.44E+01	3.80E+01	7.52E+01	5.19E+02	5.22E+02
	McGowan Lake	5.87E+01	5.87E+01	3.41E+01	7.23E+01	4.42E+02	4.47E+02
	Russell Lake Inlet	4.48E+01	4.48E+01	3.15E+01	7.04E+01	4.14E+02	4.20E+02

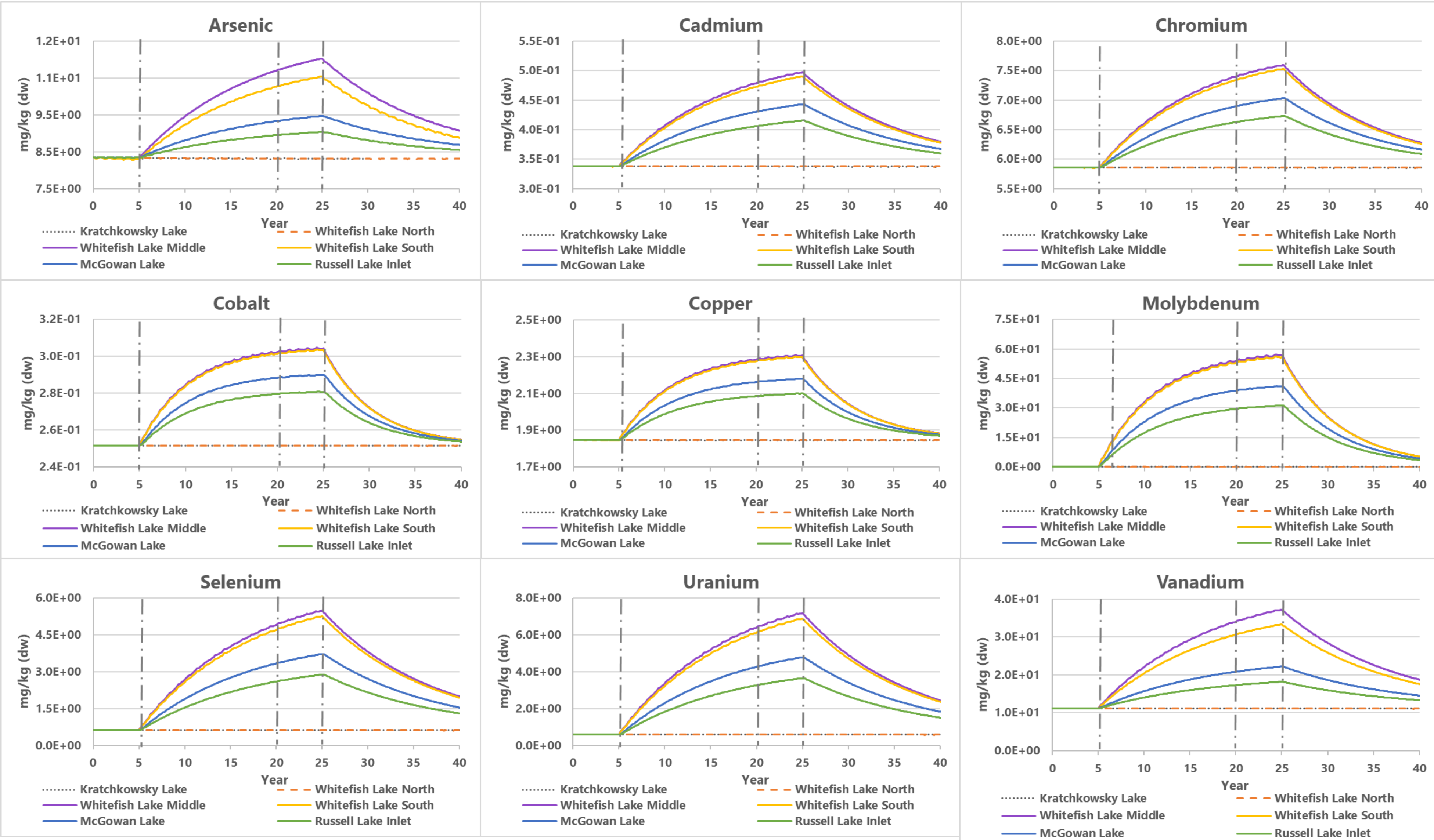
n/a = not applicable
Water quality guidelines are as shown in Table 3-1 and sediment quality guidelines are as shown in Table 3-6.

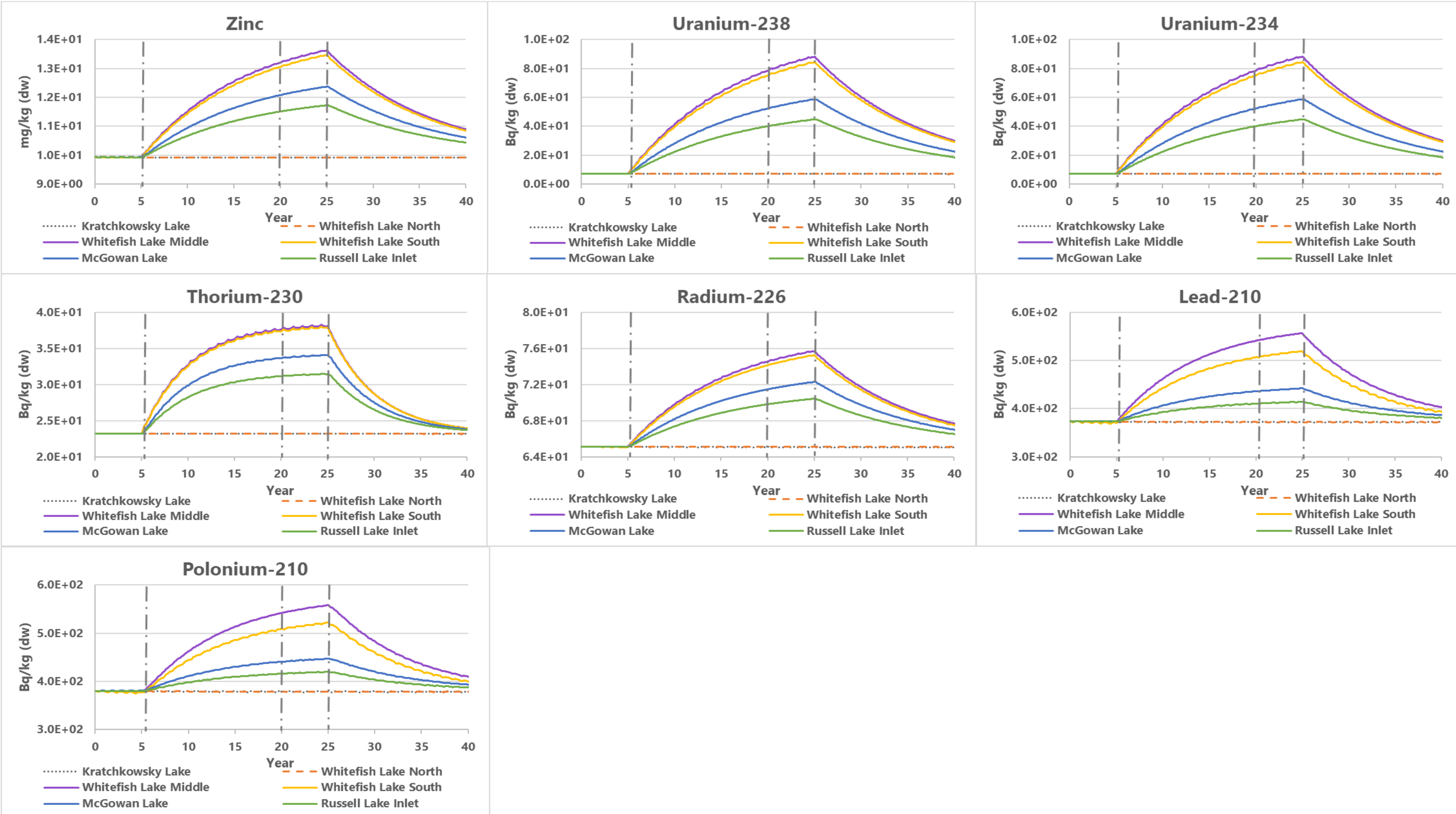

Arsenic
1.7E-04
1.5E-04
1.3E-04
1.1E-04
9.0E-05
7.0E-05
mg/L
0 5 10 15 20 25 30 35 40
Year
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Cadmium
4.5E-05
4.0E-05
3.5E-05
3.0E-05
2.5E-05
2.0E-05
Chromium
8.5E-04
7.5E-04
6.5E-04
5.5E-04
4.5E-04
Cobalt
1.4E-04
1.3E-04
1.2E-04
1.1E-04
9.5E-05
Copper
8.5E-04
8.0E-04
7.5E-04
7.0E-04
6.5E-04
6.0E-04
Molybdenum
2.5E-02
2.0E-02
1.5E-02
1.0E-02
5.0E-03
0.0E+00
Selenium
5.0E-04
4.0E-04
3.0E-04
2.0E-04
1.0E-04
0.0E+00
Uranium
8.0E-04
6.0E-04
4.0E-04
2.0E-04
0.0E+00
Vanadium
8.0E-04
6.0E-04
4.0E-04
2.0E-04
0.0E+00



Long dash dot lines separate the time periods of project phases: 3 years baseline; 2 years construction; 15 years operation; 5 years decommissioning; first 15 years post-decommissioning

Figure 3-2: Modelled Concentrations of COPCs in Water during Project Phases


Arsenic
1.2E+01
1.1E+01
9.5E+00
8.5E+00
7.5E+00
mg/kg (dw)
0 5 10 15 20 25 30 35 40
Year
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Cadmium
5.5E-01
5.0E-01
4.5E-01
4.0E-01
3.5E-01
3.0E-01
mg/kg (dw)
0 5 10 15 20 25 30 35 40
Year
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Chromium
8.0E+00
7.5E+00
7.0E+00
6.5E+00
6.0E+00
5.5E+00
mg/kg (dw)
0 5 10 15 20 25 30 35 40
Year
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Cobalt
3.2E-01
3.0E-01
2.8E-01
2.6E-01
2.4E-01
mg/kg (dw)
0 5 10 15 20 25 30 35 40
Year
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Copper
2.5E+00
2.3E+00
2.1E+00
1.9E+00
1.7E+00
mg/kg (dw)
0 5 10 15 20 25 30 35 40
Year
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Molybdenum
7.5E+01
6.0E+01
4.5E+01
3.0E+01
1.5E+01
0.0E+00
mg/kg (dw)
0 5 10 15 20 25 30 35 40
Year
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Selenium
6.0E+00
4.5E+00
3.0E+00
1.5E+00
0.0E+00
mg/kg (dw)
0 5 10 15 20 25 30 35 40
Year
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Uranium
8.0E+00
6.0E+00
4.0E+00
2.0E+00
0.0E+00
mg/kg (dw)
0 5 10 15 20 25 30 35 40
Year
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Vanadium
4.0E+01
3.0E+01
2.0E+01
1.0E+01
0.0E+00
mg/kg (dw)
0 5 10 15 20 25 30 35 40
Year
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet



Long dash dot lines separate the time periods of project phases: 3 years baseline; 2 years construction; 15 years operation; 5 years decommissioning; first 15 years post-decommissioning

Figure 3-3: Modelled Concentrations of COPCs in Sediment during Project Phases

3.1.2.2 Future Centuries

The potential migration of constituents from groundwater into Whitefish Lake (LA-5) which could influence the surface water quality is modelled in a "future centuries" scenario.

During decommissioning, groundwater quality within the ISR mining zone will be remediated to meet decommissioning objectives. In post-decommissioning, the freeze wall will be allowed to thaw and natural groundwater flow conditions will be re-established, as discussed in Section 9 of the EIS, Geology and Hydrogeology. During the "future centuries", groundwater plumes may develop from residual mass (i.e., remediated groundwater) remaining post mining (this is based on bench-scale lab tests of core flushing, and subsequent numerical modelling of reactive fate and transport).

Groundwater flow and reactive transport of dissolved constituents were modelled using three-dimensional modelling whereby the reactions were computed using PHREEQC and the transport was computed using FEFLOW (Ecometrix, 2022). Groundwater flow observed, and simulated in the calibrated groundwater model, travels eastward from the mining zone within the Lower Sandstone Aquifer before moving upward through the Desilicified Zone in the Athabasca Sandstone and overlying overburden deposits toward Whitefish Lake. Modelled transport of dissolved constituents along the groundwater flow path allowed for interactions of the dissolved constituents with the geologic media through which they are flowing. Due to the relatively low groundwater velocities between the mining zone and Whitefish Lake and chemical reactions along the groundwater flow pathway, the "future centuries" scenario spans 100s to 1000s of years.

The results of the numerical model (as provided in Section 7 of the EIS) indicate that dissolved constituent concentrations emanating over hundreds to thousands of years in the future from the deep Ore Zone to Whitefish Lake remain below fresh water environmental quality criteria in Whitefish Lake.

For the COPCs identified in the effluent, the predicted mass flux from groundwater into Whitefish Lake Middle starting 200 years after the Project phases, during the future centuries, was input to the IMPACT model to predict the water and sediment concentrations over time at the exposed locations. The COPCs in groundwater will be released to Whitefish Lake Middle at a predicted mass flux as shown in Table 3-4 (Ecometrix, 2022). The same modelling approach as described in Section 3.1.2 was applied in the "future centuries" scenario except that the annual average flow of the receiving water and a 2-year monitoring time step were used due to the long modelling time period of 1000 years.

The predicted maximum concentrations of COPCs in water and sediment during future centuries are shown in Table 3-5. There are no predicted exceedances of water and sediment quality guidelines for any of the COPCs, except for copper in water where baseline concentrations exceed the FEQG. Figure 3-4 and Figure 3-5 show the predicted concentrations of COPCs in water and sediment over time at the exposed locations (Whitefish Lake Middle, Whitefish Lake South, McGowan Lake, and Russell Lake) and reference locations (Kratchkowsky Lake and Whitefish Lake North) during future centuries.

Table 3-4: Summary of Predicted Mass Flux of COPCs in Groundwater for Future Centuries

Mass Flux (mg/s or Bq/s)									
Year after Project Phases	200	300	400	500	600	700	800	900	1000
General Chemistry									
Chloride	1.26E+02	1.28E+02	1.29E+02	1.29E+02	1.29E+02	1.29E+02	1.29E+02	1.28E+02	1.28E+02
Sulphate	4.08E+01	4.47E+01	4.69E+01	4.62E+01	4.44E+01	4.28E+01	4.16E+01	4.07E+01	3.99E+01
Metals and Metalloids									
Arsenic	5.73E-03	5.73E-03	5.73E-03	5.73E-03	5.73E-03	5.73E-03	5.73E-03	5.73E-03	5.74E-03
Cadmium	1.89E-04	1.89E-04	1.89E-04	1.89E-04	1.89E-04	1.89E-04	1.89E-04	1.88E-04	1.88E-04
Chromium	9.45E-03	9.45E-03	9.44E-03	9.43E-03	9.42E-03	9.42E-03	9.41E-03	9.40E-03	9.40E-03
Cobalt	7.51E-03	7.50E-03	7.49E-03	7.47E-03	7.46E-03	7.44E-03	7.43E-03	7.41E-03	7.40E-03
Copper	1.15E-02	1.15E-02	1.14E-02	1.14E-02	1.14E-02	1.14E-02	1.14E-02	1.14E-02	1.14E-02
Molybdenum	1.34E-02	1.34E-02	1.35E-02	1.35E-02	1.35E-02	1.35E-02	1.35E-02	1.35E-02	1.35E-02
Selenium	1.52E-02	1.52E-02	1.51E-02	1.51E-02	1.51E-02	1.51E-02	1.51E-02	1.51E-02	1.51E-02
Uranium	9.47E-03	9.47E-03	9.47E-03	9.46E-03	9.46E-03	9.45E-03	9.45E-03	9.45E-03	9.45E-03
Vanadium	1.89E-03	1.89E-03	1.90E-03	1.90E-03	1.91E-03	1.91E-03	1.91E-03	1.91E-03	1.92E-03
Zinc	8.30E-02	8.30E-02	8.30E-02	8.29E-02	8.29E-02	8.28E-02	8.28E-02	8.28E-02	8.28E-02
Radionuclides									
Uranium-238	1.17E-01	1.17E-01	1.17E-01	1.17E-01	1.17E-01	1.17E-01	1.17E-01	1.17E-01	1.17E-01
Uranium-234	1.17E-01	1.17E-01	1.17E-01	1.17E-01	1.17E-01	1.17E-01	1.17E-01	1.17E-01	1.17E-01
Thorium-230	3.69E-01	3.70E-01	3.71E-01	3.71E-01	3.72E-01	3.72E-01	3.72E-01	3.73E-01	3.73E-01
Radium-226	1.14E+00	1.14E+00	1.15E+00	1.15E+00	1.15E+00	1.15E+00	1.15E+00	1.15E+00	1.15E+00
Lead-210	1.14E+00	1.14E+00	1.15E+00	1.15E+00	1.15E+00	1.15E+00	1.15E+00	1.15E+00	1.15E+00
Polonium-210	1.16E+00	1.16E+00	1.17E+00	1.17E+00	1.17E+00	1.17E+00	1.17E+00	1.17E+00	1.17E+00

Note:

a) Estimated from uranium using the specific activity of 12356 Bq/g and assuming secular equilibrium between uranium-238 and uranium-234.

b) Unit conversion from mg/s to Bq/s using the specific activity of 7.47E+08 Bq/g which was calculated from its half-life of 77000 y.

c) Unit conversion from mg/s to Bq/s using the specific activity of 3.66E+10 Bq/g which was calculated from its half-life of 1600 y.

d) Assuming equilibrium between radium-226 and lead-210 due to the long half-life of radium-226.

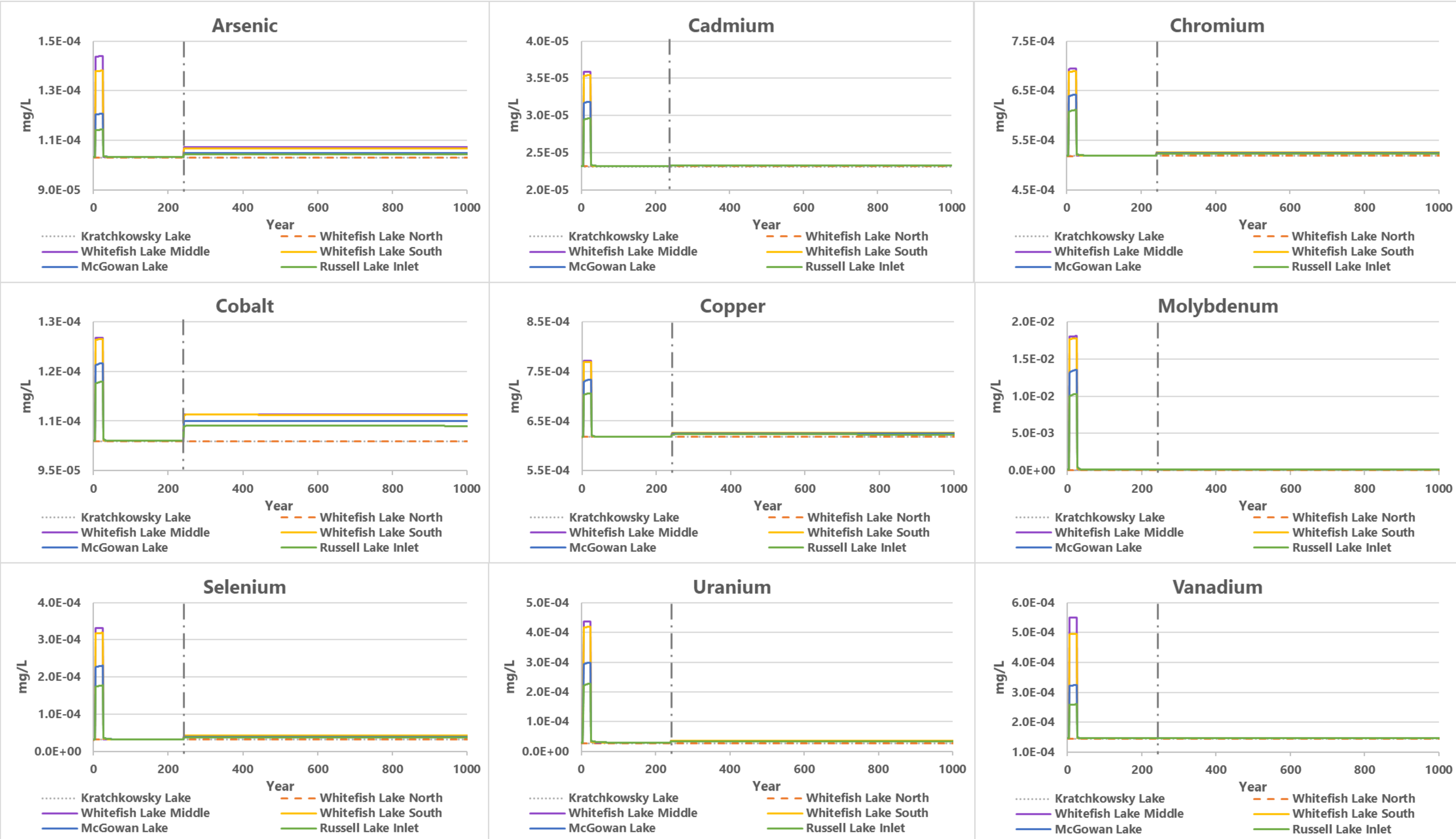
e) Calculated from lead-210 assuming transient equilibrium between lead-210 and polonium-210.

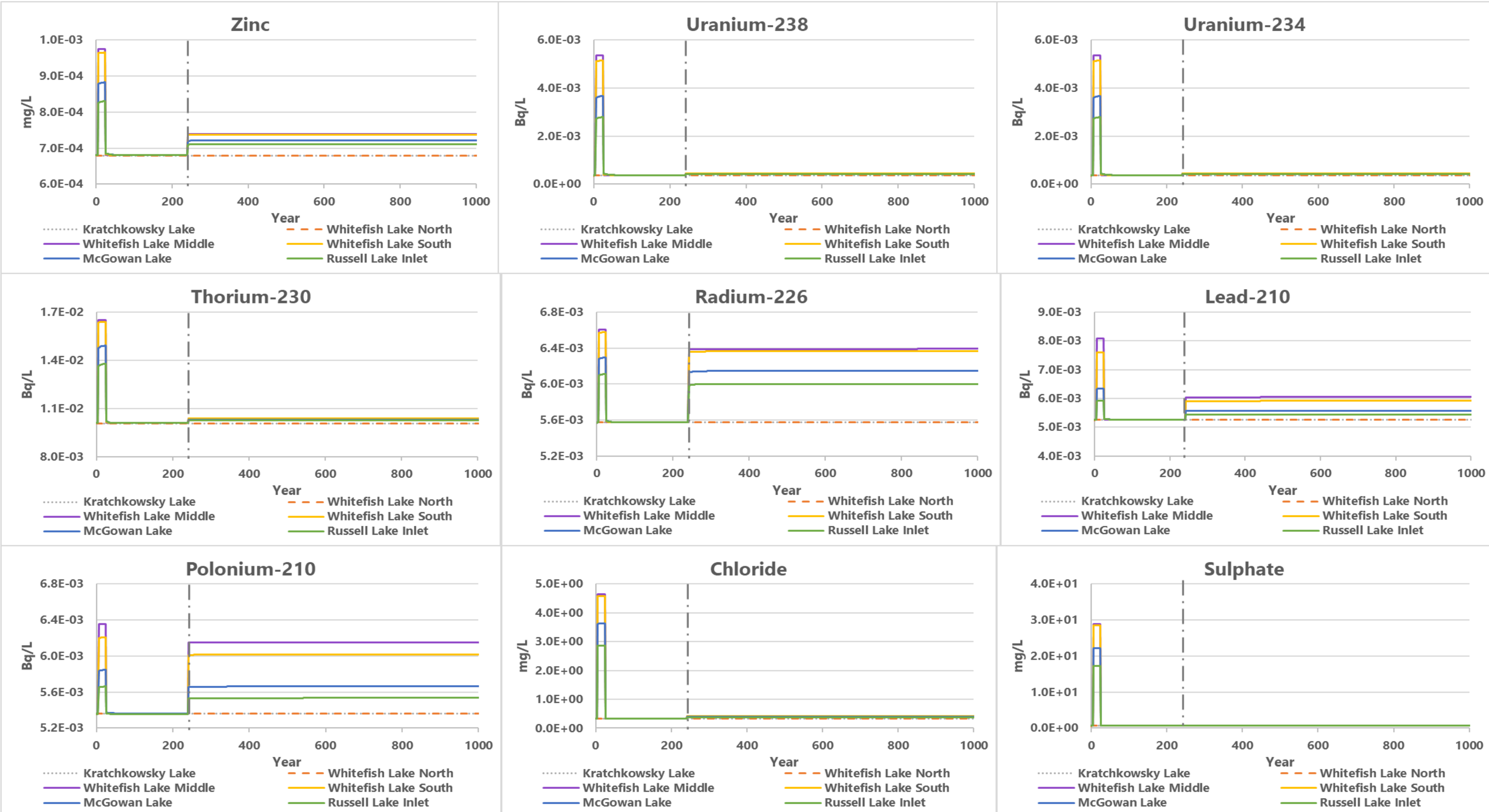
Table 3-5: Maximum Concentration of COPCs in Water and Sediment during Future Centuries

Environmental Media	Location	Maximum Concentration of Non-radionuclides during Project Phases											
		Arsenic	Cadmium	Chloride	Cobalt	Chromium	Copper	Molybdenum	Sulphate	Selenium	Uranium	Vanadium	Zinc
Water (mg/L)	Quality Guideline	5.00E-03	4.00E-05	1.20E+02	2.95E-04	1.00E-03	2.00E-04	7.60E+00	1.28E+02	1.00E-03	1.50E-02	1.20E-01	1.30E-02
	Kratchkowsky Lake	1.03E-04	2.32E-05	3.22E-01	1.01E-04	5.19E-04	6.18E-04	1.07E-04	6.87E-01	3.23E-05	3.01E-05	1.46E-04	6.81E-04
	Whitefish Lake North	1.03E-04	2.32E-05	3.22E-01	1.01E-04	5.19E-04	6.18E-04	1.07E-04	6.87E-01	3.23E-05	3.01E-05	1.46E-04	6.81E-04
	Whitefish Lake Middle	1.07E-04	2.33E-05	4.15E-01	1.06E-04	5.26E-04	6.26E-04	1.16E-04	7.21E-01	4.30E-05	3.68E-05	1.47E-04	7.40E-04
	Whitefish Lake South	1.07E-04	2.33E-05	4.14E-01	1.06E-04	5.26E-04	6.26E-04	1.16E-04	7.20E-01	4.26E-05	3.65E-05	1.47E-04	7.37E-04
	McGowan Lake	1.05E-04	2.33E-05	3.93E-01	1.05E-04	5.24E-04	6.24E-04	1.14E-04	7.13E-01	3.94E-05	3.45E-05	1.46E-04	7.21E-04
	Icelander River	1.05E-04	2.33E-05	3.92E-01	1.05E-04	5.24E-04	6.24E-04	1.14E-04	7.13E-01	3.94E-05	3.45E-05	1.46E-04	7.21E-04
	Russell Lake Inlet	1.04E-04	2.32E-05	3.76E-01	1.04E-04	5.23E-04	6.23E-04	1.12E-04	7.07E-01	3.76E-05	3.33E-05	1.46E-04	7.11E-04
Sediment (mg/kg dw)	Quality Guideline	2.10E+01	6.00E-01	n/a	n/a	3.15E+01	2.20E+01	2.30E+01	n/a	3.60E+00	9.70E+01	3.51E+01	1.23E+02
	Kratchkowsky Lake	8.35E+00	3.38E-01	n/a	2.52E-01	5.86E+00	1.85E+00	3.37E-01	n/a	6.22E-01	5.78E-01	1.12E+01	9.93E+00
	Whitefish Lake North	8.35E+00	3.38E-01	n/a	2.52E-01	5.86E+00	1.85E+00	3.37E-01	n/a	6.22E-01	5.78E-01	1.12E+01	9.93E+00
	Whitefish Lake Middle	8.66E+00	3.40E-01	n/a	2.65E-01	5.94E+00	1.87E+00	3.68E-01	n/a	8.28E-01	7.07E-01	1.13E+01	1.08E+01
	Whitefish Lake South	8.62E+00	3.40E-01	n/a	2.65E-01	5.93E+00	1.87E+00	3.67E-01	n/a	8.19E-01	7.02E-01	1.13E+01	1.08E+01
	McGowan Lake	8.48E+00	3.39E-01	n/a	2.62E-01	5.91E+00	1.87E+00	3.60E-01	n/a	7.59E-01	6.64E-01	1.13E+01	1.05E+01
	Russell Lake Inlet	8.43E+00	3.39E-01	n/a	2.59E-01	5.90E+00	1.86E+00	3.55E-01	n/a	7.22E-01	6.41E-01	1.12E+01	1.04E+01

Environmental Media	Location	Maximum Concentration of Radionuclides during Project Phases					
		Uranium-238	Uranium-234	Thorium-230	Radium-226	Lead-210	Polonium-210
Water (Bq/L)	Quality Guideline	n/a	n/a	n/a	1.10E-01	n/a	n/a
	Kratchkowsky Lake	3.71E-04	3.71E-04	1.01E-02	5.57E-03	5.27E-03	5.36E-03
	Whitefish Lake North	3.71E-04	3.71E-04	1.01E-02	5.57E-03	5.27E-03	5.36E-03
	Whitefish Lake Middle	4.54E-04	4.54E-04	1.04E-02	6.39E-03	6.05E-03	6.15E-03
	Whitefish Lake South	4.51E-04	4.51E-04	1.04E-02	6.37E-03	5.92E-03	6.02E-03
	McGowan Lake	4.26E-04	4.26E-04	1.03E-02	6.15E-03	5.57E-03	5.66E-03
	Icelander River	4.26E-04	4.26E-04	1.03E-02	6.14E-03	5.56E-03	5.64E-03
	Russell Lake Inlet	4.12E-04	4.12E-04	1.03E-02	6.00E-03	5.45E-03	5.53E-03
Sediment (Bq/kg dw)	Quality Guideline	n/a	n/a	n/a	6.00E+02	9.00E+02	8.00E+02
	Kratchkowsky Lake	7.14E+00	7.14E+00	2.32E+01	6.51E+01	3.74E+02	3.80E+02
	Whitefish Lake North	7.14E+00	7.14E+00	2.32E+01	6.51E+01	3.74E+02	3.80E+02
	Whitefish Lake Middle	8.74E+00	8.74E+00	2.38E+01	7.47E+01	4.29E+02	4.36E+02
	Whitefish Lake South	8.67E+00	8.67E+00	2.38E+01	7.44E+01	4.19E+02	4.27E+02
	McGowan Lake	8.20E+00	8.20E+00	2.36E+01	7.18E+01	3.95E+02	4.01E+02
	Russell Lake Inlet	7.92E+00	7.92E+00	2.35E+01	7.01E+01	3.86E+02	3.93E+02

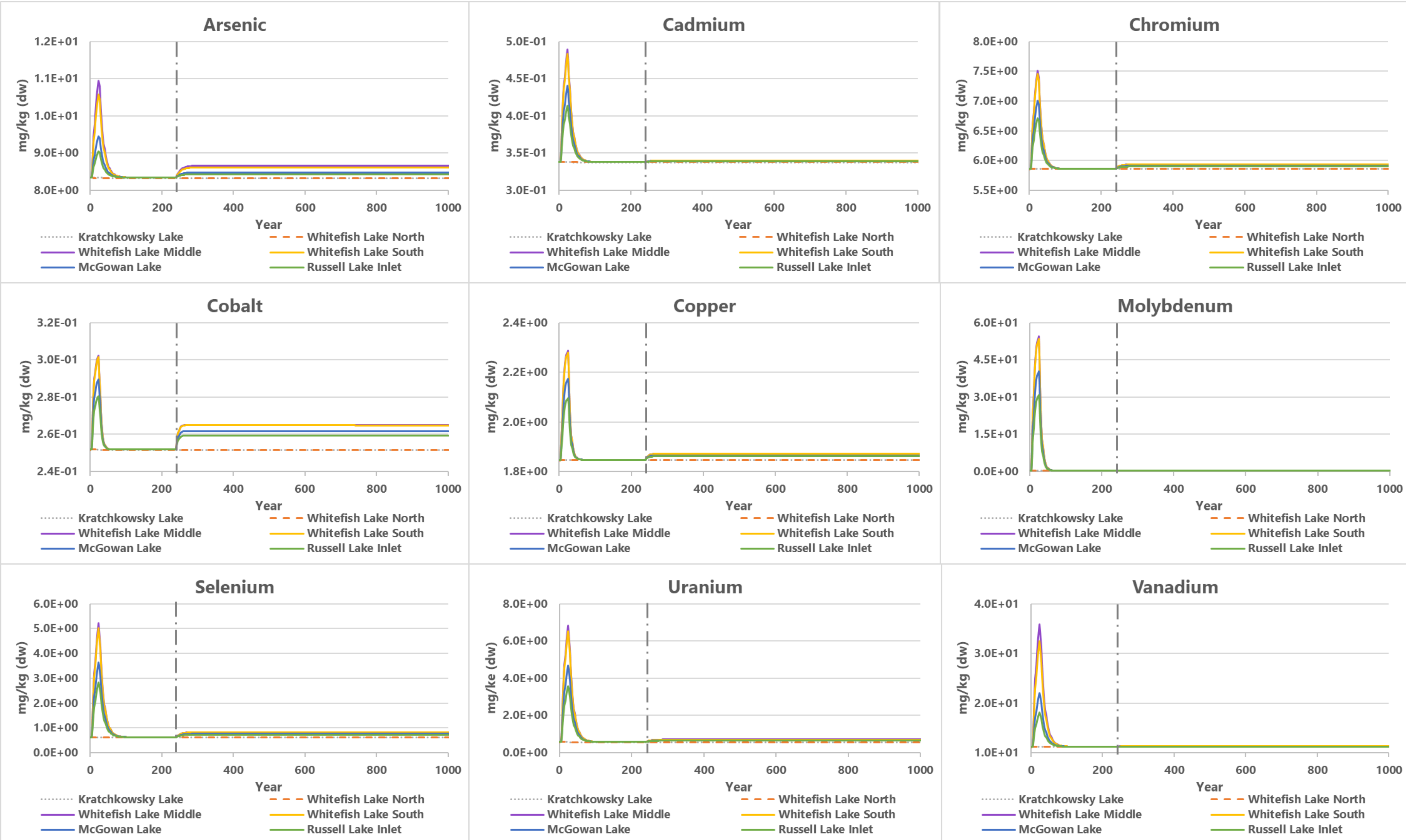
n/a = not applicable
Water quality guidelines are as shown in Table 3-1 and sediment quality guidelines are as shown in Table 3-6.

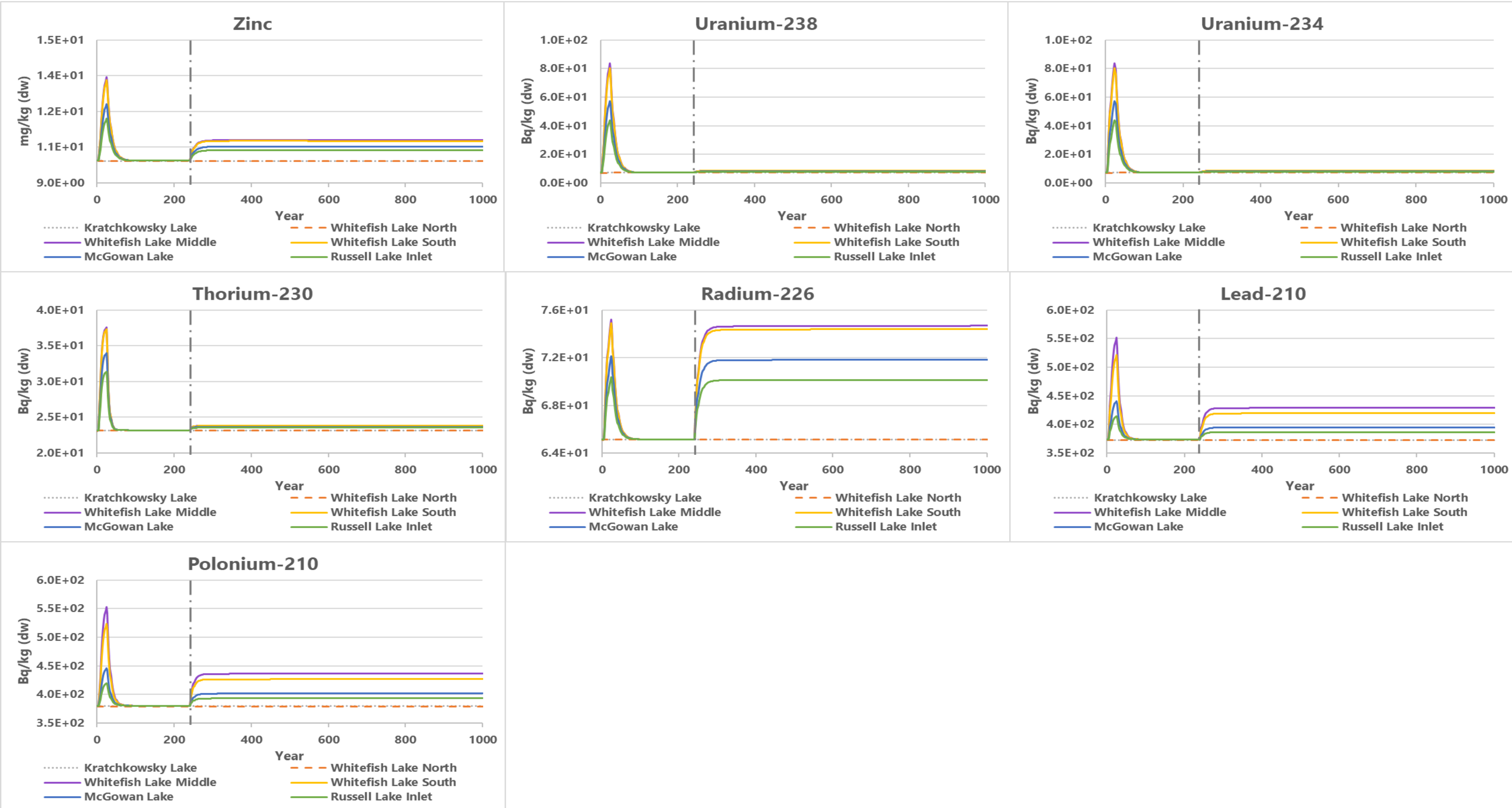

Arsenic
1.5E-04
1.3E-04
1.1E-04
9.0E-05
mg/L
0
200
400
600
800
1000
Year
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Cadmium
4.0E-05
3.5E-05
3.0E-05
2.5E-05
2.0E-05
mg/L
Year
Chromium
7.5E-04
6.5E-04
5.5E-04
4.5E-04
mg/L
Year
Cobalt
1.3E-04
1.2E-04
1.1E-04
9.5E-05
mg/L
Year
Copper
8.5E-04
7.5E-04
6.5E-04
5.5E-04
mg/L
Year
Molybdenum
2.0E-02
1.5E-02
1.0E-02
5.0E-03
0.0E+00
mg/L
Year
Selenium
4.0E-04
3.0E-04
2.0E-04
1.0E-04
0.0E+00
mg/L
Year
Uranium
5.0E-04
4.0E-04
3.0E-04
2.0E-04
1.0E-04
0.0E+00
mg/L
Year
Vanadium
6.0E-04
5.0E-04
4.0E-04
3.0E-04
2.0E-04
1.0E-04
mg/L
Year



Long dash dot lines represent the beginning of the future centuries period when the groundwater solutes reach Whitefish Lake.

Figure 3-4: Modelled Concentrations of COPCs in Water during Future Centuries


Arsenic
mg/kg (dw)
1.2E+01
1.1E+01
1.0E+01
9.0E+00
8.0E+00
Cadmium
5.0E-01
4.5E-01
4.0E-01
3.5E-01
3.0E-01
Chromium
8.0E+00
7.5E+00
7.0E+00
6.5E+00
6.0E+00
5.5E+00
Cobalt
3.2E-01
3.0E-01
2.8E-01
2.6E-01
2.4E-01
Copper
2.4E+00
2.2E+00
2.0E+00
1.8E+00
Molybdenum
6.0E+01
4.5E+01
3.0E+01
1.5E+01
0.0E+00
Selenium
6.0E+00
5.0E+00
4.0E+00
3.0E+00
2.0E+00
1.0E+00
0.0E+00
Uranium
mg/ke (dw)
8.0E+00
6.0E+00
4.0E+00
2.0E+00
0.0E+00
Vanadium
4.0E+01
3.0E+01
2.0E+01
1.0E+01
0
200
400
600
800
1000
Year
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet



Long dash dot lines represent the beginning of the future centuries period when the groundwater solutes reach Whitefish Lake.

Figure 3-5: Modelled Concentrations of COPCs in Sediment during Future Centuries

3.1.2.3 Constituents of Potential Concern in Sediment

A sediment screening was performed as a secondary check to determine if there are any constituents not identified as COPCs in the surface water screening that would be identified as COPCs based on exceedances of sediment quality guidelines. Predicted maximum concentrations of constituents of interest in sediment were compared against sediment quality guidelines for the protection of aquatic life and other relevant screening values. Sediment concentrations were predicted from surface water concentrations using IMPACT according to the equations outlined in the IMPACT model (Appendix A).

Sediment quality screening values were selected based on the following of sources:

- reference (REF) and no-effect (NE2) sediment quality values from Burnett-Seidel and Liber (Burnett-Seidel and Liber, 2013);
- lowest effect levels (LELs) and severe effect levels (SELs) from Thompson et al. (Thompson et al., 2005); and
- Canadian interim sediment quality guidelines (ISQGs) and probable effect levels (PELs) from the CCME (CCME, 1999a).

Burnett-Seidel and Liber (2013) was selected as the preferred source, as the reported NE2 and REF values are specifically applicable to Saskatchewan waterbodies. The REF values refer to locations upstream of mining or milling activities or located within separate but nearby drainages. Exceedances of REF values indicate that sediments downstream of predicted discharges contain elevated metal concentrations compared to natural background conditions. The NE2 values refer to exposed (lightly contaminated) areas with elevated concentrations but no significant effect on benthic invertebrate abundance, richness, and evenness. Concentrations below the NE2 values indicate that benthic invertebrate community metrics (abundance, richness, and evenness) downstream of discharges are not expected to differ significantly (less than 20% difference) from those observed at natural background conditions.

Two tiers of sediment quality guidelines are defined by Thompson et al. (2005): LELs and SELs. The CCME also provides two tiers of guidelines in sediments: ISQGs and PELs. If a predicted COPC concentration in sediment is less than the LEL or ISQG, adverse effects on benthic invertebrate communities are not anticipated for that constituent. Predicted concentrations in sediments that exceed the LEL or ISQG would not necessarily indicate that adverse effects are occurring but suggest that further investigation is warranted. These levels were, therefore, used for screening levels where there were no available REF levels.

An exceedance of a PEL or SEL is more likely to be associated with ecological effects. The SEL has been interpreted by some practitioners to be the specific COPC concentration in sediment that the majority of benthic organisms are not expected to tolerate (Persaud et al., 1993). The PEL is defined as the concentration of a COPC above which adverse effects are expected to occur frequently (more than approximately 50% of adverse effects occur above the PEL; (CCME, 1995)).

The sediment screening (Table 3-6) focused on COPCs identified in the surface water screening as exceeding screening values, and on other constituents of interest from other uranium mining and milling operations. Based on comparison of maximum predicted sediment quality in Whitefish Lake (LA-5) against the REF values from Burnett-Seidel and Liber (2013), molybdenum and selenium would exceed the REF values; however, they are not predicted to exceed the NE2 values. Molybdenum and selenium were already identified as COPCs based on the surface water screening, and are assessed further in the quantitative ERA, considering both water and sediment concentrations. The maximum vanadium concentration in sediment is 37.2 mg/kg dw in Whitefish Lake (LA-5), which exceeds its sediment quality guideline of 35.1 mg/kg dw (REF value from Burnett-Seidel and Liber, 2013). Therefore, vanadium was identified as a COPC in sediment. Note that, as indicated above, exceedances of REF values do not necessarily indicate effects, but indicate that sediments downstream of predicted discharges contain elevated metal concentrations compared to natural background conditions.

There is no sediment screening value for cobalt; however, cobalt has already been identified as a COPC in surface water. As such, it will be subject to further quantitative assessment in the ERA, considering both water and sediment concentrations.

Predicted concentrations of all other COPCs do not exceed sediment quality guidelines. The COPCs that were already considered COPCs based on the results of the surface water screening, as well as vanadium based on the results of the sediment screening, were evaluated further in the ERA, considering both water and sediment concentrations.

Table 3-6: Sediment Quality Screening for the Wheeler River Project

Constituent	Units	Maximum – Whitefish Lake (LA-5)	Sediment Quality Guidelines						Selected Sediment Screening Value	Is Concentration Greater than Selected Screening Value? (Y/N)
			Burnett-Seidel and Liber[b]		Thompson et al.[c]		CCME[d]			
			REF	NE2	LEL	SEL	ISQG	PEL		
Metals and Metalloids										
Arsenic	mg/kg dw	11.03	21	522	9.8	346	5.9	17	21	No
Cadmium	mg/kg dw	0.50	n/d	n/d	n/d	n/d	0.6	3.5	0.6	No
Chromium	mg/kg dw	7.59	31.5	26.2	47.6	115.4	37.3	90	31.5	No
Cobalt	mg/kg dw	0.30	n/d	n/d	n/d	n/d	n/d	n/d	n/d	n/a
Copper	mg/kg dw	2.31	9.1	11.3	22	268.8	35.7	197	9.1	No
Lead	mg/kg dw	10.24	16.3	19.7	37	412	35	91.3	16.3	No
Molybdenum	**mg/kg dw**	**57.20**	**23**	**245**	**14**	**1,239**	**n/d**	**n/d**	**23**	**Yes**
Nickel	mg/kg dw	4.08	21	326	23	484	n/d	n/d	21	No
Selenium	**mg/kg dw**	**5.48**	**3.6**	**30**	**1.9**	**16**	**n/d**	**n/d**	**3.6**	**Yes**
Uranium	mg/kg dw	7.18	97	2,296	104	5,874	n/d	n/d	97	No
Vanadium	**mg/kg dw**	**37.20**	**35.1**	**31.8**	**35.2**	**160**	**n/d**	**n/d**	**35.1**	**Yes**
Zinc	mg/kg dw	13.63	n/d	n/d	n/d	n/d	123	315	123	No
Radionuclides										
Uranium-234	Bq/kg dw	88.20	n/d	n/d	n/d	n/d	n/d	n/d	n/d	n/a
Uranium-238	Bq/kg dw	88.20	n/d	n/d	n/d	n/d	n/d	n/d	n/d	n/a
Thorium-230	Bq/kg dw	38.27	n/d	n/d	n/d	n/d	n/d	n/d	n/d	n/a
Radium-226	Bq/kg dw	75.71	n/d	n/d	600	14,400	n/d	n/d	600	No
Lead-210	Bq/kg dw	556.58	n/d	n/d	900	20,800	n/d	n/d	900	No
Polonium-210	Bq/kg dw	558.00	n/d	n/d	800	12,100	n/d	n/d	800	No

Bold and Grey shading indicates sediment concentration exceeds the REF or LEL value.

a) Sediment concentrations predicted based on release of aqueous source-terms to LA-5 and interaction with sediment. Modelling performed in IMPACT according to the equations outlined in Appendix A.

b) Burnett-Seidel and Liber (2013) – Sediment quality values derived for application at Saskatchewan uranium operations; reference (REF) values based on reference sites unaffected by mining and milling (representing background), and no-effect level (NE2) values based on sites with no significant difference in benthic invertebrate community effects criteria of abundance, richness and evenness between reference and exposure locations.
c) Thompson et al. (2005) – Sediment quality guidelines derived for application to uranium ore bearing regions of northern Saskatchewan and Ontario; lowest effect levels (LELs) and severe effect levels (SELs) from the "weighted method".
d) CCME – Canadian Sediment Quality Guidelines for the Protection of Freshwater Aquatic Life (CCME, 1999a); updated September 2007; accessed July 2021: **http://ceqg-rcqe.ccme.ca/**).

3.2 Atmospheric Sources

The Project has the potential to change air quality through the emission of gases and particulates as well as deposition of particulates generated by Project activities. For emission to the atmosphere, the ERA focused on the Construction, Operation and Decommissioning phases when effects on air quality are expected to be the greatest due to the intensity and number of Project-related activities.

The Project-related atmospheric releases considered in the ERA were consistent with the air emissions inventory detailed in the Air Quality Impact Assessment (EIS Section 6). The emissions will vary over time based on the schedule of Project activities. The major air emission sources considered for the ERA include the following:

- fossil fuel combustion emissions from mobile equipment and stationary equipment (e.g., generators, heaters, vehicle and equipment movements);
- fugitive dust emissions from drilling and blasting, material handling, crushing, vehicle-generated road dust, and wind erosion from waste piles;
- air emissions released from processing (e.g., the ISR calciner, dryer and hygiene scrubber stacks); and
- removal of site infrastructure and reclamation of waste piles and other storage areas/ponds during the decommissioning phase.

Project-related atmospheric releases would include criteria air contaminants (CACs; nitrogen oxides [assessed as nitrogen dioxide], sulphur dioxide, hydrogen sulphide, ozone, carbon monoxide, total suspended particulates [TSP], and fine particulate matter [PM_{10} and $PM_{2.5}$]), metals including uranium in dust, and radon.

Criteria air contaminants have either federal or provincial ambient air quality criteria or both. Nitrogen oxides, sulphur dioxide, carbon monoxide, and particulates (TSP, PM_{10}, and $PM_{2.5}$) would be CACs directly emitted by the Project from stationary and mobile sources. Sources of hydrogen sulphide and ozone are expected to be negligible and therefore were not retained for further assessment of impacts to air quality.

Particulates would be associated with such activities as road dust from unpaved roads; wind erosion; materials handling; dozing at the wellfield and waste pads; the ISR calciner, dryer and hygiene scrubber stacks (dusts emitted in the form of yellowcake); and construction activities. Particulates would be measured in terms of TSP, PM_{10}, and $PM_{2.5}$.

Metals would be emitted as a portion of dust. Dust emissions were assumed to contain metals from emissions from wellfield drilling in mineralized waste, wind erosion from the mineralized waste pad, material handling at the wellfield and mineralized waste pad, and stack emissions from the ISR Plant (the dryer, calciner, and hygiene scrubber stacks).

Long-lived radioactive dust is of primary concern at the back end of the ISR process, since the process is wet until the yellowcake product (uranium oxides) is precipitated out of solution and dried. The long-lived species of concern at that point are uraniuim-238 and uranium-234. The uranium mass is almost entirely uraniuim-238; on an activity basis, uranium-238 and uranium-234 contribute equal activity. It was assumed that other radionuclides in the uranium-238 decay chain would not be present at the point of release but decay and ingrowth is accounted for over time at the point of exposure.

Radon emissions from a number of sources were included in the air quality assessment: wellfield drilling, groundwater exposure to the atmosphere, mining solution venting from wellheads and leaking transport piping, radon surge tank venting, recovered solution pond, ISR plant ventilation, and the mineralized waste and Fe-Ra precipitates storage pads.

3.2.1 Screening for Constituents of Potential Concern

Constituents of potential concern for air, as defined by Health Canada (Health Canada, 2016a), are chemicals whose concentration(s) may become elevated in ambient air as a result of project-related activities, and which have the potential for adverse human or ecological health effects based on documented scientific evidence or suspected causal relationships. The purpose of this section is to identify those Project-related constituents in air that may be of concern for human and/or ecological health and require further assessment.

The screening of air quality constituents was based on maximum predicted concentrations of CACs, metals including uranium, radon, and maximum dust deposition, at air quality model locations that correspond with receptor locations (Table 3-7 below, see Figure 2 in Air Quality Impact Assessment, Section 6 of the EIS), as described in Section 4.2.1, Exposure Locations, Duration, and Frequency, for the human health risk assessment, and Section 5.2.1, Exposure Locations, for the ecological risk assessment.

Maximum predicted concentrations are total concentrations, including background, except for radon which is an incremental concentration.

Table 3-7: Concordance between Air Quality Model and Receptor Locations

Air Quality Model Location	Human and Ecological Receptor Location	Air Quality Model Coordinates	
		X (m)	Y (m)
Risk1	Ecological Location – On-site	477708	6374351
Risk2	Human Location – Recreational Fisher/Trapper (Seasonal resident at McGowan Lake [LA-1])	478245	6372039
Risk3	Human Location – Camp Worker	476896	6373487
Risk4	Human location – Seasonal Resident (Russell Lake)	478415	6368289
Risk5	Human location – Reference Receptor (LA-7)	473146	6375099

Human and ecological receptors at receptor locations were assumed to be in contact with air emissions for prolonged periods of time, at intervals that may be long-term (i.e., annual average) or repeated and short-term (i.e., 24 hours or less) over a lifetime. For this reason, long-term and short-term screening values at the receptor locations were used for the screening of constituents in air at receptor locations.

In addition to the specific receptor locations shown in Table 3-7 above, the screening also considered a fenceline receptor (a receptor at the Project boundary) for short-term exposures (i.e., 24 hours or less). Although the Wheeler River site is remote and access to the site fenceline by a receptor, other than at the locations of trails or roads is unlikely, receptors were assessed along the fenceline boundary. For each air constituent, concentrations were predicted all along the project fenceline boundary and the highest predicted concentration was retained as the maximum for screening purposes. This means that the “fenceline” receptor could occur in different discrete locations for different constituents.

Screening of constituents in air for the receptor locations was based on maximum predicted concentrations for all receptor locations for the relevant time period, as follows:

1. If the model results from the Air Quality Impact Assessment (EIS Section 6) for a constituent were below its relevant air quality screening values for all averaging times at all receptor locations, the constituent was assumed to be below levels associated with potential human health and ecological risks and was not considered further in the ERA for direct atmospheric exposures.

2. If the model result for an air quality constituent was greater than any one of its relevant air quality screening values at any receptor location, the constituent was evaluated further in secondary screening to determine if it should be carried forward as a COPC for quantitative risk assessment.

3.2.1.1 Screening Value Selection

Ambient air quality criteria are available for different exposure averaging periods (e.g., 1-hour, 24-hour, annual). Ambient air quality criteria for the relevant averaging periods were selected based on the following hierarchy:

- Saskatchewan Ambient Air Quality Standards (SAAQS) are maximum concentrations in ambient air from all sources as stipulated in *The Clean Air Regulations* (Government of Saskatchewan, 2015).

- Alberta Ambient Air Quality Objectives (AAAQO) are based on an evaluation of scientific, social, technical, and economic factors (Alberta, 2021).

- Ontario Ambient Air Quality Criteria (OAAQC) are concentrations of a constituent in air that are protective against adverse effects on health and/or the environment (MECP, 2020).

- Texas effects screening levels (ESLs) are air concentrations at or below which adverse health effect in the general public, including sensitive subgroups such as children, the elderly, pregnant women, and people with pre-existing health conditions, are not likely to occur (TCEQ, 2016).

Canadian Ambient Air Quality Standards (CAAQS) established under the national Air Quality Management System were considered as screening criteria, as appropriate.

Screening values for radionuclide concentrations in ambient air were not available. All relevant radionuclides were assessed in the ERA in terms of their contribution to the total radiological dose to human and ecological receptors.

As noted in the Air Quality assessment, the Ontario criteria for uranium in PM_{10} were conservatively selected given that the literature suggests that the particle size distribution for yellowcake is 80% less than PM_{10} (US EPA, 1980). The predictions for all other metals were compared to criteria based on TSP.

The selected ambient air quality screening values for different averaging periods, their source, and their rationale in terms of potential effects are summarized in Table 3-8. Where multiple sources recommended the same criterion value, each of the relevant sources is identified. The rationale provided in Table 3-8 for each of the selected screening values describes the sensitive effect that is the basis for the value cited by the relevant source.

Table 3-8: Screening Values for the Selection of Air Quality Constituents of Potential Concern for the Environmental Risk Assessment

Constituent	Averaging Period	Selected Screening Value	Source	Rationale
CACs				
Nitrogen dioxide (NO_2)	1 hour	300 (79)	SAAQS/AAAQO (CAAQS 2025)	Respiratory effects
	24-hour	200	SAAQS/OAAQC	Human health
	Annual	45 (23)	SAAQS/AAAQO (CAAQS 2025)	Vegetation
Sulphur dioxide (SO_2)	1 hour	450 (170)	SAAQS/AAAQO (CAAQS 2025)	Pulmonary function
	24-hour	125	SAAQS/AAAQO	Human health
	Annual	20 (11)	SAAQS/AAAQO (CAAQS 2025)	Ecosystem health
Carbon monoxide (CO)	1 hour	15000	SAAQS/AAAQO	Oxygen carrying capacity of blood
	8-hour	6000	SAAQS/AAAQO	Oxygen carrying capacity of blood
Total suspended particulates (TSP)	24-hour	100	SAAQS/AAAQO	Human health. Pulmonary effects
	Annual	60	SAAQS/OAAQC	Visibility
Particulate matter (PM_{10})	24-hour	50	SAAQS/OAAQC	Human health
Particulate matter ($PM_{2.5}$)	24-hour	27	OAAQC/CAAQS	Human health
	Annual	8.8	OAAQC/CAAQS	Human health
Dustfall				
TSP deposition	Annual	4.6	OAAQC	Dustfall criterion. Aesthetics (g/m^2/yr)
	30-day	2	SAAQS	Aesthetics (mg/cm^2/30 days)
Radionuclides				
	24-hour	n/v	n/a	Addressed in terms of radiation dose in the ERA

Constituent	Averaging Period	Selected Screening Value	Source	Rationale
Thorium-230, Radium-226, Lead-210, Polonium-210	Annual	n/v	n/a	Addressed in terms of radiation dose in the ERA
Radon				
Radon	Annual	n/v	n/a	Addressed in terms of radiation dose in the ERA
Metals				
Arsenic (As)	24-hour	0.3	OAAQC	Human health. Applies to arsenic and arsenic compounds.
	Annual	0.01	AAAQO	Human health. Carcinogenic effects.
Cadmium (Cd)	24-hour	0.025	OAAQC	Human health. Applies to cadmium and cadmium compounds. Converted from the annual AAQC to allow assessment of 24-hour air quality data.
	Annual	0.005	OAAQC	Human health. Applies to cadmium and cadmium compounds.
Cobalt (Co)	24-hour	0.1	OAAQC	Human health
	Annual	n/v	n/a	n/a
Chromium (Cr)	24-hour	0.5	OAAQC	Human health. Applies to either chromium metallic, divalent, and trivalent, or to the percentage of chromium metallic, divalent, and trivalent relative to total chromium.
	Annual	n/v	n/a	n/a
Copper (Cu)	24-hour	50	OAAQC	Human health
	Annual	n/v	n/a	n/a
Molybdenum (Mo)	24-hour	120	OAAQC	Particulate – visibility; molybdenum is more likely emitted as TSP, and therefore the AAQC for TSP is applied.
	Annual	n/v	n/a	n/a

Constituent	Averaging Period	Selected Screening Value	Source	Rationale
Nickel (Ni)	24-hour	0.2	OAAQC	In TSP. Human health. Applies to nickel and nickel compounds. Converted from the annual criterion to allow assessment of the 24-hour data (TSP). Intended to protect from development of chronic effects.
	Annual	0.04	OAAQC	In TSP. Human health. Applies to nickel and nickel compounds.
	24-hour	0.1	OAAQC	In PM_{10}. Human health. Applies to nickel and nickel compounds. Converted from the annual criterion to allow assessment of the 24-hour data (PM_{10}). Intended to protect from development of chronic effects
	Annual	0.02	OAAQC	In PM_{10}. Human health. Applies to nickel and nickel compounds.
Lead (Pb)	24-hour	0.5	OAAQC	Human health. Applies to lead and lead compounds. Converted from the 30-day AAQC to allow assessment of 24-hour air quality data
	Monthly	0.2	OAAQC	Human health. Applies to lead and lead compounds. As arithmetic mean of a 30-day period.
	Annual	n/v	n/a	n/a
Selenium (Se)	24-hour	10	OAAQC	Human health
	Annual	n/v	n/a	n/a
Uranium (U)	24-hour	0.3	OAAQC	In TSP. Human health. Applies to uranium and uranium compounds. Converted from the annual AAQC to allow assessment of 24-hour air quality data.
	Annual	0.06	OAAQC	In TSP. Human health. Applies to uranium and uranium compounds.
	24-hour	0.15	OAAQC	In PM_{10}. Human health. Applies to uranium and uranium compounds. Converted from the annual AAQC to allow assessment of 24-hour air quality data.
	Annual	0.03	OAAQC	In PM_{10}. Human health. Applies to uranium and uranium compounds.
Vanadium (V)	24-hour	2	OAAQC	Human health
	Annual	n/v	n/a	n/a

Constituent	Averaging Period	Selected Screening Value	Source	Rationale
Zinc (Zn)	24-hour	120	OAAQC	Particulates
	Annual	n/v	n/a	n/a
Other				
Acrolein	1-hour	4.5	OAAQC	Human health
	24-hour	0.4	OAAQC	Human health
	Annual	0.02	US EPA IRIS	Human Health. Chronic Reference Concentration

Notes:

Units are µg/m^3 unless otherwise specified.

3.2.1.2 Screening of Air Quality Constituents

The screening of air quality constituents involved the following two types of screenings:

- Primary Screening - Comparing the predicted maximum (short or long-term) air concentrations from the air quality model at all human and ecological receptor locations against the corresponding (short or long-term) air quality criteria (Table 3-9). For the fenceline receptor, comparison of the predicted maximum (short-term) air concentrations from the air quality model against the corresponding short-term air quality criteria (Table 3-10).

- Secondary Screening - For constituents exceeding air quality criteria, screening based on consideration of the locations, receptors present, the type of criterion exceeded (short or long-term) and the frequency of exceedance.

The primary screening of air quality constituents at the human and ecological receptor locations for short- and long-term averaging periods at receptor locations is provided in Table 3-9. Both human and ecological receptors were assumed to be present for extended periods of time at these locations and therefore susceptible to both short- and long-term exposures to airborne constituents. Constituents were not considered further if the maximum predicted concentrations for both short and long-term averaging periods was less than the applicable screening value, as shown in Table 3-9.

Air quality constituents with maximum concentrations that exceeded either their short- or long-term screening value at receptor locations were nitrogen dioxide, particulate matter (TSP, PM_{10}), and uranium. Air quality constituents with maximum concentrations that exceeded their short-term screening value at the fenceline were nitrogen dioxide and particulate matter (TSP, PM_{10}). These constituents were subjected to secondary screening in Section 3.2.1.3, to identify COPCs that require further evaluation in terms of human health and/or ecological risk.

Baseline concentrations were compared to the Project air quality criteria in EIS Appendix 6-A, Table 5.

Table 3-9: Air Quality Screening for Short-term and Long-term Exposures to Constituents in Air at Human and Ecological Receptor Locations

Constituent	Maximum Concentration at Receptor Locations			Screening Value	Averaging Period	Source	Is Concentration Greater than Selected Screening Value? (Yes/No)	Considered Further in Secondary Screening? (Yes/No)
	Construction	Operation	Decommissioning					
CACs								
Nitrogen dioxide (NO_2)	17.1	11.3	16.4	23	Annual	CAAQS	**Yes (1-hour)**	**Yes. No exceedances of annual or 24-hour screening values, but there is a 1-hour exceedance at the camp worker location during all phases of the project.**
	70.6	100	120	200	24-hour	SAAQS/OAAQC		
	181	**275**	**355**	79	1-hour	CAAQS		
Sulphur dioxide (SO_2)	0.0165	0.0111	0.0174	11	Annual	CAAQS	No	No
	0.0814	0.123	0.154	125	24-hour	SAAQS/AAAQO		
	0.216	0.371	0.471	450	1-hour	SAAQS/AAAQO		
Carbon monoxide (CO)	614	639	661	6000	8-hour	SAAQS/AAAQO	No	No. Toxicity of CO is only relevant for short-term (i.e., 8 hours or less) timeframes.
	646	691	741	15000	1-hour	SAAQS/AAAQO		
TSP	48.0	20.6	22.1	60	Annual	SAAQS/OAAQC	**Yes (24-hour)**	**Yes. No exceedances of its annual screening value, but there are exceedances of the 24-hour screening value during all phases of the project.**
	286	**124**	**135**	100	24-hour	SAAQS/AAAQO		
PM_{10}	**136**	**57.0**	**61.1**	50	24-hour	SAAQS/OAAQC	**Yes (24-hour)**	**Yes. No annual screening value but considered further because it exceeds its 24-hour screening value during all phases of the project.**
$PM_{2.5}$	5.4	3.66	3.99	8.8	Annual	OAAQC/CAAQS	No	No
	21	11.0	14.5	27	24-hour	OAAQC/CAAQS		

Constituent	Maximum Concentration at Receptor Locations			Screening Value	Averaging Period	Source	Is Concentration Greater than Selected Screening Value? (Yes/No)	Considered Further in Secondary Screening? (Yes/No)
	Construction	Operation	Decommissioning					
Dustfall								
TSP deposition	0.701	0.0802	0.811	7	Annual	OAAQC Dustfall Criteria ($g/m^2/yr$)	No	No
	1.05	0.181	0.197	2	Monthly	SAAQS ($mg/cm^2/30$ days)		
Radon (Bq/m^3)								
Radon (incremental)	2.15	33.3	15.7	<7.4 to 25	Annual	EIS *Appendix 6-A*	Yes	**Yes. Assessed in terms of radiation dose in the ERA**
Metals								
Arsenic (As)	7.05E-04	7.12E-04	7.01E-04	0.01	Annual	AAAQO	No	No
	3.03E-03	3.13E-03	3.01E-03	0.3	24-hour	OAAQC		
Cadmium (Cd)	7.50E-05	7.75E-05	7.45E-05	0.005	Annual	OAAQC	No	No
	2.81E-04	3.01E-04	2.79E-04	0.025	24-hour	OAAQC		
Cobalt (Co)	2.65E-03	2.75E-03	2.64E-03	0.1	24-hour	OAAQC	No	No. No annual screening value but not considered further because it does not exceed its 24-hour screening value
Chromium (Cr)	5.82E-04	8.96E-04	5.74E-04	0.5	24-hour	OAAQC	No	No. No annual screening value but not considered further because it does not exceed its 24-hour screening value
Copper (Cu)	3.30E-01	3.35E-01	3.29E-01	50	24-hour	OAAQC	No	No. No annual screening value but not considered further because it does not exceed its 24-hour screening value

Constituent	Maximum Concentration at Receptor Locations			Screening Value	Averaging Period	Source	Is Concentration Greater than Selected Screening Value? (Yes/No)	Considered Further in Secondary Screening? (Yes/No)
	Construction	Operation	Decommissioning					
Molybdenum (Mo)	2.71E-03	2.83E-03	2.70E-03	120	24-hour	OAAQC	No	No. No annual screening value but not considered further because it does not exceed its 24-hour screening value
Nickel (Ni) in TSP	4.08E-04	4.41E-04	4.02E-04	0.04	Annual	OAAQC	No	No
	2.05E-03	2.32E-03	2.02E-03	0.2	24-hour	OAAQC	No	No
Nickel (Ni) in PM_{10}	4.08E-04	4.41E-04	4.02E-04	0.02	Annual	OAAQC	No	No
	2.05E-03	2.32E-03	2.02E-03	0.1	24-hour	OAAQC	No	No
Lead (Pb)	6.43E-03	7.48E-03	6.31E-03	0.2	Monthly	OAAQC	No	No. No annual screening value but not considered further because it does not exceed its monthly or 24-hour screening values
	1.71E-02	2.32E-02	1.66E-02	0.5	24-hour	OAAQC		
Selenium (Se)	8.11E-04	8.58E-04	8.07E-04	10	24-hour	OAAQC	No	No. No annual screening value but not considered further because it does not exceed its 24-hour screening value
Uranium (U) in PM_{10}	4.12E-03	**3.45E-02**	1.47E-03	0.03	Annual	OAAQC	**Yes (24-hour and annual)**	**Yes. Exceedances of the 24-hour screening value during the Operation phase at the on-site ecological receptor location and the camp worker location, and of the annual screening value at the on-site ecological location only.**
	2.49E-02	**2.60E-01**	1.25E-02	0.15	24-hour	OAAQC		
Vanadium (V)	5.40E-03	5.93E-03	5.35E-03	2	24-hour	OAAQC	No	No. No annual screening value but not considered further because it

Constituent	Maximum Concentration at Receptor Locations			Screening Value	Averaging Period	Source	Is Concentration Greater than Selected Screening Value? (Yes/No)	Considered Further in Secondary Screening? (Yes/No)
	Construction	Operation	Decommissioning					
								does not exceed its 24-hour screening value
Zinc (Zn)	1.13E+00	1.13E+00	1.13E+00	120	24-hour	OAAQC	No	No. No annual screening value but not considered further because it does not exceed its 24-hour screening value
<u>Other</u>								
Acrolein	4.84E-02	3.91E-02	8.29E-02	4.5	1-hour	OAAQC	No	No
	1.75E-02	1.35E-02	2.66E-02	0.4	24-hour	OAAQC	No	No
	3.19E-03	6.02E-03	2.44E-03	0.02	Annual	US EPA IRIS	No	No

Notes:
Air Concentrations are maximum predicted values (including background) from the Air Quality model for human health and ecological receptor locations Risk1 to Risk5, inclusively, for the period indicated.
Maximum Concentration values are rounded to 3 significant figures.
Units are µg/m^3 unless otherwise specified.
Bold represents air quality parameters predicted to exceed screening values at receptor locations, or parameters that did not exceed the screening level but are discussed further in the ERA.
n/c = not calculated; n/v = no value; n/a = not applicable; ERA = environmental risk assessment; SAAQS = Saskatchewan Ambient Air Quality Standards (Government of Saskatchewan 2015); AAAQO = Alberta Ambient Air Quality Objectives (Alberta 2021); OAAQC = Ontario Ambient Air Quality Criteria (MECP 2020); CAAQS = Canadian Ambient Air Quality Standards (CCME 2021b); < = less than; Bq/m^3 = becquerels per cubic metre; TSP = total suspended particulates; PM_{10} = particulate matter with a diameter of 10 microns or less; $PM_{2.5}$ = particulate matter with a diameter of 2.5 microns or less; CAC = criteria air contaminant.

Table 3-10: Air Quality Screening for Short-term Exposures to Constituents in Air at the Fenceline

Constituent	Maximum Concentration at Fenceline			Screening Value	Averaging Period	Source	Is Concentration Greater than Selected Screening Value? (Yes/No)	Considered Further in Secondary Screening? (Yes/No)
	Construction	Operation	Decommissioning					
CACs								
Nitrogen dioxide (NO_2)	42.9	46.8	42.7	200	24-hour	SAAQS/OAAQC	**Yes (1-hour)**	**Yes. There are exceedances of the 1-hour screening value during all phases of the project.**
	176	**178**	**178**	79	1-hour	SAAQS/AAAQO		
Sulphur dioxide (SO_2)	0.0329	0.0403	0.0342	125	24-hour	SAAQS/AAAQO	No	No
	0.171	0.172	0.166	170	1-hour	CAAQS		
Carbon monoxide (CO)	596	596	596	6000	8-hour	SAAQS/AAAQO	No	No. Toxicity of CO is only relevant for short-term (i.e., 8 hours or less) timeframes.
	615	614	615	15000	1-hour	SAAQS/AAAQO		
TSP	**313**	**281**	**115**	100	24-hour	SAAQS/AAAQO	**Yes (24-hour)**	**Yes. There are exceedances of the 24-hour screening value during all phases of the project.**
PM_{10}	**116**	**104**	47.4	50	24-hour	SAAQS/OAAQC	**Yes (24-hour)**	**Yes. There are exceedances of the 24-hour screening value during Construction and Operation.**
$PM_{2.5}$	16.3	15.0	10.0	27	24-hour	OAAQC/CAAQS	No	No
Radon (Bq/m³)								
Radon (incremental)	1.12	12.5	7.04	<7.4 to 25	Annual	EIS *Appendix 6-A*	No	**Yes. Assessed in terms of radiation dose in the ERA**
Metals								
Arsenic (As)	3.01E-03	3.07E-03	3.01E-03	0.3	24-hour	OAAQC	No	No

Constituent	Maximum Concentration at Fenceline			Screening Value	Averaging Period	Source	Is Concentration Greater than Selected Screening Value? (Yes/No)	Considered Further in Secondary Screening? (Yes/No)
	Construction	Operation	Decommissioning					
Cadmium (Cd)	2.78E-04	2.94E-04	2.78E-04	0.025	24-hour	OAAQC	No	No
Cobalt (Co)	2.64E-03	2.72E-03	2.64E-03	0.1	24-hour	OAAQC	No	No
Chromium (Cr)	5.62E-04	7.98E-04	5.63E-04	0.5	24-hour	OAAQC	No	No
Copper (Cu)	3.29E-01	3.33E-01	3.29E-01	50	24-hour	OAAQC	No	No
Molybdenum (Mo)	2.69E-03	2.76E-03	2.69E-03	120	24-hour	OAAQC	No	No
Nickel (Ni) in TSP	2.01E-03	2.22E-03	2.01E-03	0.2	24-hour	OAAQC	No	No
Nickel (Ni) in PM_{10}	2.01E-03	2.22E-03	2.01E-03	0.1	24-hour	OAAQC	No	No
Lead (Pb)	1.64E-02	2.05E-02	1.64E-02	0.5	24-hour	OAAQC	No	No
Selenium (Se)	8.05E-04	8.42E-04	8.05E-04	10	24-hour	OAAQC	No	No
Uranium (U) in PM_{10}	8.75E-03	**2.23E-01**	7.41E-03	0.15	24-hour	OAAQC	**Yes**	**Yes. Exceedances of the 24-hour screening value during the Operation phase at the fenceline.**
Vanadium (V)	5.34E-03	5.75E-03	5.33E-03	2	24-hour	OAAQC	No	No
Zinc (Zn)	1.13E+00	1.13E+00	1.13E+00	120	24-hour	OAAQC	No	No
<u>Other</u>								
Acrolein	4.71E-02	2.47E-02	4.01E-02	4.5	1-hour	OAAQC	No	No
	9.56E-03	5.55E-03	8.02E-03	0.4	24-hour	OAAQC	No	No

Notes:
Air Concentrations are maximum predicted values (including background) from the Air Quality model for locations along the project fenceline, for the period indicated.
Maximum Concentration values are rounded to 3 significant figures.
Units are µg/m³ unless otherwise specified.
Bold represents air quality parameters predicted to exceed screening values at receptor locations, or parameters that did not exceed the screening level but are discussed further in the ERA.

n/c = not calculated; n/v = no value; n/a = not applicable; ERA = environmental risk assessment; SAAQS = Saskatchewan Ambient Air Quality Standards (Government of Saskatchewan 2015); AAAQO = Alberta Ambient Air Quality Objectives (Alberta 2021); OAAQC = Ontario Ambient Air Quality Criteria (MECP 2020); CAAQS = Canadian Ambient Air Quality Standards (CCME 2021b); < = less than; Bq/m^3 = becquerels per cubic metre; TSP = total suspended particulates; PM_{10} = particulate matter with a diameter of 10 microns or less; $PM_{2.5}$ = particulate matter with a diameter of 2.5 microns or less; CAC = criteria air contaminant.

3.2.1.3 Secondary Screening of Air Quality Constituents

Air quality constituents that exceeded a screening value were nitrogen dioxide, particulate matter (TSP, PM_{10}), and uranium (Table 3-11). These constituents were further evaluated to determine if they require additional quantitative assessment in the ERA.

Table 3-11: Summary of Air Quality Constituents that Exceed a Screening Value

Constituent	Screening Criteria Exceeded		Predicted Exceedances at Human/Ecological Locations	Hours/Days Exceeding at Human/Ecological Locations	Frequency of Exceedance at Human/Ecological Locations
	Short-Term	Long-Term			
Nitrogen dioxide	1-hour	none exceeded	Construction: exceedance of 1-hour screening value at the camp worker location and fenceline; no 24-hour or annual exceedances Operation: exceedance of 1-hour screening value at the camp worker location and fenceline; no 24-hour or annual exceedances Decommissioning: exceedance of 1-hour screening value at the camp worker location and fenceline; no 24-hour or annual exceedances	Construction: 1-hr: 296 hours (Camp) 28 hours (fenceline) Operation: 1-hr: 402 hours (Camp) 28 hours (fenceline) Decommissioning: 1-hr: 494 hours (Camp) 25 hours (fenceline)	Construction: 1-hr: 3.4% (Camp) 0.3% (fenceline) Operation: 1-hr: 4.6% (Camp) 0.3% (fenceline) Decommissioning: 1-hr: 5.6% (Camp) 0.2% (fenceline)
Particulate Matter: TSP	24-hour	none exceeded	Construction: exceedance of 24-hour screening value at camp worker location and fenceline; no annual exceedances Operation: exceedance of 24-hour screening value at camp worker location and fenceline; no annual exceedances Decommissioning: exceedance of 24-hour screening value at camp worker location and fenceline; no annual exceedances	Construction: 24-hr: 108 days (Camp), 104 days (fenceline) Operation: 24-hr: 8 days (Camp), 80 days (fenceline) Decommissioning: 24-hr: 6 days (Camp), 2 days (fenceline)	Construction: 24-hr: 30% (Camp), 29% (fenceline) Operation: 24-hr: 2.2% (Camp), 22% (fenceline) Decommissioning: 24-hr: 1.6% (Camp), 0.5% (fenceline)
Particulate Matter: PM_{10}	24-hour	n/a	Construction: exceedance of 24-hour screening value at camp worker location and fenceline	Construction: 24-hr: 78 days (Camp), 61 days (fenceline) Operation: 24-hr: 4 days (Camp), 42 days (fenceline)	Construction: 24-hr: 21% (Camp), 17% (fenceline) Operation: 24-hr: 1.1% (Camp), 12% (fenceline)

Constituent	Screening Criteria Exceeded		Predicted Exceedances at Human/Ecological Locations	Hours/Days Exceeding at Human/Ecological Locations	Frequency of Exceedance at Human/Ecological Locations
	Short-Term	Long-Term			
			Operation: exceedance of 24-hour screening value at camp worker location and fenceline Decommissioning: exceedance of 24-hour screening value at camp worker location	Decommissioning: 24-hr: 6 days	Decommissioning: 24-hr: 1.6%
Uranium	24-hour	Annual	Construction: no exceedances Operation: exceedance of 24-hour screening value at the on-site ecological receptor location and camp worker location, also fenceline; annual exceedance at the on-site ecological location Decommissioning: no exceedances	Construction: n/a Operation: 24-hr: 8 days (Camp), 3 days (fenceline) Decommissioning: 24-hr: 5%	Construction: n/a Operation: 24-hr: 5% (Camp), 0.8% (fenceline) Decommissioning: n/a

3.2.1.3.1 Nitrogen Dioxide

Screening values were available for 1-hour, 24-hour, and annual averaging periods for nitrogen dioxide. The exceedances are summarized below, followed by a discussion of the critical effects upon which the screening values were based and an overall conclusion related to whether nitrogen dioxide was ultimately retained for further evaluation in the ERA.

Summary of Exceedances at Human/Ecological Locations

- 1-hour: Exceedances during all project phases; however, the maximum 1-hour NO_2 concentration is during the decommissioning phase. The camp worker location (Risk3) had a predicted max 1-hour NO_2 concentration during decommissioning of 355 µg/m^3, which exceeds its screening value from the CAAQS of 79 µg/m^3. Exceedances at the camp worker location were noted for a maximum of 5.6% of the year (decommissioning), which corresponds to 494 hours out of 8760 hours in a year. Exceedances were also noted for 1-hour NO_2 at the fenceline for 0.3% of the year (for approximately 28 hours per year during construction and operation), although concentrations at the fenceline were lower than at the camp worker location.

- There were no exceedances of the 24-hour or annual screening values at any human or ecological locations for any Project phase.

Health/Environmental Effect(s) for Short-term and Long-term Exposures

- Long-term (annual): As noted, there are no predicted exceedances of annual screening values at any receptor location during all Project phases; therefore, no long-term effects are expected.

- Short-term (1-hour, 24-hour): There are no predicted exceedances of 24-hr screening values at any receptor location during all Project phases; however, there are infrequent predicted exceedances of 1-hr NO_2 at the camp worker location and the fenceline. There are no exceedances at other receptor locations.

To put the exceedances of NO_2 into context, hazard quotients (HQ) for all receptors have been calculated using the 1-hr and annual CAAQSs as the toxicity reference values (see Table 3-12). HQs above 1 require further discussion. As shown in Table 3-12, HQs are below 1 for long-term NO_2 exposure at all receptor locations, and HQs exceed 1 for short-term 1-hr NO_2 exposure only for the on-site receptors (camp worker, on-site ecological location), and the fenceline receptor.

Potential adverse health effects that are attributed to short-term exposures to ambient nitrogen dioxide include asthma exacerbations and possibly increased risk of cardiopulmonary effects, and to a lesser extent cardiovascular and respiratory mortality (Health Canada, 2016b). Individuals with certain pre-existing diseases such as asthma appear to be sensitive to exposure to ambient NO_2. Although it has been suggested that there may not be a threshold for the health effects of NO_2 even considering short-term (1-hour) exposures (CCME, 2020), at least some reviews (e.g. (Hesterberg TW et al., 2009) do not support this assertion and rather support a 1-hour threshold. Hesterberg et al. (2009) completed a critical review of over 50 human clinical studies in which human volunteers (including sensitive sub-populations: the elderly, children, and asthmatics) were exposed to NO_2 at concentrations ranging from 0.1 to 3.5 ppm (equivalent to 188 to 6,580 µg/m^3 [1 ppm = 1880 µg/m^3) for periods of 30 minutes to 6 hours, often combined with exercise and co-pollutants. Their findings indicated that there is evidence of no-effect at low concentrations, and that a threshold of approximately 0.2 ppm (or 376 µg/m^3) is supported. The maximum predicted concentration of 1-hour NO_2 was 355 µg/m^3, which is less than the concentration protective for short-term exposures in asthmatics per Hesterberg et al. (2009). If sensitive individuals are present at the camp worker location or the fenceline during periods when ambient NO_2 concentrations exceed the screening value, it is possible that they could experience minor irritation of the respiratory system. These effects would be reversible and would subside after exposure.

Additionally, as reported in Health Canada (2016b), both the WHO and US EPA concluded that healthy individuals do not experience any adverse effects at concentrations up to 1 ppm (or 1880 µg/m^3), and as such would not be affected by short-term exposures to NO_2 at the concentrations predicted for the Project.

Conclusion

Overall, the predicted exceedance of the 1-hour short-term screening value for nitrogen dioxide at the camp worker location (Risk3) and the fenceline would be limited to a small percentage of the time, and any health effects would be reversible and would subside after exposure. The elevated predicted NO_2 concentrations are based on the conservative assumption that backup diesel generators will be used continuously to supply power to support site activities; however, it is anticipated that power will be obtained from the provincial grid during the Project phases. The backup diesel generators make up more than 85% of the NO_2 emission sources, with the remaining coming from vehicle/equipment combustion, propane heaters, and the ISR Plant stacks.

Other strategies to reduce NO_2 emissions will include planning vehicle and equipment routes, to minimize travel distances and limit idling, and employing standard operating procedures for equipment and machinery use, completing regular inspections of equipment machinery to make sure it is in good working order.

Denison has committed to NO_2 monitoring during all Project phases. Monitoring will include monthly collection using passive samplers, and will follow an adaptive management process to identify if (and when) more frequent monitoring would be needed.

Considering the above discussion, NO_2 was not considered for further assessment in the ERA.

Table 3-12: Predicated 1-hr and Annual NO_2 Concentrations at Receptor Locations during all Project Phases and Associated Hazard Quotients

		NO_2 1 hr Air Concentration (µg/m³)			NO_2 annual Air Concentration (µg/m³)		
Location	**Name**	**Construction**	**Operation**	**Decommissioning**	**Construction**	**Operation**	**Decommissioning**
On-Site Ecological Location	Risk1	**124.3**	**116.3**	**120.9**	8.3	4.4	7.1
Recreational Fisher/Trapper (LA1) - McGowan Lake	Risk2	43.0	40.2	41.6	4.7	4.0	4.6
Camp Worker	Risk3	**181.0**	**274.8**	**355.1**	17.1	11.3	16.4
Seasonal Resident (Russell Lake)	Risk4	22.9	24.0	22.7	4.0	3.8	4.0
Reference Receptor (LA-7)	Risk5	40.2	43.2	39.0	4.2	3.9	4.2
Fenceline	-	**176.5**	**177.7**	**177.7**	6.8	4.4	6.6
	CAAQS	**79.0**	**79.0**	**79.0**	**23.0**	**23.0**	**23.0**
		NO_2 1 hr Hazard Quotient			**NO_2 annual Hazard Quotient**		
Location	**Name**	**Construction**	**Operation**	**Decommissioning**	**Construction**	**Operation**	**Decommissioning**
On-Site Ecological Location	Risk1	**1.6**	**1.5**	**1.5**	0.4	0.2	0.3
Recreational Fisher/Trapper (LA1) - McGowan Lake	Risk2	0.5	0.5	0.5	0.2	0.2	0.2
Camp Worker	Risk3	**2.3**	**3.5**	**4.5**	0.7	0.5	0.7
Seasonal Resident (Russell Lake)	Risk4	0.3	0.3	0.3	0.2	0.2	0.2
Reference Receptor (LA-7)	Risk5	0.5	0.5	0.5	0.2	0.2	0.2
Fenceline	-	**2.2**	**2.2**	**2.2**	0.3	0.2	0.3

Notes:
Bold and shaded values indicate exceedance of the CAAQS. Hazard quotients greater than 1 are bold and shaded.
Air concentrations are obtained from EIS Section 6, Appendix 6-A.

3.2.1.3.2 Particulate Matter

Particulate matter is defined as liquid or solid particles, or a mixture of both, less than 100 µm in diameter. Particulate matter includes TSP, particulate matter less that 10 µm (PM_{10}), and particulate matter less than 2.5 µm ($PM_{2.5}$). Particulate matter in the form of TSP, PM_{10}, $PM_{2.5}$, and TSP deposition were screened. Screening values were based on 24-hour and annual averaging periods for TSP, and a 24-hour averaging period for PM_{10}. No exceedances of $PM_{2.5}$ are predicted.

3.2.1.3.2.1 Total Suspended Particulates

Screening values were available for 24-hour and annual averaging periods for TSP. The exceedances are summarized below, followed by a discussion of the critical effects upon which the screening values were based and an overall conclusion related to whether TSP was ultimately retained for further evaluation in the ERA.

Summary of Exceedances at Human/Ecological Locations

- 24-hour: During the Construction, Operation and Decommissioning phases of the project, the camp worker location (Risk3) had predicted 24-hour TSP concentrations that exceeded the screening value. Compared to the 24-hour TSP screening value of 100 µg/m^3, concentrations ranged up to 286 µg/m^3 during Construction, 124 µg/m^3 during Operation, and 135 µg/m^3 during Decommissioning. The frequency of exceedance ranged from 30% during Construction, to 2.2% and 1.6% for Operation and Decommissioning, respectively.

- There were no exceedances of the annual screening value at any human or ecological locations for any phase of the project.

Summary of Exceedances at the Fenceline

- 24-hour: During the Construction, Operation and Decommissioning phases of the project, 24-hour TSP concentrations were predicted to exceed the screening value at the fenceline. Compared to the 24-hour TSP screening value of 100 µg/m^3, concentrations ranged up to 313 µg/m^3 during Construction, 281 µg/m^3 during Operation, and 115 µg/m^3 during Decommissioning. The frequency of exceedance ranged from 29% during Construction and 22% during Operation, to 0.5% for Decommissioning.

Health/Environmental Effect(s) for Short-term and Long-term Exposures

- The 24-hour screening value of 100 µg/m^3 for TSP is an ambient air quality standard cited by both Saskatchewan and Alberta. The 24-hour ambient air quality objective is based on potential adverse pulmonary effects (Alberta, 2021). A higher 24-hour effects-based screening value of 120 µg/m^3 for TSP in ambient air is available from Ontario. The Ontario 24-hour and annual ambient air quality criteria (OAAQC) are meant to be protective of chronic effects. Ontario identifies visibility as the sensitive endpoint for the TSP OAAQC rather than human or ecological health. Elevated TSP concentrations are generally not considered to pose significant health risks because these particles are too large to be inhaled deep into the lungs; therefore, TSP was not considered for further assessment in the ERA.

Discussion and Conclusion

As described above, TSP particles are too large to be inhaled deep into the lungs and the air quality objectives for TSP are generally based on an aesthetic endpoint (visibility) rather than a health endpoint. As such, TSP was not considered further in the ERA.

3.2.1.3.2.2 Fine Particulate Matter (PM_{10})

Screening values were available for the 24-hour averaging period for PM_{10}.

Summary of Exceedances at Human/Ecological Locations

- 24-hour: During the Construction, Operation and Decommissioning phases of the project, the camp worker location (Risk3) had predicted 24-hour PM_{10} concentrations that exceeded the screening value. Compared to the 24-hour PM_{10} screening value of 50 µg/m^3, concentrations ranged up to 136 µg/m^3 during Construction, 57.0 µg/m^3 during Operation, and 61.1 µg/m^3 during Decommissioning. The frequency of exceedance ranged from 21% during Construction, to 1.1% and 1.6% for Operation and Decommissioning, respectively.

Summary of Exceedances at the Fenceline

- 24-hour: During the Construction and Operation phases of the project, 24-hour PM_{10} concentrations had predicted concentrations exceeding the screening value at the fenceline. Compared to the 24-hour TSP screening value of 50 µg/m^3, concentrations ranged up to 116 µg/m^3 during Construction and 104 µg/m^3 during Operation. The frequency of exceedance ranged from 17% during Construction to 12% for Operation.

Health/Environmental Effect(s) for Short-term and Long-term Exposures

- Human health has been shown to be the most sensitive receptor for exposure to PM_{10} in ambient air (Health Canada, 1998). Exposure to elevated concentrations of PM_{10} are associated with various respiratory and cardiovascular effects in humans. The finer particles that can be inhaled deeply into the lungs (i.e., $PM_{2.5}$) are associated with greater risk because they are more chemically active and have more complex characteristics than larger particles (Health Canada, 2016c). For example, WHO has derived its particulate matter guidelines on $PM_{2.5}$, and its guidelines for PM_{10}, assuming that 50% of PM_{10} is present as $PM_{2.5}$ (i.e., the criteria for $PM_{2.5}$ are multiplied by 2)(WHO, 2006). If individuals are present during short-term periods of elevated PM_{10} and/or $PM_{2.5}$, they may experience respiratory symptoms such as coughing or difficulty breathing, or asthma symptoms and chronic bronchitis. For most individuals, effects would be reversible and would subside after exposure.

Discussion and Conclusion

Overall, exceedances of the 24-hour short-term screening values for PM_{10} were identified at the camp worker location during Construction, Operation and Decommissioning, with infrequent exceedances occurring during Operation and Decommissioning. Exceedances of the 24-hour short-term screening values were also identified at the fenceline during Construction and Operation. There were no exceedances of $PM_{2.5}$ which is generally considered to be a more reliable indicator of potential health effects. However, health effects would be infrequent and reversible, subsiding after exposure; therefore, PM_{10} was not considered for further quantitative assessment in the ERA.

3.2.1.3.3 Uranium

Summary of Exceedances at Human/Ecological Locations

- 24-hour: During the Operation phase, the on-site ecological location (Risk1) and the camp worker location (risk3) both had predicted 24-hour uranium concentrations that exceeded the screening value. Compared to the 24-hour screening value of 0.15 µg/m^3, concentrations ranged up to 0.26 µg/m^3 at the on-site ecological location and 0.208 µg/m^3 at the camp worker location, with the frequency of exceedance at 4.7% and 2.2%, respectively. The published 24-hour criterion for uranium is converted from the annual criterion to allow for assessment of the 24-hour data.

- Annual: During the Operation phase, the on-site ecological location (Risk 1) had a predicted annual uranium concentration of 0.0345 µg/m^3 which slightly exceeds its screening value of 0.03 µg/m^3.

Summary of Exceedances at the Fenceline

- 24-hour: During the Operation phase, the fenceline had predicted 24-hour uranium concentrations that exceeded the screening value. Compared to the 24-hour screening value of 0.15 µg/m^3, concentrations ranged up to 0.223 µg/m^3 with a frequency of exceedance of 0.8%.

Health/Environmental Effect(s) for Short-term and Long-term Exposures

- Uranium can be toxic to humans due to its chemical and radiological properties. The ambient air quality criteria for uranium (Ontario MOE, 2011) are based on non-radiological effects; kidney toxicity was the most sensitive endpoint associated with chronic exposure to uranium in air.

Discussion and Conclusion

The health effects associated with uranium (kidney toxicity) are linked to chronic exposures. However, there were no exceedances of the annual screening value at any potential human receptor location. Exceedances of the short-term, 24-hour screening value were identified at the camp worker location (Risk3) and the fenceline. However, these exceedances were infrequent, and as such uranium was not retained for further consideration in the ERA.

Uranium concentrations exceeded both the 24-hour and annual screening values at the on-site ecological location (Risk1). Given its exceedance of an annual screening value and that uranium is a metal and persistent in the environment, there is the potential that long-term generation of uranium in dust may contribute to deposition onto soil and subsequent uptake into the food chain. This pathway was assessed in Section 3.2.1.5 related to the screening of COPCs in soil.

3.2.1.4 Constituents of Potential Concern in Air

There were no non-radiological COPCs identified for further quantitative assessment in the air pathway. The secondary screening of NO_2, PM_{10} and uranium indicated that although there are exceedances of air quality screening values, these constituents are unlikely to be associated with a human health or environmental risk and as such were not carried forward as COPCs in air.

The only COPCs identified for air include radionuclides and radon due to public interest and not due to exceeding a screening value.

3.2.1.5 Constituents of Potential Concern in Soil

No specific COPCs were retained from the screening of atmospheric constituents; however, as a secondary check, mine-related metals which could potentially partition from air to soil were further assessed in terms of concentration in soil (Table 3-13).

The soil type selected for modeling of deposition to soil is sandy soil, consistent with baseline studies that describe sandy and gravelly Podzols, Brunisols, and Luvisols occurring on till materials, while sand and sandy loam Brunisols have developed on glaciofluvial deposits (Omnia, 2020).

Predicted soil concentrations were estimated from atmospheric deposition, using the maximum air concentrations at the on-site ecological receptor location (Table 3-14), along with constituent-specific deposition rates, according to the equations defined in the IMPACT Model Report (Appendix A, Section 2.3.4, Terrestrial Pathways). The on-site ecological receptor location has the highest concentration of metals in air compared to other locations assessed, and represents a worst-case location for deposition modelling.

Predicted maximum concentrations of constituents in soil from atmospheric deposition were compared against soil quality guidelines. The selected soil quality guidelines were the federal CCME (CCME, 1999b) soil quality guidelines for protection of human health and environmental health. Agricultural soil quality values were used, because these guidelines account for soil to plant uptake and ingestion of plants by birds and mammals. As shown in Table 3-13, all predicted soil concentrations were below the CCME soil quality guidelines. As such, no additional COPCs were identified for further quantitative assessment in the ERA based on the soil pathway. However, considering the multi-media pathways analysis, all terrestrial pathways (other than air inhalation) were considered further for the COPCs identified in the aquatic environment.

A summary of the maximum modelled concentrations at human and ecological receptor locations of interest is shown in Table 3-14.

Table 3-13: Soil Quality Screening for the Wheeler River ERA

Parameter	Maximum Predicted Air Concentrations (a)	Maximum Predicted Soil Concentration from Atmospheric Deposition(b)	Soil Screening Guideline(c)				Is Concentration Greater than Selected Screening Value? (Y/N)
			Agricultural	Residential/ Parkland	Commercial	Industrial	
Non-radionuclides	**µg/m³**	**mg/kg dw**	**mg/kg dw**	**mg/kg dw**	**mg/kg dw**	**mg/kg dw**	
Arsenic	7.12E-04	0.62	**12**	12	12	12	N
Cadmium	7.75E-05	0.36	**1.4**	10	22	22	N
Chromium	1.93E-04	3.31	**64**	64	87	87	N
Cobalt	7.22E-04	0.27	**40**	50	300	300	N
Copper	6.38E-02	1.51	**63**	63	91	91	N
Lead	3.89E-03	2.98	**70**	140	260	600	N
Molybdenum	7.34E-04	0.12	**5**	10	40	40	N
Nickel	4.41E-04	1.00	**45**	45	89	89	N
Selenium	1.61E-04	0.11	**1**	1	2.9	2.9	N
Uranium	3.45E-02	2.89	**23**	23	33	300	N
Vanadium	1.51E-03	4.82	**130**	130	130	130	N
Zinc	2.16E-01	5.33	**250**	250	410	410	N

Bold indicates soil guideline value selected for this assessment.
a) Maximum annual average concentrations out of all human/ecological receptor locations from CALPUFF (EIS Section 6).
b) Maximum soil concentrations estimated from maximum annual air concentrations in Table 3-14 of the HHRA and constituent-specific deposition rates in IMPACT.
c) (CCME, 1999b)
N = no; Y = yes; dw = dry weight.

Table 3-14: Maximum Concentration of COPCs in Air and Soil – Project Phases

Environmental Media	Location	Maximum Concentration of Non-radionuclides during Project Phases										
		Arsenic	Cadmium	Chloride	Cobalt	Chromium	Copper	Molybdenum	Sulphate	Selenium	Uranium	Zinc
Air (mg/m^3)	Reference Location	7.00E-07	7.44E-08	n/a	7.07E-07	1.49E-07	6.30E-05	7.19E-07	n/a	1.54E-07	6.00E-07	2.16E-04
	Camp Location	7.05E-07	7.58E-08	n/a	7.14E-07	1.68E-07	6.33E-05	7.25E-07	n/a	1.57E-07	1.77E-05	2.16E-04
	Ecological On-site	7.12E-07	7.75E-08	n/a	7.22E-07	1.93E-07	6.38E-05	7.34E-07	n/a	1.61E-07	3.45E-05	2.16E-04
	McGowan Lake	7.01E-07	7.49E-08	n/a	7.09E-07	1.56E-07	6.31E-05	7.20E-07	n/a	1.55E-07	6.65E-06	2.16E-04
	Russell Lake Inlet	7.00E-07	7.45E-08	n/a	7.07E-07	1.50E-07	6.30E-05	7.19E-07	n/a	1.54E-07	1.79E-06	2.16E-04
Soil (mg/kg dw)	Reference Location	6.16E-01	3.61E-01	n/a	2.65E-01	3.31E+00	1.46E+00	1.15E-01	n/a	1.07E-01	3.82E-01	5.31E+00
	Camp Location	6.16E-01	3.61E-01	n/a	2.66E-01	3.31E+00	1.48E+00	1.15E-01	n/a	1.07E-01	1.68E+00	5.32E+00
	Ecological On-site	6.16E-01	3.61E-01	n/a	2.67E-01	3.31E+00	1.51E+00	1.15E-01	n/a	1.08E-01	2.89E+00	5.33E+00
	McGowan Lake	6.16E-01	3.61E-01	n/a	2.65E-01	3.31E+00	1.46E+00	1.15E-01	n/a	1.07E-01	8.30E-01	5.31E+00
	Russell Lake Inlet	6.16E-01	3.61E-01	n/a	2.65E-01	3.31E+00	1.46E+00	1.15E-01	n/a	1.07E-01	4.70E-01	5.31E+00

Environmental Media	Location	Maximum Concentration of Radionuclides during Project Phases						
		Uranium-238	Uranium-234	Thorium-230	Radium-226	Radon-222	Lead-210	Polonium-210
Air (Bq/m^3)	Reference Location	7.41E-06	7.41E-06	n/a	n/a	0.00E+00	n/a	n/a
	Camp Location	2.19E-04	2.19E-04	n/a	n/a	1.24E+01	n/a	n/a
	Ecological On-site	4.26E-04	4.26E-04	n/a	n/a	3.61E+01	n/a	n/a
	McGowan Lake	8.22E-05	8.22E-05	n/a	n/a	2.50E+00	n/a	n/a
	Russell Lake Inlet	2.21E-05	2.21E-05	n/a	n/a	5.92E-01	n/a	n/a
Soil (Bq/kg dw)	Reference Location	4.72E+00	4.72E+00	2.00E+01	1.52E+01	n/a	7.29E+01	6.55E+01
	Camp Location	2.08E+01	2.08E+01	2.00E+01	1.52E+01	n/a	7.29E+01	6.55E+01
	Ecological On-site	3.57E+01	3.57E+01	2.00E+01	1.52E+01	n/a	7.29E+01	6.55E+01
	McGowan Lake	1.03E+01	1.03E+01	2.00E+01	1.52E+01	n/a	7.29E+01	6.55E+01
	Russell Lake Inlet	5.81E+00	5.81E+00	2.00E+01	1.52E+01	n/a	7.29E+01	6.55E+01

n/a = not applicable

3.3 Final List of Constituents of Potential Concern

Based on evaluation of aqueous and atmospheric sources, including a conservative screening of maximum predicted concentrations in surface water, sediment, air and soil, the final list of COPCs to be evaluated further in the HHRA and EcoRA is presented in Table 3-15.

No specific COPCs were identified in air for further quantitative assessment in the ERA; however, to be sure exposures were not underestimated in the multi-media pathways analysis, evaluation of potential human and ecological health risk via indirect exposures such as air to soil deposition, soil contact and exposure through the food chain was included for all COPCs identified in water.

Table 3-15: Final List of Constituents of Potential Concern for Wheeler River Environmental Risk Assessment

Major Ions	Physical Media where Guideline Exceeded
Chloride	Water
Sulphate	Water
Metals and Metalloids	
Arsenic	Water
Cadmium	Water
Chromium	Water
Cobalt	Water
Copper	Water
Molybdenum	Water, Sediment
Selenium	Water, Sediment
Uranium	Water
Vanadium	Sediment
Zinc	Water
Radionuclides	
Uranium-238	All pathways (based on public concern)
Uranium-234	All pathways (based on public concern)
Thorium-230	All pathways (based on public concern)
Radium-226	All pathways (based on public concern)
Radon-222	Air only
Lead-210	All pathways (based on public concern)
Polonium-210	All pathways (based on public concern)

COPC = constituent of potential concern.

4.0 Human Health Risk Assessment

The components of a human health risk assessment (HHRA) include: Problem Formulation (Section 4.1); Exposure Assessment (Section 4.2); Toxicity Assessment (Section 4.3); and Risk Characterization (Section 4.4).

4.1 Problem Formulation

The intent of the problem formulation for an HHRA is to define the goals of the risk assessment, develop an understanding of site conditions, and develop working hypotheses as to how potential exposure of people to constituents may result in potential risks to human health. The assessment endpoint of interest for the HHRA is the health of individual humans.

The problem formulation for this HHRA:

- Identifies COPCs for human health risks;
- Identifies and characterizes non-nuclear energy workers and other members of the public who may frequent the site, and the human health receptor groups that represent them in the ERA; and
- Identifies the complete exposure pathways by which the COPCs may affect the human health receptors in a conceptual site model.

The conceptual site model for the HHRA summarizes the links between constituent sources, exposure pathways, and receptors of concern.

4.1.1 Indigenous and Local Knowledge

Indigenous and Local Knowledge was used to inform assumptions for human health receptors (i.e., people) who consume Traditional Foods in terms of their locations, residency times, components, and quantities of the Traditional Foods diet.

The following studies and reports were reviewed to inform assumptions:

- Kineepik Métis Local (KML) and Northern Village of Pinehouse Lake (NVP). 2022a. Kineepik Métis Local #9 Kineepik Valued Ecosystem Components. KML Pre-statement for Denison EIS (KML and NVP, 2022a).
- Kineepik Métis Local and Northern Village of Pinehouse Lake. 2022b. Response to the Environment Impact Assessment. For the Proposed Ministry of Highways 914 Extension Project. Submitted February 11, 2022 (KML and NVP, 2022b).
- English River First Nation (ERFN) and Shared Value Solutions (SVS). 2022a. Wheeler River Project – Summary of Health and Socio-Economy Study Results – English River First Nation. Shared Value Solutions. Prepared for English River First Nation. March 2022 (ERFN and SVS, 2022a).

- English River First Nation and Shared Value Solutions. 2022b. Wheeler River Project – Summary of Traditional Knowledge Study Results – English River First Nation. Shared Value Solutions. Prepared for English River First Nation. March 2022 (ERFN and SVS, 2022b).

- CanNorth. 2017. English River First Nation Country Foods Study – Final Report (Project No. 2147). Canada North Environmental Services Limited Partnership (CanNorth, 2017).

- English River First Nation. 2011. English River First Nation, Aboriginal Traditional Knowledge Summary Report. Compiled by Environment Canada, September 2011 (ERFN, 2011).

- Ya'thi Néné Lands and Resources Office (YNLRO). 2022. An Exploration of Recorded Athabasca Denesųłine Traditional Knowledge, Land Use, and Occupancy Study in the Vicinity of Denison Mines Wheeler River Project. March 2022 (YNLRO, 2022).

A number of these studies including YNLRO (2022), ERFN and SVS (2022a, 2022b), and CanNorth (2017) provided guidance for identifying locations where people may reside, areas where traditional foods are hunted, fished, and gathered, and mammal, bird, and plant species that are traditionally used by local Indigenous communities for food, medicine, and other traditional uses. Additionally, available land use maps and information about local cabin locations was used to inform receptor locations as well as receptor types, and specific engagement activities (e.g., formal and informal engagement meetings with one or more community members) were used to better incorporate LK into the assessment of human health. Other sources of engagement included:

- Key Person Interview Program (KPI Program). 2018. ERFN Patuanak Reserve workshop conducted by Denison Mines. May 3, 2018 (KPI Program, 2018).

- Key Person Interview Program (KPI Program). 2019. Interview with the English River First Nation trapper conducted by Denison Mines. October 29, 2019. Notes finalized January 2, 2020 (KPI Program, 2019).

- Key Person Interview Program (KPI Program). 2020. Cabin owner survey conducted by Denison Mines. February 14–24, 2020 (KPI Program, 2020).

Information regarding IK and LK was primarily available for two Indigenous communities:

- English River First Nation; and

- Kineepik Métis Local 9.

4.1.2 Human Receptor Selection and Characterization

The human receptors for the HHRA were selected and characterized to represent potential exposures from both radiological and non-radiological COPCs. Human receptors would potentially be exposed to low levels of airborne or waterborne constituents being released during Project activities.

Nuclear Energy Workers (NEWs) and other workers on-Site (ISR mine and processing plant) are not addressed for the radiological assessment because their radiation exposure is monitored and their doses are controlled through a Radiation Protection Program. They are protected from non-radiological exposures through the Health and Safety Program. However, workers at the Denison Mine Camp (non-NEWs) will be assessed for both radiological and non-radiological exposures. This approach is consistent with CSA N288.6-22 (CSA, 2022) .

Recreational land users (fishers, hunters, firewood gatherers) and seasonal residents (visitors and lodge operators) may be present in the LSA and RSA for part of the year. The presence of industrial leases in the LSA and RSA suggest that workers may be present within the study area. The non-NEW workers at the Denison Mine residing part of the year at Denison's camp would be subject to the highest levels of exposures to COPCs from the operation given their close proximity to the source.

No permanent communities or residences have been identified within the LSA and RSA. Although it is not expected that individuals are present who harvest traditional foods from the area for subsistence on a permanent basis, individuals who hunt and/or fish are known to use the area and depend on a higher proportion of country foods in their diet than the general regional population. Therefore, an adult fisher/trapper receptor has been included in the assessment during all Project phases. The residency and dietary assumptions for the fisher/trapper, and for the recreational fisher/hunter, have been developed through engagement with communities during the EA process.

For the purposes of the assessment, a future permanent resident has been included as a conservative assumption that would cover off other types of receptors for post-decommissioning.

Human receptors are assumed to be in the project area during all phases of the project, with the exception of the Camp Worker which will be replaced by a Permanent Resident during the future centuries after all Project phases.

In summary, human receptors for the Project include:

- camp worker during all Project phases;
- seasonal resident during all Project phases;
- recreational fisher/hunter during all Project phases;
- fisher/trapper during all Project phases; and,
- future permanent resident in the future centuries.

During Post-Decommissioning, the Project area could be accessed intermittently by members of the public for various land use purposes. Any risks to these members of the public would be less than those assessed for the camp worker and therefore additional on-site receptors were not assessed during Post-Decommissioning.

4.1.2.1 Camp Worker

The camp worker is a non-NEW worker such as a camp cook. A camp worker is an adult male or female. This receptor group is assumed to work and reside at the Denison camp for 50% of the year and away from the site for the other 50% of the year, based on a two-weeks in and two-weeks out schedule. The camp worker would be present during construction, operation, decommissioning and post-decommissioning phases.

It is assumed that a camp worker will occasionally consume traditional foods and will hunt, fish or gather berries/plants in the area during operation. Drinking water and water for bathing would be obtained from local groundwater and surface water sources. A camp worker could come in direct contact with surface water through swimming, and with sediments through activities such as wading. Finally, a camp worker would be exposed to project related COPCs through inhalation of air and dermal contact with and/or incidental ingestion of dust deposited to soil.

4.1.2.2 Seasonal Resident

Seasonal residents are adults and one-year-olds (male and female), who would visit and reside in the area for part of the year, every year, during all project phases. Their residence during that time would be at the nearest reasonable location to the site. As indicated in Section 2.3, potential recreational leases occur at Russell Lake, McGowan Lake and Whitefish Lake North, with the majority surrounding Russell Lake (Denison, 2019), and traditional land use within the LSA and RSA also includes camping near Russell Lake. Therefore, the nearest reasonable location to the site for seasonal residents could be Russell Lake. The seasonal residents may be assumed to reside at a lodge on Russell Lake for three months of the year during the tourist season, or approximately 30% of the year.

While at Russell Lake, seasonal residents may ingest local country foods fished, hunted and gathered in the vicinity of Russell Lake as part of their diet while residing in the area. While at the lodge, water for drinking, bathing and swimming would be obtained from Russell Lake. The seasonal resident could come in contact with the surface water of Russell Lake while swimming, and with sediments during the practice of activities such as wading. Finally, a seasonal resident may be exposed to project related COPCs through inhalation of air and dermal contact and/or incidental ingestion of dust deposited to soil.

4.1.2.3 Recreational Fisher/Hunter

Recreational fishers/hunters are adults, male and female, who would visit and reside in the area for part of the year, every year, during all project phases. Traditional land uses that have been identified from available Traditional Land Use studies include hunting (large game and game birds), fishing, and firewood gathering. The traditional land use activities closest to the Project site are reported to occur in the Russell Lake area. Land use activities have also been reported further west, outside the RSA, near the MacIntyre Lake and Holgar Lake areas, which are representative of background environmental conditions. These regions have also been identified as overnight tent sites (ERFN and SVS, 2022b; YNLRO, 2022). Additionally, a potential recreational lease has been identified at McGowan Lake. A survey conducted by Denison determined a number of cabins used by local residents for recreational and outfitting/guiding purposes (KPI Program, 2020).

Traditional land use studies of the region around the Project site identified two camps considered by local Indigenous groups to be important locations for the facilitation of traditional land-based activities and Indigenous Knowledge transfer. These camps include:

- The ERFN culture camp, located approximately 85 km southwest of Russell Lake. This camp is an area where recreational activities occur, in addition to youth education activities, traditional Indigenous games and activities, and contemporary gathering.
- The Kineepik Metis (Pinehouse) camp, located approximately 67 km north of the village of Pinehouse. This camp is situated in an area where hunting, fishing and harvesting of country foods is commonly reportedly.

The two camps are situated well beyond the boundaries of the RSA; therefore, it is expected that the recreational fisher/hunter receptor will represent a highly conservative assessment of potential risk for Indigenous peoples engaging in traditional land-based activities at these culturally-significant camp sites.

Recreational fishers/hunters may ingest local country foods fished, hunted and gathered at and near Russell Lake or McGowan Lake; therefore, two recreational fishers/hunters were identified – one at McGowan Lake and one at Russell Lake.

They may also conserve local country foods collected from the area for consumption with their family throughout the year; therefore, a one-year old is also assessed. While at the lodge, water for drinking, bathing and swimming would be obtained from Russell Lake or McGowan Lake. The recreational fisher/hunter may come in contact with surface waters of Russell Lake or McGowan Lake while swimming, and with sediments during the practice of activities such as wading. In comparison to a seasonal resident, a recreational fisher/hunter would spend approximately the same amount of time annually in the study area, but obtain a higher portion of local country foods in their overall annual diet from the study area. Finally, a recreational fisher/hunter may be exposed to project related COPCs through inhalation of air and dermal contact and/or incidental ingestion of dust deposited to soil. The recreational fishers/hunters are assumed to reside at the exposure locations for approximately 30% of the year, as indicated in Table 4-2 in Section 4.2.1.

The Wheeler River is considered both culturally and economically important to ERFN, and is an area where traditional land activities such as hunting, fishing and trapping occur year-round.

Members of ERFN have expressed the importance of protecting the area and managing impacts to the environment to protect the ability for Indigenous residents to continue to engage in traditional land activities (ERFN and SVS, 2022a). The recreational fisher/hunter receptor is expected to adequately represent the traditional land uses identified in the Traditional Land Use studies, and to capture any potential risk to local Indigenous and non-Indigenous hunters and fishers.

4.1.2.4 Fisher/Trapper

The adult fisher/trapper represents a member of the public who lives in the region year-round and regularly consumes local country foods and water. The fisher/trapper will be assessed for all project phases. Assumptions made about the fisher/trapper receptor were formed following consultation with local Indigenous community members. Denison recognizes that ERFN considers the fisher/trapper's use of the area as representative of current and future land users and expects that their relationship to the Project Area will be continued and strengthened through generations of future use.

The residency characteristics of the fisher/trapper have been developed from resource use information collected from a local trapper. The local fisher/trapper had:

- A primary cabin along the Wheeler River upstream of its confluence with Moon Creek at Bobby's Pond (represented by Reference conditions);
- A secondary cabin at Russell Lake (which is downstream of the Icelander Creek drainage and represents a far-field exposure location); and,
- Two other minor residences away from the Project area (represented by Reference conditions).

For assessment purposes, it is assumed that the fisher/trapper spends 6 months of the year at a primary residence (a reference location) and the other 6 months of the year at a secondary residence on Russell Lake. Subsistence hunting is assumed to occur while at both cabin locations. While at the Russell Lake cabin, the fisher/trapper is assumed to hunt mallard ducks as indicated by the resource use information. In contrast to the resource use information which suggests that subsistence fishing would occur at multiple locations including Russell Lake and reference lakes in the Project area, it was conservatively assumed that 100% of the fish in the fisher/trapper's diet would be from the far-field exposure location at Russell Lake and no fish would be from the Reference location.

In comparison to the other adult human receptor groups, the fisher/trapper consumes a greater proportion of country game and fish in his diet annually. The fisher/trapper is assumed to consume local country foods and store foods in equal proportions on an annual basis. Country game meats and fish sources are assumed to be equally distributed in the diet, each representing approximately 25% of the annual diet based on fresh weight.

Similar to the recreational fisher/hunter, the fisher/trapper receptor is expected to sufficiently represent the traditional land uses recognized in the Traditional Land Use studies, and to capture any potential risk to local Indigenous community members who live in the region year-round, regularly partake in land-based traditional activities, and frequently consume a higher proportion of traditional foods in their diet.

4.1.2.5 Future Permanent Resident

The future permanent resident is a hypothetical adult and one-year-old (male or female) who would reside full time at the Denison camp site after the post-decommissioning phase has been fully implemented, during the future centuries. Currently, there are no permanent residents or communities within 150 km of the Project Area.

Permanent residents would have a diet similar to that of the seasonal resident and the recreational fisher but would ingest a high proportion of local country foods fished, hunted and gathered in the area because of their full-time residency in the Project area. Local country foods would likely be sourced from drainages affected and not affected by the former operation. Drinking water and water for bathing would be obtained from a local surface water source, such as Whitefish Lake Middle and Whitefish Lake South. A permanent resident could come in direct contact with surface water through swimming, and with sediments through the practice of activities such as wading. It is anticipated that a permanent resident would not be exposed to project related COPCs through inhalation of air after decommissioning; however, they could be exposed by dermal contact and/or incidental ingestion of dust deposited to soil for some time after decommissioning. Assumptions for a permanent resident after decommissioning should be refined near the time of decommissioning with community input where possible.

4.1.3 Selection of Chemical, Radiological, and Other Stressors

The selection of COPCs retained for the HHRA is presented in Section 3.0 of this report. The selection of chemical stressors to be evaluated in the HHRA followed a tiered screening approach to reduce the risk of overlooking Project-related COPCs relevant to human health that would be emitted through water and air.

The screening involved a conservative process of comparing the expected treated effluent quality against the selected water quality guidelines protective of human health (refer to Table 3-1 in Section 3.0). While chloride and sulphate were identified as COPCs for further assessment in the ERA, they are not considered further in the HHRA. These COPCs are associated with water ingestion. Chloride does not have a drinking water standard and is not considered to present a risk to human health at concentrations found in drinking water or at concentrations predicted for Whitefish Lake (LA-5). Sulphate in drinking water is associated with adverse physiological effects such as diarrhoea or dehydration at concentrations above 500 mg/L. The predicted maximum concentration of sulphate in LA-5 is 58 mg/L (Table 3-3), which is below 500 mg/L; therefore, concentrations at exposure points farther downstream would be less than those associated with adverse physiological effects. For these reasons, chloride and sulphate were not assessed further in the HHRA.

No formal screening was conducted for radionuclides. However, since radiation dose to human receptors is of public and regulatory interest, the radionuclides in the uranium-238 decay series are carried forward as COPCs for further assessment.

No specific COPCs were identified in air for further quantitative assessment in the ERA; however, to be sure exposures were not underestimated in the multi-media pathways analysis, evaluation of potential human health risk via indirect exposures such as air to soil deposition, soil contact and exposure through the food chain was included for all COPCs identified in water. Exposure to constituents that may deposit from air to surface water was not considered, as that pathway is considered negligible according to CSA N288.1-20.

4.1.4 Selection of Exposure Pathways

The potential exposure pathways are expected to be the same for most human receptors. Exposure pathways for human receptors are summarized in Table 4-1.

Table 4-1: Summary of Human Health Exposure Pathways

Human Receptor Group	Environmental Exposure Pathway				
	Air	Soil	Water	Sediment	Traditional Foods
Camp Worker	Inhalation(a)	Direct contact Incidental ingestion	Direct contact Ingestion	Direct contact Incidental ingestion	Ingestion
Seasonal Resident	Inhalation(a)	Direct contact Incidental ingestion	Direct contact Ingestion	Direct contact Incidental ingestion	Ingestion
Recreational Fisher/ Hunter	Inhalation(a)	Direct contact Incidental ingestion	Direct contact Ingestion	Direct contact Incidental ingestion	Ingestion
Fisher / Trapper	Inhalation(a)	Direct contact Incidental ingestion	Direct contact Ingestion	Direct contact Incidental ingestion	Ingestion
Future Permanent Resident	Incomplete Pathway	Direct contact Incidental ingestion	Direct contact Ingestion	Direct contact Incidental ingestion	Ingestion

Note:
(a) Inhalation pathway was only evaluated for radionuclides, as inhalation was not identified as a pathway of concern for non-radionuclides based on the atmospheric screening in Section 3.2.

4.1.4.1 Summary of Complete Exposure Pathways

Radiological and non-radiological exposure pathways were assessed in the HHRA. The primary exposure routes for human health included:

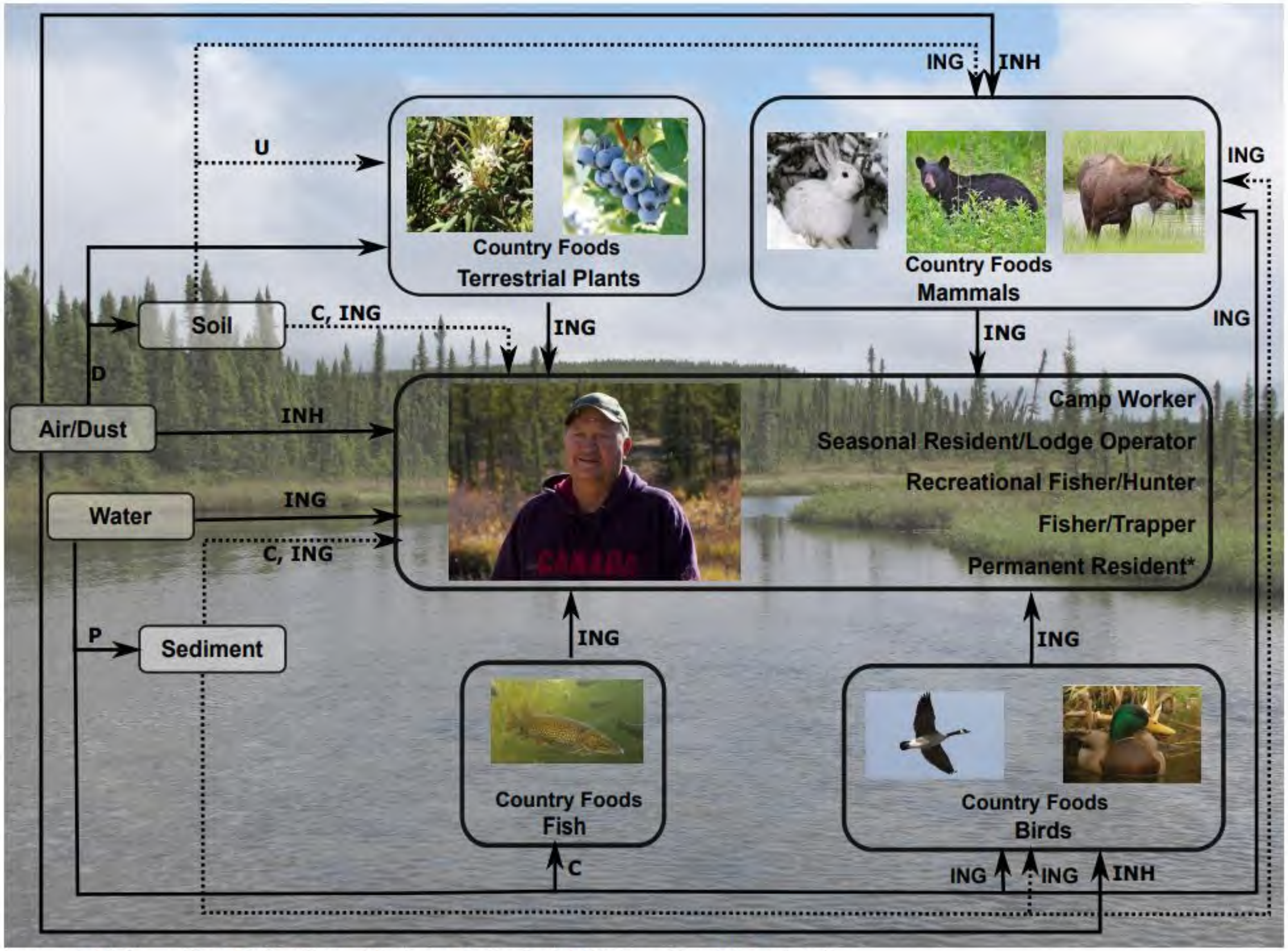
- Inhalation of airborne COPCs (outdoor air) for radionuclides only;

- Dermal contact with soil while gardening or harvesting;
- Ingestion of country foods (e.g., fish, vegetation, game), and ingestion of store-bought foods;
- Ingestion of surface water as drinking water and incidental ingestion during bathing and swimming;
- Incidental ingestion of soil (i.e., while harvesting) or sediment (i.e., while wading);
- Dermal contact with surface water and sediment while swimming or doing other recreational activities; and
- External exposure to radiation from air, water, soil, and sediment.

4.1.5 Human Health Conceptual Site Model

The human health conceptual model illustrates how receptors are exposed to COPCs. It represents the relationship between the source and receptors by identifying the source of constituents, the receptors, and the exposure pathways to be considered in the assessment for each receptor. Exposure pathways represent the various routes by which radionuclides and/or chemicals may enter the body of the receptor, or for radionuclides, how they may exert effects from outside the body.

The complete exposure pathways for the human receptors that are considered in the HHRA are illustrated in Figure 4-1 below.



Legend: D: Deposition; **P:** Partition; **U:** Uptake; **C:** Contact; **ING:** Ingestion; **INH:** Inhalation;
⟶ Exposure pathway from primary media; ┈┈➤ Exposure pathway from secondary media.

* Human Receptors are assumed to be present during all project stages, except the Permanent Resident who is assumed to be present during future centuries.

Figure 4-1: Human Health Conceptual Site Model (CSM) for the Wheeler River Project

Note: Denison would like to gratefully acknowledge the contributions of Bobby John (shown in the centre of this image) to this EIS and extend a thank you to his family for granting permission to use his image herein.

4.1.6 Uncertainty in the Problem Formulation

The assumptions used to characterize human health receptors and develop the conceptual site model followed best industry practices and CSA guidance. Where possible, region-specific information was used to develop initial assumptions for human health receptor groups, locations and frequency, and duration of exposures. Communities and regulators were engaged in the process, which resulted in adjustments to the initial assumptions to better represent affected communities and increase conservatism in areas (such as the Traditional Foods diet) where regional information was scarce.

The selection of Project-related COPCs was based on comparing maximum predicted water, sediment, air, and soil concentrations at the human health receptor locations to relevant environmental guideline concentrations (i.e., screening values). Numerous conservative measures were integrated into the models used to predict COPC concentrations used in the screening process (refer to Appendix A for a discussion of the modelling used to inform the ERA). The predicted concentrations were compared to screening values protective of both human health and ecological biota. There is, therefore, a high level of confidence that the HHRA captures all Project-related COPCs that would be emitted by Project activities to water and air.

4.2 Exposure Assessment

The exposure assessment included identification of exposure locations and exposure factors for each receptor, presentation of exposure concentrations and doses (radiological and non-radiological), and discussion of uncertainties. This section presents at a high-level, the information used in the IMPACT model; however, the details of the model are included in Appendix A.

4.2.1 Exposure Locations, Duration, and Frequency

The selection of exposure locations for human receptors groups was based on current understanding of how people use the LSA and RSA, including Indigenous and Local Knowledge from land use maps, as well as the potential for exposure to Project-related media concentrations during one or more Project phases. Exposure locations are shown in Figure 4-2.

The residency assumptions for human receptors used for the human health risk assessment are summarized in Table 4-2. This includes the fraction of time the receptor spends at a given location as well as the exposure frequency (which refers to the frequency at which the activity causing the exposure occurs). The exposure duration (which refers to the length of time the receptor engages in the activity causing the exposure) was either the duration of the Project phases (30 years) for non-carcinogens, or the lifetime of the receptor (80 years) for carcinogens, except for the camp worker, where only the adult life stage would be relevant for carcinogens.

With the exception of the future permanent resident, all of the human receptors were assumed to spend part of their time away from the LSA and RSA at a location represented in the model by the reference location.

Table 4-2: Summary of Residency Assumptions for Human Health Receptor Groups

Human Health Receptor Group	Age Group(s)	Residence within Study Area	Project Phases	Fraction of Time at Residence/ Reference Location	Exposure Frequency at Residence/Refence Location (months/year)
Camp Worker (such as a cook)	Adult	Whitefish Lake (LA-5)	Construction Operation Decommissioning Post-decommissioning	0.5/0.5	6/6
Recreational Fisher/Hunter	Adult and one-year-old	McGowan Lake (LA-1) Russell Lake	Construction Operation Decommissioning Post-decommissioning Future centuries	0.3/0.7	4/8
Seasonal Resident	Adult and one-year-old	Russell Lake			
Fisher/Trapper	Adult	Russell Lake		0.5/0.5	6/6
Future Permanent Resident	Adult and one-year-old	Whitefish Lake (LA-5)	Future centuries	1	12

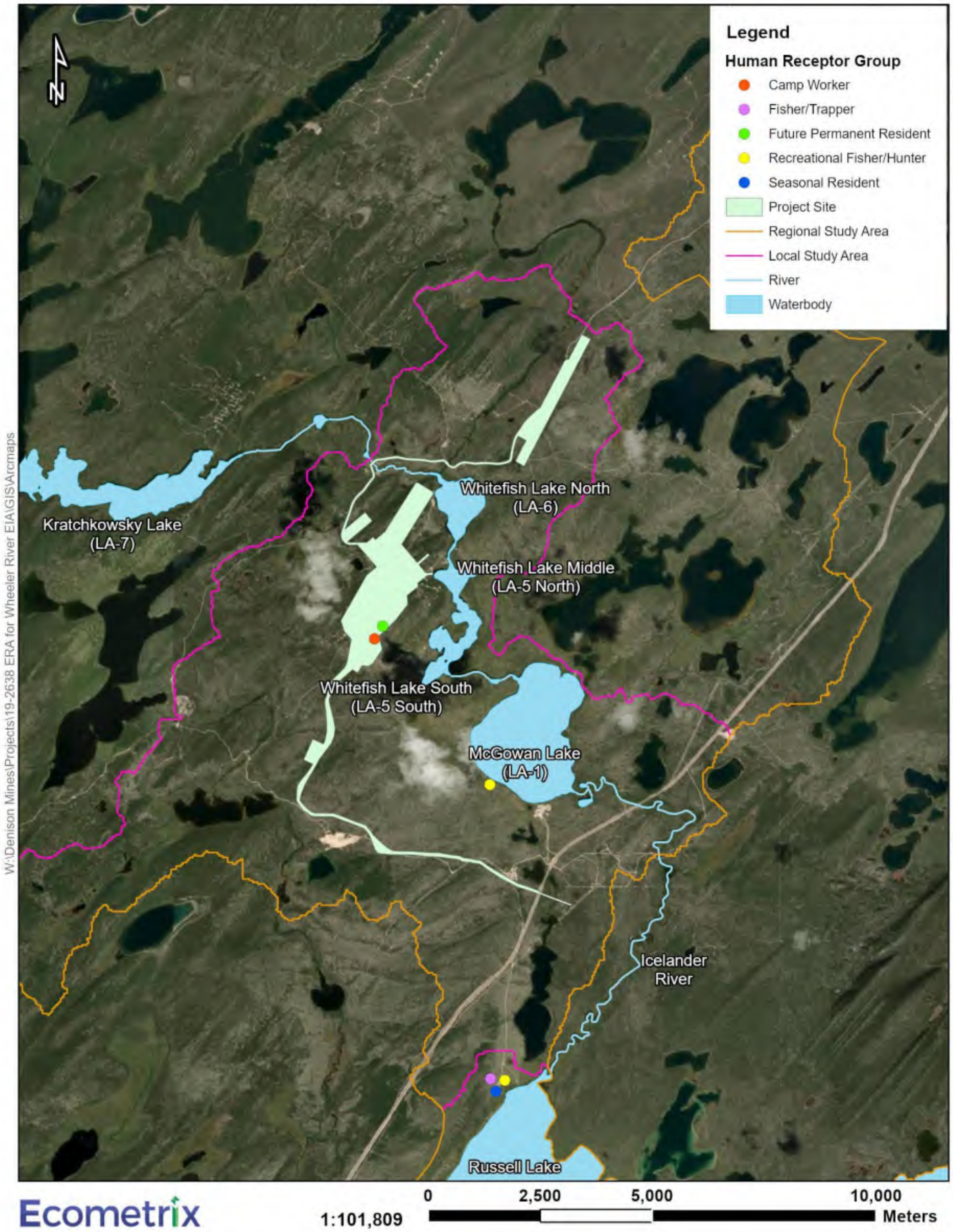


Figure 4-2: Human Receptor Locations for the Wheeler River HHRA

4.2.2 Exposure and Dose Calculations

Exposure and dose calculations for human receptors were completed using IMPACT version 5.6.0. IMPACT is consistent with the COPC transport equations and radiological dose calculations outlined in CSA N288.1-20. Equations used for non-radiological dose calculations are consistent with CSA N288.6-22, which have generally been obtained from Health Canada guidance.

The equations are outlined in the Wheeler River IMPACT Model Report, in Appendix A.

4.2.3 Exposure Factors

Exposure estimates rely on several COPC- and media-specific exposure factors for the dose calculations. These parameters include body characteristics and intake rates as well as exposure duration and frequency (Section 4.2.1, Exposure Locations, Durations, and Frequency) and dose coefficients.

Exposure factors are outlined in detail in the IMPACT Model Report for the Wheeler River Project, Appendix A. Exposure factors including inhalation rates, water, sediment and soil ingestion rates and total food ingestion rates were generally mean values from CSA N288.1-20 (CSA, 2020). Ingestion rates including the Traditional Foods diet are discussed in Section 4.2.4, Human Diet.

Dose coefficients (DCFs) for all internal and external exposure routes for humans are used to estimate radiological exposure. The DCFs for ingestion and inhalation by human receptors were taken from CSA N288.1-20 (CSA, 2020). The external DCFs used in the IMPACT model were derived based on the methods described in N288.1-20. Dose coefficients used in the IMPACT model are provided in Appendix A.

For non-radiological dose calculations relative absorption factors (RAF) were needed. The RAF for soil ingestion was assumed to be 1 for all non-radiological COPCs. The RAFs for soil dermal exposure were COPC specific and generally obtained from Health Canada (Health Canada, 2021b) or Ontario MECP (MECP, 2011).

4.2.3.1 Bioavailability

In general, the IMPACT model was used to calculate exposure doses for arsenic. However, the general assumption in IMPACT is that a COPC is 100% bioavailable from all media types, including food.

Arsenic may be present in the environment in different chemical forms such as arsenopyrite and arsenic trioxide. Some forms of arsenic can be absorbed in the gastrointestinal tract and taken up by plants, while other forms are poorly absorbed.

To account for that uncertainty, and provide a more realistic interpretation of results, the model outputs were amended to incorporate arsenic bioaccessibility into the outputs for moose meat and moose organs, using data collected as part of a study based out of British Columbia (Laird and Chan, 2013). Laird and Chan (2013) collected samples of various types of traditional foods including moose organs (kidney and liver) and moose meat. The mean percent in vitro bioaccessibility (a surrogate for bioavailability) ranged from 7% to 19% for moose organs, and was 59% for moose meat. These bioaccessibilities were incorporated into the exposure assessment by adjusting the model outputs from IMPACT by 0.19 for moose organs and 0.59 for moose meat. The bioaccessibility for moose meat of 0.59 was also applied to caribou meat.

ATSDR indicates that in seafood (i.e., fish), approximately 10% of arsenic is present in the inorganic form, while the remainder is in an organic form (arsenobetaine) that is generally not associated with toxicity (ATSDR, 2007). Therefore, the estimates of exposure generated by IMPACT overestimate arsenic exposure from the fish consumption pathway. As such, the model outputs from IMPACT were adjusted such that the exposure doses from fish were multiplied by a factor of 0.10.

These are reasonable estimates of bioaccessibility and are expected to reduce the uncertainty associated with the risk estimates for those food types. However, 100% bioaccessibility was assumed for the remaining food types (i.e., terrestrial plants, muskrat, mallard, and goose), and as such, exposure and risks for those other food types may be overestimated.

4.2.4 Human Diet

The total human diet is comprised of the portion of the diet obtained from Traditional Foods and the portion of the diet obtained from store bought foods. Traditional Foods are those animals and plants that are fished, hunted, or gathered from the land and consumed as food (Health Canada, 2018).

4.2.4.1 Total Diet

The initial assumptions for ingestion rates and components of the total foods diet for the HHRA were taken from CSA N288.1-20 Adult (Table G.9b – Central) total diet. The CSA N288.1-20 dietary composition was based on the 2004 Canadian nutrition survey results (Health Canada, 2004), processed for International Commission on Radiological Protection (ICRP) age groups and for two sexes in the adult age group. The dietary intakes for ICRP ages were adjusted to align with ICRP reference energy intakes for each age group (ICRP, 2003).

The N288.1-20 human diet was selected over the Health Canada human diet for the HHRA (Health Canada, 2010a). Health Canada references Richardson (Richardson, 1997), which used survey results from the late 1970s. The Richardson diet was also a combined adult male/female diet. The CSA N288.1-20 total adult diet is a smaller overall diet (706 kg/yr) than the Richardson diet (808 kg/yr; by about 100 kg/yr) and is based on more recent data.

Annual food consumption rates for the one-year-old diet were calculated using adult-to-one-year-old ratios from CSA N288.1-20 for each of the selected food categories. Annual ingestion rates for individual food categories were combined into relevant food categories, and the adult-to-one-year-old ratios were determined for each of these food categories.

4.2.4.2 Traditional Foods Diet

Human receptors were assumed to consume lower or higher proportions of Traditional Foods in their overall diets depending on their lifestyles. These are referred to as average Traditional Foods consumers and high Traditional Foods consumers, respectively. In both cases, the proportion of Traditional Foods in the overall diet of human health receptor groups in the HHRA was based on dietary studies from local and Indigenous communities.

The Project is a remote site, with no communities in close proximity. By distance, the closest communities are approximately 150 km away in the northern settlement of Wallaston Lake and Lac La Hache. The closest community by road is Pinehouse which is approximately 260 km away. The communities and associated Indigenous Communities of Interest that Denison has identified for engagement activities includes: the English River First Nation (ERFN), the Kineepik Métis Local 9, the Sipisishik Métis Local 37, the A La Baie Métis Local 21, and the Patuanak Métis Local 82.

Indigenous Knowledge was available from Indigenous Communities of Interest, including a dietary study for the ERFN (CanNorth, 2017). Local Knowledge was available from a local fisher/trapper whose primary residence has been in the LSA, that has extensive experience fishing, hunting, and trapping throughout the LSA and RSA.

The ERFN is comprised of seven reserve lands across Saskatchewan. Patuanak is located on the Churchill River and the north end of Lac-Île-à-la-Crosse, approximately 90 km north of Beauval and over 500 km from Saskatoon. Patuanak has 625 members on reserve and a hamlet with approximately 75 residents. La Plonge is located approximately 90 km south of Patuanak 8 km east of the town of Beauval near the Beaver River, and has approximately 148 people living on reserve. ERFN community members also travel to a seasonal culture camp along Highway 914 approximately 50 km south of the Key Lake Operation to hunt, fish, and gather berries (CanNorth, 2017).

A dietary study was performed for residents of Patuanak and La Plonge to understand which traditional foods were consumed by each community and the approximate amounts consumed. The results of the survey were summarized in CanNorth (2017) by average daily intake in grams (fresh weight) of country foods by species and season, for Patuanak, La Plonge, and an average. A summary of the ERFN traditional food ingestion rates by food type is shown in Table 4-3 and the proportions of food types are shown in Figure 4-3. Overall, fish, large mammals (meat and organs) and plants make up the majority of the traditional food diet, in similar proportions. Small mammals and birds make up a smaller proportion of the traditional food diet. Moose (*Alces americanus)* is the most commonly eaten large mammal. The most commonly eaten fish include walleye (*Sander vitreus*) and lake whitefish (*Coregonus clupeaformis*).

The results of the dietary study indicate that Patuanak has a higher traditional food ingestion rate than La Plonge, and has a similar distribution of country food types as the average diet. As a conservative approach for this assessment, the Patuanak diet was selected to represent the average traditional foods consumer in the HHRA. This includes the seasonal resident and the recreational fisher/hunter.

The traditional foods diet for past assessments for other uranium mining facilities in the area were based on the Hatchet Lake First Nation study (CanNorth, 2000). Overall, the quantities and types of traditional foods documented in the Hatchet Lake First Nation study were similar to the results from the ERFN dietary study, with the exception of the high ingestion rate of barren-ground caribou (*Rangifer tarandus groenlandicus*). Responses from the ERFN dietary study indicated that the Patuanak and La Plonge communities consume small quantities of caribou and preferred to eat moose.

Table 4-3: ERFN Ingestion Rates – Traditional Food

Country Food Type	La Plonge (g/d)	Patuanak (g/d)	All (g/d)
Birds	4.1	13.3	10.2
Edible Plants	62.8	54.3	57.2
Fish	16.4	73.0	53.7
Mammals (meat)	19.4	35.5	30.0
Mammals (organs)	6.2	16.2	12.8
Small mammal	3.3	6.7	5.5
Total	**112.2**	**199.0**	**169.4**

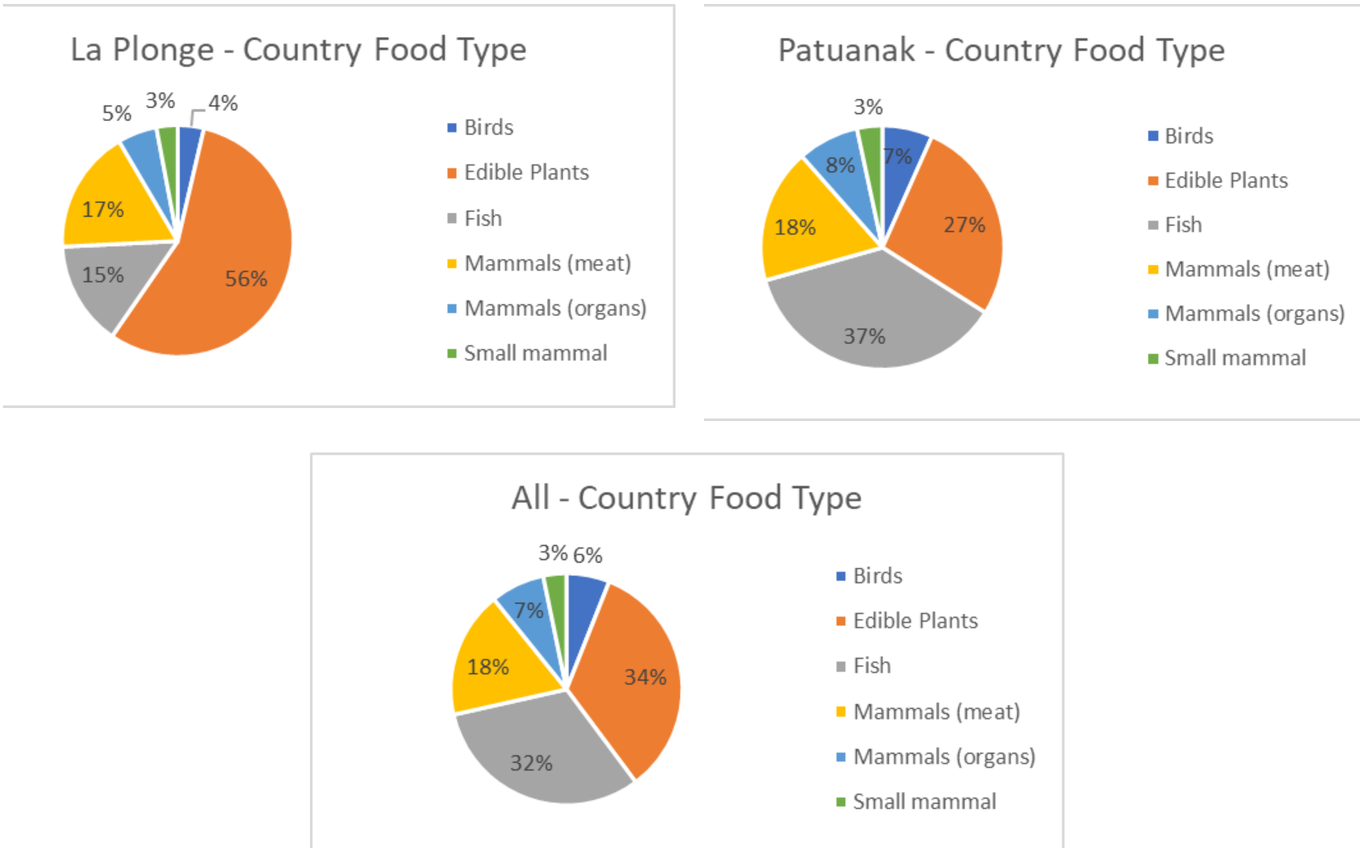


Figure 4-3: Proportion of Food Types in ERFN Traditional Food Diet

For the high traditional foods consumer, the dietary assumptions were from resource use information from a local fisher/trapper that has been used for past assessments in the area. The overall assumptions regarding types of food consumed and general proportions were re-confirmed with the local fisher/trapper during an interview with Denison on October 29, 2019 (KPI Program, 2019).

A detailed breakdown of diet by food type for each Traditional Foods consumer, as modelled in the HHRA, is shown in Table 4-4. Representative ecological receptors were selected from the IMPACT model to represent each Traditional Foods group. The Total Food Intake row is the total food intake from both traditional foods and store-bought foods. Since it is assumed that someone would obtain a portion of their overall diet from traditional foods and the rest from store bought foods, Table 4-4 shows the breakdown between the total food intake from traditional foods and the remaining food intake from store bought foods.

Table 4-4: Annual Food Intakes for Components of the Human Receptors' Diet

Food Components	Unit	Average Traditional Foods Consumer				High Traditional Foods Consumer			
		Adult [1]		One-year-old [2]		Adult [1]		One-year-old [2]	
Country Meat and Fish	kg/yr	52.82	-	9.34	-	366.88	-	63.50	-
Caribou	kg/yr	-	2.63	-	0.33	-	175.28	-	21.79
Moose	kg/yr	-	11.75	-	1.46	-	4.65	-	0.58
Moose (organs)	kg/yr	-	4.49	-	0.56	-	0	-	0
Small Mammals [4]	kg/yr	-	2.45	-	0.23	-	0.87	-	0.08
Mallard [5]	kg/yr	-	2.99	-	0.53	-	1.55	-	0.28
Canada Goose [6]	kg/yr	-	1.86	-	0.33	-	1.09	-	0.19
Fish [7]	kg/yr	-	26.65	-	5.89	-	183.44	-	40.58
Country Plants [8]	kg/yr	19.82	-	10.83	-	0	-	0	-
Blueberries	kg/yr	-	19.64	-	10.79	-	0	-	0
Labrador Tea	kg/yr	-	0.18	-	0.04	-	0	-	0
Store Foods	kg/yr	633.38		389.28		339.13		345.95	
Total Food Intake [3] (fresh weight)	kg/yr	706.01	-	409.45	-	706.01	-	409.45	-

Notes:

[1] Food intake for human receptors that are average Traditional Foods consumers were developed from the results of a dietary survey of the English River First Nation (CanNorth, 2017).

[2] CanNorth (2017) provides survey results for adults. Food intake for one-year-olds was proportioned from the adult receptor group using Central Adult - to Central 1-Year-Old derived from the N288.1-20 Human Diet (Table G.9b).

[3] The total food intake is from Table G.9b in CSA N288.1-20 (2020) which represents the central dietary intake based on reference energy intakes.

[4] While ERFN predominantly eat hare, modelling for small mammals is represented by muskrat to have a stronger link to the aquatic environment.

[5] Mallard was selected to represent all waterbirds in the country food diet.

[6] Canada goose was selected to represent upland birds in the country food diet.

[7] Assumed to include 50% predator fish (northern pike) and 50% forage fish (white sucker) based on ERFN dietary survey (CanNorth, 2017).

[8] Blueberries include edible fruits and berries. Labrador Tea includes edible plants other than fruits and berries.

4.2.5 Exposure Point Concentrations and Doses

Concentrations of COPCs in environmental media including water, sediment, soil, and Traditional Food items were predicted using the environmental pathways model IMPACT at defined human receptor locations. Air concentrations at human receptor locations were obtained from the air quality model (Section 8 of the EIS) and dictated into the IMPACT model. Concentrations of COPCs in environmental media were predicted over all Project phases. Water and sediment concentrations at exposure locations (Whitefish Lake Middle, Whitefish Lake South, McGowan Lake, and Russell Lake) and reference locations (Kratchkowsky Lake and Whitefish Lake North) are summarized in Figure 3-2 and Figure 3-3 showing the variation of concentrations over time. Maximum water and sediment concentrations are shown in Table 3-3. Maximum air and soil concentrations are shown in Table 3-14. The estimated non-radiological and radiological concentrations in environmental media and biota tissue concentrations relevant to human ingestion pathways are also summarized in Appendix B, Model Results in Support of the ERA.

Assessment of radiation exposures to members of the public is commonly based on estimation of the incremental effects of the project or site. Assessments consider the radiation dose received from external exposure to radiation as well as the dose received from inhalation and ingestion of radionuclides. The radionuclide dose to human receptors from all pathways is converted into a dose that is presented in millisieverts per year (mSv/yr).

Assessment of non-radiological exposures to members of the public is commonly based on estimation of the total effects of the project or site. Assessments consider the dose received from ingestion of constituents of concern as well as dermal absorption due to contact with soil. The inhalation dose was not included as no air COPCs were identified in the screening. This is presented as a dose in milligrams per kilogram per day (mg/kg/d) for each pathway.

The estimated non-radiological doses and radiological doses to human receptors due to releases from the Project during all phases are presented in the following subsections. Non-radiological doses are presented as baseline doses (based on existing exposures prior to the Project), Project doses (includes the Project dose in addition to the baseline dose), as well as incremental Project doses (includes the Project dose only with baseline component removed). For radiological doses, only the incremental doses are presented, as the dose limit is based on an incremental dose. Doses from ingestion of store-bought foods are considered as a portion of the baseline dose.

The results represent the expected EA case based on the source term presented in Section 3.0, Source Term Characterization for the COPCs identified. Sample calculations for radiological and non-radiological dose are presented in Appendix B.

4.2.5.1 Non-radiological Dose to Human Receptors

4.2.5.1.1 Non-carcinogen Dose

The estimated non-radiological doses to human receptors due to releases from the Project during all phases are presented in Table 4-5. The doses are presented for existing conditions (baseline) as well as for the Project, and represent the maximum dose predicted during the Project phases. This is a conservative representation as exposure varies over the different Project phases. The non-carcinogens evaluated include: cadmium, cobalt, chromium, copper, molybdenum, selenium, uranium, vanadium, and zinc. Doses are presented for the camp worker, recreational fisher/hunter, fisher/trapper, and seasonal resident for the Project phases (Table 4-5). Doses are presented for the future permanent resident, recreational fisher/hunter, fisher/trapper, and seasonal resident for the future centuries (Table 4-6).

Table 4-5: Estimated Non-radiological Doses to Human Receptors – Project Phases

Human Receptor	COPC	Non-radiological Dose by Pathway during Project Phases (mg/kg/d)									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
Camp Worker Adult (Whitefish Lake)		**Average Baseline Dose**									
	Cadmium	3.40E-07	7.55E-09	3.46E-08	2.35E-09	1.08E-08	0.00E+00	3.57E-08	3.51E-06	2.05E-04	**2.09E-04**
	Chromium	7.62E-06	6.93E-08	3.17E-06	4.08E-08	1.87E-06	0.00E+00	1.47E-05	5.58E-06	1.50E-05	**4.80E-05**
	Cobalt	1.48E-06	5.55E-09	2.54E-08	1.76E-09	8.04E-09	0.00E+00	6.25E-07	3.14E-05	1.64E-04	**1.97E-04**
	Copper	9.09E-06	3.05E-08	8.37E-07	1.29E-08	3.54E-07	0.00E+00	1.59E-04	2.19E-03	2.06E-02	**2.29E-02**
	Molybdenum	1.57E-06	2.40E-09	1.10E-08	2.35E-09	1.08E-08	0.00E+00	5.51E-09	2.59E-05	2.53E-03	**2.56E-03**
	Selenium	4.74E-07	2.24E-09	1.03E-08	4.33E-09	1.98E-08	0.00E+00	8.37E-05	2.19E-05	1.69E-03	**1.79E-03**
	Uranium	4.41E-07	8.00E-09	3.66E-07	4.03E-09	1.84E-07	0.00E+00	3.08E-07	1.36E-05	3.67E-05	**5.17E-05**
	Vanadium	2.13E-06	1.01E-07	4.61E-06	7.79E-08	3.57E-06	0.00E+00	7.12E-06	3.60E-06	3.62E-04	**3.83E-04**
	Zinc	9.99E-06	1.11E-07	5.09E-06	6.92E-08	3.17E-06	0.00E+00	6.99E-04	5.35E-03	1.21E-01	**1.27E-01**
		Project Total Dose - Project Phases									
	Cadmium	4.56E-07	7.55E-09	3.46E-08	2.91E-09	1.33E-08	0.00E+00	5.01E-08	3.51E-06	2.05E-04	**2.09E-04**
	Chromium	9.19E-06	6.93E-08	3.17E-06	4.69E-08	2.15E-06	0.00E+00	1.84E-05	5.58E-06	1.63E-05	**5.49E-05**
	Cobalt	1.68E-06	5.56E-09	2.54E-08	1.94E-09	8.88E-09	0.00E+00	7.34E-07	3.15E-05	1.64E-04	**1.98E-04**
	Copper	1.06E-05	3.07E-08	8.44E-07	1.45E-08	3.98E-07	0.00E+00	1.93E-04	2.20E-03	2.06E-02	**2.30E-02**
	Molybdenum	1.79E-04	2.41E-09	1.10E-08	2.01E-07	9.18E-07	0.00E+00	7.95E-07	2.59E-05	2.57E-03	**2.78E-03**
	Selenium	3.41E-06	2.25E-09	1.03E-08	2.13E-08	9.74E-08	0.00E+00	5.39E-04	2.19E-05	1.75E-03	**2.31E-03**
	Uranium	4.43E-06	2.16E-08	9.88E-07	2.70E-08	1.24E-06	0.00E+00	3.36E-06	3.03E-05	3.93E-05	**7.96E-05**
	Vanadium	5.86E-06	1.01E-07	4.61E-06	1.69E-07	7.72E-06	0.00E+00	1.59E-05	3.61E-06	3.70E-04	**4.08E-04**
	Zinc	1.26E-05	1.11E-07	5.09E-06	8.21E-08	3.76E-06	0.00E+00	9.20E-04	5.35E-03	1.21E-01	**1.27E-01**
		Project Incremental Dose - Project Phases									
	Cadmium	1.16E-07	1.13E-12	5.19E-12	5.56E-10	2.55E-09	0.00E+00	1.44E-08	1.66E-09	1.22E-07	**2.58E-07**
	Chromium	1.57E-06	6.66E-12	3.05E-10	6.07E-09	2.78E-07	0.00E+00	3.72E-06	6.63E-09	1.29E-06	**6.87E-06**
	Cobalt	1.99E-07	5.98E-12	2.74E-11	1.85E-10	8.46E-10	0.00E+00	1.09E-07	1.72E-08	3.71E-07	**6.98E-07**
	Copper	1.47E-06	2.72E-10	7.47E-09	1.61E-09	4.42E-08	0.00E+00	3.33E-05	8.27E-06	3.60E-05	**7.92E-05**
	Molybdenum	1.78E-04	1.85E-12	8.46E-12	1.98E-07	9.08E-07	0.00E+00	7.90E-07	9.28E-09	4.11E-05	**2.21E-04**
	Selenium	2.94E-06	2.38E-12	1.09E-11	1.70E-08	7.76E-08	0.00E+00	4.55E-04	1.38E-08	6.36E-05	**5.21E-04**
	Uranium	3.99E-06	1.36E-08	6.22E-07	2.30E-08	1.05E-06	0.00E+00	3.05E-06	1.66E-05	2.50E-06	**2.79E-05**
	Vanadium	3.73E-06	3.03E-11	1.39E-09	9.08E-08	4.16E-06	0.00E+00	8.77E-06	1.12E-08	7.65E-06	**2.44E-05**
	Zinc	2.65E-06	9.51E-11	4.36E-09	1.29E-08	5.92E-07	0.00E+00	2.21E-04	1.87E-06	1.01E-04	**3.27E-04**

Human Receptor	COPC	Non-radiological Dose by Pathway during Project Phases (mg/kg/d)									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
Rec F/H Adult (McGowan Lake)		**Average Baseline Dose**									
	Cadmium	3.40E-07	7.55E-09	3.46E-09	2.35E-09	1.08E-09	0.00E+00	7.14E-08	7.02E-06	1.99E-04	**2.06E-04**
	Chromium	7.62E-06	6.93E-08	3.17E-07	4.08E-08	1.87E-07	0.00E+00	2.94E-05	1.12E-05	3.03E-05	**7.90E-05**
	Cobalt	1.48E-06	5.55E-09	2.54E-09	1.76E-09	8.04E-10	0.00E+00	1.25E-06	6.29E-05	1.77E-04	**2.42E-04**
	Copper	9.09E-06	3.05E-08	8.37E-08	1.29E-08	3.54E-08	0.00E+00	3.19E-04	4.37E-03	2.55E-02	**3.02E-02**
	Molybdenum	1.57E-06	2.40E-09	1.10E-09	2.35E-09	1.08E-09	0.00E+00	1.10E-08	5.17E-05	2.41E-03	**2.47E-03**
	Selenium	4.74E-07	2.24E-09	1.03E-09	4.33E-09	1.98E-09	0.00E+00	1.68E-04	4.39E-05	1.65E-03	**1.86E-03**
	Uranium	4.41E-07	8.00E-09	3.66E-08	4.03E-09	1.84E-08	0.00E+00	6.16E-07	2.73E-05	3.52E-05	**6.36E-05**
	Vanadium	2.13E-06	1.01E-07	4.61E-07	7.79E-08	3.57E-07	0.00E+00	1.42E-05	7.20E-06	3.60E-04	**3.85E-04**
	Zinc	9.99E-06	1.11E-07	5.09E-07	6.92E-08	3.17E-07	0.00E+00	1.40E-03	1.07E-02	1.33E-01	**1.45E-01**
		Project Total Dose - Project Phases									
	Cadmium	3.82E-07	7.55E-09	3.46E-09	2.57E-09	1.18E-09	0.00E+00	1.00E-07	7.03E-06	1.99E-04	**2.06E-04**
	Chromium	8.25E-06	6.93E-08	3.17E-07	4.33E-08	1.98E-07	0.00E+00	3.68E-05	1.12E-05	3.29E-05	**8.97E-05**
	Cobalt	1.56E-06	5.55E-09	2.54E-09	1.84E-09	8.40E-10	0.00E+00	1.47E-06	6.29E-05	1.77E-04	**2.43E-04**
	Copper	9.63E-06	3.05E-08	8.38E-08	1.36E-08	3.73E-08	0.00E+00	3.86E-04	4.39E-03	2.55E-02	**3.03E-02**
	Molybdenum	7.07E-05	2.40E-09	1.10E-09	8.77E-08	4.02E-08	0.00E+00	1.59E-06	5.17E-05	2.50E-03	**2.62E-03**
	Selenium	1.46E-06	2.24E-09	1.03E-09	1.08E-08	4.94E-09	0.00E+00	1.08E-03	4.39E-05	1.78E-03	**2.90E-03**
	Uranium	1.79E-06	1.01E-08	4.61E-08	1.28E-08	5.87E-08	0.00E+00	6.71E-06	6.05E-05	4.02E-05	**1.09E-04**
	Vanadium	3.12E-06	1.01E-07	4.61E-07	1.01E-07	4.62E-07	0.00E+00	3.18E-05	7.22E-06	3.76E-04	**4.19E-04**
	Zinc	1.10E-05	1.11E-07	5.09E-07	7.43E-08	3.40E-07	0.00E+00	1.84E-03	1.07E-02	1.34E-01	**1.46E-01**
		Project Incremental Dose - Project Phases									
	Cadmium	4.22E-08	1.58E-13	7.19E-14	2.20E-10	1.01E-10	0.00E+00	2.88E-08	3.32E-09	2.47E-07	**3.21E-07**
	Chromium	6.24E-07	1.03E-12	4.72E-12	2.47E-09	1.13E-08	0.00E+00	7.44E-06	1.33E-08	2.59E-06	**1.07E-05**
	Cobalt	7.28E-08	8.30E-13	3.80E-13	8.01E-11	3.66E-11	0.00E+00	2.18E-07	3.44E-08	7.40E-07	**1.07E-06**
	Copper	5.35E-07	3.79E-11	1.04E-10	6.96E-10	1.91E-09	0.00E+00	6.67E-05	1.65E-05	7.20E-05	**1.56E-04**
	Molybdenum	6.91E-05	1.85E-13	8.48E-14	8.54E-08	3.91E-08	0.00E+00	1.58E-06	1.86E-08	8.21E-05	**1.53E-04**
	Selenium	9.85E-07	3.33E-13	1.52E-13	6.47E-09	2.96E-09	0.00E+00	9.10E-04	2.75E-08	1.28E-04	**1.04E-03**
	Uranium	1.34E-06	2.07E-09	9.47E-09	8.79E-09	4.02E-08	0.00E+00	6.10E-06	3.32E-05	5.02E-06	**4.58E-05**
	Vanadium	9.91E-07	4.21E-12	1.93E-11	2.31E-08	1.06E-07	0.00E+00	1.75E-05	2.24E-08	1.53E-05	**3.40E-05**
	Zinc	1.03E-06	1.33E-11	6.07E-11	5.13E-09	2.35E-08	0.00E+00	4.42E-04	3.74E-06	2.02E-04	**6.49E-04**
Rec F/H One-year-old		**Average Baseline Dose**									
	Cadmium	3.80E-07	4.93E-07	5.91E-09	1.54E-07	1.84E-09	0.00E+00	6.76E-08	1.57E-05	5.03E-04	**5.20E-04**

Human Receptor	COPC	Non-radiological Dose by Pathway during Project Phases (mg/kg/d)									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
(McGowan Lake)	Chromium	8.51E-06	4.53E-06	5.42E-07	2.67E-06	3.20E-07	0.00E+00	2.78E-05	2.58E-05	1.76E-05	**8.78E-05**
	Cobalt	1.66E-06	3.63E-07	4.35E-09	1.15E-07	1.37E-09	0.00E+00	1.18E-06	1.46E-04	3.78E-04	**5.27E-04**
	Copper	1.02E-05	1.99E-06	1.43E-07	8.42E-07	6.05E-08	0.00E+00	3.02E-04	1.01E-02	4.29E-02	**5.33E-02**
	Molybdenum	1.75E-06	1.57E-07	1.88E-09	1.54E-07	1.84E-09	0.00E+00	1.04E-08	1.20E-04	6.29E-03	**6.41E-03**
	Selenium	5.30E-07	1.47E-07	1.76E-09	2.83E-07	3.39E-09	0.00E+00	1.59E-04	1.03E-04	4.13E-03	**4.39E-03**
	Uranium	4.93E-07	5.22E-07	6.26E-08	2.63E-07	3.15E-08	0.00E+00	5.84E-07	6.25E-05	9.10E-05	**1.55E-04**
	Vanadium	2.38E-06	6.58E-06	7.89E-07	5.09E-06	6.10E-07	0.00E+00	1.35E-05	1.30E-05	8.78E-04	**9.20E-04**
	Zinc	1.12E-05	7.26E-06	8.70E-07	4.52E-06	5.42E-07	0.00E+00	1.32E-03	2.45E-02	2.76E-01	**3.02E-01**
		Project Total Dose - Project Phases									
	Cadmium	4.27E-07	4.93E-07	5.91E-09	1.68E-07	2.02E-09	0.00E+00	9.49E-08	1.58E-05	5.03E-04	**5.20E-04**
	Chromium	9.21E-06	4.53E-06	5.42E-07	2.83E-06	3.39E-07	0.00E+00	3.48E-05	2.58E-05	1.93E-05	**9.74E-05**
	Cobalt	1.74E-06	3.63E-07	4.35E-09	1.20E-07	1.44E-09	0.00E+00	1.39E-06	1.46E-04	3.78E-04	**5.28E-04**
	Copper	1.07E-05	1.99E-06	1.43E-07	8.87E-07	6.38E-08	0.00E+00	3.65E-04	1.01E-02	4.29E-02	**5.35E-02**
	Molybdenum	7.89E-05	1.57E-07	1.88E-09	5.73E-06	6.87E-08	0.00E+00	1.51E-06	1.20E-04	6.33E-03	**6.54E-03**
	Selenium	1.63E-06	1.47E-07	1.76E-09	7.06E-07	8.46E-09	0.00E+00	1.02E-03	1.03E-04	4.21E-03	**5.34E-03**
	Uranium	1.99E-06	6.58E-07	7.88E-08	8.37E-07	1.00E-07	0.00E+00	6.36E-06	1.29E-04	9.42E-05	**2.33E-04**
	Vanadium	3.49E-06	6.58E-06	7.89E-07	6.60E-06	7.91E-07	0.00E+00	3.01E-05	1.31E-05	8.86E-04	**9.48E-04**
	Zinc	1.23E-05	7.26E-06	8.70E-07	4.86E-06	5.82E-07	0.00E+00	1.74E-03	2.46E-02	2.76E-01	**3.02E-01**
		Project Incremental Dose - Project Phases									
	Cadmium	4.71E-08	1.03E-11	1.23E-13	1.44E-08	1.73E-10	0.00E+00	2.73E-08	6.84E-09	1.71E-07	**2.66E-07**
	Chromium	6.97E-07	6.73E-11	8.07E-12	1.61E-07	1.93E-08	0.00E+00	7.05E-06	1.73E-08	1.71E-06	**9.65E-06**
	Cobalt	8.13E-08	5.42E-11	6.50E-13	5.23E-09	6.27E-11	0.00E+00	2.07E-07	7.64E-08	4.22E-07	**7.92E-07**
	Copper	5.97E-07	2.48E-09	1.78E-10	4.54E-08	3.27E-09	0.00E+00	6.32E-05	3.87E-05	4.19E-05	**1.44E-04**
	Molybdenum	7.71E-05	1.21E-11	1.45E-13	5.58E-06	6.69E-08	0.00E+00	1.50E-06	4.15E-08	4.67E-05	**1.31E-04**
	Selenium	1.10E-06	2.18E-11	2.61E-13	4.23E-07	5.07E-09	0.00E+00	8.62E-04	6.26E-08	8.15E-05	**9.45E-04**
	Uranium	1.50E-06	1.35E-07	1.62E-08	5.74E-07	6.88E-08	0.00E+00	5.77E-06	6.60E-05	3.17E-06	**7.73E-05**
	Vanadium	1.11E-06	2.76E-10	3.30E-11	1.51E-06	1.81E-07	0.00E+00	1.66E-05	2.88E-08	8.46E-06	**2.79E-05**
	Zinc	1.15E-06	8.65E-10	1.04E-10	3.35E-07	4.02E-08	0.00E+00	4.19E-04	8.72E-06	1.02E-04	**5.30E-04**
		Average Baseline Dose									
Rec F/H Adult (Russell Lake)	Cadmium	3.40E-07	7.55E-09	3.46E-09	2.35E-09	1.08E-09	0.00E+00	7.14E-08	7.02E-06	1.99E-04	**2.06E-04**
	Chromium	7.62E-06	6.93E-08	3.17E-07	4.08E-08	1.87E-07	0.00E+00	2.94E-05	1.12E-05	3.03E-05	**7.90E-05**
	Cobalt	1.48E-06	5.55E-09	2.54E-09	1.76E-09	8.04E-10	0.00E+00	1.25E-06	6.29E-05	1.77E-04	**2.42E-04**

Human Receptor	COPC	Non-radiological Dose by Pathway during Project Phases (mg/kg/d)									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Copper	9.09E-06	3.05E-08	8.37E-08	1.29E-08	3.54E-08	0.00E+00	3.19E-04	4.37E-03	2.55E-02	**3.02E-02**
	Molybdenum	1.57E-06	2.40E-09	1.10E-09	2.35E-09	1.08E-09	0.00E+00	1.10E-08	5.17E-05	2.41E-03	**2.47E-03**
	Selenium	4.74E-07	2.24E-09	1.03E-09	4.33E-09	1.98E-09	0.00E+00	1.68E-04	4.39E-05	1.65E-03	**1.86E-03**
	Uranium	4.41E-07	8.00E-09	3.66E-08	4.03E-09	1.84E-08	0.00E+00	6.16E-07	2.73E-05	3.52E-05	**6.36E-05**
	Vanadium	2.13E-06	1.01E-07	4.61E-07	7.79E-08	3.57E-07	0.00E+00	1.42E-05	7.20E-06	3.60E-04	**3.85E-04**
	Zinc	9.99E-06	1.11E-07	5.09E-07	6.92E-08	3.17E-07	0.00E+00	1.40E-03	1.07E-02	1.33E-01	**1.45E-01**
		Project Total Dose - Project Phases									
Rec F/H One-year-old (Russell Lake)	Cadmium	3.74E-07	7.55E-09	3.46E-09	2.52E-09	1.15E-09	0.00E+00	9.23E-08	7.03E-06	1.99E-04	**2.06E-04**
	Chromium	8.14E-06	6.93E-08	3.17E-07	4.27E-08	1.95E-07	0.00E+00	3.48E-05	1.12E-05	3.22E-05	**8.70E-05**
	Cobalt	1.54E-06	5.55E-09	2.54E-09	1.82E-09	8.31E-10	0.00E+00	1.41E-06	6.29E-05	1.77E-04	**2.43E-04**
	Copper	9.49E-06	3.05E-08	8.37E-08	1.34E-08	3.68E-08	0.00E+00	3.69E-04	4.38E-03	2.55E-02	**3.03E-02**
	Molybdenum	5.34E-05	2.40E-09	1.10E-09	6.71E-08	3.07E-08	0.00E+00	1.20E-06	5.17E-05	2.48E-03	**2.58E-03**
	Selenium	1.18E-06	2.24E-09	1.03E-09	9.06E-09	4.15E-09	0.00E+00	8.36E-04	4.39E-05	1.74E-03	**2.62E-03**
	Uranium	1.41E-06	8.55E-09	3.91E-08	1.04E-08	4.78E-08	0.00E+00	5.01E-06	3.62E-05	3.81E-05	**8.08E-05**
	Vanadium	2.89E-06	1.01E-07	4.61E-07	9.26E-08	4.24E-07	0.00E+00	2.60E-05	7.20E-06	3.71E-04	**4.08E-04**
	Zinc	1.08E-05	1.11E-07	5.09E-07	7.30E-08	3.34E-07	0.00E+00	1.72E-03	1.07E-02	1.33E-01	**1.46E-01**
		Project Incremental Dose - Project Phases									
	Cadmium	3.42E-08	4.09E-14	1.82E-14	1.63E-10	7.44E-11	0.00E+00	2.09E-08	8.54E-10	1.83E-07	**2.39E-07**
	Chromium	5.12E-07	2.70E-13	1.22E-12	1.83E-09	8.40E-09	0.00E+00	5.45E-06	3.45E-09	1.95E-06	**7.93E-06**
	Cobalt	5.45E-08	2.13E-13	9.75E-14	6.09E-11	2.79E-11	0.00E+00	1.64E-07	8.85E-09	5.35E-07	**7.63E-07**
	Copper	4.00E-07	9.75E-12	2.68E-11	5.28E-10	1.45E-09	0.00E+00	5.01E-05	4.26E-06	3.94E-05	**9.41E-05**
	Molybdenum	5.18E-05	3.73E-14	1.70E-14	6.48E-08	2.97E-08	0.00E+00	1.19E-06	3.71E-09	6.22E-05	**1.15E-04**
	Selenium	7.07E-07	8.57E-14	3.92E-14	4.73E-09	2.16E-09	0.00E+00	6.68E-04	7.08E-09	9.41E-05	**7.63E-04**
	Uranium	9.66E-07	5.52E-10	2.53E-09	6.42E-09	2.94E-08	0.00E+00	4.40E-06	8.88E-06	2.95E-06	**1.72E-05**
	Vanadium	7.62E-07	1.08E-12	4.95E-12	1.47E-08	6.71E-08	0.00E+00	1.18E-05	5.77E-09	1.03E-05	**2.30E-05**
	Zinc	8.49E-07	3.40E-12	1.56E-11	3.78E-09	1.73E-08	0.00E+00	3.21E-04	9.64E-07	1.48E-04	**4.71E-04**
		Average Baseline Dose									
	Cadmium	3.80E-07	4.93E-07	5.91E-09	1.54E-07	1.84E-09	0.00E+00	6.76E-08	1.57E-05	5.03E-04	**5.20E-04**
	Chromium	8.51E-06	4.53E-06	5.42E-07	2.67E-06	3.20E-07	0.00E+00	2.78E-05	2.58E-05	1.76E-05	**8.78E-05**
	Cobalt	1.66E-06	3.63E-07	4.35E-09	1.15E-07	1.37E-09	0.00E+00	1.18E-06	1.46E-04	3.78E-04	**5.27E-04**
	Copper	1.02E-05	1.99E-06	1.43E-07	8.42E-07	6.05E-08	0.00E+00	3.02E-04	1.01E-02	4.29E-02	**5.33E-02**
	Molybdenum	1.75E-06	1.57E-07	1.88E-09	1.54E-07	1.84E-09	0.00E+00	1.04E-08	1.20E-04	6.29E-03	**6.41E-03**

Human Receptor	COPC	Non-radiological Dose by Pathway during Project Phases (mg/kg/d)									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
Seasonal Resident Adult (Russell Lake)	Selenium	5.30E-07	1.47E-07	1.76E-09	2.83E-07	3.39E-09	0.00E+00	1.59E-04	1.03E-04	4.13E-03	**4.39E-03**
	Uranium	4.93E-07	5.22E-07	6.26E-08	2.63E-07	3.15E-08	0.00E+00	5.84E-07	6.25E-05	9.10E-05	**1.55E-04**
	Vanadium	2.38E-06	6.58E-06	7.89E-07	5.09E-06	6.10E-07	0.00E+00	1.35E-05	1.30E-05	8.78E-04	**9.20E-04**
	Zinc	1.12E-05	7.26E-06	8.70E-07	4.52E-06	5.42E-07	0.00E+00	1.32E-03	2.45E-02	2.76E-01	**3.02E-01**
		Project Total Dose - Project Phases									
	Cadmium	4.18E-07	4.93E-07	5.91E-09	1.64E-07	1.97E-09	0.00E+00	8.74E-08	1.57E-05	5.03E-04	**5.20E-04**
	Chromium	9.08E-06	4.53E-06	5.42E-07	2.79E-06	3.34E-07	0.00E+00	3.30E-05	2.58E-05	1.89E-05	**9.49E-05**
	Cobalt	1.72E-06	3.63E-07	4.35E-09	1.19E-07	1.42E-09	0.00E+00	1.34E-06	1.46E-04	3.78E-04	**5.27E-04**
	Copper	1.06E-05	1.99E-06	1.43E-07	8.76E-07	6.30E-08	0.00E+00	3.49E-04	1.01E-02	4.29E-02	**5.34E-02**
	Molybdenum	5.96E-05	1.57E-07	1.88E-09	4.39E-06	5.26E-08	0.00E+00	1.13E-06	1.20E-04	6.32E-03	**6.51E-03**
	Selenium	1.32E-06	1.47E-07	1.76E-09	5.92E-07	7.09E-09	0.00E+00	7.91E-04	1.03E-04	4.19E-03	**5.09E-03**
	Uranium	1.57E-06	5.59E-07	6.69E-08	6.82E-07	8.18E-08	0.00E+00	4.75E-06	8.01E-05	9.29E-05	**1.81E-04**
	Vanadium	3.23E-06	6.58E-06	7.89E-07	6.05E-06	7.25E-07	0.00E+00	2.47E-05	1.30E-05	8.84E-04	**9.39E-04**
	Zinc	1.21E-05	7.26E-06	8.70E-07	4.77E-06	5.71E-07	0.00E+00	1.63E-03	2.45E-02	2.76E-01	**3.02E-01**
		Project Incremental Dose - Project Phases									
	Cadmium	3.82E-08	2.67E-12	3.15E-14	1.06E-08	1.27E-10	0.00E+00	1.98E-08	1.76E-09	1.26E-07	**1.97E-07**
	Chromium	5.72E-07	1.77E-11	2.10E-12	1.20E-07	1.44E-08	0.00E+00	5.17E-06	4.50E-09	1.29E-06	**7.16E-06**
	Cobalt	6.08E-08	1.40E-11	1.67E-13	3.98E-09	4.77E-11	0.00E+00	1.55E-07	1.96E-08	3.06E-07	**5.46E-07**
	Copper	4.47E-07	6.37E-10	4.58E-11	3.45E-08	2.48E-09	0.00E+00	4.74E-05	9.94E-06	2.38E-05	**8.16E-05**
	Molybdenum	5.79E-05	2.43E-12	2.89E-14	4.23E-06	5.07E-08	0.00E+00	1.12E-06	8.30E-09	3.54E-05	**9.87E-05**
	Selenium	7.90E-07	5.60E-12	6.72E-14	3.09E-07	3.70E-09	0.00E+00	6.33E-04	1.61E-08	6.00E-05	**6.94E-04**
	Uranium	1.08E-06	3.61E-08	4.32E-09	4.19E-07	5.03E-08	0.00E+00	4.16E-06	1.76E-05	1.86E-06	**2.52E-05**
	Vanadium	8.51E-07	7.09E-11	8.47E-12	9.58E-07	1.15E-07	0.00E+00	1.12E-05	7.42E-09	5.67E-06	**1.88E-05**
	Zinc	9.48E-07	2.22E-10	2.67E-11	2.47E-07	2.96E-08	0.00E+00	3.04E-04	2.24E-06	7.44E-05	**3.82E-04**
		Average Baseline Dose									
	Cadmium	3.40E-07	7.55E-09	3.46E-09	2.35E-09	1.08E-09	0.00E+00	7.14E-08	7.02E-06	1.99E-04	**2.06E-04**
	Chromium	7.62E-06	6.93E-08	3.17E-07	4.08E-08	1.87E-07	0.00E+00	2.94E-05	1.12E-05	3.03E-05	**7.90E-05**
	Cobalt	1.48E-06	5.55E-09	2.54E-09	1.76E-09	8.04E-10	0.00E+00	1.25E-06	6.29E-05	1.77E-04	**2.42E-04**
	Copper	9.09E-06	3.05E-08	8.37E-08	1.29E-08	3.54E-08	0.00E+00	3.19E-04	4.37E-03	2.55E-02	**3.02E-02**
	Molybdenum	1.57E-06	2.40E-09	1.10E-09	2.35E-09	1.08E-09	0.00E+00	1.10E-08	5.17E-05	2.41E-03	**2.47E-03**
	Selenium	4.74E-07	2.24E-09	1.03E-09	4.33E-09	1.98E-09	0.00E+00	1.68E-04	4.39E-05	1.65E-03	**1.86E-03**
	Uranium	4.41E-07	8.00E-09	3.66E-08	4.03E-09	1.84E-08	0.00E+00	6.16E-07	2.73E-05	3.52E-05	**6.36E-05**

Human Receptor	COPC	Non-radiological Dose by Pathway during Project Phases (mg/kg/d)									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Vanadium	2.13E-06	1.01E-07	4.61E-07	7.79E-08	3.57E-07	0.00E+00	1.42E-05	7.20E-06	3.60E-04	**3.85E-04**
	Zinc	9.99E-06	1.11E-07	5.09E-07	6.92E-08	3.17E-07	0.00E+00	1.40E-03	1.07E-02	1.33E-01	**1.45E-01**
		Project Total Dose - Project Phases									
Seasonal Resident One-year-old (Russell Lake)	**Cadmium**	3.74E-07	7.55E-09	3.46E-09	2.52E-09	1.15E-09	0.00E+00	7.83E-08	7.03E-06	1.99E-04	**2.06E-04**
	Chromium	8.14E-06	6.93E-08	3.17E-07	4.27E-08	1.95E-07	0.00E+00	3.12E-05	1.12E-05	3.09E-05	**8.21E-05**
	Cobalt	1.54E-06	5.55E-09	2.54E-09	1.82E-09	8.31E-10	0.00E+00	1.30E-06	6.29E-05	1.77E-04	**2.42E-04**
	Copper	9.49E-06	3.05E-08	8.37E-08	1.34E-08	3.68E-08	0.00E+00	3.33E-04	4.38E-03	2.55E-02	**3.02E-02**
	Molybdenum	5.34E-05	2.40E-09	1.10E-09	6.71E-08	3.07E-08	0.00E+00	3.67E-07	5.17E-05	2.43E-03	**2.54E-03**
	Selenium	1.18E-06	2.24E-09	1.03E-09	9.06E-09	4.15E-09	0.00E+00	3.64E-04	4.39E-05	1.68E-03	**2.09E-03**
	Uranium	1.41E-06	8.55E-09	3.91E-08	1.04E-08	4.78E-08	0.00E+00	1.92E-06	3.00E-05	3.65E-05	**6.99E-05**
	Vanadium	2.89E-06	1.01E-07	4.61E-07	9.26E-08	4.24E-07	0.00E+00	1.91E-05	7.20E-06	3.64E-04	**3.94E-04**
	Zinc	1.08E-05	1.11E-07	5.09E-07	7.30E-08	3.34E-07	0.00E+00	1.51E-03	1.07E-02	1.33E-01	**1.46E-01**
		Project Incremental Dose - Project Phases									
	Cadmium	3.42E-08	4.09E-14	1.82E-14	1.63E-10	7.44E-11	0.00E+00	6.90E-09	2.56E-10	5.90E-08	**1.01E-07**
	Chromium	5.12E-07	2.70E-13	1.22E-12	1.83E-09	8.40E-09	0.00E+00	1.89E-06	1.05E-09	6.36E-07	**3.05E-06**
	Cobalt	5.45E-08	2.13E-13	9.75E-14	6.09E-11	2.79E-11	0.00E+00	4.55E-08	2.66E-09	1.49E-07	**2.51E-07**
	Copper	4.00E-07	9.75E-12	2.68E-11	5.28E-10	1.45E-09	0.00E+00	1.39E-05	1.28E-06	1.16E-05	**2.72E-05**
	Molybdenum	5.18E-05	3.73E-14	1.70E-14	6.48E-08	2.97E-08	0.00E+00	3.56E-07	1.12E-09	1.86E-05	**7.09E-05**
	Selenium	7.07E-07	8.57E-14	3.92E-14	4.73E-09	2.16E-09	0.00E+00	1.97E-04	2.12E-09	2.99E-05	**2.27E-04**
	Uranium	9.66E-07	5.52E-10	2.53E-09	6.42E-09	2.94E-08	0.00E+00	1.30E-06	2.67E-06	1.33E-06	**6.32E-06**
	Vanadium	7.62E-07	1.08E-12	4.95E-12	1.47E-08	6.71E-08	0.00E+00	4.82E-06	1.75E-09	3.98E-06	**9.65E-06**
	Zinc	8.49E-07	3.40E-12	1.56E-11	3.78E-09	1.73E-08	0.00E+00	1.14E-04	2.89E-07	5.70E-05	**1.72E-04**
		Average Baseline Dose									
	Cadmium	3.80E-07	4.93E-07	5.91E-09	1.54E-07	1.84E-09	0.00E+00	6.76E-08	1.57E-05	5.03E-04	**5.20E-04**
	Chromium	8.51E-06	4.53E-06	5.42E-07	2.67E-06	3.20E-07	0.00E+00	2.78E-05	2.58E-05	1.76E-05	**8.78E-05**
	Cobalt	1.66E-06	3.63E-07	4.35E-09	1.15E-07	1.37E-09	0.00E+00	1.18E-06	1.46E-04	3.78E-04	**5.27E-04**
	Copper	1.02E-05	1.99E-06	1.43E-07	8.42E-07	6.05E-08	0.00E+00	3.02E-04	1.01E-02	4.29E-02	**5.33E-02**
	Molybdenum	1.75E-06	1.57E-07	1.88E-09	1.54E-07	1.84E-09	0.00E+00	1.04E-08	1.20E-04	6.29E-03	**6.41E-03**
	Selenium	5.30E-07	1.47E-07	1.76E-09	2.83E-07	3.39E-09	0.00E+00	1.59E-04	1.03E-04	4.13E-03	**4.39E-03**
	Uranium	4.93E-07	5.22E-07	6.26E-08	2.63E-07	3.15E-08	0.00E+00	5.84E-07	6.25E-05	9.10E-05	**1.55E-04**
	Vanadium	2.38E-06	6.58E-06	7.89E-07	5.09E-06	6.10E-07	0.00E+00	1.35E-05	1.30E-05	8.78E-04	**9.20E-04**
	Zinc	1.12E-05	7.26E-06	8.70E-07	4.52E-06	5.42E-07	0.00E+00	1.32E-03	2.45E-02	2.76E-01	**3.02E-01**

Human Receptor	COPC	Non-radiological Dose by Pathway during Project Phases (mg/kg/d)									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
		Project Total Dose - Project Phases									
	Cadmium	4.18E-07	4.93E-07	5.91E-09	1.64E-07	1.97E-09	0.00E+00	7.41E-08	1.57E-05	5.03E-04	**5.20E-04**
	Chromium	9.08E-06	4.53E-06	5.42E-07	2.79E-06	3.34E-07	0.00E+00	2.96E-05	2.58E-05	1.80E-05	**9.07E-05**
	Cobalt	1.72E-06	3.63E-07	4.35E-09	1.19E-07	1.42E-09	0.00E+00	1.23E-06	1.46E-04	3.78E-04	**5.27E-04**
	Copper	1.06E-05	1.99E-06	1.43E-07	8.76E-07	6.30E-08	0.00E+00	3.15E-04	1.01E-02	4.29E-02	**5.34E-02**
	Molybdenum	5.96E-05	1.57E-07	1.88E-09	4.39E-06	5.26E-08	0.00E+00	3.47E-07	1.20E-04	6.30E-03	**6.48E-03**
	Selenium	1.32E-06	1.47E-07	1.76E-09	5.92E-07	7.09E-09	0.00E+00	3.45E-04	1.03E-04	4.15E-03	**4.60E-03**
	Uranium	1.57E-06	5.59E-07	6.69E-08	6.82E-07	8.18E-08	0.00E+00	1.82E-06	6.78E-05	9.18E-05	**1.64E-04**
	Vanadium	3.23E-06	6.58E-06	7.89E-07	6.05E-06	7.25E-07	0.00E+00	1.81E-05	1.30E-05	8.80E-04	**9.29E-04**
	Zinc	1.21E-05	7.26E-06	8.70E-07	4.77E-06	5.71E-07	0.00E+00	1.43E-03	2.45E-02	2.76E-01	**3.02E-01**
		Project Incremental Dose - Project Phases									
	Cadmium	3.82E-08	2.67E-12	3.15E-14	1.06E-08	1.27E-10	0.00E+00	6.53E-09	5.28E-10	3.87E-08	**9.47E-08**
	Chromium	5.72E-07	1.77E-11	2.10E-12	1.20E-07	1.44E-08	0.00E+00	1.79E-06	1.34E-09	4.03E-07	**2.90E-06**
	Cobalt	6.08E-08	1.40E-11	1.67E-13	3.98E-09	4.77E-11	0.00E+00	4.31E-08	5.88E-09	8.25E-08	**1.96E-07**
	Copper	4.47E-07	6.37E-10	4.58E-11	3.45E-08	2.48E-09	0.00E+00	1.32E-05	2.98E-06	6.81E-06	**2.34E-05**
	Molybdenum	5.79E-05	2.43E-12	2.89E-14	4.23E-06	5.07E-08	0.00E+00	3.37E-07	2.49E-09	1.03E-05	**7.27E-05**
	Selenium	7.90E-07	5.60E-12	6.72E-14	3.09E-07	3.70E-09	0.00E+00	1.86E-04	4.83E-09	1.85E-05	**2.06E-04**
	Uranium	1.08E-06	3.61E-08	4.32E-09	4.19E-07	5.03E-08	0.00E+00	1.24E-06	5.28E-06	8.05E-07	**8.91E-06**
	Vanadium	8.51E-07	7.09E-11	8.47E-12	9.58E-07	1.15E-07	0.00E+00	4.57E-06	2.21E-09	2.19E-06	**8.69E-06**
	Zinc	9.48E-07	2.22E-10	2.67E-11	2.47E-07	2.96E-08	0.00E+00	1.07E-04	6.76E-07	2.94E-05	**1.39E-04**
		Average Baseline Dose									
	Cadmium	3.40E-07	7.55E-09	3.46E-09	2.35E-09	1.08E-09	0.00E+00	4.91E-07	0.00E+00	1.61E-04	**1.62E-04**
	Chromium	7.62E-06	6.93E-08	3.17E-07	4.08E-08	1.87E-07	0.00E+00	2.02E-04	0.00E+00	8.27E-04	**1.04E-03**
	Cobalt	1.48E-06	5.55E-09	2.54E-09	1.76E-09	8.04E-10	0.00E+00	8.60E-06	0.00E+00	7.79E-05	**8.80E-05**
	Copper	9.09E-06	3.05E-08	8.37E-08	1.29E-08	3.54E-08	0.00E+00	2.19E-03	0.00E+00	1.19E-02	**1.41E-02**
Fisher/Trapper Adult (Russell Lake)	**Molybdenum**	1.57E-06	2.40E-09	1.10E-09	2.35E-09	1.08E-09	0.00E+00	7.58E-08	0.00E+00	1.28E-03	**1.28E-03**
	Selenium	4.74E-07	2.24E-09	1.03E-09	4.33E-09	1.98E-09	0.00E+00	1.15E-03	0.00E+00	1.58E-03	**2.73E-03**
	Uranium	4.41E-07	8.00E-09	3.66E-08	4.03E-09	1.84E-08	0.00E+00	4.24E-06	0.00E+00	2.19E-05	**2.66E-05**
	Vanadium	2.13E-06	1.01E-07	4.61E-07	7.79E-08	3.57E-07	0.00E+00	9.80E-05	0.00E+00	7.72E-04	**8.73E-04**
	Zinc	9.99E-06	1.11E-07	5.09E-07	6.92E-08	3.17E-07	0.00E+00	9.62E-03	0.00E+00	3.08E-01	**3.18E-01**
		Project Total Dose - Project Phases									
	Cadmium	3.90E-07	7.55E-09	3.46E-09	2.63E-09	1.20E-09	0.00E+00	6.35E-07	0.00E+00	1.62E-04	**1.63E-04**

Human Receptor	COPC	Non-radiological Dose by Pathway during Project Phases (mg/kg/d)									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Chromium	8.36E-06	6.93E-08	3.17E-07	4.39E-08	2.01E-07	0.00E+00	2.40E-04	0.00E+00	8.37E-04	**1.09E-03**
	Cobalt	1.58E-06	5.55E-09	2.54E-09	1.86E-09	8.50E-10	0.00E+00	9.73E-06	0.00E+00	7.80E-05	**8.94E-05**
	Copper	9.79E-06	3.05E-08	8.37E-08	1.38E-08	3.78E-08	0.00E+00	2.54E-03	0.00E+00	1.20E-02	**1.46E-02**
	Molybdenum	8.79E-05	2.40E-09	1.10E-09	1.10E-07	5.05E-08	0.00E+00	8.24E-06	0.00E+00	1.32E-03	**1.41E-03**
	Selenium	1.66E-06	2.24E-09	1.03E-09	1.22E-08	5.59E-09	0.00E+00	5.75E-03	0.00E+00	1.91E-03	**7.67E-03**
	Uranium	2.06E-06	8.92E-09	4.08E-08	1.47E-08	6.74E-08	0.00E+00	3.45E-05	0.00E+00	9.70E-05	**1.34E-04**
	Vanadium	3.18E-06	1.01E-07	4.61E-07	1.02E-07	4.68E-07	0.00E+00	1.79E-04	0.00E+00	8.55E-04	**1.04E-03**
	Zinc	1.12E-05	1.11E-07	5.09E-07	7.55E-08	3.46E-07	0.00E+00	1.18E-02	0.00E+00	3.09E-01	**3.21E-01**
		Project Incremental Dose - Project Phases									
	Cadmium	5.04E-08	6.75E-14	3.09E-14	2.71E-10	1.24E-10	0.00E+00	1.44E-07	0.00E+00	5.73E-07	**7.68E-07**
	Chromium	7.37E-07	4.48E-13	2.02E-12	3.05E-09	1.40E-08	0.00E+00	3.75E-05	0.00E+00	1.01E-05	**4.84E-05**
	Cobalt	9.49E-08	3.56E-13	1.63E-13	1.01E-10	4.64E-11	0.00E+00	1.13E-06	0.00E+00	1.37E-07	**1.36E-06**
	Copper	6.96E-07	1.63E-11	4.46E-11	8.80E-10	2.42E-09	0.00E+00	3.45E-04	0.00E+00	6.32E-05	**4.08E-04**
	Molybdenum	8.64E-05	6.22E-14	2.82E-14	1.08E-07	4.94E-08	0.00E+00	8.17E-06	0.00E+00	3.40E-05	**1.29E-04**
	Selenium	1.19E-06	1.43E-13	6.54E-14	7.88E-09	3.61E-09	0.00E+00	4.60E-03	0.00E+00	3.35E-04	**4.93E-03**
	Uranium	1.62E-06	9.20E-10	4.21E-09	1.07E-08	4.90E-08	0.00E+00	3.03E-05	0.00E+00	7.52E-05	**1.07E-04**
	Vanadium	1.05E-06	1.80E-12	8.27E-12	2.44E-08	1.12E-07	0.00E+00	8.12E-05	0.00E+00	8.30E-05	**1.65E-04**
	Zinc	1.22E-06	5.68E-12	2.60E-11	6.30E-09	2.88E-08	0.00E+00	2.21E-03	0.00E+00	1.07E-03	**3.28E-03**

COPC = constituent of potential concern.

Table 4-6: Estimated Non-radiological Doses to Human Receptors – Future Centuries

Human Receptor	COPC	Maximum Dose by Pathway during Future Centuries (mg/kg/d)									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
Permanent Resident (Whitefish Lake)		Baseline Dose									
	Cadmium	3.41E-07	7.55E-09	3.46E-09	2.36E-09	1.08E-09	0.00E+00	7.15E-08	7.02E-06	1.99E-04	**2.06E-04**
	Chromium	7.63E-06	6.93E-08	3.17E-07	4.09E-08	1.87E-07	0.00E+00	2.94E-05	1.12E-05	3.03E-05	**7.91E-05**
	Cobalt	1.49E-06	5.55E-09	2.54E-09	1.76E-09	8.04E-10	0.00E+00	1.25E-06	6.29E-05	1.77E-04	**2.42E-04**
	Copper	9.09E-06	3.05E-08	8.37E-08	1.29E-08	3.54E-08	0.00E+00	3.19E-04	4.37E-03	2.55E-02	**3.02E-02**
	Molybdenum	1.57E-06	2.40E-09	1.10E-09	2.35E-09	1.08E-09	0.00E+00	1.10E-08	5.17E-05	2.41E-03	**2.47E-03**
	Selenium	4.75E-07	2.24E-09	1.03E-09	4.34E-09	1.98E-09	0.00E+00	1.68E-04	4.39E-05	1.65E-03	**1.86E-03**
	Uranium	4.42E-07	8.00E-09	3.66E-08	4.03E-09	1.85E-08	0.00E+00	6.18E-07	2.73E-05	3.52E-05	**6.36E-05**
	Vanadium	2.14E-06	1.01E-07	4.61E-07	7.82E-08	3.58E-07	0.00E+00	1.43E-05	7.20E-06	3.60E-04	**3.85E-04**
	Zinc	1.00E-05	1.11E-07	5.09E-07	6.93E-08	3.17E-07	0.00E+00	1.40E-03	1.07E-02	1.33E-01	**1.45E-01**
		Project Total Dose - Future Centuries									
	Cadmium	3.43E-07	7.55E-09	3.46E-09	2.37E-09	1.09E-09	0.00E+00	7.19E-08	7.03E-06	1.99E-04	**2.06E-04**
	Chromium	7.73E-06	6.93E-08	3.17E-07	4.14E-08	1.90E-07	0.00E+00	2.98E-05	1.12E-05	3.05E-05	**7.97E-05**
	Cobalt	1.56E-06	5.56E-09	2.54E-09	1.85E-09	8.47E-10	0.00E+00	1.32E-06	6.30E-05	1.77E-04	**2.43E-04**
	Copper	9.22E-06	3.05E-08	8.37E-08	1.31E-08	3.59E-08	0.00E+00	3.23E-04	4.38E-03	2.55E-02	**3.02E-02**
	Molybdenum	1.71E-06	2.40E-09	1.10E-09	2.56E-09	1.17E-09	0.00E+00	1.20E-08	5.17E-05	2.41E-03	**2.47E-03**
	Selenium	6.33E-07	2.24E-09	1.03E-09	5.77E-09	2.64E-09	0.00E+00	2.17E-04	4.39E-05	1.66E-03	**1.92E-03**
	Uranium	5.41E-07	9.53E-09	4.36E-08	4.93E-09	2.26E-08	0.00E+00	7.56E-07	3.69E-05	3.53E-05	**7.36E-05**
	Vanadium	2.16E-06	1.01E-07	4.61E-07	7.89E-08	3.61E-07	0.00E+00	1.44E-05	7.20E-06	3.60E-04	**3.85E-04**
	Zinc	1.09E-05	1.11E-07	5.09E-07	7.53E-08	3.45E-07	0.00E+00	1.52E-03	1.07E-02	1.33E-01	**1.46E-01**
		Project Incremental Dose - Future Centuries									
	Cadmium	1.97E-09	1.26E-13	5.75E-14	1.37E-11	6.25E-12	0.00E+00	4.14E-10	2.29E-10	4.19E-09	**6.83E-09**
	Chromium	9.89E-08	0.00E+00	0.00E+00	5.29E-10	2.42E-09	0.00E+00	3.81E-07	0.00E+00	1.58E-07	**6.41E-07**
	Cobalt	7.89E-08	5.50E-12	2.52E-12	9.33E-11	4.27E-11	0.00E+00	6.64E-08	1.29E-07	1.80E-07	**4.55E-07**
	Copper	1.21E-07	1.72E-11	4.71E-11	1.71E-10	4.70E-10	0.00E+00	4.24E-06	4.64E-06	3.31E-06	**1.23E-05**
	Molybdenum	1.42E-07	0.00E+00	0.00E+00	2.13E-10	9.73E-11	0.00E+00	9.97E-10	0.00E+00	4.63E-08	**1.90E-07**
	Selenium	1.58E-07	2.35E-14	1.08E-14	1.44E-09	6.59E-10	0.00E+00	4.96E-05	9.64E-10	7.47E-06	**5.73E-05**

Human Receptor	COPC	Maximum Dose by Pathway during Future Centuries (mg/kg/d)									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Uranium	9.87E-08	1.53E-09	7.02E-09	9.00E-10	4.12E-09	0.00E+00	1.38E-07	9.63E-06	1.03E-07	**9.98E-06**
	Vanadium	1.93E-08	8.39E-12	3.85E-11	7.04E-10	3.22E-09	0.00E+00	1.29E-07	6.47E-10	1.24E-07	**2.77E-07**
	Zinc	8.67E-07	1.06E-11	4.86E-11	6.00E-09	2.74E-08	0.00E+00	1.21E-04	1.82E-06	5.55E-05	**1.79E-04**
Permanent Resident One-year-old (Whitefish Lake)		**Baseline Dose**									
	Cadmium	3.80E-07	4.93E-07	5.91E-09	1.54E-07	1.85E-09	0.00E+00	6.77E-08	1.57E-05	5.03E-04	**5.20E-04**
	Chromium	8.52E-06	4.53E-06	5.42E-07	2.67E-06	3.20E-07	0.00E+00	2.78E-05	2.58E-05	1.76E-05	**8.78E-05**
	Cobalt	1.66E-06	3.63E-07	4.35E-09	1.15E-07	1.38E-09	0.00E+00	1.18E-06	1.46E-04	3.78E-04	**5.27E-04**
	Copper	1.02E-05	1.99E-06	1.43E-07	8.42E-07	6.05E-08	0.00E+00	3.02E-04	1.01E-02	4.29E-02	**5.33E-02**
	Molybdenum	1.75E-06	1.57E-07	1.88E-09	1.54E-07	1.84E-09	0.00E+00	1.04E-08	1.20E-04	6.29E-03	**6.41E-03**
	Selenium	5.31E-07	1.47E-07	1.76E-09	2.83E-07	3.39E-09	0.00E+00	1.59E-04	1.03E-04	4.13E-03	**4.39E-03**
	Uranium	4.94E-07	5.22E-07	6.26E-08	2.63E-07	3.16E-08	0.00E+00	5.85E-07	6.25E-05	9.10E-05	**1.55E-04**
	Vanadium	2.39E-06	6.58E-06	7.89E-07	5.11E-06	6.12E-07	0.00E+00	1.35E-05	1.30E-05	8.78E-04	**9.20E-04**
	Zinc	1.12E-05	7.26E-06	8.70E-07	4.53E-06	5.42E-07	0.00E+00	1.33E-03	2.45E-02	2.76E-01	**3.02E-01**
		Project Total Dose - Future Centuries									
	Cadmium	3.83E-07	4.93E-07	5.91E-09	1.55E-07	1.86E-09	0.00E+00	6.81E-08	1.57E-05	5.03E-04	**5.20E-04**
	Chromium	8.63E-06	4.53E-06	5.42E-07	2.71E-06	3.24E-07	0.00E+00	2.82E-05	2.58E-05	1.77E-05	**8.84E-05**
	Cobalt	1.75E-06	3.63E-07	4.35E-09	1.21E-07	1.45E-09	0.00E+00	1.25E-06	1.46E-04	3.78E-04	**5.27E-04**
	Copper	1.03E-05	1.99E-06	1.43E-07	8.53E-07	6.13E-08	0.00E+00	3.06E-04	1.01E-02	4.29E-02	**5.33E-02**
	Molybdenum	1.91E-06	1.57E-07	1.88E-09	1.68E-07	2.01E-09	0.00E+00	1.14E-08	1.20E-04	6.29E-03	**6.41E-03**
	Selenium	7.07E-07	1.47E-07	1.76E-09	3.77E-07	4.52E-09	0.00E+00	2.06E-04	1.03E-04	4.13E-03	**4.44E-03**
	Uranium	6.04E-07	6.23E-07	7.46E-08	3.22E-07	3.86E-08	0.00E+00	7.16E-07	8.51E-05	9.11E-05	**1.79E-04**
	Vanadium	2.41E-06	6.58E-06	7.89E-07	5.16E-06	6.18E-07	0.00E+00	1.37E-05	1.30E-05	8.78E-04	**9.20E-04**
	Zinc	1.21E-05	7.26E-06	8.70E-07	4.92E-06	5.89E-07	0.00E+00	1.44E-03	2.45E-02	2.76E-01	**3.02E-01**
		Project Incremental Dose - Future Centuries									
	Cadmium	2.20E-09	8.24E-12	9.81E-14	8.92E-10	1.07E-11	0.00E+00	3.92E-10	5.17E-10	2.91E-09	**6.93E-09**
	Chromium	1.10E-07	0.00E+00	0.00E+00	3.46E-08	4.14E-09	0.00E+00	3.60E-07	0.00E+00	1.05E-07	**6.14E-07**
	Cobalt	8.81E-08	3.59E-10	4.30E-12	6.10E-09	7.31E-11	0.00E+00	6.29E-08	3.03E-07	1.06E-07	**5.67E-07**
	Copper	1.35E-07	1.12E-09	8.06E-11	1.12E-08	8.04E-10	0.00E+00	4.01E-06	1.09E-05	2.04E-06	**1.71E-05**

Human Receptor	COPC	Maximum Dose by Pathway during Future Centuries (mg/kg/d)									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Molybdenum	1.59E-07	0.00E+00	0.00E+00	1.39E-08	1.67E-10	0.00E+00	9.44E-10	0.00E+00	2.70E-08	**2.01E-07**
	Selenium	1.76E-07	1.53E-12	1.84E-14	9.41E-08	1.13E-09	0.00E+00	4.70E-05	2.26E-09	4.90E-06	**5.22E-05**
	Uranium	1.10E-07	1.00E-07	1.20E-08	5.88E-08	7.05E-09	0.00E+00	1.31E-07	2.26E-05	7.20E-08	**2.31E-05**
	Vanadium	2.15E-08	5.49E-10	6.58E-11	4.60E-08	5.51E-09	0.00E+00	1.22E-07	1.52E-09	6.90E-08	**2.66E-07**
	Zinc	9.68E-07	6.93E-10	8.31E-11	3.92E-07	4.70E-08	0.00E+00	1.15E-04	4.27E-06	2.81E-05	**1.49E-04**
Rec F/H (McGowan Lake)		**Baseline Dose**									
	Cadmium	3.41E-07	7.55E-09	3.46E-09	2.36E-09	1.08E-09	0.00E+00	7.15E-08	7.02E-06	1.99E-04	**2.06E-04**
	Chromium	7.63E-06	6.93E-08	3.17E-07	4.09E-08	1.87E-07	0.00E+00	2.94E-05	1.12E-05	3.03E-05	**7.91E-05**
	Cobalt	1.49E-06	5.55E-09	2.54E-09	1.76E-09	8.04E-10	0.00E+00	1.25E-06	6.29E-05	1.77E-04	**2.42E-04**
	Copper	9.09E-06	3.05E-08	8.37E-08	1.29E-08	3.54E-08	0.00E+00	3.19E-04	4.37E-03	2.55E-02	**3.02E-02**
	Molybdenum	1.57E-06	2.40E-09	1.10E-09	2.35E-09	1.08E-09	0.00E+00	1.10E-08	5.17E-05	2.41E-03	**2.47E-03**
	Selenium	4.75E-07	2.24E-09	1.03E-09	4.34E-09	1.98E-09	0.00E+00	1.68E-04	4.39E-05	1.65E-03	**1.86E-03**
	Uranium	4.42E-07	8.00E-09	3.66E-08	4.03E-09	1.85E-08	0.00E+00	6.18E-07	2.73E-05	3.52E-05	**6.36E-05**
	Vanadium	2.14E-06	1.01E-07	4.61E-07	7.82E-08	3.58E-07	0.00E+00	1.43E-05	7.20E-06	3.60E-04	**3.85E-04**
	Zinc	1.00E-05	1.11E-07	5.09E-07	6.93E-08	3.17E-07	0.00E+00	1.40E-03	1.07E-02	1.33E-01	**1.45E-01**
		Project Total Dose - Future Centuries									
	Cadmium	3.41E-07	7.55E-09	3.46E-09	2.36E-09	1.08E-09	0.00E+00	7.18E-08	7.02E-06	1.99E-04	**2.06E-04**
	Chromium	7.66E-06	6.93E-08	3.17E-07	4.10E-08	1.88E-07	0.00E+00	2.97E-05	1.12E-05	3.04E-05	**7.95E-05**
	Cobalt	1.50E-06	5.55E-09	2.54E-09	1.78E-09	8.13E-10	0.00E+00	1.30E-06	6.29E-05	1.77E-04	**2.42E-04**
	Copper	9.12E-06	3.05E-08	8.37E-08	1.29E-08	3.55E-08	0.00E+00	3.22E-04	4.38E-03	2.55E-02	**3.02E-02**
	Molybdenum	1.60E-06	2.40E-09	1.10E-09	2.40E-09	1.10E-09	0.00E+00	1.18E-08	5.17E-05	2.41E-03	**2.47E-03**
	Selenium	5.07E-07	2.24E-09	1.03E-09	4.62E-09	2.12E-09	0.00E+00	2.01E-04	4.39E-05	1.65E-03	**1.90E-03**
	Uranium	4.62E-07	8.11E-09	3.71E-08	4.21E-09	1.93E-08	0.00E+00	7.09E-07	2.86E-05	3.52E-05	**6.50E-05**
	Vanadium	2.14E-06	1.01E-07	4.61E-07	7.83E-08	3.58E-07	0.00E+00	1.44E-05	7.20E-06	3.60E-04	**3.85E-04**
	Zinc	1.02E-05	1.11E-07	5.09E-07	7.05E-08	3.23E-07	0.00E+00	1.48E-03	1.07E-02	1.33E-01	**1.46E-01**
		Project Incremental Dose - Future Centuries									
	Cadmium	4.06E-10	8.88E-15	3.77E-15	2.81E-12	1.29E-12	0.00E+00	2.84E-10	2.50E-11	3.04E-09	**3.76E-09**
	Chromium	2.09E-08	0.00E+00	0.00E+00	1.12E-10	5.11E-10	0.00E+00	2.68E-07	0.00E+00	1.16E-07	**4.05E-07**

Human Receptor	COPC	Maximum Dose by Pathway during Future Centuries (mg/kg/d)									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Cobalt	1.77E-08	3.81E-13	1.75E-13	2.10E-11	9.61E-12	0.00E+00	4.98E-08	1.40E-08	1.68E-07	**2.49E-07**
	Copper	2.71E-08	1.20E-12	3.29E-12	3.83E-11	1.05E-10	0.00E+00	3.16E-06	5.02E-07	2.65E-06	**6.34E-06**
	Molybdenum	3.18E-08	0.00E+00	0.00E+00	4.76E-11	2.18E-11	0.00E+00	7.43E-10	0.00E+00	4.33E-08	**7.59E-08**
	Selenium	3.15E-08	1.55E-15	6.66E-16	2.87E-10	1.31E-10	0.00E+00	3.31E-05	1.06E-10	5.14E-06	**3.83E-05**
	Uranium	1.97E-08	1.17E-10	5.34E-10	1.79E-10	8.21E-10	0.00E+00	9.16E-08	1.25E-06	4.54E-08	**1.41E-06**
	Vanadium	2.54E-09	5.76E-13	2.67E-12	9.29E-11	4.25E-10	0.00E+00	5.66E-08	7.05E-11	5.72E-08	**1.17E-07**
	Zinc	1.79E-07	7.46E-13	3.41E-12	1.24E-09	5.66E-09	0.00E+00	8.33E-05	1.97E-07	3.81E-05	**1.22E-04**
Rec F/H One-year-old (McGowan Lake)		Baseline Dose									
	Cadmium	3.80E-07	4.93E-07	5.91E-09	1.54E-07	1.85E-09	0.00E+00	6.77E-08	1.57E-05	5.03E-04	**5.20E-04**
	Chromium	8.52E-06	4.53E-06	5.42E-07	2.67E-06	3.20E-07	0.00E+00	2.78E-05	2.58E-05	1.76E-05	**8.78E-05**
	Cobalt	1.66E-06	3.63E-07	4.35E-09	1.15E-07	1.38E-09	0.00E+00	1.18E-06	1.46E-04	3.78E-04	**5.27E-04**
	Copper	1.02E-05	1.99E-06	1.43E-07	8.42E-07	6.05E-08	0.00E+00	3.02E-04	1.01E-02	4.29E-02	**5.33E-02**
	Molybdenum	1.75E-06	1.57E-07	1.88E-09	1.54E-07	1.84E-09	0.00E+00	1.04E-08	1.20E-04	6.29E-03	**6.41E-03**
	Selenium	5.31E-07	1.47E-07	1.76E-09	2.83E-07	3.39E-09	0.00E+00	1.59E-04	1.03E-04	4.13E-03	**4.39E-03**
	Uranium	4.94E-07	5.22E-07	6.26E-08	2.63E-07	3.16E-08	0.00E+00	5.85E-07	6.25E-05	9.10E-05	**1.55E-04**
	Vanadium	2.39E-06	6.58E-06	7.89E-07	5.11E-06	6.12E-07	0.00E+00	1.35E-05	1.30E-05	8.78E-04	**9.20E-04**
	Zinc	1.12E-05	7.26E-06	8.70E-07	4.53E-06	5.42E-07	0.00E+00	1.33E-03	2.45E-02	2.76E-01	**3.02E-01**
		Project Total Dose - Future Centuries									
	Cadmium	3.81E-07	4.93E-07	5.91E-09	1.54E-07	1.85E-09	0.00E+00	6.80E-08	1.57E-05	5.03E-04	**5.20E-04**
	Chromium	8.55E-06	4.53E-06	5.42E-07	2.68E-06	3.21E-07	0.00E+00	2.81E-05	2.58E-05	1.77E-05	**8.82E-05**
	Cobalt	1.68E-06	3.63E-07	4.35E-09	1.16E-07	1.39E-09	0.00E+00	1.23E-06	1.46E-04	3.78E-04	**5.27E-04**
	Copper	1.02E-05	1.99E-06	1.43E-07	8.44E-07	6.07E-08	0.00E+00	3.05E-04	1.01E-02	4.29E-02	**5.33E-02**
	Molybdenum	1.79E-06	1.57E-07	1.88E-09	1.57E-07	1.88E-09	0.00E+00	1.11E-08	1.20E-04	6.29E-03	**6.41E-03**
	Selenium	5.66E-07	1.47E-07	1.76E-09	3.02E-07	3.62E-09	0.00E+00	1.90E-04	1.03E-04	4.13E-03	**4.43E-03**
	Uranium	5.16E-07	5.30E-07	6.35E-08	2.75E-07	3.30E-08	0.00E+00	6.72E-07	6.55E-05	9.11E-05	**1.59E-04**
	Vanadium	2.39E-06	6.58E-06	7.89E-07	5.12E-06	6.13E-07	0.00E+00	1.36E-05	1.30E-05	8.78E-04	**9.20E-04**
	Zinc	1.14E-05	7.26E-06	8.70E-07	4.61E-06	5.52E-07	0.00E+00	1.41E-03	2.45E-02	2.76E-01	**3.02E-01**
		Project Incremental Dose - Future Centuries									

Human Receptor	COPC	Maximum Dose by Pathway during Future Centuries (mg/kg/d)									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Cadmium	4.54E-10	5.68E-13	6.66E-15	1.84E-10	2.20E-12	0.00E+00	2.69E-10	5.64E-11	2.10E-09	**3.06E-09**
	Chromium	2.33E-08	0.00E+00	0.00E+00	7.30E-09	8.75E-10	0.00E+00	2.54E-07	0.00E+00	7.68E-08	**3.62E-07**
	Cobalt	1.98E-08	2.49E-11	2.98E-13	1.37E-09	1.64E-11	0.00E+00	4.72E-08	3.29E-08	9.69E-08	**1.98E-07**
	Copper	3.02E-08	7.82E-11	5.61E-12	2.50E-09	1.80E-10	0.00E+00	3.00E-06	1.18E-06	1.62E-06	**5.83E-06**
	Molybdenum	3.55E-08	0.00E+00	0.00E+00	3.11E-09	3.73E-11	0.00E+00	7.04E-10	0.00E+00	2.47E-08	**6.40E-08**
	Selenium	3.51E-08	9.95E-14	1.22E-15	1.88E-08	2.25E-10	0.00E+00	3.14E-05	2.47E-10	3.35E-06	**3.48E-05**
	Uranium	2.20E-08	7.63E-09	9.14E-10	1.17E-08	1.40E-09	0.00E+00	8.68E-08	2.95E-06	3.30E-08	**3.11E-06**
	Vanadium	2.84E-09	3.87E-11	4.55E-12	6.07E-09	7.27E-10	0.00E+00	5.36E-08	1.65E-10	3.18E-08	**9.53E-08**
	Zinc	1.99E-07	4.77E-11	5.80E-12	8.07E-08	9.68E-09	0.00E+00	7.89E-05	4.62E-07	1.93E-05	**9.89E-05**
Rec F/H (Russell Lake)		**Baseline Dose**									
	Cadmium	3.41E-07	7.55E-09	3.46E-09	2.36E-09	1.08E-09	0.00E+00	7.15E-08	7.02E-06	1.99E-04	**2.06E-04**
	Chromium	7.63E-06	6.93E-08	3.17E-07	4.09E-08	1.87E-07	0.00E+00	2.94E-05	1.12E-05	3.03E-05	**7.91E-05**
	Cobalt	1.49E-06	5.55E-09	2.54E-09	1.76E-09	8.04E-10	0.00E+00	1.25E-06	6.29E-05	1.77E-04	**2.42E-04**
	Copper	9.09E-06	3.05E-08	8.37E-08	1.29E-08	3.54E-08	0.00E+00	3.19E-04	4.37E-03	2.55E-02	**3.02E-02**
	Molybdenum	1.57E-06	2.40E-09	1.10E-09	2.35E-09	1.08E-09	0.00E+00	1.10E-08	5.17E-05	2.41E-03	**2.47E-03**
	Selenium	4.75E-07	2.24E-09	1.03E-09	4.34E-09	1.98E-09	0.00E+00	1.68E-04	4.39E-05	1.65E-03	**1.86E-03**
	Uranium	4.42E-07	8.00E-09	3.66E-08	4.03E-09	1.85E-08	0.00E+00	6.18E-07	2.73E-05	3.52E-05	**6.36E-05**
	Vanadium	2.14E-06	1.01E-07	4.61E-07	7.82E-08	3.58E-07	0.00E+00	1.43E-05	7.20E-06	3.60E-04	**3.85E-04**
	Zinc	1.00E-05	1.11E-07	5.09E-07	6.93E-08	3.17E-07	0.00E+00	1.40E-03	1.07E-02	1.33E-01	**1.45E-01**
		Project Total Dose - Future Centuries									
	Cadmium	3.41E-07	7.55E-09	3.46E-09	2.36E-09	1.08E-09	0.00E+00	7.17E-08	7.02E-06	1.99E-04	**2.06E-04**
	Chromium	7.65E-06	6.93E-08	3.17E-07	4.10E-08	1.87E-07	0.00E+00	2.96E-05	1.12E-05	3.04E-05	**7.94E-05**
	Cobalt	1.50E-06	5.55E-09	2.54E-09	1.77E-09	8.11E-10	0.00E+00	1.29E-06	6.29E-05	1.77E-04	**2.42E-04**
	Copper	9.12E-06	3.05E-08	8.37E-08	1.29E-08	3.55E-08	0.00E+00	3.21E-04	4.37E-03	2.55E-02	**3.02E-02**
	Molybdenum	1.60E-06	2.40E-09	1.10E-09	2.39E-09	1.09E-09	0.00E+00	1.16E-08	5.17E-05	2.41E-03	**2.47E-03**
	Selenium	4.98E-07	2.24E-09	1.03E-09	4.55E-09	2.08E-09	0.00E+00	1.92E-04	4.39E-05	1.65E-03	**1.89E-03**
	Uranium	4.57E-07	8.03E-09	3.67E-08	4.16E-09	1.91E-08	0.00E+00	6.85E-07	2.76E-05	3.52E-05	**6.41E-05**
	Vanadium	2.14E-06	1.01E-07	4.61E-07	7.82E-08	3.58E-07	0.00E+00	1.43E-05	7.20E-06	3.60E-04	**3.85E-04**

Human Receptor	COPC	Maximum Dose by Pathway during Future Centuries (mg/kg/d)									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Zinc	1.01E-05	1.11E-07	5.09E-07	7.02E-08	3.21E-07	0.00E+00	1.46E-03	1.07E-02	1.33E-01	**1.46E-01**
		Project Incremental Dose - Future Centuries									
	Cadmium	3.02E-10	2.66E-15	1.11E-15	2.09E-12	9.55E-13	0.00E+00	2.11E-10	6.37E-12	2.27E-09	**2.79E-09**
	Chromium	1.56E-08	0.00E+00	0.00E+00	8.35E-11	3.82E-10	0.00E+00	2.00E-07	0.00E+00	8.78E-08	**3.04E-07**
	Cobalt	1.35E-08	9.81E-14	4.46E-14	1.60E-11	7.32E-12	0.00E+00	3.80E-08	3.59E-09	1.25E-07	**1.81E-07**
	Copper	2.06E-08	3.09E-13	8.53E-13	2.92E-11	8.02E-11	0.00E+00	2.41E-06	1.29E-07	1.74E-06	**4.30E-06**
	Molybdenum	2.42E-08	0.00E+00	0.00E+00	3.62E-11	1.66E-11	0.00E+00	5.66E-10	0.00E+00	3.28E-08	**5.77E-08**
	Selenium	2.31E-08	2.22E-16	1.11E-16	2.11E-10	9.65E-11	0.00E+00	2.44E-05	2.55E-11	3.82E-06	**2.82E-05**
	Uranium	1.44E-08	3.11E-11	1.42E-10	1.32E-10	6.03E-10	0.00E+00	6.73E-08	3.35E-07	3.04E-08	**4.48E-07**
	Vanadium	1.63E-09	1.42E-13	7.11E-13	5.94E-11	2.72E-10	0.00E+00	3.62E-08	1.77E-11	3.82E-08	**7.64E-08**
	Zinc	1.33E-07	1.92E-13	8.53E-13	9.17E-10	4.20E-09	0.00E+00	6.18E-05	5.03E-08	2.89E-05	**9.09E-05**
Rec F/H One-year-old (Russell Lake)		**Baseline Dose**									
	Cadmium	3.80E-07	4.93E-07	5.91E-09	1.54E-07	1.85E-09	0.00E+00	6.77E-08	1.57E-05	5.03E-04	**5.20E-04**
	Chromium	8.52E-06	4.53E-06	5.42E-07	2.67E-06	3.20E-07	0.00E+00	2.78E-05	2.58E-05	1.76E-05	**8.78E-05**
	Cobalt	1.66E-06	3.63E-07	4.35E-09	1.15E-07	1.38E-09	0.00E+00	1.18E-06	1.46E-04	3.78E-04	**5.27E-04**
	Copper	1.02E-05	1.99E-06	1.43E-07	8.42E-07	6.05E-08	0.00E+00	3.02E-04	1.01E-02	4.29E-02	**5.33E-02**
	Molybdenum	1.75E-06	1.57E-07	1.88E-09	1.54E-07	1.84E-09	0.00E+00	1.04E-08	1.20E-04	6.29E-03	**6.41E-03**
	Selenium	5.31E-07	1.47E-07	1.76E-09	2.83E-07	3.39E-09	0.00E+00	1.59E-04	1.03E-04	4.13E-03	**4.39E-03**
	Uranium	4.94E-07	5.22E-07	6.26E-08	2.63E-07	3.16E-08	0.00E+00	5.85E-07	6.25E-05	9.10E-05	**1.55E-04**
	Vanadium	2.39E-06	6.58E-06	7.89E-07	5.11E-06	6.12E-07	0.00E+00	1.35E-05	1.30E-05	8.78E-04	**9.20E-04**
	Zinc	1.12E-05	7.26E-06	8.70E-07	4.53E-06	5.42E-07	0.00E+00	1.33E-03	2.45E-02	2.76E-01	**3.02E-01**
		Project Total Dose - Future Centuries									
	Cadmium	3.81E-07	4.93E-07	5.91E-09	1.54E-07	1.85E-09	0.00E+00	6.79E-08	1.57E-05	5.03E-04	**5.20E-04**
	Chromium	8.54E-06	4.53E-06	5.42E-07	2.68E-06	3.21E-07	0.00E+00	2.80E-05	2.58E-05	1.77E-05	**8.81E-05**
	Cobalt	1.67E-06	3.63E-07	4.35E-09	1.16E-07	1.39E-09	0.00E+00	1.22E-06	1.46E-04	3.78E-04	**5.27E-04**
	Copper	1.02E-05	1.99E-06	1.43E-07	8.44E-07	6.07E-08	0.00E+00	3.04E-04	1.01E-02	4.29E-02	**5.33E-02**
	Molybdenum	1.78E-06	1.57E-07	1.88E-09	1.56E-07	1.87E-09	0.00E+00	1.10E-08	1.20E-04	6.29E-03	**6.41E-03**
	Selenium	5.57E-07	1.47E-07	1.76E-09	2.97E-07	3.56E-09	0.00E+00	1.82E-04	1.03E-04	4.13E-03	**4.42E-03**

Human Receptor	COPC	Maximum Dose by Pathway during Future Centuries (mg/kg/d)									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Uranium	5.10E-07	5.25E-07	6.29E-08	2.72E-07	3.26E-08	0.00E+00	6.49E-07	6.33E-05	9.10E-05	**1.56E-04**
	Vanadium	2.39E-06	6.58E-06	7.89E-07	5.11E-06	6.13E-07	0.00E+00	1.36E-05	1.30E-05	8.78E-04	**9.20E-04**
	Zinc	1.13E-05	7.26E-06	8.70E-07	4.59E-06	5.50E-07	0.00E+00	1.38E-03	2.45E-02	2.76E-01	**3.02E-01**
		Project Incremental Dose - Future Centuries									
	Cadmium	3.37E-10	1.71E-13	1.78E-15	1.36E-10	1.63E-12	0.00E+00	2.00E-10	1.46E-11	1.57E-09	**2.26E-09**
	Chromium	1.74E-08	0.00E+00	0.00E+00	5.46E-09	6.54E-10	0.00E+00	1.90E-07	0.00E+00	5.81E-08	**2.71E-07**
	Cobalt	1.51E-08	6.39E-12	7.64E-14	1.05E-09	1.25E-11	0.00E+00	3.60E-08	8.44E-09	7.26E-08	**1.33E-07**
	Copper	2.30E-08	2.00E-11	1.45E-12	1.91E-09	1.37E-10	0.00E+00	2.28E-06	3.04E-07	1.09E-06	**3.70E-06**
	Molybdenum	2.70E-08	0.00E+00	0.00E+00	2.37E-09	2.84E-11	0.00E+00	5.36E-10	0.00E+00	1.91E-08	**4.91E-08**
	Selenium	2.58E-08	1.42E-14	2.22E-16	1.38E-08	1.65E-10	0.00E+00	2.31E-05	6.55E-11	2.49E-06	**2.56E-05**
	Uranium	1.61E-08	2.03E-09	2.44E-10	8.61E-09	1.03E-09	0.00E+00	6.37E-08	7.87E-07	2.25E-08	**9.01E-07**
	Vanadium	1.82E-09	1.00E-11	1.19E-12	3.88E-09	4.65E-10	0.00E+00	3.43E-08	4.18E-11	2.11E-08	**6.16E-08**
	Zinc	1.48E-07	1.23E-11	1.53E-12	5.99E-08	7.18E-09	0.00E+00	5.85E-05	1.21E-07	1.46E-05	**7.35E-05**
Seasonal Resident (Russell Lake)		**Baseline Dose**									
	Cadmium	3.41E-07	7.55E-09	3.46E-09	2.36E-09	1.08E-09	0.00E+00	7.15E-08	7.02E-06	1.99E-04	**2.06E-04**
	Chromium	7.63E-06	6.93E-08	3.17E-07	4.09E-08	1.87E-07	0.00E+00	2.94E-05	1.12E-05	3.03E-05	**7.91E-05**
	Cobalt	1.49E-06	5.55E-09	2.54E-09	1.76E-09	8.04E-10	0.00E+00	1.25E-06	6.29E-05	1.77E-04	**2.42E-04**
	Copper	9.09E-06	3.05E-08	8.37E-08	1.29E-08	3.54E-08	0.00E+00	3.19E-04	4.37E-03	2.55E-02	**3.02E-02**
	Molybdenum	1.57E-06	2.40E-09	1.10E-09	2.35E-09	1.08E-09	0.00E+00	1.10E-08	5.17E-05	2.41E-03	**2.47E-03**
	Sulphate	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
	Selenium	4.75E-07	2.24E-09	1.03E-09	4.34E-09	1.98E-09	0.00E+00	1.68E-04	4.39E-05	1.65E-03	**1.86E-03**
	Uranium	4.42E-07	8.00E-09	3.66E-08	4.03E-09	1.85E-08	0.00E+00	6.18E-07	2.73E-05	3.52E-05	**6.36E-05**
	Vanadium	2.14E-06	1.01E-07	4.61E-07	7.82E-08	3.58E-07	0.00E+00	1.43E-05	7.20E-06	3.60E-04	**3.85E-04**
	Zinc	1.00E-05	1.11E-07	5.09E-07	6.93E-08	3.17E-07	0.00E+00	1.40E-03	1.07E-02	1.33E-01	**1.45E-01**
		Project Total Dose - Future Centuries									
	Cadmium	3.41E-07	7.55E-09	3.46E-09	2.36E-09	1.08E-09	0.00E+00	7.16E-08	7.02E-06	1.99E-04	**2.06E-04**
	Chromium	7.65E-06	6.93E-08	3.17E-07	4.10E-08	1.87E-07	0.00E+00	2.95E-05	1.12E-05	3.03E-05	**7.92E-05**
	Cobalt	1.50E-06	5.55E-09	2.54E-09	1.77E-09	8.11E-10	0.00E+00	1.26E-06	6.29E-05	1.77E-04	**2.42E-04**

Human Receptor	COPC	Maximum Dose by Pathway during Future Centuries (mg/kg/d)									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Copper	9.12E-06	3.05E-08	8.37E-08	1.29E-08	3.55E-08	0.00E+00	3.20E-04	4.37E-03	2.55E-02	**3.02E-02**
	Molybdenum	1.60E-06	2.40E-09	1.10E-09	2.39E-09	1.09E-09	0.00E+00	1.12E-08	5.17E-05	2.41E-03	**2.47E-03**
	Selenium	4.98E-07	2.24E-09	1.03E-09	4.55E-09	2.08E-09	0.00E+00	1.75E-04	4.39E-05	1.65E-03	**1.87E-03**
	Uranium	4.57E-07	8.03E-09	3.67E-08	4.16E-09	1.91E-08	0.00E+00	6.38E-07	2.74E-05	3.52E-05	**6.38E-05**
	Vanadium	2.14E-06	1.01E-07	4.61E-07	7.82E-08	3.58E-07	0.00E+00	1.43E-05	7.20E-06	3.60E-04	**3.85E-04**
	Zinc	1.01E-05	1.11E-07	5.09E-07	7.02E-08	3.21E-07	0.00E+00	1.42E-03	1.07E-02	1.33E-01	**1.45E-01**
		Project Incremental Dose - Future Centuries									
	Cadmium	3.02E-10	2.66E-15	1.11E-15	2.09E-12	9.55E-13	0.00E+00	6.33E-11	1.82E-12	7.13E-10	**1.08E-09**
	Chromium	1.56E-08	0.00E+00	0.00E+00	8.35E-11	3.82E-10	0.00E+00	6.01E-08	0.00E+00	2.85E-08	**1.05E-07**
	Cobalt	1.35E-08	9.81E-14	4.46E-14	1.60E-11	7.32E-12	0.00E+00	1.14E-08	1.08E-09	3.73E-08	**6.33E-08**
	Copper	2.06E-08	3.09E-13	8.53E-13	2.92E-11	8.02E-11	0.00E+00	7.23E-07	3.86E-08	5.22E-07	**1.30E-06**
	Molybdenum	2.42E-08	0.00E+00	0.00E+00	3.62E-11	1.66E-11	0.00E+00	1.70E-10	0.00E+00	9.78E-09	**3.42E-08**
	Selenium	2.31E-08	2.22E-16	1.11E-16	2.11E-10	9.65E-11	0.00E+00	7.31E-06	7.28E-12	1.22E-06	**8.56E-06**
	Uranium	1.44E-08	3.11E-11	1.42E-10	1.32E-10	6.03E-10	0.00E+00	2.02E-08	1.00E-07	9.43E-09	**1.45E-07**
	Vanadium	1.63E-09	1.42E-13	7.11E-13	5.94E-11	2.72E-10	0.00E+00	1.09E-08	5.00E-12	1.33E-08	**2.61E-08**
	Zinc	1.33E-07	1.92E-13	8.53E-13	9.17E-10	4.20E-09	0.00E+00	1.85E-05	1.49E-08	9.63E-06	**2.83E-05**
Seasonal Resident One-year-old (Russell Lake)		**Baseline Dose**									
	Cadmium	3.80E-07	4.93E-07	5.91E-09	1.54E-07	1.85E-09	0.00E+00	6.77E-08	1.57E-05	5.03E-04	**5.20E-04**
	Chromium	8.52E-06	4.53E-06	5.42E-07	2.67E-06	3.20E-07	0.00E+00	2.78E-05	2.58E-05	1.76E-05	**8.78E-05**
	Cobalt	1.66E-06	3.63E-07	4.35E-09	1.15E-07	1.38E-09	0.00E+00	1.18E-06	1.46E-04	3.78E-04	**5.27E-04**
	Copper	1.02E-05	1.99E-06	1.43E-07	8.42E-07	6.05E-08	0.00E+00	3.02E-04	1.01E-02	4.29E-02	**5.33E-02**
	Molybdenum	1.75E-06	1.57E-07	1.88E-09	1.54E-07	1.84E-09	0.00E+00	1.04E-08	1.20E-04	6.29E-03	**6.41E-03**
	Selenium	5.31E-07	1.47E-07	1.76E-09	2.83E-07	3.39E-09	0.00E+00	1.59E-04	1.03E-04	4.13E-03	**4.39E-03**
	Uranium	4.94E-07	5.22E-07	6.26E-08	2.63E-07	3.16E-08	0.00E+00	5.85E-07	6.25E-05	9.10E-05	**1.55E-04**
	Vanadium	2.39E-06	6.58E-06	7.89E-07	5.11E-06	6.12E-07	0.00E+00	1.35E-05	1.30E-05	8.78E-04	**9.20E-04**
	Zinc	1.12E-05	7.26E-06	8.70E-07	4.53E-06	5.42E-07	0.00E+00	1.33E-03	2.45E-02	2.76E-01	**3.02E-01**
		Project Total Dose - Future Centuries									
	Cadmium	3.81E-07	4.93E-07	5.91E-09	1.54E-07	1.85E-09	0.00E+00	6.78E-08	1.57E-05	5.03E-04	**5.20E-04**

Human Receptor	COPC	Maximum Dose by Pathway during Future Centuries (mg/kg/d)									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Chromium	8.54E-06	4.53E-06	5.42E-07	2.68E-06	3.21E-07	0.00E+00	2.79E-05	2.58E-05	1.76E-05	**8.79E-05**
	Cobalt	1.67E-06	3.63E-07	4.35E-09	1.16E-07	1.39E-09	0.00E+00	1.19E-06	1.46E-04	3.78E-04	**5.27E-04**
	Copper	1.02E-05	1.99E-06	1.43E-07	8.44E-07	6.07E-08	0.00E+00	3.03E-04	1.01E-02	4.29E-02	**5.33E-02**
	Molybdenum	1.78E-06	1.57E-07	1.88E-09	1.56E-07	1.87E-09	0.00E+00	1.06E-08	1.20E-04	6.29E-03	**6.41E-03**
	Selenium	5.57E-07	1.47E-07	1.76E-09	2.97E-07	3.56E-09	0.00E+00	1.66E-04	1.03E-04	4.13E-03	**4.40E-03**
	Uranium	5.10E-07	5.25E-07	6.29E-08	2.72E-07	3.26E-08	0.00E+00	6.04E-07	6.27E-05	9.10E-05	**1.56E-04**
	Vanadium	2.39E-06	6.58E-06	7.89E-07	5.11E-06	6.13E-07	0.00E+00	1.36E-05	1.30E-05	8.78E-04	**9.20E-04**
	Zinc	1.13E-05	7.26E-06	8.70E-07	4.59E-06	5.50E-07	0.00E+00	1.34E-03	2.45E-02	2.76E-01	**3.02E-01**
		Project Incremental Dose - Future Centuries									
	Cadmium	3.37E-10	1.71E-13	1.78E-15	1.36E-10	1.63E-12	0.00E+00	5.99E-11	3.64E-12	4.66E-10	**1.00E-09**
	Chromium	1.74E-08	0.00E+00	0.00E+00	5.46E-09	6.54E-10	0.00E+00	5.69E-08	0.00E+00	1.82E-08	**9.86E-08**
	Cobalt	1.51E-08	6.39E-12	7.64E-14	1.05E-09	1.25E-11	0.00E+00	1.08E-08	2.52E-09	2.08E-08	**5.03E-08**
	Copper	2.30E-08	2.00E-11	1.45E-12	1.91E-09	1.37E-10	0.00E+00	6.84E-07	9.22E-08	3.13E-07	**1.11E-06**
	Molybdenum	2.70E-08	0.00E+00	0.00E+00	2.37E-09	2.84E-11	0.00E+00	1.61E-10	0.00E+00	5.59E-09	**3.52E-08**
	Selenium	2.58E-08	1.42E-14	2.22E-16	1.38E-08	1.65E-10	0.00E+00	6.93E-06	2.18E-11	7.66E-07	**7.73E-06**
	Uranium	1.61E-08	2.03E-09	2.44E-10	8.61E-09	1.03E-09	0.00E+00	1.91E-08	2.36E-07	6.59E-09	**2.90E-07**
	Vanadium	1.82E-09	1.00E-11	1.19E-12	3.88E-09	4.65E-10	0.00E+00	1.03E-08	1.18E-11	7.39E-09	**2.39E-08**
	Zinc	1.48E-07	1.23E-11	1.53E-12	5.99E-08	7.18E-09	0.00E+00	1.76E-05	3.54E-08	5.07E-06	**2.29E-05**
Fisher/Trapper (Russell Lake)		Baseline Dose									
	Cadmium	3.41E-07	7.55E-09	3.46E-09	2.36E-09	1.08E-09	0.00E+00	4.92E-07	0.00E+00	1.61E-04	**1.62E-04**
	Chromium	7.63E-06	6.93E-08	3.17E-07	4.09E-08	1.87E-07	0.00E+00	2.02E-04	0.00E+00	8.27E-04	**1.04E-03**
	Cobalt	1.49E-06	5.55E-09	2.54E-09	1.76E-09	8.04E-10	0.00E+00	8.61E-06	0.00E+00	7.79E-05	**8.80E-05**
	Copper	9.09E-06	3.05E-08	8.37E-08	1.29E-08	3.54E-08	0.00E+00	2.20E-03	0.00E+00	1.19E-02	**1.41E-02**
	Molybdenum	1.57E-06	2.40E-09	1.10E-09	2.35E-09	1.08E-09	0.00E+00	7.59E-08	0.00E+00	1.28E-03	**1.28E-03**
	Selenium	4.75E-07	2.24E-09	1.03E-09	4.34E-09	1.98E-09	0.00E+00	1.16E-03	0.00E+00	1.58E-03	**2.74E-03**
	Uranium	4.42E-07	8.00E-09	3.66E-08	4.03E-09	1.85E-08	0.00E+00	4.25E-06	0.00E+00	2.19E-05	**2.66E-05**
	Vanadium	2.14E-06	1.01E-07	4.61E-07	7.82E-08	3.58E-07	0.00E+00	9.85E-05	0.00E+00	7.72E-04	**8.74E-04**
	Zinc	1.00E-05	1.11E-07	5.09E-07	6.93E-08	3.17E-07	0.00E+00	9.64E-03	0.00E+00	3.08E-01	**3.18E-01**

Human Receptor	COPC	Maximum Dose by Pathway during Future Centuries (mg/kg/d)									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
		Project Total Dose - Future Centuries									
	Cadmium	3.41E-07	7.55E-09	3.46E-09	2.36E-09	1.08E-09	0.00E+00	4.94E-07	0.00E+00	1.61E-04	**1.62E-04**
	Chromium	7.66E-06	6.93E-08	3.17E-07	4.10E-08	1.88E-07	0.00E+00	2.04E-04	0.00E+00	8.27E-04	**1.04E-03**
	Cobalt	1.51E-06	5.55E-09	2.54E-09	1.78E-09	8.16E-10	0.00E+00	8.87E-06	0.00E+00	7.79E-05	**8.83E-05**
	Copper	9.13E-06	3.05E-08	8.37E-08	1.29E-08	3.55E-08	0.00E+00	2.21E-03	0.00E+00	1.19E-02	**1.42E-02**
	Molybdenum	1.61E-06	2.40E-09	1.10E-09	2.41E-09	1.10E-09	0.00E+00	7.98E-08	0.00E+00	1.28E-03	**1.28E-03**
	Selenium	5.14E-07	2.24E-09	1.03E-09	4.69E-09	2.15E-09	0.00E+00	1.32E-03	0.00E+00	1.59E-03	**2.92E-03**
	Uranium	4.66E-07	8.05E-09	3.68E-08	4.25E-09	1.95E-08	0.00E+00	4.72E-06	0.00E+00	2.19E-05	**2.72E-05**
	Vanadium	2.14E-06	1.01E-07	4.61E-07	7.83E-08	3.58E-07	0.00E+00	9.87E-05	0.00E+00	7.73E-04	**8.74E-04**
	Zinc	1.02E-05	1.11E-07	5.09E-07	7.08E-08	3.24E-07	0.00E+00	1.01E-02	0.00E+00	3.08E-01	**3.18E-01**
		Project Incremental Dose - Future Centuries									
	Cadmium	5.03E-10	3.55E-15	1.55E-15	3.48E-12	1.59E-12	0.00E+00	1.45E-09	0.00E+00	6.43E-09	**8.39E-09**
	Chromium	2.60E-08	0.00E+00	0.00E+00	1.39E-10	6.37E-10	0.00E+00	1.38E-06	0.00E+00	3.77E-07	**1.78E-06**
	Cobalt	2.26E-08	1.63E-13	7.46E-14	2.67E-11	1.22E-11	0.00E+00	2.61E-07	0.00E+00	2.61E-08	**3.10E-07**
	Copper	3.43E-08	5.15E-13	1.41E-12	4.87E-11	1.34E-10	0.00E+00	1.66E-05	0.00E+00	1.07E-06	**1.77E-05**
	Molybdenum	4.03E-08	0.00E+00	0.00E+00	6.04E-11	2.76E-11	0.00E+00	3.90E-09	0.00E+00	1.84E-08	**6.27E-08**
	Selenium	3.85E-08	6.66E-16	3.33E-16	3.51E-10	1.61E-10	0.00E+00	1.68E-04	0.00E+00	1.31E-05	**1.81E-04**
	Uranium	2.41E-08	5.19E-11	2.37E-10	2.20E-10	1.00E-09	0.00E+00	4.63E-07	0.00E+00	5.65E-08	**5.45E-07**
	Vanadium	2.71E-09	2.49E-13	1.14E-12	9.89E-11	4.53E-10	0.00E+00	2.49E-07	0.00E+00	3.16E-07	**5.68E-07**
	Zinc	2.21E-07	3.13E-13	1.42E-12	1.53E-09	7.00E-09	0.00E+00	4.25E-04	0.00E+00	1.78E-04	**6.04E-04**

COPC = constituent of potential concern.

4.2.5.1.2 Carcinogen Dose

Arsenic was evaluated in the HHRA as a non-threshold carcinogen (i.e., a linear dose-response relationship); therefore, predicted exposure was averaged over the receptor's lifetime to estimate a lifetime average daily dose representing a combination of all life stages (Health Canada, 2021a). For this assessment, the lifetime average daily dose was estimated for various age groups (toddler, child, teen, adult) to permit estimation of the lifetime risk to a composite receptor for each of the recreational fisher/hunter, and seasonal resident (Table 4-7) for the Project phases. Therefore, a composite receptor was calculated assuming 4.5 years as a toddler, 7 years as a child, 8 years as a teen and 60 years as an adult. For the camp worker, an adult receptor was considered appropriate. The composite receptor represents a person exposed to the constituent throughout all stages of a lifetime. The lifetime average daily dose was estimated during the future centuries for a permanent resident, recreational fisher/hunter, seasonal resident, and fisher/trapper (Table 4-8).

Cadmium is considered a carcinogen due to inhalation exposure; however, since cadmium has not been identified as an air COPC, cadmium is not evaluated separately as a carcinogen.

Table 4-7: Estimated Carcinogen Doses for Arsenic to Human Receptors – Project Phases

	Lifetime Average Daily Dose (mg/kg/d)				
Age Group	Camp Worker	Recreational Fisher/Hunter (LA-1)	Recreational Fisher/Hunter (Russell Lake)	Seasonal Resident (Russell Lake)	Fisher/Trapper (Russell Lake)
1-year-old	n/a	8.81E-08	5.21E-08	1.56E-08	n/a
Child	n/a	2.04E-07	1.21E-07	3.63E-08	n/a
Teen	n/a	1.71E-07	1.03E-07	3.09E-08	n/a
Adult	5.54E-07	1.94E-06	1.17E-06	3.51E-07	6.55E-06

n/a = not applicable, life stage was not assessed for the receptor.

Table 4-8: Estimated Carcinogen Doses for Arsenic to Human Receptors – Future Centuries

	Lifetime Average Daily Dose (mg/kg/d)				
Age Group	Permanent Resident (LA-5)	Recreational Fisher/Hunter (LA-1)	Recreational Fisher/Hunter (Russell Lake)	Seasonal Resident (Russell Lake)	Fisher/Trapper (Russell Lake)
1-year-old	2.65E-08	1.26E-08	8.12E-09	2.43E-09	n/a
Child	6.13E-08	2.92E-08	1.89E-08	5.66E-09	n/a
Teen	5.03E-08	2.42E-08	1.57E-08	4.70E-09	n/a
Adult	5.65E-07	2.72E-07	1.76E-07	5.29E-08	9.67E-07

n/a = not applicable, life stage was not assessed for the receptor.

4.2.5.2 Radiological Dose

The estimated radiological doses to human receptors due to releases from the Project during all phases is presented in Table 4-9, and in the future centuries in Table 4-10. The doses shown represent the maximum annual dose over the assessment period. The tables present the dose breakdown by radionuclide and exposure pathway, as well as the total dose. The radiation dose is presented as an incremental dose (i.e., only considering Project effects) because the dose limit is an incremental value.

During the Project phases, the maximum predicted incremental dose is 0.06 mSv/yr for the fisher/trapper (adult) who fishes in the embayment at the inlet to Russell Lake and hunts in the area around Russell Lake. The main contribution to total dose is from polonium-210 from eating local fish (white sucker and northern pike). During the future centuries, the maximum predicted incremental dose is 0.04 mSv/yr for the permanent resident (one-year old) who lives on the former Project site and fishes and hunts around Whitefish Lake. The main contribution to total dose is from polonium-210 from consuming terrestrial animals hunted in the area.

Table 4-9: Estimated Radiological Doses to Human Receptor – Project Phases

Human Receptor	COPC	Maximum Incremental Dose by Pathway during Project Phases (mSv/yr)												
		Air (internal)	Air (external)	Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by Radionuclide
Camp Worker Adult (Whitefish Lake)	Uranium-238	1.83E-03	5.02E-12	5.69E-05	4.32E-10	1.95E-07	2.16E-03	3.28E-07	3.50E-06	0.00E+00	4.35E-05	2.38E-04	3.59E-05	**4.37E-03**
	Uranium-234	2.21E-03	1.23E-11	6.20E-05	7.53E-11	2.12E-07	1.09E-05	3.58E-07	1.27E-08	0.00E+00	4.73E-05	2.60E-04	3.90E-05	**2.63E-03**
	Thorium-230	0.00E+00	0.00E+00	3.40E-04	2.30E-10	1.99E-10	3.06E-09	2.85E-07	7.05E-09	0.00E+00	9.20E-05	2.97E-08	4.31E-04	**8.63E-04**
	Radium-226	0.00E+00	0.00E+00	6.14E-05	2.74E-08	1.82E-12	4.10E-08	2.68E-07	3.21E-05	0.00E+00	3.31E-05	4.66E-09	1.08E-05	**1.38E-04**
	Lead-210	0.00E+00	0.00E+00	4.82E-04	4.24E-10	0.00E+00	0.00E+00	1.15E-05	6.48E-07	0.00E+00	7.32E-04	0.00E+00	1.30E-03	**2.52E-03**
	Polonium-210	0.00E+00	0.00E+00	5.39E-04	1.62E-12	0.00E+00	0.00E+00	1.94E-05	2.66E-09	0.00E+00	2.04E-03	0.00E+00	1.21E-02	**1.47E-02**
	Total by Pathway	**4.03E-03**	**1.73E-11**	**1.54E-03**	**2.86E-08**	**4.07E-07**	**2.17E-03**	**3.21E-05**	**3.63E-05**	**0.00E+00**	**2.98E-03**	**4.98E-04**	**1.39E-02**	**2.52E-02**
Rec F/H Adult (McGowan Lake)	Uranium-238	2.84E-04	7.80E-13	1.92E-05	1.46E-10	2.97E-08	3.29E-04	1.25E-07	1.34E-06	0.00E+00	8.69E-05	4.77E-04	7.19E-05	**1.27E-03**
	Uranium-234	3.43E-04	1.91E-12	2.09E-05	2.54E-11	3.23E-08	1.66E-06	1.36E-07	4.85E-09	0.00E+00	9.47E-05	5.19E-04	7.82E-05	**1.06E-03**
	Thorium-230	0.00E+00	0.00E+00	1.31E-04	8.84E-11	3.00E-11	4.62E-10	1.24E-07	3.06E-09	0.00E+00	1.84E-04	5.94E-08	8.57E-04	**1.17E-03**
	Radium-226	0.00E+00	0.00E+00	3.21E-05	1.43E-08	2.27E-13	7.45E-09	1.09E-07	1.31E-05	0.00E+00	6.62E-05	9.31E-09	2.15E-05	**1.33E-04**
	Lead-210	0.00E+00	0.00E+00	2.92E-04	2.58E-10	0.00E+00	0.00E+00	2.63E-06	1.49E-07	0.00E+00	1.47E-03	0.00E+00	2.58E-03	**4.34E-03**
	Polonium-210	0.00E+00	0.00E+00	4.39E-04	1.32E-12	0.00E+00	0.00E+00	4.49E-06	6.16E-10	0.00E+00	4.07E-03	0.00E+00	2.45E-02	**2.90E-02**
	Total by Pathway	**6.28E-04**	**2.69E-12**	**9.34E-04**	**1.49E-08**	**6.20E-08**	**3.31E-04**	**7.61E-06**	**1.46E-05**	**0.00E+00**	**5.97E-03**	**9.96E-04**	**2.81E-02**	**3.70E-02**
Rec F/H One-year-old (McGowan Lake)	Uranium-238	2.84E-04	1.01E-12	1.33E-05	3.60E-11	1.21E-06	4.40E-04	5.10E-06	1.74E-06	0.00E+00	5.12E-05	5.90E-04	2.82E-05	**1.41E-03**
	Uranium-234	3.32E-04	2.48E-12	1.44E-05	6.28E-12	1.31E-06	2.22E-06	5.52E-06	6.30E-09	0.00E+00	5.55E-05	6.39E-04	3.06E-05	**1.08E-03**
	Thorium-230	0.00E+00	0.00E+00	6.64E-05	2.19E-11	9.02E-10	5.24E-10	3.68E-06	3.97E-09	0.00E+00	7.94E-05	6.37E-08	2.06E-04	**3.55E-04**
	Radium-226	0.00E+00	0.00E+00	2.87E-05	3.55E-09	1.46E-11	7.45E-09	5.70E-06	1.71E-05	0.00E+00	5.01E-05	2.24E-08	8.82E-06	**1.10E-04**
	Lead-210	0.00E+00	0.00E+00	3.97E-04	5.22E-11	0.00E+00	0.00E+00	2.09E-04	1.93E-07	0.00E+00	1.69E-03	0.00E+00	1.66E-03	**3.96E-03**
	Polonium-210	0.00E+00	0.00E+00	8.39E-04	3.27E-13	0.00E+00	0.00E+00	5.02E-04	8.00E-10	0.00E+00	6.60E-03	0.00E+00	3.21E-02	**4.00E-02**

Human Receptor	COPC	Maximum Incremental Dose by Pathway during Project Phases (mSv/yr)												
		Air (internal)	Air (external)	Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by Radionuclide
	Total by Pathway	**6.15E-04**	**3.50E-12**	**1.36E-03**	**3.67E-09**	**2.51E-06**	**4.43E-04**	**7.31E-04**	**1.90E-05**	**0.00E+00**	**8.53E-03**	**1.23E-03**	**3.40E-02**	**4.69E-02**
Rec F/H Adult (Russell Lake)														
	Uranium-238	7.60E-05	2.08E-13	1.38E-05	1.05E-10	7.92E-09	8.79E-05	9.15E-08	9.76E-07	0.00E+00	6.27E-05	1.27E-04	4.23E-05	**4.11E-04**
	Uranium-234	9.17E-05	5.10E-13	1.50E-05	1.82E-11	8.63E-09	4.43E-07	9.97E-08	3.54E-09	0.00E+00	6.83E-05	1.39E-04	4.60E-05	**3.60E-04**
	Thorium-230	0.00E+00	0.00E+00	9.75E-05	6.61E-11	7.73E-12	1.20E-10	9.40E-08	2.32E-09	0.00E+00	1.39E-04	1.59E-08	6.45E-04	**8.81E-04**
	Radium-226	0.00E+00	0.00E+00	2.75E-05	1.23E-08	0.00E+00	0.00E+00	8.11E-08	9.72E-06	0.00E+00	4.99E-05	1.86E-09	1.66E-05	**1.04E-04**
	Lead-210	0.00E+00	0.00E+00	2.71E-04	2.39E-10	0.00E+00	0.00E+00	1.60E-06	9.03E-08	0.00E+00	1.17E-03	0.00E+00	2.03E-03	**3.47E-03**
	Polonium-210	0.00E+00	0.00E+00	4.30E-04	1.29E-12	0.00E+00	0.00E+00	2.72E-06	3.74E-10	0.00E+00	3.66E-03	0.00E+00	1.48E-02	**1.89E-02**
	Total by Pathway	**1.68E-04**	**7.18E-13**	**8.55E-04**	**1.27E-08**	**1.66E-08**	**8.83E-05**	**4.69E-06**	**1.08E-05**	**0.00E+00**	**5.15E-03**	**2.66E-04**	**1.76E-02**	**2.42E-02**
Rec F/H One-year-old (Russell Lake)														
	Uranium-238	7.57E-05	2.71E-13	9.58E-06	2.58E-11	3.22E-07	1.18E-04	3.72E-06	1.27E-06	0.00E+00	3.69E-05	1.57E-04	1.65E-05	**4.19E-04**
	Uranium-234	8.86E-05	6.63E-13	1.04E-05	4.51E-12	3.49E-07	5.93E-07	4.03E-06	4.60E-09	0.00E+00	4.00E-05	1.71E-04	1.79E-05	**3.32E-04**
	Thorium-230	0.00E+00	0.00E+00	4.96E-05	1.64E-11	2.40E-10	1.42E-10	2.80E-06	3.02E-09	0.00E+00	5.98E-05	1.70E-08	1.55E-04	**2.67E-04**
	Radium-226	0.00E+00	0.00E+00	2.46E-05	3.04E-09	0.00E+00	0.00E+00	4.24E-06	1.27E-05	0.00E+00	3.78E-05	3.73E-09	6.80E-06	**8.61E-05**
	Lead-210	0.00E+00	0.00E+00	3.68E-04	4.84E-11	0.00E+00	0.00E+00	1.27E-04	1.17E-07	0.00E+00	1.35E-03	0.00E+00	1.30E-03	**3.15E-03**
	Polonium-210	0.00E+00	0.00E+00	8.22E-04	3.20E-13	0.00E+00	0.00E+00	3.05E-04	4.86E-10	0.00E+00	5.94E-03	0.00E+00	1.94E-02	**2.64E-02**
	Total by Pathway	**1.64E-04**	**9.34E-13**	**1.28E-03**	**3.14E-09**	**6.71E-07**	**1.18E-04**	**4.46E-04**	**1.41E-05**	**0.00E+00**	**7.46E-03**	**3.28E-04**	**2.09E-02**	**3.07E-02**
Seasonal Resident Adult (Russell Lake)														
	Uranium-238	7.60E-05	2.08E-13	1.38E-05	1.05E-10	7.92E-09	8.79E-05	9.15E-08	9.76E-07	0.00E+00	1.86E-05	3.83E-05	1.91E-05	**2.55E-04**
	Uranium-234	9.17E-05	5.10E-13	1.50E-05	1.82E-11	8.63E-09	4.43E-07	9.97E-08	3.54E-09	0.00E+00	2.03E-05	4.18E-05	2.08E-05	**1.90E-04**
	Thorium-230	0.00E+00	0.00E+00	9.75E-05	6.61E-11	7.73E-12	1.20E-10	9.40E-08	2.32E-09	0.00E+00	4.05E-05	4.77E-09	1.85E-04	**3.23E-04**
	Radium-226	0.00E+00	0.00E+00	2.75E-05	1.23E-08	0.00E+00	0.00E+00	8.11E-08	9.72E-06	0.00E+00	2.17E-05	0.00E+00	7.15E-06	**6.62E-05**
	Lead-210	0.00E+00	0.00E+00	2.71E-04	2.39E-10	0.00E+00	0.00E+00	1.60E-06	9.03E-08	0.00E+00	1.01E-03	0.00E+00	1.67E-03	**2.96E-03**
	Polonium-210	0.00E+00	0.00E+00	4.30E-04	1.29E-12	0.00E+00	0.00E+00	2.72E-06	3.74E-10	0.00E+00	4.02E-03	0.00E+00	4.82E-03	**9.28E-03**

Human Receptor	COPC	Maximum Incremental Dose by Pathway during Project Phases (mSv/yr)												
		Air (internal)	Air (external)	Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by Radionuclide
	Total by Pathway	**1.68E-04**	**7.18E-13**	**8.55E-04**	**1.27E-08**	**1.66E-08**	**8.83E-05**	**4.69E-06**	**1.08E-05**	**0.00E+00**	**5.13E-03**	**8.01E-05**	**6.73E-03**	**1.31E-02**
Seasonal Resident One-year-old (Russell Lake)														
	Uranium-238	7.57E-05	2.71E-13	9.58E-06	2.58E-11	3.22E-07	1.18E-04	3.72E-06	1.27E-06	0.00E+00	1.10E-05	4.71E-05	7.17E-06	**2.73E-04**
	Uranium-234	8.86E-05	6.63E-13	1.04E-05	4.51E-12	3.49E-07	5.93E-07	4.03E-06	4.60E-09	0.00E+00	1.19E-05	5.11E-05	7.77E-06	**1.75E-04**
	Thorium-230	0.00E+00	0.00E+00	4.96E-05	1.64E-11	2.40E-10	1.42E-10	2.80E-06	3.02E-09	0.00E+00	1.75E-05	5.12E-09	4.30E-05	**1.13E-04**
	Radium-226	0.00E+00	0.00E+00	2.46E-05	3.04E-09	0.00E+00	0.00E+00	4.24E-06	1.27E-05	0.00E+00	1.65E-05	3.73E-09	2.97E-06	**6.10E-05**
	Lead-210	0.00E+00	0.00E+00	3.68E-04	4.84E-11	0.00E+00	0.00E+00	1.27E-04	1.17E-07	0.00E+00	1.17E-03	0.00E+00	1.07E-03	**2.73E-03**
	Polonium-210	0.00E+00	0.00E+00	8.22E-04	3.20E-13	0.00E+00	0.00E+00	3.05E-04	4.86E-10	0.00E+00	6.52E-03	0.00E+00	5.86E-03	**1.35E-02**
	Total by Pathway	**1.64E-04**	**9.34E-13**	**1.28E-03**	**3.14E-09**	**6.71E-07**	**1.18E-04**	**4.46E-04**	**1.41E-05**	**0.00E+00**	**7.74E-03**	**9.82E-05**	**6.99E-03**	**1.69E-02**
Fisher/ Trapper Adult (Russell Lake)														
	Uranium-238	1.27E-04	3.47E-13	2.31E-05	1.76E-10	1.32E-08	1.46E-04	1.53E-07	1.63E-06	0.00E+00	4.32E-04	0.00E+00	1.08E-03	**1.81E-03**
	Uranium-234	1.53E-04	8.50E-13	2.52E-05	3.06E-11	1.44E-08	7.38E-07	1.66E-07	5.90E-09	0.00E+00	4.70E-04	0.00E+00	1.17E-03	**1.82E-03**
	Thorium-230	0.00E+00	0.00E+00	1.65E-04	1.12E-10	1.32E-11	2.04E-10	1.57E-07	3.88E-09	0.00E+00	9.53E-04	0.00E+00	6.56E-05	**1.18E-03**
	Radium-226	0.00E+00	0.00E+00	3.65E-05	1.63E-08	0.00E+00	0.00E+00	1.35E-07	1.62E-05	0.00E+00	3.43E-04	0.00E+00	1.04E-04	**5.00E-04**
	Lead-210	0.00E+00	0.00E+00	2.81E-04	2.47E-10	0.00E+00	0.00E+00	2.63E-06	1.49E-07	0.00E+00	8.06E-03	0.00E+00	2.25E-03	**1.06E-02**
	Polonium-210	0.00E+00	0.00E+00	4.15E-04	1.25E-12	0.00E+00	0.00E+00	4.48E-06	6.15E-10	0.00E+00	2.52E-02	0.00E+00	1.56E-02	**4.12E-02**
	Total by Pathway	**2.79E-04**	**1.20E-12**	**9.45E-04**	**1.68E-08**	**2.76E-08**	**1.47E-04**	**7.72E-06**	**1.80E-05**	**0.00E+00**	**3.55E-02**	**0.00E+00**	**2.02E-02**	**5.71E-02**

Table 4-10: Estimated Radiological Doses to Human Receptor – Future Centuries

Human Receptor	COPC	Maximum Incremental Dose by Pathway during Future Centuries (mSv/yr)										
		Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by Radionuclide
Permanent Resident Adult (Whitefish Lake)												
	Uranium-238	1.42E-06	1.07E-11	2.20E-08	2.44E-04	1.29E-08	1.38E-07	0.00E+00	1.98E-06	1.38E-04	1.48E-06	**3.87E-04**
	Uranium-234	1.54E-06	1.87E-12	2.40E-08	1.23E-06	1.41E-08	4.99E-10	0.00E+00	2.15E-06	1.50E-04	1.62E-06	**1.57E-04**
	Thorium-230	2.12E-05	1.44E-11	7.69E-10	1.18E-08	2.31E-08	5.71E-10	0.00E+00	8.93E-06	8.84E-07	3.11E-05	**6.22E-05**
	Radium-226	8.68E-05	3.87E-08	9.39E-11	2.43E-06	4.80E-07	5.75E-05	0.00E+00	7.28E-05	2.07E-06	2.40E-05	**2.46E-04**
	Lead-210	2.03E-04	1.79E-10	0.00E+00	0.00E+00	6.83E-06	3.86E-07	0.00E+00	8.12E-04	0.00E+00	7.09E-04	**1.73E-03**
	Polonium-210	3.59E-04	1.08E-12	0.00E+00	0.00E+00	1.21E-05	1.66E-09	0.00E+00	3.59E-03	0.00E+00	2.02E-02	**2.42E-02**
	Total by Pathway	**6.73E-04**	**3.89E-08**	**4.68E-08**	**2.48E-04**	**1.94E-05**	**5.81E-05**	**0.00E+00**	**4.49E-03**	**2.91E-04**	**2.10E-02**	**2.67E-02**
Permanent Resident One-year-old (Whitefish Lake)												
	Uranium-238	9.84E-07	2.66E-12	8.95E-07	3.27E-04	5.25E-07	1.79E-07	0.00E+00	1.17E-06	2.02E-04	6.43E-07	**5.33E-04**
	Uranium-234	1.07E-06	4.64E-13	9.70E-07	1.65E-06	5.69E-07	6.49E-10	0.00E+00	1.26E-06	2.19E-04	6.97E-07	**2.25E-04**
	Thorium-230	1.08E-05	3.56E-12	2.29E-08	1.34E-08	6.88E-07	7.42E-10	0.00E+00	3.85E-06	9.46E-07	7.46E-06	**2.38E-05**
	Radium-226	7.75E-05	9.59E-09	4.90E-09	3.26E-06	2.51E-05	7.51E-05	0.00E+00	5.52E-05	3.90E-06	9.87E-06	**2.50E-04**
	Lead-210	2.76E-04	3.63E-11	0.00E+00	0.00E+00	5.43E-04	5.02E-07	0.00E+00	9.36E-04	0.00E+00	4.63E-04	**2.22E-03**
	Polonium-210	6.87E-04	2.68E-13	0.00E+00	0.00E+00	1.35E-03	2.15E-09	0.00E+00	5.82E-03	0.00E+00	2.65E-02	**3.43E-02**
	Total by Pathway	**1.05E-03**	**9.63E-09**	**1.89E-06**	**3.32E-04**	**1.92E-03**	**7.58E-05**	**0.00E+00**	**6.82E-03**	**4.26E-04**	**2.69E-02**	**3.76E-02**
Rec F/H Adult (McGowan Lake)												
	Uranium-238	2.82E-07	2.14E-12	1.67E-09	1.86E-05	2.57E-09	2.75E-08	0.00E+00	1.31E-06	1.80E-05	6.51E-07	**3.89E-05**
	Uranium-234	3.07E-07	3.73E-13	1.82E-09	9.36E-08	2.80E-09	9.95E-11	0.00E+00	1.43E-06	1.96E-05	7.09E-07	**2.22E-05**
	Thorium-230	4.78E-06	3.24E-12	5.84E-11	8.91E-10	5.20E-09	1.29E-10	0.00E+00	6.70E-06	1.15E-07	3.09E-05	**4.25E-05**
	Radium-226	1.82E-05	8.15E-09	7.05E-12	1.83E-07	1.01E-07	1.21E-05	0.00E+00	5.11E-05	2.68E-07	1.76E-05	**9.96E-05**
	Lead-210	2.31E-05	2.03E-11	0.00E+00	0.00E+00	7.76E-07	4.39E-08	0.00E+00	3.07E-04	0.00E+00	5.62E-04	**8.93E-04**
	Polonium-210	4.08E-05	1.23E-13	0.00E+00	0.00E+00	1.37E-06	1.88E-10	0.00E+00	1.36E-03	0.00E+00	7.67E-03	**9.07E-03**
	Total by Pathway	**8.75E-05**	**8.17E-09**	**3.56E-09**	**1.88E-05**	**2.26E-06**	**1.22E-05**	**0.00E+00**	**1.73E-03**	**3.80E-05**	**8.28E-03**	**1.02E-02**

Human Receptor	COPC	Maximum Incremental Dose by Pathway during Future Centuries (mSv/yr)										
		Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by Radionuclide
Rec F/H One-year-old (McGowan Lake)	Uranium-238	1.96E-07	5.30E-13	6.81E-08	2.48E-05	1.05E-07	3.57E-08	0.00E+00	7.75E-07	2.63E-05	2.95E-07	**5.27E-05**
	Uranium-234	2.13E-07	9.24E-14	7.38E-08	1.25E-07	1.13E-07	1.29E-10	0.00E+00	8.39E-07	2.85E-05	3.19E-07	**3.02E-05**
	Thorium-230	2.43E-06	8.02E-13	1.75E-09	1.02E-09	1.55E-07	1.67E-10	0.00E+00	2.89E-06	1.23E-07	7.40E-06	**1.30E-05**
	Radium-226	1.63E-05	2.02E-09	3.78E-10	2.46E-07	5.28E-06	1.58E-05	0.00E+00	3.87E-05	5.07E-07	7.27E-06	**8.41E-05**
	Lead-210	3.14E-05	4.13E-12	0.00E+00	0.00E+00	6.17E-05	5.71E-08	0.00E+00	3.55E-04	0.00E+00	3.63E-04	**8.10E-04**
	Polonium-210	7.80E-05	3.04E-14	0.00E+00	0.00E+00	1.54E-04	2.45E-10	0.00E+00	2.20E-03	0.00E+00	1.00E-02	**1.25E-02**
	Total by Pathway	**1.29E-04**	**2.02E-09**	**1.44E-07**	**2.52E-05**	**2.21E-04**	**1.59E-05**	**0.00E+00**	**2.60E-03**	**5.55E-05**	**1.04E-02**	**1.35E-02**
Rec F/H Adult (Russell Lake)	Uranium-238	2.07E-07	1.57E-12	4.47E-10	4.95E-06	1.89E-09	2.02E-08	0.00E+00	9.65E-07	4.80E-06	4.36E-07	**1.14E-05**
	Uranium-234	2.26E-07	2.74E-13	4.86E-10	2.50E-08	2.06E-09	7.31E-11	0.00E+00	1.05E-06	5.23E-06	4.74E-07	**7.01E-06**
	Thorium-230	3.64E-06	2.47E-12	1.55E-11	2.40E-10	3.97E-09	9.81E-11	0.00E+00	5.11E-06	3.07E-08	2.35E-05	**3.23E-05**
	Radium-226	1.36E-05	6.08E-09	1.82E-12	4.84E-08	7.54E-08	9.04E-06	0.00E+00	3.81E-05	7.26E-08	1.35E-05	**7.45E-05**
	Lead-210	1.40E-05	1.23E-11	0.00E+00	0.00E+00	4.69E-07	2.65E-08	0.00E+00	1.86E-04	0.00E+00	3.42E-04	**5.42E-04**
	Polonium-210	2.33E-05	7.01E-14	0.00E+00	0.00E+00	8.27E-07	1.14E-10	0.00E+00	7.80E-04	0.00E+00	4.63E-03	**5.44E-03**
	Total by Pathway	**5.50E-05**	**6.10E-09**	**9.50E-10**	**5.03E-06**	**1.38E-06**	**9.09E-06**	**0.00E+00**	**1.01E-03**	**1.01E-05**	**5.01E-03**	**6.10E-03**
Rec F/H One-year-old (Russell Lake)	Uranium-238	1.44E-07	3.89E-13	1.82E-08	6.63E-06	7.69E-08	2.62E-08	0.00E+00	5.69E-07	7.02E-06	2.01E-07	**1.47E-05**
	Uranium-234	1.56E-07	6.79E-14	1.97E-08	3.34E-08	8.33E-08	9.50E-11	0.00E+00	6.16E-07	7.61E-06	2.17E-07	**8.74E-06**
	Thorium-230	1.85E-06	6.11E-13	4.66E-10	2.73E-10	1.18E-07	1.27E-10	0.00E+00	2.21E-06	3.28E-08	5.65E-06	**9.86E-06**
	Radium-226	1.22E-05	1.51E-09	9.46E-11	6.71E-08	3.94E-06	1.18E-05	0.00E+00	2.89E-05	1.38E-07	5.56E-06	**6.26E-05**
	Lead-210	1.90E-05	2.49E-12	0.00E+00	0.00E+00	3.73E-05	3.45E-08	0.00E+00	2.14E-04	0.00E+00	2.21E-04	**4.92E-04**
	Polonium-210	4.46E-05	1.74E-14	0.00E+00	0.00E+00	9.25E-05	1.48E-10	0.00E+00	1.26E-03	0.00E+00	6.06E-03	**7.46E-03**
	Total by Pathway	**7.79E-05**	**1.51E-09**	**3.84E-08**	**6.73E-06**	**1.34E-04**	**1.19E-05**	**0.00E+00**	**1.51E-03**	**1.48E-05**	**6.29E-03**	**8.04E-03**

Human Receptor	COPC	Maximum Incremental Dose by Pathway during Future Centuries (mSv/yr)										
		Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by Radionuclide
Seasonal Resident Adult (Russell Lake)	Uranium-238	2.07E-07	1.57E-12	4.47E-10	4.95E-06	1.89E-09	2.02E-08	0.00E+00	2.90E-07	1.44E-06	1.35E-07	**7.05E-06**
	Uranium-234	2.26E-07	2.74E-13	4.86E-10	2.50E-08	2.06E-09	7.31E-11	0.00E+00	3.15E-07	1.57E-06	1.47E-07	**2.28E-06**
	Thorium-230	3.64E-06	2.47E-12	1.55E-11	2.40E-10	3.97E-09	9.81E-11	0.00E+00	1.53E-06	9.31E-09	6.94E-06	**1.21E-05**
	Radium-226	1.36E-05	6.08E-09	1.82E-12	4.84E-08	7.54E-08	9.04E-06	0.00E+00	1.14E-05	2.05E-08	4.51E-06	**3.88E-05**
	Lead-210	1.40E-05	1.23E-11	0.00E+00	0.00E+00	4.69E-07	2.65E-08	0.00E+00	5.58E-05	0.00E+00	1.03E-04	**1.73E-04**
	Polonium-210	2.33E-05	7.01E-14	0.00E+00	0.00E+00	8.27E-07	1.14E-10	0.00E+00	2.34E-04	0.00E+00	1.42E-03	**1.68E-03**
	Total by Pathway	**5.50E-05**	**6.10E-09**	**9.50E-10**	**5.03E-06**	**1.38E-06**	**9.09E-06**	**0.00E+00**	**3.03E-04**	**3.04E-06**	**1.54E-03**	**1.91E-03**
Seasonal Resident One-year-old (Russell Lake)												
	Uranium-238	1.44E-07	3.89E-13	1.82E-08	6.63E-06	7.69E-08	2.62E-08	0.00E+00	1.71E-07	2.11E-06	5.89E-08	**9.23E-06**
	Uranium-234	1.56E-07	6.79E-14	1.97E-08	3.34E-08	8.33E-08	9.50E-11	0.00E+00	1.85E-07	2.28E-06	6.39E-08	**2.82E-06**
	Thorium-230	1.85E-06	6.11E-13	4.66E-10	2.73E-10	1.18E-07	1.27E-10	0.00E+00	6.62E-07	9.90E-09	1.62E-06	**4.26E-06**
	Radium-226	1.22E-05	1.51E-09	9.46E-11	6.71E-08	3.94E-06	1.18E-05	0.00E+00	8.67E-06	4.10E-08	1.91E-06	**3.86E-05**
	Lead-210	1.90E-05	2.49E-12	0.00E+00	0.00E+00	3.73E-05	3.45E-08	0.00E+00	6.43E-05	0.00E+00	6.53E-05	**1.86E-04**
	Polonium-210	4.46E-05	1.74E-14	0.00E+00	0.00E+00	9.25E-05	1.48E-10	0.00E+00	3.79E-04	0.00E+00	1.75E-03	**2.26E-03**
	Total by Pathway	**7.79E-05**	**1.51E-09**	**3.84E-08**	**6.73E-06**	**1.34E-04**	**1.19E-05**	**0.00E+00**	**4.53E-04**	**4.44E-06**	**1.82E-03**	**2.50E-03**
Fisher/ Trapper Adult (Russell Lake)												
	Uranium-238	3.45E-07	2.62E-12	7.44E-10	8.26E-06	3.15E-09	3.36E-08	0.00E+00	6.65E-06	0.00E+00	8.10E-07	**1.61E-05**
	Uranium-234	3.76E-07	4.57E-13	8.11E-10	4.16E-08	3.43E-09	1.22E-10	0.00E+00	7.24E-06	0.00E+00	8.82E-07	**8.54E-06**
	Thorium-230	6.07E-06	4.11E-12	2.57E-11	4.00E-10	6.61E-09	1.63E-10	0.00E+00	3.52E-05	0.00E+00	2.40E-06	**4.37E-05**
	Radium-226	2.27E-05	1.01E-08	3.18E-12	8.20E-08	1.26E-07	1.51E-05	0.00E+00	2.63E-04	0.00E+00	8.59E-05	**3.86E-04**
	Lead-210	2.33E-05	2.05E-11	0.00E+00	0.00E+00	7.82E-07	4.42E-08	0.00E+00	1.28E-03	0.00E+00	3.90E-04	**1.69E-03**
	Polonium-210	3.89E-05	1.17E-13	0.00E+00	0.00E+00	1.38E-06	1.89E-10	0.00E+00	5.37E-03	0.00E+00	4.57E-03	**9.98E-03**
	Total by Pathway	**9.16E-05**	**1.02E-08**	**1.58E-09**	**8.38E-06**	**2.30E-06**	**1.51E-05**	**0.00E+00**	**6.96E-03**	**0.00E+00**	**5.05E-03**	**1.21E-02**

4.2.5.3 Radon Dose

Radon will be released to the environment during all Project phases. During construction, the main source of radon to air will be during wellfield drilling from radium-bearing ore cuttings. During operation, radon from the ore body will be removed by the mining solution as it travels through the wellfield. The main source of radon to air will be from venting of the process water in the radon surge tank. During decommissioning radon will be released during wellfield restoration, and the main source of radon to air will also be from venting of the radon surge tank.

The radon dose was calculated separately from the dose from other radionuclides and was estimated outside of IMPACT. The atmospheric model used for the Project to estimate radon concentrations at various locations based on radon source emissions was CALPUFF, an advanced three-dimensional dispersion model (EIS Section 8).

The camp worker would be exposed to radon through inhalation while at the camp site, located southwest of the wellfield. The camp worker represents an adult who resides at the camp for 6 months of the year and away from the site for the remaining 6 months of the year. For exposure to radon, it has been conservatively assumed that the camp worker spends 100% of their time indoors when on site. The predicted radon concentrations at the camp site, from CALPUFF, are 2.1 Bq/m^3 during construction, 12.4 Bq/m^3 during operation, and 8.6 Bq/m^3 during decommissioning. These radon concentrations are incremental concentrations (excluding any background radon).

The dose from radon in air considers ingrowth of radon decay progeny (polonium-218, lead-214, bismuth-214) during dispersion of radon gas from the source to receptor. Ingrowth was quantified in terms of the radon progeny equilibrium ratio, according to the methods outlined in Health Canada's federal guidance on contaminated site radiological risk assessment in Canada, Part VI (Health Canada, 2010b). Radon dose is dependent on the radon equilibrium fraction as well as the exposure time for the receptor.

Consistent with recommendations in CSA N288.6-22 and Health Canada, the dose from radon in air was calculated according to the equation in Appendix A, Section 2.4.3, with input values shown in Table 4-11.

Indoor radon dose dominates over outdoor radon dose; and therefore, only indoor radon dose was quantified. However, the outdoor equilibrium fraction (F_{out}) was needed to estimate the indoor equilibrium fraction (F_{in}), which is needed to include short-lived progeny in the radon dose calculation.

The maximum predicted radon dose to the camp worker would be 0.13 mSv/yr during operation. A summary of the predicted radon dose to the camp worker during all Project phases is shown in Table 4-12.

Table 4-11: Summary of Input Parameters for Radon Dose Calculation

Parameter	Construction	Operation	Decommissioning	Source
Incremental C_{Rn} (at camp)	2.15 Bq/m^3	12.4 Bq/m^3	8.57 Bq/m^3	Atmospheric Model (EIS Section 7.2)
Distance from source to camp	403 m	981 m	981 m	From CALPUFF
Mean wind speed	204 m/min	204 m/min	204 m/min	From meteorological dataset
t (travel time to camp)	2.0 min	4.8 min	4.8 min	Calculated t = distance / wind speed
Exposure time	4,380 h/yr	4,380 h/yr	4,380 h/yr	Assumption based on camp worker residency of 0.5 of the year
F_{out}	0.04	0.10	0.10	Calculated
F_{in}	0.37	0.38	0.38	Calculated

Bq/m^3 = becquerels per cubic metre; F_{out} = outdoor equilibrium fraction; F_{in} = indoor equilibrium fraction; C_{Rn} = concentration of radon in air

Table 4-12: Predicted Radon Dose to Camp Worker during all Project Phases

Project Phase	Radon Dose at Camp (mSv/yr)
Construction	2.2E-02
Operation	1.3E-01
Decommissioning	9.2E-02

4.2.6 Uncertainty in Exposure Assessment

The exposure assessment followed CSA and Health Canada guidance. Key uncertainties in the human health exposure assumptions and how they are addressed in the HHRA are summarized in Table 4-13.

Concentrations of COPCs in environmental media including water, sediment, air, soil, and Traditional Food items were estimated based on the assumption that human and ecological receptors are exposed to the maximum exposure concentrations at their location for each model scenario and Project phase. The duration of this exposure was assumed to be sufficient for each receptor to be in equilibrium with their environment. This results in conservatively high predicted uptakes of COPCs by ecological receptors and exposures to human health receptors.

The assumptions to address uncertainties in the exposure assessment were anticipated to produce conservative exposure estimates for human health receptors. Therefore, the risk that the exposure assessment underestimated potential exposure of human health receptors to COPCs from the Project is low.

Table 4-13: Uncertainties in the Human Health Exposure Assessment

Area of Uncertainty	Description of Uncertainty	How Uncertainty has been Addressed
Receptor Selection	There are no permanent residents in the LSA or RSA, but the area is known to be used for harvesting including fishing, hunting, and gathering, and there are cabins in the LSA. There are uncertainties on how potential receptors would realistically use the LSA and RSA (i.e., locations and residency times).	• Based residency and location assumptions on current understanding of how people use the LSA and RSA. • Assumed reasonably conservative residency times for receptors that conservatively represent receptors with shorter residency times. • Located receptors in the LSA and RSA at locations known to have cabins and camps.
Traditional Foods Diet	Applied ERFN country foods study to the Traditional Diet for all average consumers of Traditional Foods. Applied Bobby John diet to the high consumer of Traditional Foods which includes a high proportion of fish and caribou in the diet	• Assumed all receptors consume Traditional Foods. Receptors included a high consumer and an average consumer of Traditional Foods. • Based the total food intake for male and female receptors on an adult male diet (N288.1-20 central tendency). • Used available information from Indigenous and Local Knowledge for the diet.
Selection of representative ecological receptors in the IMPACT model to represent Traditional Food components	Where possible, there is interest to simplify the environmental pathways model used to estimate potential human health risks without leading to an underestimate of potential risk.	• Selected representative foods from the Traditional Foods types known to be used by Indigenous and Local Communities. • Representative foods with linkages to the aquatic environment were preferred over terrestrial receptors from the same location because they have the potential to be more exposed to Project related COPCs through atmospheric and aquatic pathways.

4.3 Toxicity Assessment

4.3.1 Toxicity Reference Values

For assessment of non-radiological COPCs, a toxicity reference value (TRV) is used. A TRV is a toxicological index, associating specific health effects with a level of exposure to a chemical. TRVs may include slope factors and unit risks for carcinogens, and reference doses, tolerable daily intakes, or acceptable daily intakes for non-carcinogens.

No COPCs in air were identified for further evaluation of potential risks for human health; therefore, toxicity via inhalation was not included in the toxicity assessment. Separate toxicity benchmarks for direct contact effects from dermal exposure are not available. Although some of the COPCs present in soil may cause direct contact dermatitis, information is not available to suggest that such effects can occur at environmental levels (CSA, 2022). A summary of the TRVs used in the HHRA is shown in Table 4-14.

Chloride and sulphate were identified as COPCs; however, as discussed in Section 4.1.3, they were not evaluated further in the HHRA.

Arsenic, cadmium, chromium, cobalt, copper, molybdenum, selenium, uranium, and zinc were retained for further evaluation in the HHRA because effluent quality for these constituents were predicted to exceed water quality screening benchmarks (Section 3.1.1).

The relevant non-cancer TRVs are expressed as a quantity of a chemical per unit body weight per unit time (mg/kg/d) for oral exposure and have generally been derived for sensitive individuals in the public based on sensitive endpoints. Additionally, these factors typically involve the incorporation of uncertainty factors by regulatory agencies to account for uncertainties inherent in the underlying studies or their applicability for protection of members of the public. Carcinogenic effects TRVs are generally referred to as slope factors or unit risks and are used to estimate upper-bound lifetime probabilities of an individual developing cancer as a result of exposure to a particular level of a potential carcinogen. The carcinogen slope factor or unit risk is, therefore, the lifetime cancer risk per unit of dose or concentration. The slope factor is expressed as risk per mg/kg/d, or $(mg/kg/d)^{-1}$, for oral exposure. Arsenic was the only Project-related COPC evaluated as a carcinogen.

Preference was given to toxicological benchmarks derived by Health Canada, the USEPA Integrated Risk Information System database, the Agency for Toxic Substances and Disease Registry (ATSDR) and the WHO. The supporting documentation for each toxicity benchmark was reviewed and professional judgment was used to evaluate the appropriateness of the benchmark value.

The human health TRVs were generally obtained from Health Canada's TRV Guidance (Health Canada, 2021b). Since Health Canada does not have a published TRV for cobalt, the cobalt TRV was obtained from the ATSDR (ATSDR, 2004).

For molybdenum, selenium and zinc, Health Canada has developed tolerable upper intake levels (ULs) for all of their defined age groups: infant, toddler, child, adolescent, and adult (Health Canada, 2021b). Given that the infant and adult life stages were assessed in the HHRA, the infant and adult ULs are shown in the table below.

Table 4-14: Human Health Oral Exposure Toxicity Reference Values

Constituent of Potential Concern	Benchmark Value	Unit	Reference
Arsenic (cancer)	1.8	$(mg/kg/d)^{-1}$	(Health Canada, 2021b)
Cadmium	0.0008	mg/kg/d	(Health Canada, 2021b)
Chromium	1.5	mg/kg/d	(Health Canada, 2021b)
Cobalt	0.01	mg/kg/d	(ATSDR, 2004)
Copper	0.426	mg/kg/d	(Health Canada, 2021b)
Molybdenum	0.023 (infant) 0.028 (adult)	mg/kg/d	(Health Canada, 2021b)
Selenium	0.0055 (infant) 0.0057 (adult)	mg/kg/d	(Health Canada, 2021b)
Uranium	0.0006	mg/kg/d	(Health Canada, 2021b)
Vanadium	0.0021	mg/kg/d	(MECP, 2011)
Zinc	0.49 (infant) 0.57 (adult)	mg/kg/d	(Health Canada, 2021b)

4.3.1.1 Arsenic

Arsenic is classified as a Group I carcinogen to humans (EC and HC, 1993). Health Canada recommends 1.8 $(mg/kg/d)^{-1}$ as the oral slope factor for arsenic (Health Canada, 2021b). It was originally developed by Health Canada when the agency was deriving a Guideline for Canadian Drinking Water Quality (Health Canada, 2006). The TRV is based on the risk of bladder, lung, and liver cancer in people exposed to arsenic in their drinking water (Chen et al., 1985; Morales et al., 2000; Wu et al., 1989).

4.3.1.2 Cadmium

Cadmium is not classified as a human carcinogen via the oral route of exposure. Health Canada provides a provisional oral tolerable daily intake (TDI) of 0.0008 mg/kg/d based on a meta-analysis of human epidemiological studies where the primary exposure route was via food (Health Canada, 2021b). A no-observed adverse effect level (NOAEL) of 1.2 µg/kg/d (corresponding with 5.24 µg Cd/g creatinine in urine) was identified (WHO, 2011). The critical endpoint was nephrotoxicity (renal tubular dysfunction). Uncertainty factors for toxicodynamic and toxicokinetic variation were incorporated into the model that calculated a lower bound TDI of 0.8 µg/kg/d (or 0.0008 mg/kg/d).

4.3.1.3 Chromium

Chromium is not classified as a human carcinogen via the oral route of exposure. Health Canada provides an oral TDI of 1.5 mg/kg/d for trivalent chromium based on a chronic dietary study in male and female BD rats administered chromic oxide (Cr_2O_3) in the diet at concentrations of 0%, 1% (360 g/kg-bw), 2% (720 g/kg-bw), or 5% (1800 g/kg-bw) for 5 days per week for a total of 600 feedings ((US EPA, 1998); based on (Ivankovic and Preussmann, 1975)). No adverse effects were observed at any dose level. As such, the highest dose level of 1800 g/kg-bw was selected as the point of departure. Uncertainty factors of 10 for interspecies variability, 10 for intraspecies variability, and 10 for database deficiencies were applied to derive the TDI of 1.5 mg/kg/d.

4.3.1.4 Cobalt

Cobalt is a trace element that is essential to human health (Health Canada, 2021b). Cobalt is not classified as a human carcinogen. Health Canada does not provide a threshold oral TRV for cobalt (Health Canada, 2021b). The listed TRV of 0.01 mg/kg/d is recommended by ATSDR (2004). The ATSDR TRV is an intermediate Minimal Risk Level, and is based on a study by Davis and Fields (Davis and Fields, 1958), in which human males ingested a 2% cobalt chloride solution (in water or milk) for up to 22 days. The critical endpoint was hematological effects (increased levels of erythrocytes). The ATSDR took the lowest observed adverse effect level (LOAEL) of 1 mg/kg/d and applied a total uncertainty factor of 100 to arrive at their intermediate minimal risk level. The ATSDR did not derive a chronic minimal risk level for cobalt due to a lack of relevant animal and human studies.

4.3.1.5 Copper

Copper is a trace element that is essential for human health (Health Canada, 2021b). Copper is not classified as a human carcinogen. Health Canada recommends 0.426 mg/kg/d as the threshold oral TRV for copper for all age groups. The TRV was originally developed by Health Canada when the agency was deriving a Guideline for Canadian Drinking Water Quality (Health Canada, 2019a). The TRV is based on a critical health effect of gastrointestinal toxicity and liver function (hepatoxicity) in human infants exposed to copper in drinking water (Olivares et al., 1998). The TRV is based directly (no uncertainty factors applied) on the upper bound of the 95th confidence interval for a NOAEL of 2 mg/L copper in drinking water (0.318 mg/kg/d).

4.3.1.6 Molybdenum

Molybdenum is considered to be an essential trace element for human health (Health Canada, 2021b). However, Health Canada recommends that potential health risks to human receptors be characterized if molybdenum is identified as a COPC (Health Canada, 2021b). The TRVs for essential trace elements are tolerable upper intake levels (ULs), which are considered to be the highest average daily nutrient intake levels that are likely to pose no risk of adverse health effects to almost all individuals in the general population. Health Canada recommends age-specific ULs for molybdenum that are based on a NOAEL value derived for adults (Health

Canada, 2010c; IOM, 2001) from sub-chronic developmental and reproductive effects on rats consuming molybdate in drinking water. An uncertainty factor of 30 was applied (10 for interspecies variability and 3 for intraspecies variability) to the NOAEL value of 0.9 mg/kg-d. The adult UL was weight adjusted to derive age-based TRVs. As with other essential trace elements, Health Canada recommends that adjustments for relative bioavailability of molybdenum may be necessary when considering oral exposures from different pathways (Health Canada, 2010c).

4.3.1.7 Selenium

Similar to molybdenum, selenium is also considered to be an essential trace element for human health (Health Canada, 2021b). Where selenium is identified as a COPC, age-based ULs are recommended. The ULs for selenium are based on the data from two epidemiological studies. The first study considered dietary intake by adults ((IOM, 2000); based on Yang and Zhou 1994) and the second study considered intake from breast milk by infants ((IOM, 2000); based on Shearer and Hadjimarkos 1975).

- The dietary study in adults identified a NOAEL of 800 µg/day based on mean selenium intake in adults associated with signs and symptoms of selenosis (hair and nail brittleness and loss). An uncertainty factor of 2 was incorporated into the derivation of the UL to account for the increased sensitivity of some individuals; furthermore, it is also noted that HC adjusted the IOM's original adult ULs to account for HC's adult age group. A UL of 0.0057 mg/kg/d was derived for adults.

- The breast milk study in infants aged up to six months considered concentrations ranging from 7 to 60 µg/L in unsupplemented women. The NOAEL of 60 µg/L adjusted for the estimated average intake of 0.78 L/d was used to derive the UL. Given that no evidence of infant or maternal toxicity was identified in the study, an uncertainty factor of 1 was applied. Considering the Health Canada (2010) age groups, age-based ULs were derived for older infants (0.006 mg/kg/d), children (0.0063 mg/kg/d) and adolescents (0.0062 mg/kg/d) based on the infant UL of 0.0055 mg/kg/d (Health Canada, 2010c).

4.3.1.8 Uranium

Health Canada recommends 6.0 x 10^{-4} mg/kg/d as the threshold oral TRV for uranium for non-radiological effects for all age groups (Health Canada, 2021b). Uranium (non-radiological) is not classified as a human carcinogen. The TRV was originally developed by Health Canada when the agency was deriving a Guideline for Canadian Drinking Water Quality and it has since been re-affirmed (Health Canada, 2019b). The TRV is based on the critical health effect of kidney toxicity in rats exposed to uranium in drinking water (Gilman et al., 1998). The TRV is based on a NOAEL of 0.06 mg/kg/d and a total uncertainty factor of 100.

4.3.1.9 Vanadium

Vanadium is present naturally in the diet of humans; an upper limit of 1.8 mg/d has been derived for adults between the ages of 18 and 50 years. Health Canada (2021b) has not derived nor adopted a TRV for vanadium. The listed TRV of 0.0021 mg/kg/d from MECP (2011) was adopted. MECP (2011) adopted its TRV from the California Office of Environmental Health Hazard Assessment (Cal OEHHA), which relied on the TRV of 0.0021 mg/kg/d to derive its action level of 15 µg/L for vanadium in drinking water. The TRV is based upon a developmental and reproductive rat study ((Cal OEHHA, 2000); based on Domingo et al. 1986) wherein no maternal toxicity was identified, but pups born to mothers administered all dose levels (5, 10 and 20 mg/kg of sodium metavanadate by oral gavage) prior to mating showed signs of developmental effects (low body weight and reduced pup length). The lowest dose level of 5 mg/kg was used to derive the point of departure of 2.1 mg/kg/d as the LOAEL. An uncertainty factor of 1000 was applied (10 for intraspecies variability, 10 for interspecies variability, and 10 for extrapolation from a LOAEL to a NOAEL).

4.3.1.10 Zinc

As described from molybdenum and selenium, zinc is an essential trace element for human health (Health Canada, 2021b). Where zinc is identified as a COPC, age-based ULs are recommended. The ULs for zinc are based on the data from two prospective epidemiological studies. The first study considered dietary supplementation by adult women ((IOM, 2001); based on Yadrick et al. 1989) and the second study considered intake from fortified formula by infants ((IOM, 2001); based on Walravens and Hambridge 1976).

- The dietary supplementation in adults identified a LOAEL of 60 mg/day based on mean zinc intake from food of 10 mg/day and supplementation of 50 mg/day as zinc gluconate. The LOAEL was associated with indications of copper deficiency (decrease in red blood cell (or erythrocyte) superoxide dismutase (ESOD) activity). An uncertainty factor of 1.5 was incorporated into the derivation of the UL to account for the increased sensitivity of some individuals and extrapolation from a LOAEL to a NOAEL; furthermore, it is also noted that HC adjusted the IOM's original adult ULs to account for HC's adult age group. A UL of 0.49 mg/kg/d was derived for adults.

- The formula study in infants aged up to six months considered concentrations of formula with 1.8 mg Zn/L, one group was given formula alone, and the other group was given formula with a 4 mg Zn/L supplement. No signs of copper deficiency or other indicators of adverse effect were identified in any exposure group. The NOAEL of 5.8 mg/L adjusted for the estimated average intake of 0.78 L/d was used to derive the UL. Given that no evidence of toxicity was identified in the study, an uncertainty factor of 1 was applied. Considering the HC (Health Canada, 2010c) age groups, age-based ULs were derived for older infants (0.48 mg/kg/d), children (0.51 mg/kg/d) and adolescents (0.54 mg/kg/d) based on the infant UL of 0.49 mg/kg/d.

4.3.2 Radiation Dose Limits and Targets

Potential effects from radiation were compared to an effective dose limit. The effective dose is defined as the sum of all tissue equivalent doses multiplied by the appropriate tissue weighting factors associated with each respective tissue (Health Canada, 2010b). The limit is incremental and is exclusive of natural background, such as natural levels of radon, and medical exposures.

The public dose limit and dose limit for a non-NEW for radiation protection is 1 mSv/yr, as described in the *Radiation Protection Regulations* under the *Nuclear Safety and Control Act*, and as recommended in CSA N288.6-22. A higher incremental dose than the effective dose limit is considered unacceptable.

Incremental dose from the Project can also be compared to a dose constraint. A dose constraint is a conservative value for the annual increment dose applied to a single operation that is considered protective without further demonstration in situations where multiple sources may contribute to incremental dose (Health Canada, 2011). Application of a dose constraint is meant to ensure that the combined doses from multiple sources do not exceed the dose limit of 1 mSv/yr. A dose constraint of 0.3 mSv/yr is used in the ERA, as recommended by Health Canada (Health Canada, 2011). The dose constraint represents a dose, lower than the dose limit that ensures that the combined dose from multiple sources does not result in exceedance of the dose limit. Exceedance of the dose constraint does not indicate that adverse effects would occur, but instead indicates that the assumptions used in the calculation of exposure estimates for the operation should be examined in more detail.

4.3.3 Uncertainties in the Toxicity Assessment

In general, TRVs are usually based on limited toxicological data. For this reason, a margin of safety is built into TRV estimates, by use of uncertainty factors or conservative confidence levels, and actual risks are lower than those estimated. In this risk assessment, TRVs recommended by Health Canada were used when available to reduce uncertainty that potential health risks for human receptors would be underestimated in the risk evaluation.

The two major areas of uncertainty introduced in this toxicity assessment are animal to human extrapolation for Health Canada's recommend TRV for uranium, and use of an intermediate-duration TRV from a regulatory agency other than Health Canada for cobalt. In both cases, uncertainty factors were applied in the derivation of the TRVs. For uranium, the chronic TRV was based on a no observed adverse effects level for rats and a total uncertainty factor of 100. For cobalt, the intermediate (sub-chronic) TRV was based on a LOAEL for humans and a total uncertainty factor of 100. As a result, overestimation of the potential for adverse effects on humans is more likely than underestimation for similar exposure scenarios.

4.4 Risk Characterization

4.4.1 Risk Estimation

The potential for adverse effects on human receptors was determined in the risk assessment through the risk characterization step, where risk estimates were calculated to determine the potential for effects on the human receptors identified. The risk estimate was determined by comparing the predicted exposures, in terms of doses, with exposures that are known to be protective based on effects data (i.e., TRVs or radiation dose limits).

The methods of non-radiological risk estimation used for the HHRA were:

- HQs for non-carcinogens; and
- ILCR for carcinogens.

Hazard quotients (HQs) were calculated in IMPACT as the ratio of the exposure concentration or intake rate divided by the benchmark value, as shown below:

$$HQ = \frac{Exposure\ (Dose)\ Estimate}{TRV}$$

The HQs were compared to benchmark values. Non-carcinogenic constituents are not expected to cause any adverse health effects at exposures below the TRV. The HQs can be compared to a benchmark value of one (1) if all exposure pathways (exposures from all pathways including background and store-bought foods) are accounted for.

To account for uncertainty in pathways beyond Project activities (i.e., exposure to background sources unrelated to the Project), it was determined that to be protective a benchmark HQ value of 0.2 per medium (e.g., water, soil, food, air) would be considered acceptable for the assessment. This approach is consistent with the approach taken by Health Canada in its guidance on human health preliminary quantitative risk assessment (Health Canada, 2021a).

For carcinogens (e.g., arsenic), the incremental risk (i.e., total risk minus background risk) of developing cancer over a lifetime was estimated by multiplying the predicted dose above background by the cancer slope factor, as shown below:

$$ILCR = \sum LADD_i \times SF \times ADAF_i$$

where,

ILCR	=	incremental lifetime cancer risk (unitless)
$LADD_i$	=	dose received during lifestage i averaged over a lifetime (mg/kg/d)
SF	=	adult cancer slope factor (per mg/kg/d)
$ADAF_i$	=	age-dependent adjustment factors for lifestage i

Health Canada recommends that for carcinogens where the mode of action is unknown or the burden of proof for a threshold mode of action is not met, that the assessment should follow the non-threshold approach (i.e., a linear dose-response relationship) (Health Canada, 2013). The Canadian drinking water guideline technical document for arsenic indicates that there is limited data on the mode of action for arsenic and that the use of a non-linear relationship may overestimate cancer risks of internal organs (Health Canada, 2006). Therefore, for this assessment, a linear approach for arsenic was used. Additionally, since the mode of action is unknown, and arsenic-specific data are not available on quantitative differences between early lifestages and adults, Health Canada's default age-dependent adjustment factors for all life stages were not used (ADAF = 1 for all life stages).

Incremental lifetime cancer risks were compared to de minimis risk levels that are considered essentially negligible compared to background cancer risks. Cancer risks that are considered acceptable can range from 1 in 10,000 to 1 in 1,000,000 in different jurisdictions. Health Canada considers an increase in lifetime cancer risk of 1 in 100,000 (or 0.00001) to be essentially negligible compared to the background cancer risk level in North America of approximately 5 in 10 (or 0.5) (Health Canada, 2021a).

Total radiation doses due to radionuclides in the uranium-238 decay series were predicted. Incremental radiation doses were compared to the regulatory public dose limit and dose limit for a non-NEW of 1 mSv/yr and a dose constraint of 0.3 mSv/yr, as described in Section 4.3.2, Radiation Dose Limits and Targets. Radon dose was also considered; and was also compared to the dose limit of 1 mSv/yr.

4.4.1.1 Non-carcinogen Risk

The HQs in Table 4-15 are presented as baseline HQs (based on existing risk prior to the Project), Project Total HQs (includes the Project risk in addition to the baseline risk), as well as Project incremental HQs (includes the Project risk only with baseline component removed). The HQs represent the maximum HQ over the Project phase for the COPCs of interest, which is a conservative representation as exposure varies within each Project phase. HQs were evaluated for the adult and the one-year-old; however, for assessment of non-carcinogens, the one-year-old is typically considered the most sensitive receptor (Health Canada 2010a).

For the Project incremental HQs, there are no exceedances of the HQ benchmark (HQ<0.2) for human receptors for non-carcinogens (cadmium, copper, chromium, cobalt, molybdenum, uranium, and zinc) during all phases of the Project, with the exception of selenium for the fisher/trapper at Russell Lake. The incremental Project HQ for the fisher/trapper from fish ingestion (northern pike and white sucker) was predicted to be 0.81. The Project incremental HQ represents an incremental HQ with existing baseline risk removed.

Since baseline risk includes all exposures not associated with the Project (including store-bought foods), it is also appropriate to discuss the Project total HQ (baseline plus Project) and compare against a HQ benchmark of 1. There are no exceedances of the HQ benchmark of 1 for human receptors for non-carcinogens (cadmium, copper, chromium, cobalt, molybdenum, uranium, vanadium, and zinc) during all phases of the Project, with the exception of selenium for the fisher/trapper at Russell Lake (Project total HQ = 1.35). The Project total HQs for the fisher/trapper for selenium are predicted to be equal to or greater than 1; and as previously indicated above, the Project incremental HQs for the fish ingestion pathway for selenium are predicted to be above 0.2. This indicates that the Project is expected to contribute to selenium in the environment and the food chain; however, conservatism in the assessment is discussed further.

The traditional foods diet for the fisher/trapper is conservative and is based on engagement with a local fisher/trapper. The diet of the fisher/trapper is representative of one person, who consumes a unique composition and quantity of traditional foods. Most people fishing, hunting, and trapping in the Project Area would consume traditional foods more consistent with the average traditional foods consumer diet which was developed from the ERFN country foods study (CanNorth, 2017). However, it is recognized that the ERFN considers the fisher/trapper's use of the area as representative of current and future land users and expects that their relationship to the Project Area will be continued and strengthened through generations of future use.

The ingestion rate for caribou based on engagement with a local fisher/trapper was 175 kg/yr of caribou (equivalent to approximately 2 to 3 servings per day). This ingestion rate is conservative compared to an annual caribou ingestion rate of 2.6 kg/yr (1 to 2 servings per month) from the ERFN's Country Food Study (CanNorth, 2017) and 54.4 kg/yr for the total game diet for a high traditional foods consumer in the Boreal Shield in the First Nations Food, Nutrition and Environment Study for Saskatchewan (Chan et al., 2018). Thus, the local fisher/trapper is relatively extreme with respect to local game consumption.

Additionally, the traditional foods diet for the fisher/trapper is conservative for fish as it assumes that all fish consumed in the diet is obtained from Russell Lake, whereas it is likely that someone would fish from many different lakes including those outside of the RSA. The annual fish consumption based on engagement with a local fisher/trapper was assumed to be 183 kg/yr (approximately 1 to 2 servings per day), which is conservative compared to an annual fish consumption of 27 kg/yr (2 servings per week) from the ERFN's Country Food Study (CanNorth, 2017) and 88 kg/yr (approximately 1 serving per day) for the high consumer for the Boreal Shield in the First Nations Food, Nutrition and Environment Study for Saskatchewan (Chan et al., 2018). Thus, the local fisher/trapper is relatively extreme with respect to local fish consumption. The Project incremental HQs are below 0.2 for all other pathways including consumption of terrestrial and riparian animals harvested in the Project area. The overall risk to the fisher/trapper from selenium is low.

The presence and concentrations of COPCs in the receiving environment would be monitored and the associated dose and risk estimates would be periodically reassessed in accordance with the processes outlined in the Environmental Protection Program.

The HQs for the future centuries (beyond the Project timeline) are presented in Table 4-16. During the future centuries a permanent resident is included on the former mine site instead of a camp worker. For the Project incremental HQs, there are no predicted exceedances of the HQ benchmark (HQ<0.2) for any human receptors for any non-carcinogens evaluated during the future centuries.

Table 4-15: Estimated Non-radiological Risk to Human Receptors – Project Phases

Human Receptor	COPC	HQs during Project Phases									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
Camp Worker Adult (Whitefish Lake)		Average Baseline HQ									
	Cadmium	4.25E-04	9.44E-06	4.32E-05	2.94E-06	1.35E-05	0.00E+00	4.46E-05	4.39E-03	2.56E-01	2.61E-01
	Chromium	5.08E-06	4.62E-08	2.11E-06	2.72E-08	1.25E-06	0.00E+00	9.78E-06	3.72E-06	1.00E-05	3.20E-05
	Cobalt	1.48E-04	5.55E-07	2.54E-06	1.76E-07	8.04E-07	0.00E+00	6.25E-05	3.14E-03	1.64E-02	1.97E-02
	Copper	2.13E-05	7.15E-08	1.96E-06	3.02E-08	8.30E-07	0.00E+00	3.74E-04	5.13E-03	4.83E-02	5.38E-02
	Molybdenum	5.61E-05	8.58E-08	3.93E-07	8.40E-08	3.84E-07	0.00E+00	1.97E-07	9.24E-04	9.05E-02	9.15E-02
	Selenium	8.32E-05	3.93E-07	1.80E-06	7.59E-07	3.48E-06	0.00E+00	1.47E-02	3.85E-03	2.96E-01	3.14E-01
	Uranium	7.35E-04	1.33E-05	6.10E-04	6.71E-06	3.07E-04	0.00E+00	5.14E-04	2.27E-02	6.12E-02	8.62E-02
	Vanadium	1.01E-03	4.80E-05	2.20E-03	3.71E-05	1.70E-03	0.00E+00	3.39E-03	1.71E-03	1.72E-01	1.82E-01
	Zinc	1.75E-05	1.95E-07	8.92E-06	1.21E-07	5.56E-06	0.00E+00	1.23E-03	9.38E-03	2.12E-01	2.23E-01
		Project Total HQ - Project Phases									
	Cadmium	5.70E-04	9.44E-06	4.32E-05	3.64E-06	1.67E-05	0.00E+00	6.26E-05	4.39E-03	2.56E-01	2.61E-01
	Chromium	6.13E-06	4.62E-08	2.11E-06	3.13E-08	1.43E-06	0.00E+00	1.23E-05	3.72E-06	1.09E-05	3.66E-05
	Cobalt	1.68E-04	5.56E-07	2.54E-06	1.94E-07	8.88E-07	0.00E+00	7.34E-05	3.15E-03	1.64E-02	1.98E-02
	Copper	2.48E-05	7.22E-08	1.98E-06	3.40E-08	9.34E-07	0.00E+00	4.52E-04	5.15E-03	4.83E-02	5.40E-02
	Molybdenum	6.41E-03	8.59E-08	3.93E-07	7.17E-06	3.28E-05	0.00E+00	2.84E-05	9.24E-04	9.20E-02	9.94E-02
	Selenium	5.98E-04	3.94E-07	1.80E-06	3.73E-06	1.71E-05	0.00E+00	9.45E-02	3.85E-03	3.07E-01	4.06E-01
	Uranium	7.39E-03	3.60E-05	1.65E-03	4.51E-05	2.06E-03	0.00E+00	5.59E-03	5.04E-02	6.54E-02	1.33E-01
	Vanadium	2.79E-03	4.80E-05	2.20E-03	8.03E-05	3.68E-03	0.00E+00	7.57E-03	1.72E-03	1.76E-01	1.94E-01
	Zinc	2.22E-05	1.95E-07	8.93E-06	1.44E-07	6.59E-06	0.00E+00	1.61E-03	9.38E-03	2.13E-01	2.24E-01
		Project Incremental HQ - Project Phases									
	Cadmium	1.45E-04	1.42E-09	6.48E-09	6.95E-07	3.18E-06	0.00E+00	1.80E-05	2.07E-06	1.53E-04	3.22E-04
	Chromium	1.05E-06	4.44E-12	2.03E-10	4.05E-09	1.85E-07	0.00E+00	2.48E-06	4.42E-09	8.57E-07	4.58E-06
	Cobalt	1.99E-05	5.98E-10	2.74E-09	1.85E-08	8.46E-08	0.00E+00	1.09E-05	1.72E-06	3.71E-05	6.98E-05
	Copper	3.45E-06	6.38E-10	1.75E-08	3.78E-09	1.04E-07	0.00E+00	7.83E-05	1.94E-05	8.46E-05	1.86E-04
	Molybdenum	6.35E-03	6.60E-11	3.02E-10	7.08E-06	3.24E-05	0.00E+00	2.82E-05	3.31E-07	1.47E-03	7.89E-03
	Selenium	5.15E-04	4.18E-10	1.91E-09	2.98E-06	1.36E-05	0.00E+00	7.98E-02	2.42E-06	1.12E-02	9.15E-02
	Uranium	6.66E-03	2.26E-05	1.04E-03	3.84E-05	1.76E-03	0.00E+00	5.08E-03	2.77E-02	4.17E-03	4.65E-02

Human Receptor	COPC	HQs during Project Phases									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Vanadium	1.77E-03	1.45E-08	6.61E-07	4.32E-05	1.98E-03	0.00E+00	4.18E-03	5.34E-06	3.64E-03	1.16E-02
	Zinc	4.64E-06	1.67E-10	7.64E-09	2.27E-08	1.04E-06	0.00E+00	3.88E-04	3.28E-06	1.77E-04	5.74E-04
Rec F/H Adult (McGowan Lake)		Average Baseline HQ									
	Cadmium	4.25E-04	9.44E-06	4.32E-06	2.94E-06	1.35E-06	0.00E+00	8.92E-05	8.78E-03	2.48E-01	2.57E-01
	Chromium	5.08E-06	4.62E-08	2.11E-07	2.72E-08	1.25E-07	0.00E+00	1.96E-05	7.43E-06	2.02E-05	5.27E-05
	Cobalt	1.48E-04	5.55E-07	2.54E-07	1.76E-07	8.04E-08	0.00E+00	1.25E-04	6.29E-03	1.77E-02	2.42E-02
	Copper	2.13E-05	7.15E-08	1.96E-07	3.02E-08	8.30E-08	0.00E+00	7.48E-04	1.03E-02	5.98E-02	7.08E-02
	Molybdenum	5.61E-05	8.58E-08	3.93E-08	8.40E-08	3.84E-08	0.00E+00	3.94E-07	1.85E-03	8.62E-02	8.81E-02
	Selenium	8.32E-05	3.93E-07	1.80E-07	7.59E-07	3.48E-07	0.00E+00	2.94E-02	7.70E-03	2.89E-01	3.26E-01
	Uranium	7.35E-04	1.33E-05	6.10E-05	6.71E-06	3.07E-05	0.00E+00	1.03E-03	4.55E-02	5.86E-02	1.06E-01
	Vanadium	1.01E-03	4.80E-05	2.20E-04	3.71E-05	1.70E-04	0.00E+00	6.78E-03	3.43E-03	1.72E-01	1.83E-01
	Zinc	1.75E-05	1.95E-07	8.92E-07	1.21E-07	5.56E-07	0.00E+00	2.45E-03	1.88E-02	2.34E-01	2.55E-01
		Project Total HQ - Project Phases									
	Cadmium	4.78E-04	9.44E-06	4.32E-06	3.22E-06	1.47E-06	0.00E+00	1.25E-04	8.79E-03	2.48E-01	2.58E-01
	Chromium	5.50E-06	4.62E-08	2.11E-07	2.89E-08	1.32E-07	0.00E+00	2.45E-05	7.44E-06	2.19E-05	5.98E-05
	Cobalt	1.56E-04	5.55E-07	2.54E-07	1.84E-07	8.40E-08	0.00E+00	1.47E-04	6.29E-03	1.77E-02	2.43E-02
	Copper	2.26E-05	7.16E-08	1.97E-07	3.19E-08	8.75E-08	0.00E+00	9.05E-04	1.03E-02	6.00E-02	7.12E-02
	Molybdenum	2.52E-03	8.59E-08	3.93E-08	3.13E-06	1.43E-06	0.00E+00	5.68E-05	1.85E-03	8.91E-02	9.36E-02
	Selenium	2.56E-04	3.94E-07	1.80E-07	1.90E-06	8.67E-07	0.00E+00	1.89E-01	7.70E-03	3.12E-01	5.09E-01
	Uranium	2.98E-03	1.68E-05	7.68E-05	2.14E-05	9.78E-05	0.00E+00	1.12E-02	1.01E-01	6.70E-02	1.82E-01
	Vanadium	1.49E-03	4.80E-05	2.20E-04	4.81E-05	2.20E-04	0.00E+00	1.51E-02	3.44E-03	1.79E-01	1.99E-01
	Zinc	1.93E-05	1.95E-07	8.93E-07	1.30E-07	5.97E-07	0.00E+00	3.23E-03	1.88E-02	2.34E-01	2.56E-01
		Project Incremental HQ - Project Phases									
	Cadmium	5.28E-05	1.97E-10	9.00E-11	2.75E-07	1.26E-07	0.00E+00	3.60E-05	4.14E-06	3.08E-04	4.01E-04
	Chromium	4.16E-07	6.86E-13	3.14E-12	1.64E-09	7.53E-09	0.00E+00	4.96E-06	8.84E-09	1.72E-06	7.12E-06
	Cobalt	7.28E-06	8.29E-11	3.80E-11	8.01E-09	3.66E-09	0.00E+00	2.18E-05	3.44E-06	7.40E-05	1.07E-04
	Copper	1.25E-06	8.90E-11	2.44E-10	1.63E-09	4.48E-09	0.00E+00	1.57E-04	3.88E-05	1.69E-04	3.66E-04
	Molybdenum	2.47E-03	6.62E-12	3.03E-12	3.05E-06	1.40E-06	0.00E+00	5.64E-05	6.63E-07	2.93E-03	5.46E-03
	Selenium	1.73E-04	5.85E-11	2.68E-11	1.14E-06	5.20E-07	0.00E+00	1.60E-01	4.83E-06	2.24E-02	1.82E-01

Human Receptor	COPC	HQs during Project Phases									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Uranium	2.24E-03	3.45E-06	1.58E-05	1.46E-05	6.70E-05	0.00E+00	1.02E-02	5.54E-02	8.36E-03	7.63E-02
	Vanadium	4.72E-04	2.01E-09	9.18E-09	1.10E-05	5.03E-05	0.00E+00	8.36E-03	1.07E-05	7.29E-03	1.62E-02
	Zinc	1.81E-06	2.32E-11	1.06E-10	9.00E-09	4.12E-08	0.00E+00	7.76E-04	6.57E-06	3.54E-04	1.14E-03
Rec F/H One-year-old (McGowan Lake)		Average Baseline HQ									
	Cadmium	4.75E-04	6.17E-04	7.39E-06	1.92E-04	2.30E-06	0.00E+00	8.45E-05	1.97E-02	6.29E-01	6.50E-01
	Chromium	5.67E-06	3.02E-06	3.62E-07	1.78E-06	2.13E-07	0.00E+00	1.85E-05	1.72E-05	1.17E-05	5.85E-05
	Cobalt	1.66E-04	3.63E-05	4.35E-07	1.15E-05	1.37E-07	0.00E+00	1.18E-04	1.46E-02	3.78E-02	5.27E-02
	Copper	2.38E-05	4.67E-06	3.36E-07	1.98E-06	1.42E-07	0.00E+00	7.09E-04	2.37E-02	1.01E-01	1.25E-01
	Molybdenum	7.63E-05	6.83E-06	8.18E-08	6.68E-06	8.00E-08	0.00E+00	4.54E-07	5.20E-03	2.73E-01	2.79E-01
	Selenium	9.63E-05	2.66E-05	3.19E-07	5.14E-05	6.16E-07	0.00E+00	2.88E-02	1.87E-02	7.51E-01	7.98E-01
	Uranium	8.21E-04	8.71E-04	1.04E-04	4.38E-04	5.25E-05	0.00E+00	9.73E-04	1.04E-01	1.52E-01	2.59E-01
	Vanadium	1.13E-03	3.13E-03	3.76E-04	2.42E-03	2.91E-04	0.00E+00	6.42E-03	6.21E-03	4.18E-01	4.38E-01
	Zinc	2.28E-05	1.48E-05	1.78E-06	9.23E-06	1.11E-06	0.00E+00	2.70E-03	5.01E-02	5.63E-01	6.16E-01
		Project Total HQ - Project Phases									
	Cadmium	5.34E-04	6.17E-04	7.39E-06	2.10E-04	2.52E-06	0.00E+00	1.19E-04	1.97E-02	6.29E-01	6.50E-01
	Chromium	6.14E-06	3.02E-06	3.62E-07	1.89E-06	2.26E-07	0.00E+00	2.32E-05	1.72E-05	1.29E-05	6.49E-05
	Cobalt	1.74E-04	3.63E-05	4.35E-07	1.20E-05	1.44E-07	0.00E+00	1.39E-04	1.46E-02	3.78E-02	5.28E-02
	Copper	2.52E-05	4.68E-06	3.36E-07	2.08E-06	1.50E-07	0.00E+00	8.57E-04	2.38E-02	1.01E-01	1.26E-01
	Molybdenum	3.43E-03	6.83E-06	8.18E-08	2.49E-04	2.99E-06	0.00E+00	6.55E-05	5.20E-03	2.75E-01	2.84E-01
	Selenium	2.96E-04	2.66E-05	3.19E-07	1.28E-04	1.54E-06	0.00E+00	1.86E-01	1.87E-02	7.66E-01	9.70E-01
	Uranium	3.32E-03	1.10E-03	1.31E-04	1.40E-03	1.67E-04	0.00E+00	1.06E-02	2.14E-01	1.57E-01	3.88E-01
	Vanadium	1.66E-03	3.13E-03	3.76E-04	3.14E-03	3.77E-04	0.00E+00	1.43E-02	6.22E-03	4.22E-01	4.51E-01
	Zinc	2.51E-05	1.48E-05	1.78E-06	9.91E-06	1.19E-06	0.00E+00	3.56E-03	5.01E-02	5.64E-01	6.17E-01
		Project Incremental HQ - Project Phases									
	Cadmium	5.89E-05	1.29E-08	1.55E-10	1.80E-05	2.16E-07	0.00E+00	3.41E-05	8.55E-06	2.13E-04	3.33E-04
	Chromium	4.64E-07	4.50E-11	5.37E-12	1.07E-07	1.29E-08	0.00E+00	4.70E-06	1.15E-08	1.14E-06	6.44E-06
	Cobalt	8.13E-06	5.42E-09	6.50E-11	5.23E-07	6.27E-09	0.00E+00	2.07E-05	7.64E-06	4.22E-05	7.92E-05
	Copper	1.40E-06	5.81E-09	4.18E-10	1.07E-07	7.67E-09	0.00E+00	1.48E-04	9.07E-05	9.83E-05	3.39E-04
	Molybdenum	3.35E-03	5.27E-10	6.31E-12	2.43E-04	2.91E-06	0.00E+00	6.51E-05	1.80E-06	2.03E-03	5.70E-03

Human Receptor	COPC	HQs during Project Phases									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Selenium	2.00E-04	3.96E-09	4.74E-11	7.69E-05	9.22E-07	0.00E+00	1.57E-01	1.14E-05	1.48E-02	1.72E-01
	Uranium	2.50E-03	2.25E-04	2.70E-05	9.57E-04	1.15E-04	0.00E+00	9.62E-03	1.10E-01	5.28E-03	1.29E-01
	Vanadium	5.27E-04	1.31E-07	1.57E-08	7.18E-04	8.61E-05	0.00E+00	7.91E-03	1.37E-05	4.03E-03	1.33E-02
	Zinc	2.35E-06	1.77E-09	2.12E-10	6.84E-07	8.20E-08	0.00E+00	8.54E-04	1.78E-05	2.07E-04	1.08E-03
Rec F/H Adult (Russell Lake)		**Average Baseline HQ**									
	Cadmium	4.25E-04	9.44E-06	4.32E-06	2.94E-06	1.35E-06	0.00E+00	8.92E-05	8.78E-03	<u>2.48E-01</u>	2.57E-01
	Chromium	5.08E-06	4.62E-08	2.11E-07	2.72E-08	1.25E-07	0.00E+00	1.96E-05	7.43E-06	2.02E-05	5.27E-05
	Cobalt	1.48E-04	5.55E-07	2.54E-07	1.76E-07	8.04E-08	0.00E+00	1.25E-04	6.29E-03	1.77E-02	2.42E-02
	Copper	2.13E-05	7.15E-08	1.96E-07	3.02E-08	8.30E-08	0.00E+00	7.48E-04	1.03E-02	5.98E-02	7.08E-02
	Molybdenum	5.61E-05	8.58E-08	3.93E-08	8.40E-08	3.84E-08	0.00E+00	3.94E-07	1.85E-03	8.62E-02	8.81E-02
	Selenium	8.32E-05	3.93E-07	1.80E-07	7.59E-07	3.48E-07	0.00E+00	2.94E-02	7.70E-03	<u>2.89E-01</u>	3.26E-01
	Uranium	7.35E-04	1.33E-05	6.10E-05	6.71E-06	3.07E-05	0.00E+00	1.03E-03	4.55E-02	5.86E-02	1.06E-01
	Vanadium	1.01E-03	4.80E-05	2.20E-04	3.71E-05	1.70E-04	0.00E+00	6.78E-03	3.43E-03	1.72E-01	1.83E-01
	Zinc	1.75E-05	1.95E-07	8.92E-07	1.21E-07	5.56E-07	0.00E+00	2.45E-03	1.88E-02	<u>2.34E-01</u>	2.55E-01
		Project Total HQ - Project Phases									
	Cadmium	4.68E-04	9.44E-06	4.32E-06	3.15E-06	1.44E-06	0.00E+00	1.15E-04	8.78E-03	<u>2.48E-01</u>	2.58E-01
	Chromium	5.42E-06	4.62E-08	2.11E-07	2.84E-08	1.30E-07	0.00E+00	2.32E-05	7.44E-06	2.15E-05	5.80E-05
	Cobalt	1.54E-04	5.55E-07	2.54E-07	1.82E-07	8.31E-08	0.00E+00	1.41E-04	6.29E-03	1.77E-02	2.43E-02
	Copper	2.23E-05	7.16E-08	1.97E-07	3.15E-08	8.64E-08	0.00E+00	8.66E-04	1.03E-02	5.99E-02	7.11E-02
	Molybdenum	1.91E-03	8.58E-08	3.93E-08	2.40E-06	1.10E-06	0.00E+00	4.28E-05	1.85E-03	8.84E-02	9.22E-02
	Selenium	2.07E-04	3.93E-07	1.80E-07	1.59E-06	7.27E-07	0.00E+00	1.47E-01	7.70E-03	<u>3.06E-01</u>	4.60E-01
	Uranium	2.35E-03	1.42E-05	6.52E-05	1.74E-05	7.97E-05	0.00E+00	8.35E-03	6.03E-02	6.36E-02	1.35E-01
	Vanadium	1.38E-03	4.80E-05	2.20E-04	4.41E-05	2.02E-04	0.00E+00	1.24E-02	3.43E-03	1.76E-01	1.94E-01
	Zinc	1.90E-05	1.95E-07	8.92E-07	1.28E-07	5.86E-07	0.00E+00	3.02E-03	1.88E-02	<u>2.34E-01</u>	2.56E-01
		Project Incremental HQ - Project Phases									
	Cadmium	4.28E-05	5.09E-11	2.32E-11	2.03E-07	9.30E-08	0.00E+00	2.62E-05	1.07E-06	2.29E-04	2.99E-04
	Chromium	3.42E-07	1.78E-13	8.10E-13	1.22E-09	5.60E-09	0.00E+00	3.64E-06	2.30E-09	1.30E-06	5.29E-06
	Cobalt	5.45E-06	2.13E-11	9.75E-12	6.09E-09	2.79E-09	0.00E+00	1.64E-05	8.85E-07	5.35E-05	7.63E-05
	Copper	9.39E-07	2.29E-11	6.29E-11	1.24E-09	3.41E-09	0.00E+00	1.18E-04	9.99E-06	9.25E-05	2.21E-04
	Molybdenum	1.85E-03	1.32E-12	6.04E-13	2.31E-06	1.06E-06	0.00E+00	4.24E-05	1.33E-07	2.22E-03	4.12E-03

Human Receptor	COPC	HQs during Project Phases									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
Rec F/H One-year-old (Russell Lake)	Selenium	1.24E-04	1.50E-11	6.88E-12	8.29E-07	3.80E-07	0.00E+00	1.17E-01	1.24E-06	1.65E-02	1.34E-01
	Uranium	1.61E-03	9.20E-07	4.21E-06	1.07E-05	4.90E-05	0.00E+00	7.33E-03	1.48E-02	4.92E-03	2.87E-02
	Vanadium	3.63E-04	5.17E-10	2.36E-09	6.98E-06	3.20E-05	0.00E+00	5.62E-03	2.75E-06	4.91E-03	1.09E-02
	Zinc	1.49E-06	5.97E-12	2.74E-11	6.64E-09	3.04E-08	0.00E+00	5.64E-04	1.69E-06	2.59E-04	8.26E-04
		Average Baseline HQ									
	Cadmium	4.75E-04	6.17E-04	7.39E-06	1.92E-04	2.30E-06	0.00E+00	8.45E-05	1.97E-02	6.29E-01	6.50E-01
	Chromium	5.67E-06	3.02E-06	3.62E-07	1.78E-06	2.13E-07	0.00E+00	1.85E-05	1.72E-05	1.17E-05	5.85E-05
	Cobalt	1.66E-04	3.63E-05	4.35E-07	1.15E-05	1.37E-07	0.00E+00	1.18E-04	1.46E-02	3.78E-02	5.27E-02
	Copper	2.38E-05	4.67E-06	3.36E-07	1.98E-06	1.42E-07	0.00E+00	7.09E-04	2.37E-02	1.01E-01	1.25E-01
	Molybdenum	7.63E-05	6.83E-06	8.18E-08	6.68E-06	8.00E-08	0.00E+00	4.54E-07	5.20E-03	2.73E-01	2.79E-01
	Selenium	9.63E-05	2.66E-05	3.19E-07	5.14E-05	6.16E-07	0.00E+00	2.88E-02	1.87E-02	7.51E-01	7.98E-01
	Uranium	8.21E-04	8.71E-04	1.04E-04	4.38E-04	5.25E-05	0.00E+00	9.73E-04	1.04E-01	1.52E-01	2.59E-01
	Vanadium	1.13E-03	3.13E-03	3.76E-04	2.42E-03	2.91E-04	0.00E+00	6.42E-03	6.21E-03	4.18E-01	4.38E-01
	Zinc	2.28E-05	1.48E-05	1.78E-06	9.23E-06	1.11E-06	0.00E+00	2.70E-03	5.01E-02	5.63E-01	6.16E-01
		Project Total HQ - Project Phases									
	Cadmium	5.22E-04	6.17E-04	7.39E-06	2.06E-04	2.46E-06	0.00E+00	1.09E-04	1.97E-02	6.29E-01	6.50E-01
	Chromium	6.06E-06	3.02E-06	3.62E-07	1.86E-06	2.23E-07	0.00E+00	2.20E-05	1.72E-05	1.26E-05	6.33E-05
	Cobalt	1.72E-04	3.63E-05	4.35E-07	1.19E-05	1.42E-07	0.00E+00	1.34E-04	1.46E-02	3.78E-02	5.27E-02
	Copper	2.49E-05	4.68E-06	3.36E-07	2.06E-06	1.48E-07	0.00E+00	8.20E-04	2.38E-02	1.01E-01	1.25E-01
	Molybdenum	2.59E-03	6.83E-06	8.18E-08	1.91E-04	2.29E-06	0.00E+00	4.93E-05	5.20E-03	2.75E-01	2.83E-01
	Selenium	2.40E-04	2.66E-05	3.19E-07	1.08E-04	1.29E-06	0.00E+00	1.44E-01	1.87E-02	7.62E-01	9.25E-01
	Uranium	2.62E-03	9.31E-04	1.12E-04	1.14E-03	1.36E-04	0.00E+00	7.91E-03	1.34E-01	1.55E-01	3.01E-01
	Vanadium	1.54E-03	3.13E-03	3.76E-04	2.88E-03	3.45E-04	0.00E+00	1.17E-02	6.21E-03	4.21E-01	4.47E-01
	Zinc	2.47E-05	1.48E-05	1.78E-06	9.73E-06	1.17E-06	0.00E+00	3.32E-03	5.01E-02	5.64E-01	6.17E-01
		Project Incremental HQ - Project Phases									
	Cadmium	4.78E-05	3.32E-09	3.96E-11	1.33E-05	1.59E-07	0.00E+00	2.48E-05	2.20E-06	1.58E-04	2.46E-04
	Chromium	3.81E-07	1.18E-11	1.39E-12	7.99E-08	9.58E-09	0.00E+00	3.44E-06	3.00E-09	8.57E-07	4.77E-06
	Cobalt	6.08E-06	1.39E-09	1.67E-11	3.98E-07	4.77E-09	0.00E+00	1.55E-05	1.96E-06	3.06E-05	5.46E-05
	Copper	1.05E-06	1.50E-09	1.08E-10	8.10E-08	5.83E-09	0.00E+00	1.11E-04	2.33E-05	5.58E-05	1.92E-04
	Molybdenum	2.52E-03	1.06E-10	1.26E-12	1.84E-04	2.21E-06	0.00E+00	4.89E-05	3.61E-07	1.54E-03	4.29E-03

Human Receptor	COPC	HQs during Project Phases									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
Seasonal Resident (Russell Lake)	Selenium	1.44E-04	1.02E-09	1.22E-11	5.62E-05	6.73E-07	0.00E+00	1.15E-01	2.93E-06	1.09E-02	1.26E-01
	Uranium	1.80E-03	6.01E-05	7.21E-06	6.99E-04	8.38E-05	0.00E+00	6.94E-03	2.94E-02	3.10E-03	4.21E-02
	Vanadium	4.05E-04	3.38E-08	4.05E-09	4.56E-04	5.47E-05	0.00E+00	5.32E-03	3.54E-06	2.70E-03	8.94E-03
	Zinc	1.94E-06	4.55E-10	5.45E-11	5.05E-07	6.05E-08	0.00E+00	6.21E-04	4.58E-06	1.52E-04	7.80E-04
		Average Baseline HQ									
	Cadmium	4.25E-04	9.44E-06	4.32E-06	2.94E-06	1.35E-06	0.00E+00	8.92E-05	8.78E-03	2.48E-01	2.57E-01
	Chromium	5.08E-06	4.62E-08	2.11E-07	2.72E-08	1.25E-07	0.00E+00	1.96E-05	7.43E-06	2.02E-05	5.27E-05
	Cobalt	1.48E-04	5.55E-07	2.54E-07	1.76E-07	8.04E-08	0.00E+00	1.25E-04	6.29E-03	1.77E-02	2.42E-02
	Copper	2.13E-05	7.15E-08	1.96E-07	3.02E-08	8.30E-08	0.00E+00	7.48E-04	1.03E-02	5.98E-02	7.08E-02
	Molybdenum	5.61E-05	8.58E-08	3.93E-08	8.40E-08	3.84E-08	0.00E+00	3.94E-07	1.85E-03	8.62E-02	8.81E-02
	Selenium	8.32E-05	3.93E-07	1.80E-07	7.59E-07	3.48E-07	0.00E+00	2.94E-02	7.70E-03	2.89E-01	3.26E-01
	Uranium	7.35E-04	1.33E-05	6.10E-05	6.71E-06	3.07E-05	0.00E+00	1.03E-03	4.55E-02	5.86E-02	1.06E-01
	Vanadium	1.01E-03	4.80E-05	2.20E-04	3.71E-05	1.70E-04	0.00E+00	6.78E-03	3.43E-03	1.72E-01	1.83E-01
	Zinc	1.75E-05	1.95E-07	8.92E-07	1.21E-07	5.56E-07	0.00E+00	2.45E-03	1.88E-02	2.34E-01	2.55E-01
		Project Total HQ - Project Phases									
	Cadmium	4.68E-04	9.44E-06	4.32E-06	3.15E-06	1.44E-06	0.00E+00	9.78E-05	8.78E-03	2.48E-01	2.58E-01
	Chromium	5.42E-06	4.62E-08	2.11E-07	2.84E-08	1.30E-07	0.00E+00	2.08E-05	7.43E-06	2.06E-05	5.47E-05
	Cobalt	1.54E-04	5.55E-07	2.54E-07	1.82E-07	8.31E-08	0.00E+00	1.30E-04	6.29E-03	1.77E-02	2.42E-02
	Copper	2.23E-05	7.16E-08	1.97E-07	3.15E-08	8.64E-08	0.00E+00	7.81E-04	1.03E-02	5.98E-02	7.09E-02
	Molybdenum	1.91E-03	8.58E-08	3.93E-08	2.40E-06	1.10E-06	0.00E+00	1.31E-05	1.85E-03	8.69E-02	9.06E-02
	Selenium	2.07E-04	3.93E-07	1.80E-07	1.59E-06	7.27E-07	0.00E+00	6.39E-02	7.70E-03	2.94E-01	3.66E-01
	Uranium	2.35E-03	1.42E-05	6.52E-05	1.74E-05	7.97E-05	0.00E+00	3.20E-03	4.99E-02	6.09E-02	1.17E-01
	Vanadium	1.38E-03	4.80E-05	2.20E-04	4.41E-05	2.02E-04	0.00E+00	9.08E-03	3.43E-03	1.73E-01	1.88E-01
	Zinc	1.90E-05	1.95E-07	8.92E-07	1.28E-07	5.86E-07	0.00E+00	2.65E-03	1.88E-02	2.34E-01	2.55E-01
		Project Incremental HQ - Project Phases									
	Cadmium	4.28E-05	5.09E-11	2.32E-11	2.03E-07	9.30E-08	0.00E+00	8.62E-06	3.21E-07	7.37E-05	1.26E-04
	Chromium	3.42E-07	1.78E-13	8.10E-13	1.22E-09	5.60E-09	0.00E+00	1.26E-06	6.97E-10	4.24E-07	2.03E-06
	Cobalt	5.45E-06	2.13E-11	9.75E-12	6.09E-09	2.79E-09	0.00E+00	4.55E-06	2.66E-07	1.49E-05	2.51E-05
	Copper	9.39E-07	2.29E-11	6.29E-11	1.24E-09	3.41E-09	0.00E+00	3.26E-05	3.00E-06	2.73E-05	6.39E-05

Human Receptor	COPC	Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
		HQs during Project Phases									
	Molybdenum	1.85E-03	1.32E-12	6.04E-13	2.31E-06	1.06E-06	0.00E+00	1.27E-05	3.99E-08	6.64E-04	2.53E-03
	Selenium	1.24E-04	1.50E-11	6.88E-12	8.29E-07	3.80E-07	0.00E+00	3.45E-02	3.73E-07	5.25E-03	3.99E-02
	Uranium	1.61E-03	9.20E-07	4.21E-06	1.07E-05	4.90E-05	0.00E+00	2.17E-03	4.45E-03	2.22E-03	1.05E-02
	Vanadium	3.63E-04	5.17E-10	2.36E-09	6.98E-06	3.20E-05	0.00E+00	2.30E-03	8.33E-07	1.89E-03	4.59E-03
	Zinc	1.49E-06	5.97E-12	2.74E-11	6.64E-09	3.04E-08	0.00E+00	1.99E-04	5.07E-07	1.00E-04	3.01E-04
Seasonal Resident One-year-old (Russell Lake)		**Average Baseline HQ**									
	Cadmium	4.75E-04	6.17E-04	7.39E-06	1.92E-04	2.30E-06	0.00E+00	8.45E-05	1.97E-02	6.29E-01	6.50E-01
	Chromium	5.67E-06	3.02E-06	3.62E-07	1.78E-06	2.13E-07	0.00E+00	1.85E-05	1.72E-05	1.17E-05	5.85E-05
	Cobalt	1.66E-04	3.63E-05	4.35E-07	1.15E-05	1.37E-07	0.00E+00	1.18E-04	1.46E-02	3.78E-02	5.27E-02
	Copper	2.38E-05	4.67E-06	3.36E-07	1.98E-06	1.42E-07	0.00E+00	7.09E-04	2.37E-02	1.01E-01	1.25E-01
	Molybdenum	7.63E-05	6.83E-06	8.18E-08	6.68E-06	8.00E-08	0.00E+00	4.54E-07	5.20E-03	2.73E-01	2.79E-01
	Selenium	9.63E-05	2.66E-05	3.19E-07	5.14E-05	6.16E-07	0.00E+00	2.88E-02	1.87E-02	7.51E-01	7.98E-01
	Uranium	8.21E-04	8.71E-04	1.04E-04	4.38E-04	5.25E-05	0.00E+00	9.73E-04	1.04E-01	1.52E-01	2.59E-01
	Vanadium	1.13E-03	3.13E-03	3.76E-04	2.42E-03	2.91E-04	0.00E+00	6.42E-03	6.21E-03	4.18E-01	4.38E-01
	Zinc	2.28E-05	1.48E-05	1.78E-06	9.23E-06	1.11E-06	0.00E+00	2.70E-03	5.01E-02	5.63E-01	6.16E-01
		Project Total HQ - Project Phases									
	Cadmium	5.22E-04	6.17E-04	7.39E-06	2.06E-04	2.46E-06	0.00E+00	9.26E-05	1.97E-02	6.29E-01	6.50E-01
	Chromium	6.06E-06	3.02E-06	3.62E-07	1.86E-06	2.23E-07	0.00E+00	1.97E-05	1.72E-05	1.20E-05	6.04E-05
	Cobalt	1.72E-04	3.63E-05	4.35E-07	1.19E-05	1.42E-07	0.00E+00	1.23E-04	1.46E-02	3.78E-02	5.27E-02
	Copper	2.49E-05	4.68E-06	3.36E-07	2.06E-06	1.48E-07	0.00E+00	7.40E-04	2.37E-02	1.01E-01	1.25E-01
	Molybdenum	2.59E-03	6.83E-06	8.18E-08	1.91E-04	2.29E-06	0.00E+00	1.51E-05	5.20E-03	2.74E-01	2.82E-01
	Selenium	2.40E-04	2.66E-05	3.19E-07	1.08E-04	1.29E-06	0.00E+00	6.27E-02	1.87E-02	7.54E-01	8.36E-01
	Uranium	2.62E-03	9.31E-04	1.12E-04	1.14E-03	1.36E-04	0.00E+00	3.03E-03	1.13E-01	1.53E-01	2.74E-01
	Vanadium	1.54E-03	3.13E-03	3.76E-04	2.88E-03	3.45E-04	0.00E+00	8.60E-03	6.21E-03	4.19E-01	4.42E-01
	Zinc	2.47E-05	1.48E-05	1.78E-06	9.73E-06	1.17E-06	0.00E+00	2.92E-03	5.01E-02	5.63E-01	6.17E-01
		Project Incremental HQ - Project Phases									
	Cadmium	4.78E-05	3.32E-09	3.96E-11	1.33E-05	1.59E-07	0.00E+00	8.17E-06	6.59E-07	4.84E-05	1.18E-04
	Chromium	3.81E-07	1.18E-11	1.39E-12	7.99E-08	9.58E-09	0.00E+00	1.19E-06	8.93E-10	2.69E-07	1.93E-06
	Cobalt	6.08E-06	1.39E-09	1.67E-11	3.98E-07	4.77E-09	0.00E+00	4.31E-06	5.89E-07	8.26E-06	1.96E-05

Human Receptor	COPC	HQs during Project Phases									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Copper	1.05E-06	1.50E-09	1.08E-10	8.10E-08	5.83E-09	0.00E+00	3.09E-05	7.00E-06	1.60E-05	5.50E-05
	Molybdenum	2.52E-03	1.06E-10	1.26E-12	1.84E-04	2.21E-06	0.00E+00	1.47E-05	1.08E-07	4.46E-04	3.16E-03
	Selenium	1.44E-04	1.02E-09	1.22E-11	5.62E-05	6.73E-07	0.00E+00	3.39E-02	8.77E-07	3.36E-03	3.75E-02
	Uranium	1.80E-03	6.01E-05	7.21E-06	6.99E-04	8.38E-05	0.00E+00	2.06E-03	8.80E-03	1.34E-03	1.48E-02
	Vanadium	4.05E-04	3.38E-08	4.05E-09	4.56E-04	5.47E-05	0.00E+00	2.18E-03	1.05E-06	1.04E-03	4.14E-03
	Zinc	1.94E-06	4.55E-10	5.45E-11	5.05E-07	6.05E-08	0.00E+00	2.19E-04	1.37E-06	6.00E-05	2.83E-04
Fisher/Trapper (Russell Lake)		Average Baseline HQ									
	Cadmium	4.25E-04	9.44E-06	4.32E-06	2.94E-06	1.35E-06	0.00E+00	6.14E-04	0.00E+00	2.01E-01	2.02E-01
	Chromium	5.08E-06	4.62E-08	2.11E-07	2.72E-08	1.25E-07	0.00E+00	1.35E-04	0.00E+00	5.51E-04	6.91E-04
	Cobalt	1.48E-04	5.55E-07	2.54E-07	1.76E-07	8.04E-08	0.00E+00	8.60E-04	0.00E+00	7.79E-03	8.80E-03
	Copper	2.13E-05	7.15E-08	1.96E-07	3.02E-08	8.30E-08	0.00E+00	5.15E-03	0.00E+00	2.80E-02	3.32E-02
	Molybdenum	5.61E-05	8.58E-08	3.93E-08	8.40E-08	3.84E-08	0.00E+00	2.71E-06	0.00E+00	4.58E-02	4.59E-02
	Selenium	8.32E-05	3.93E-07	1.80E-07	7.59E-07	3.48E-07	0.00E+00	2.02E-01	0.00E+00	2.77E-01	4.79E-01
	Uranium	7.35E-04	1.33E-05	6.10E-05	6.71E-06	3.07E-05	0.00E+00	7.07E-03	0.00E+00	3.64E-02	4.44E-02
	Vanadium	1.01E-03	4.80E-05	2.20E-04	3.71E-05	1.70E-04	0.00E+00	4.67E-02	0.00E+00	3.67E-01	4.16E-01
	Zinc	1.75E-05	1.95E-07	8.92E-07	1.21E-07	5.56E-07	0.00E+00	1.69E-02	0.00E+00	5.40E-01	5.57E-01
		Project Total HQ - Project Phases									
	Cadmium	4.88E-04	9.44E-06	4.32E-06	3.28E-06	1.50E-06	0.00E+00	7.94E-04	0.00E+00	2.02E-01	2.03E-01
	Chromium	5.57E-06	4.62E-08	2.11E-07	2.93E-08	1.34E-07	0.00E+00	1.60E-04	0.00E+00	5.58E-04	7.24E-04
	Cobalt	1.58E-04	5.55E-07	2.54E-07	1.86E-07	8.50E-08	0.00E+00	9.73E-04	0.00E+00	7.80E-03	8.94E-03
	Copper	2.30E-05	7.16E-08	1.97E-07	3.23E-08	8.87E-08	0.00E+00	5.96E-03	0.00E+00	2.82E-02	3.42E-02
	Molybdenum	3.14E-03	8.59E-08	3.93E-08	3.94E-06	1.80E-06	0.00E+00	2.94E-04	0.00E+00	4.70E-02	5.05E-02
	Selenium	2.92E-04	3.93E-07	1.80E-07	2.14E-06	9.80E-07	0.00E+00	1.01E+00	0.00E+00	3.36E-01	**1.35E+00**
	Uranium	3.44E-03	1.49E-05	6.80E-05	2.45E-05	1.12E-04	0.00E+00	5.75E-02	0.00E+00	1.62E-01	2.23E-01
	Vanadium	1.52E-03	4.80E-05	2.20E-04	4.87E-05	2.23E-04	0.00E+00	8.53E-02	0.00E+00	4.07E-01	4.94E-01
	Zinc	1.97E-05	1.95E-07	8.93E-07	1.32E-07	6.06E-07	0.00E+00	2.08E-02	0.00E+00	5.42E-01	5.63E-01
		Project Incremental HQ - Project Phases									
	Cadmium	6.30E-05	8.46E-11	3.87E-11	3.39E-07	1.55E-07	0.00E+00	1.80E-04	0.00E+00	7.17E-04	9.60E-04
	Chromium	4.92E-07	2.98E-13	1.35E-12	2.04E-09	9.33E-09	0.00E+00	2.50E-05	0.00E+00	6.74E-06	3.23E-05

Human Receptor	COPC	HQs during Project Phases									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Cobalt	9.49E-06	3.55E-11	1.63E-11	1.01E-08	4.64E-09	0.00E+00	1.13E-04	0.00E+00	1.37E-05	1.36E-04
	Copper	1.63E-06	3.81E-11	1.05E-10	2.06E-09	5.67E-09	0.00E+00	8.09E-04	0.00E+00	1.48E-04	9.59E-04
	Molybdenum	3.08E-03	2.20E-12	1.01E-12	3.86E-06	1.76E-06	0.00E+00	2.92E-04	0.00E+00	1.21E-03	4.59E-03
	Selenium	2.09E-04	2.51E-11	1.15E-11	1.38E-06	6.33E-07	0.00E+00	8.07E-01	0.00E+00	5.87E-02	8.66E-01
	Uranium	2.70E-03	1.53E-06	7.02E-06	1.78E-05	8.16E-05	0.00E+00	5.04E-02	0.00E+00	1.25E-01	1.79E-01
	Vanadium	5.01E-04	8.62E-10	3.94E-09	1.16E-05	5.32E-05	0.00E+00	3.87E-02	0.00E+00	3.95E-02	7.88E-02
	Zinc	2.13E-06	9.96E-12	4.56E-11	1.11E-08	5.06E-08	0.00E+00	3.88E-03	0.00E+00	1.87E-03	5.75E-03

Underlined values indicate exceedance of the HQ of 0.2 for a given exposure pathway; **Bolded** values indicate exceedance of the HQ of 1 for all exposure pathways.
HQ = hazard quotient; COPC = constituent of potential concern.

Table 4-16: Estimated Non-radiological Risk to Human Receptors – Future Centuries

Human Receptor	COPC	HQ during Future Centuries									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
Permanent Resident Adult (Whitefish Lake)		Baseline HQ									
	Cadmium	4.26E-04	9.44E-06	4.32E-06	2.95E-06	1.35E-06	0.00E+00	8.94E-05	8.78E-03	2.48E-01	2.57E-01
	Chromium	5.09E-06	4.62E-08	2.11E-07	2.73E-08	1.25E-07	0.00E+00	1.96E-05	7.43E-06	2.02E-05	5.27E-05
	Cobalt	1.49E-04	5.55E-07	2.54E-07	1.76E-07	8.04E-08	0.00E+00	1.25E-04	6.29E-03	1.77E-02	2.42E-02
	Copper	2.13E-05	7.15E-08	1.96E-07	3.02E-08	8.31E-08	0.00E+00	7.49E-04	1.03E-02	5.98E-02	7.08E-02
	Molybdenum	5.61E-05	8.58E-08	3.93E-08	8.40E-08	3.85E-08	0.00E+00	3.94E-07	1.85E-03	8.62E-02	8.81E-02
	Selenium	8.34E-05	3.93E-07	1.80E-07	7.61E-07	3.48E-07	0.00E+00	2.94E-02	7.70E-03	2.89E-01	3.26E-01
	Uranium	7.37E-04	1.33E-05	6.10E-05	6.72E-06	3.08E-05	0.00E+00	1.03E-03	4.55E-02	5.86E-02	1.06E-01
	Vanadium	1.02E-03	4.80E-05	2.20E-04	3.72E-05	1.70E-04	0.00E+00	6.81E-03	3.43E-03	1.72E-01	1.83E-01
	Zinc	1.76E-05	1.95E-07	8.92E-07	1.22E-07	5.56E-07	0.00E+00	2.46E-03	1.88E-02	2.34E-01	2.55E-01
		Project Total HQ - Future Centuries									
	Cadmium	4.28E-04	9.44E-06	4.32E-06	2.96E-06	1.36E-06	0.00E+00	8.99E-05	8.78E-03	2.48E-01	2.57E-01
	Chromium	5.16E-06	4.62E-08	2.11E-07	2.76E-08	1.26E-07	0.00E+00	1.98E-05	7.43E-06	2.03E-05	5.32E-05
	Cobalt	1.56E-04	5.56E-07	2.54E-07	1.85E-07	8.47E-08	0.00E+00	1.32E-04	6.30E-03	1.77E-02	2.43E-02
	Copper	2.16E-05	7.16E-08	1.97E-07	3.06E-08	8.42E-08	0.00E+00	7.59E-04	1.03E-02	5.98E-02	7.09E-02
	Molybdenum	6.12E-05	8.58E-08	3.93E-08	9.16E-08	4.19E-08	0.00E+00	4.29E-07	1.85E-03	8.62E-02	8.81E-02
	Selenium	1.11E-04	3.93E-07	1.80E-07	1.01E-06	4.64E-07	0.00E+00	3.82E-02	7.70E-03	2.91E-01	3.37E-01
	Uranium	9.01E-04	1.59E-05	7.27E-05	8.22E-06	3.76E-05	0.00E+00	1.26E-03	6.15E-02	5.88E-02	1.23E-01
	Vanadium	1.03E-03	4.80E-05	2.20E-04	3.76E-05	1.72E-04	0.00E+00	6.87E-03	3.43E-03	1.72E-01	1.83E-01
	Zinc	1.91E-05	1.95E-07	8.93E-07	1.32E-07	6.04E-07	0.00E+00	2.67E-03	1.88E-02	2.34E-01	2.55E-01
		Project Incremental HQ - Future Centuries									
	Cadmium	2.47E-06	1.57E-10	7.19E-11	1.71E-08	7.81E-09	0.00E+00	5.17E-07	2.86E-07	5.25E-06	8.54E-06
	Chromium	6.59E-08	0.00E+00	0.00E+00	3.53E-10	1.62E-09	0.00E+00	2.54E-07	0.00E+00	1.05E-07	4.27E-07
	Cobalt	7.89E-06	5.50E-10	2.52E-10	9.33E-09	4.27E-09	0.00E+00	6.64E-06	1.29E-05	1.80E-05	4.55E-05
	Copper	2.84E-07	4.03E-11	1.11E-10	4.02E-10	1.10E-09	0.00E+00	9.94E-06	1.09E-05	7.76E-06	2.89E-05
	Molybdenum	5.07E-06	0.00E+00	0.00E+00	7.59E-09	3.48E-09	0.00E+00	3.56E-08	0.00E+00	1.66E-06	6.78E-06

Human Receptor	COPC	HQ during Future Centuries									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Selenium	2.77E-05	4.12E-12	1.89E-12	2.53E-07	1.16E-07	0.00E+00	8.71E-03	1.69E-07	1.31E-03	1.00E-02
	Uranium	1.64E-04	2.56E-06	1.17E-05	1.50E-06	6.87E-06	0.00E+00	2.30E-04	1.60E-02	1.72E-04	1.66E-02
	Vanadium	9.19E-06	4.00E-09	1.83E-08	3.35E-07	1.54E-06	0.00E+00	6.14E-05	3.08E-07	5.90E-05	1.32E-04
	Zinc	1.52E-06	1.86E-11	8.53E-11	1.05E-08	4.82E-08	0.00E+00	2.13E-04	3.19E-06	9.73E-05	3.15E-04
Permanent Resident One-year-old (Whitefish Lake)		Baseline HQ									
	Cadmium	4.76E-04	6.17E-04	7.39E-06	1.93E-04	2.31E-06	0.00E+00	8.46E-05	1.97E-02	6.29E-01	6.50E-01
	Chromium	5.68E-06	3.02E-06	3.62E-07	1.78E-06	2.13E-07	0.00E+00	1.86E-05	1.72E-05	1.17E-05	5.85E-05
	Cobalt	1.66E-04	3.63E-05	4.35E-07	1.15E-05	1.38E-07	0.00E+00	1.18E-04	1.46E-02	3.78E-02	5.27E-02
	Copper	2.38E-05	4.67E-06	3.36E-07	1.98E-06	1.42E-07	0.00E+00	7.09E-04	2.37E-02	1.01E-01	1.25E-01
	Molybdenum	7.63E-05	6.83E-06	8.18E-08	6.68E-06	8.01E-08	0.00E+00	4.54E-07	5.20E-03	2.73E-01	2.79E-01
	Selenium	9.65E-05	2.66E-05	3.19E-07	5.15E-05	6.17E-07	0.00E+00	2.89E-02	1.87E-02	7.51E-01	7.99E-01
	Uranium	8.23E-04	8.71E-04	1.04E-04	4.39E-04	5.26E-05	0.00E+00	9.75E-04	1.04E-01	1.52E-01	2.59E-01
	Vanadium	1.14E-03	3.13E-03	3.76E-04	2.43E-03	2.92E-04	0.00E+00	6.45E-03	6.21E-03	4.18E-01	4.38E-01
	Zinc	2.28E-05	1.48E-05	1.78E-06	9.24E-06	1.11E-06	0.00E+00	2.71E-03	5.01E-02	5.63E-01	6.16E-01
		Project Total HQ - Future Centuries									
	Cadmium	4.78E-04	6.17E-04	7.39E-06	1.94E-04	2.32E-06	0.00E+00	8.51E-05	1.97E-02	6.29E-01	6.50E-01
	Chromium	5.76E-06	3.02E-06	3.62E-07	1.80E-06	2.16E-07	0.00E+00	1.88E-05	1.72E-05	1.18E-05	5.90E-05
	Cobalt	1.75E-04	3.63E-05	4.35E-07	1.21E-05	1.45E-07	0.00E+00	1.25E-04	1.46E-02	3.78E-02	5.27E-02
	Copper	2.42E-05	4.68E-06	3.36E-07	2.00E-06	1.44E-07	0.00E+00	7.18E-04	2.38E-02	1.01E-01	1.25E-01
	Molybdenum	8.32E-05	6.83E-06	8.18E-08	7.29E-06	8.73E-08	0.00E+00	4.95E-07	5.20E-03	2.73E-01	2.79E-01
	Selenium	1.29E-04	2.66E-05	3.19E-07	6.86E-05	8.22E-07	0.00E+00	3.74E-02	1.87E-02	7.52E-01	8.08E-01
	Uranium	1.01E-03	1.04E-03	1.24E-04	5.37E-04	6.44E-05	0.00E+00	1.19E-03	1.42E-01	1.52E-01	2.98E-01
	Vanadium	1.15E-03	3.13E-03	3.76E-04	2.45E-03	2.94E-04	0.00E+00	6.51E-03	6.21E-03	4.18E-01	4.38E-01
	Zinc	2.48E-05	1.48E-05	1.78E-06	1.00E-05	1.20E-06	0.00E+00	2.94E-03	5.01E-02	5.63E-01	6.17E-01
		Project Incremental HQ - Future Centuries									
	Cadmium	2.75E-06	1.03E-08	1.23E-10	1.12E-06	1.34E-08	0.00E+00	4.90E-07	6.48E-07	3.64E-06	8.67E-06
	Chromium	7.36E-08	0.00E+00	0.00E+00	2.31E-08	2.76E-09	0.00E+00	2.40E-07	0.00E+00	6.99E-08	4.10E-07
	Cobalt	8.81E-06	3.59E-08	4.30E-10	6.10E-07	7.31E-09	0.00E+00	6.29E-06	3.03E-05	1.06E-05	5.67E-05

Human Receptor	COPC	HQ during Future Centuries									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Copper	3.17E-07	2.63E-09	1.89E-10	2.62E-08	1.89E-09	0.00E+00	9.42E-06	2.56E-05	4.80E-06	4.02E-05
	Molybdenum	6.90E-06	0.00E+00	0.00E+00	6.04E-07	7.24E-09	0.00E+00	4.10E-08	0.00E+00	1.16E-06	8.71E-06
	Selenium	3.21E-05	2.78E-10	3.33E-12	1.71E-05	2.05E-07	0.00E+00	8.55E-03	4.10E-07	8.92E-04	9.49E-03
	Uranium	1.84E-04	1.67E-04	2.00E-05	9.80E-05	1.17E-05	0.00E+00	2.18E-04	3.77E-02	1.20E-04	3.85E-02
	Vanadium	1.03E-05	2.61E-07	3.13E-08	2.19E-05	2.63E-06	0.00E+00	5.81E-05	7.25E-07	3.29E-05	1.27E-04
	Zinc	1.97E-06	1.42E-09	1.70E-10	8.00E-07	9.58E-08	0.00E+00	2.34E-04	8.70E-06	5.74E-05	3.03E-04
Rec F/H Adult (McGowan Lake)		Baseline HQ									
	Cadmium	4.26E-04	9.44E-06	4.32E-06	2.95E-06	1.35E-06	0.00E+00	8.94E-05	8.78E-03	2.48E-01	2.57E-01
	Chromium	5.09E-06	4.62E-08	2.11E-07	2.73E-08	1.25E-07	0.00E+00	1.96E-05	7.43E-06	2.02E-05	5.27E-05
	Cobalt	1.49E-04	5.55E-07	2.54E-07	1.76E-07	8.04E-08	0.00E+00	1.25E-04	6.29E-03	1.77E-02	2.42E-02
	Copper	2.13E-05	7.15E-08	1.96E-07	3.02E-08	8.31E-08	0.00E+00	7.49E-04	1.03E-02	5.98E-02	7.08E-02
	Molybdenum	5.61E-05	8.58E-08	3.93E-08	8.40E-08	3.85E-08	0.00E+00	3.94E-07	1.85E-03	8.62E-02	8.81E-02
	Selenium	8.34E-05	3.93E-07	1.80E-07	7.61E-07	3.48E-07	0.00E+00	2.94E-02	7.70E-03	2.89E-01	3.26E-01
	Uranium	7.37E-04	1.33E-05	6.10E-05	6.72E-06	3.08E-05	0.00E+00	1.03E-03	4.55E-02	5.86E-02	1.06E-01
	Vanadium	1.02E-03	4.80E-05	2.20E-04	3.72E-05	1.70E-04	0.00E+00	6.81E-03	3.43E-03	1.72E-01	1.83E-01
	Zinc	1.76E-05	1.95E-07	8.92E-07	1.22E-07	5.56E-07	0.00E+00	2.46E-03	1.88E-02	2.34E-01	2.55E-01
		Project Total HQ - Future Centuries									
	Cadmium	4.26E-04	9.44E-06	4.32E-06	2.95E-06	1.35E-06	0.00E+00	8.97E-05	8.78E-03	2.48E-01	2.57E-01
	Chromium	5.10E-06	4.62E-08	2.11E-07	2.73E-08	1.25E-07	0.00E+00	1.98E-05	7.43E-06	2.03E-05	5.30E-05
	Cobalt	1.50E-04	5.55E-07	2.54E-07	1.78E-07	8.13E-08	0.00E+00	1.30E-04	6.29E-03	1.77E-02	2.42E-02
	Copper	2.14E-05	7.15E-08	1.96E-07	3.03E-08	8.33E-08	0.00E+00	7.56E-04	1.03E-02	5.98E-02	7.09E-02
	Molybdenum	5.73E-05	8.58E-08	3.93E-08	8.57E-08	3.92E-08	0.00E+00	4.20E-07	1.85E-03	8.62E-02	8.81E-02
	Selenium	8.89E-05	3.93E-07	1.80E-07	8.11E-07	3.71E-07	0.00E+00	3.53E-02	7.70E-03	2.90E-01	3.33E-01
	Uranium	7.70E-04	1.35E-05	6.19E-05	7.02E-06	3.21E-05	0.00E+00	1.18E-03	4.76E-02	5.87E-02	1.08E-01
	Vanadium	1.02E-03	4.80E-05	2.20E-04	3.73E-05	1.71E-04	0.00E+00	6.84E-03	3.43E-03	1.72E-01	1.83E-01
	Zinc	1.79E-05	1.95E-07	8.92E-07	1.24E-07	5.66E-07	0.00E+00	2.60E-03	1.88E-02	2.34E-01	2.55E-01
		Project Incremental HQ - Future Centuries									
	Cadmium	5.08E-07	1.09E-11	5.00E-12	3.52E-09	1.61E-09	0.00E+00	3.55E-07	3.17E-08	3.80E-06	4.70E-06

Human Receptor	COPC	HQ during Future Centuries									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Chromium	1.39E-08	0.00E+00	0.00E+00	7.45E-11	3.41E-10	0.00E+00	1.78E-07	0.00E+00	7.72E-08	2.70E-07
	Cobalt	1.77E-06	3.81E-11	1.75E-11	2.10E-09	9.61E-10	0.00E+00	4.98E-06	1.40E-06	1.68E-05	2.49E-05
	Copper	6.35E-08	2.81E-12	7.72E-12	9.00E-11	2.47E-10	0.00E+00	7.43E-06	1.18E-06	6.22E-06	1.49E-05
	Molybdenum	1.14E-06	0.00E+00	0.00E+00	1.70E-09	7.78E-10	0.00E+00	2.66E-08	0.00E+00	1.53E-06	2.70E-06
	Selenium	5.52E-06	2.84E-13	1.28E-13	5.03E-08	2.30E-08	0.00E+00	5.81E-03	1.82E-08	9.02E-04	6.72E-03
	Uranium	3.28E-05	1.94E-07	8.90E-07	2.99E-07	1.37E-06	0.00E+00	1.53E-04	2.09E-03	7.56E-05	2.36E-03
	Vanadium	1.21E-06	2.80E-10	1.27E-09	4.42E-08	2.02E-07	0.00E+00	2.70E-05	3.35E-08	2.73E-05	5.57E-05
	Zinc	3.13E-07	1.29E-12	5.97E-12	2.17E-09	9.92E-09	0.00E+00	1.46E-04	3.45E-07	6.69E-05	2.14E-04
Rec F/H One-year-old (McGowan Lake)		Baseline HQ									
	Cadmium	4.76E-04	6.17E-04	7.39E-06	1.93E-04	2.31E-06	0.00E+00	8.46E-05	1.97E-02	6.29E-01	6.50E-01
	Chromium	5.68E-06	3.02E-06	3.62E-07	1.78E-06	2.13E-07	0.00E+00	1.86E-05	1.72E-05	1.18E-05	5.85E-05
	Cobalt	1.66E-04	3.63E-05	4.35E-07	1.15E-05	1.38E-07	0.00E+00	1.18E-04	1.46E-02	3.78E-02	5.27E-02
	Copper	2.38E-05	4.67E-06	3.36E-07	1.98E-06	1.42E-07	0.00E+00	7.09E-04	2.37E-02	1.01E-01	1.25E-01
	Molybdenum	7.63E-05	6.83E-06	8.18E-08	6.68E-06	8.01E-08	0.00E+00	4.54E-07	5.20E-03	2.73E-01	2.79E-01
	Selenium	9.65E-05	2.66E-05	3.19E-07	5.15E-05	6.17E-07	0.00E+00	2.89E-02	1.87E-02	7.51E-01	7.99E-01
	Uranium	8.23E-04	8.71E-04	1.04E-04	4.39E-04	5.26E-05	0.00E+00	9.75E-04	1.04E-01	1.52E-01	2.59E-01
	Vanadium	1.14E-03	3.13E-03	3.76E-04	2.43E-03	2.92E-04	0.00E+00	6.45E-03	6.21E-03	4.18E-01	4.38E-01
	Zinc	2.28E-05	1.48E-05	1.78E-06	9.24E-06	1.11E-06	0.00E+00	2.71E-03	5.01E-02	5.63E-01	6.16E-01
		Project Total HQ - Future Centuries									
	Cadmium	4.76E-04	6.17E-04	7.39E-06	1.93E-04	2.31E-06	0.00E+00	8.50E-05	1.97E-02	6.29E-01	6.50E-01
	Chromium	5.70E-06	3.02E-06	3.62E-07	1.79E-06	2.14E-07	0.00E+00	1.87E-05	1.72E-05	1.18E-05	5.88E-05
	Cobalt	1.68E-04	3.63E-05	4.35E-07	1.16E-05	1.39E-07	0.00E+00	1.23E-04	1.46E-02	3.78E-02	5.27E-02
	Copper	2.39E-05	4.67E-06	3.36E-07	1.98E-06	1.43E-07	0.00E+00	7.16E-04	2.37E-02	1.01E-01	1.25E-01
	Molybdenum	7.78E-05	6.83E-06	8.18E-08	6.82E-06	8.17E-08	0.00E+00	4.84E-07	5.20E-03	2.73E-01	2.79E-01
	Selenium	1.03E-04	2.66E-05	3.19E-07	5.49E-05	6.58E-07	0.00E+00	3.46E-02	1.87E-02	7.51E-01	8.05E-01
	Uranium	8.59E-04	8.84E-04	1.06E-04	4.59E-04	5.50E-05	0.00E+00	1.12E-03	1.09E-01	1.52E-01	2.64E-01
	Vanadium	1.14E-03	3.13E-03	3.76E-04	2.44E-03	2.92E-04	0.00E+00	6.48E-03	6.21E-03	4.18E-01	4.38E-01
	Zinc	2.32E-05	1.48E-05	1.78E-06	9.40E-06	1.13E-06	0.00E+00	2.87E-03	5.01E-02	5.63E-01	6.16E-01

Human Receptor	COPC	HQ during Future Centuries									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
		Project Incremental HQ - Future Centuries									
	Cadmium	5.67E-07	7.57E-10	8.64E-12	2.30E-07	2.75E-09	0.00E+00	3.37E-07	7.08E-08	2.68E-06	3.89E-06
	Chromium	1.55E-08	0.00E+00	0.00E+00	4.87E-09	5.83E-10	0.00E+00	1.69E-07	0.00E+00	5.12E-08	2.41E-07
	Cobalt	1.98E-06	2.49E-09	2.99E-11	1.37E-07	1.64E-09	0.00E+00	4.72E-06	3.29E-06	9.69E-06	1.98E-05
	Copper	7.09E-08	1.83E-10	1.32E-11	5.88E-09	4.23E-10	0.00E+00	7.03E-06	2.77E-06	3.81E-06	1.37E-05
	Molybdenum	1.54E-06	0.00E+00	0.00E+00	1.35E-07	1.62E-09	0.00E+00	3.06E-08	0.00E+00	1.07E-06	2.78E-06
	Selenium	6.39E-06	1.82E-11	2.27E-13	3.41E-06	4.09E-08	0.00E+00	5.70E-03	4.28E-08	6.10E-04	6.32E-03
	Uranium	3.66E-05	1.27E-05	1.52E-06	1.95E-05	2.34E-06	0.00E+00	1.45E-04	4.91E-03	5.50E-05	5.19E-03
	Vanadium	1.35E-06	1.82E-08	2.18E-09	2.89E-06	3.46E-07	0.00E+00	2.55E-05	7.87E-08	1.52E-05	4.54E-05
	Zinc	4.07E-07	9.91E-11	1.18E-11	1.65E-07	1.97E-08	0.00E+00	1.61E-04	9.42E-07	3.95E-05	2.02E-04
Rec F/H Adult (Russell Lake)		**Baseline HQ**									
	Cadmium	4.26E-04	9.44E-06	4.32E-06	2.95E-06	1.35E-06	0.00E+00	8.94E-05	8.78E-03	<u>2.48E-01</u>	2.57E-01
	Chromium	5.09E-06	4.62E-08	2.11E-07	2.73E-08	1.25E-07	0.00E+00	1.96E-05	7.43E-06	2.02E-05	5.27E-05
	Cobalt	1.49E-04	5.55E-07	2.54E-07	1.76E-07	8.04E-08	0.00E+00	1.25E-04	6.29E-03	1.77E-02	2.42E-02
	Copper	2.13E-05	7.15E-08	1.96E-07	3.02E-08	8.31E-08	0.00E+00	7.49E-04	1.03E-02	5.98E-02	7.08E-02
	Molybdenum	5.61E-05	8.58E-08	3.93E-08	8.40E-08	3.85E-08	0.00E+00	3.94E-07	1.85E-03	8.62E-02	8.81E-02
	Selenium	8.34E-05	3.93E-07	1.80E-07	7.61E-07	3.48E-07	0.00E+00	2.94E-02	7.70E-03	<u>2.89E-01</u>	3.26E-01
	Uranium	7.37E-04	1.33E-05	6.10E-05	6.72E-06	3.08E-05	0.00E+00	1.03E-03	4.55E-02	5.86E-02	1.06E-01
	Vanadium	1.02E-03	4.80E-05	2.20E-04	3.72E-05	1.70E-04	0.00E+00	6.81E-03	3.43E-03	1.72E-01	1.83E-01
	Zinc	1.76E-05	1.95E-07	8.92E-07	1.22E-07	5.56E-07	0.00E+00	2.46E-03	1.88E-02	<u>2.34E-01</u>	2.55E-01
		Project Total HQ - Future Centuries									
	Cadmium	4.26E-04	9.44E-06	4.32E-06	2.95E-06	1.35E-06	0.00E+00	8.96E-05	8.78E-03	<u>2.48E-01</u>	2.57E-01
	Chromium	5.10E-06	4.62E-08	2.11E-07	2.73E-08	1.25E-07	0.00E+00	1.97E-05	7.43E-06	2.03E-05	5.29E-05
	Cobalt	1.50E-04	5.55E-07	2.54E-07	1.77E-07	8.11E-08	0.00E+00	1.29E-04	6.29E-03	1.77E-02	2.42E-02
	Copper	2.14E-05	7.15E-08	1.96E-07	3.03E-08	8.32E-08	0.00E+00	7.54E-04	1.03E-02	5.98E-02	7.09E-02
	Molybdenum	5.70E-05	8.58E-08	3.93E-08	8.53E-08	3.90E-08	0.00E+00	4.14E-07	1.85E-03	8.62E-02	8.81E-02
	Selenium	8.75E-05	3.93E-07	1.80E-07	7.98E-07	3.65E-07	0.00E+00	3.37E-02	7.70E-03	<u>2.90E-01</u>	3.31E-01
	Uranium	7.61E-04	1.34E-05	6.12E-05	6.94E-06	3.18E-05	0.00E+00	1.14E-03	4.61E-02	5.87E-02	1.07E-01

Human Receptor	COPC	HQ during Future Centuries									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Vanadium	1.02E-03	4.80E-05	2.20E-04	3.73E-05	1.71E-04	0.00E+00	6.83E-03	3.43E-03	1.72E-01	1.83E-01
	Zinc	1.78E-05	1.95E-07	8.92E-07	1.23E-07	5.64E-07	0.00E+00	2.57E-03	1.88E-02	2.34E-01	2.55E-01
		Project Incremental HQ - Future Centuries									
	Cadmium	3.77E-07	2.73E-12	9.09E-13	2.61E-09	1.19E-09	0.00E+00	2.64E-07	8.38E-09	2.85E-06	3.50E-06
	Chromium	1.04E-08	0.00E+00	0.00E+00	5.57E-11	2.55E-10	0.00E+00	1.33E-07	0.00E+00	5.85E-08	2.03E-07
	Cobalt	1.35E-06	9.78E-12	4.46E-12	1.60E-09	7.32E-10	0.00E+00	3.80E-06	3.59E-07	1.26E-05	1.81E-05
	Copper	4.84E-08	7.18E-13	1.99E-12	6.85E-11	1.88E-10	0.00E+00	5.66E-06	3.04E-07	4.08E-06	1.01E-05
	Molybdenum	8.64E-07	0.00E+00	0.00E+00	1.29E-09	5.92E-10	0.00E+00	2.02E-08	0.00E+00	1.17E-06	2.06E-06
	Selenium	4.05E-06	8.53E-14	2.84E-14	3.70E-08	1.69E-08	0.00E+00	4.28E-03	4.66E-09	6.71E-04	4.95E-03
	Uranium	2.41E-05	5.19E-08	2.37E-07	2.20E-07	1.00E-06	0.00E+00	1.12E-04	5.58E-04	5.06E-05	7.46E-04
	Vanadium	7.74E-07	7.28E-11	3.20E-10	2.83E-08	1.29E-07	0.00E+00	1.72E-05	8.61E-09	1.82E-05	3.64E-05
	Zinc	2.32E-07	3.27E-13	1.53E-12	1.61E-09	7.36E-09	0.00E+00	1.08E-04	8.75E-08	5.07E-05	1.59E-04
Rec F/H One-year-old (Russell Lake)		Baseline HQ									
	Cadmium	4.76E-04	6.17E-04	7.39E-06	1.93E-04	2.31E-06	0.00E+00	8.46E-05	1.97E-02	6.29E-01	6.50E-01
	Chromium	5.68E-06	3.02E-06	3.62E-07	1.78E-06	2.13E-07	0.00E+00	1.86E-05	1.72E-05	1.17E-05	5.85E-05
	Cobalt	1.66E-04	3.63E-05	4.35E-07	1.15E-05	1.38E-07	0.00E+00	1.18E-04	1.46E-02	3.78E-02	5.27E-02
	Copper	2.38E-05	4.67E-06	3.36E-07	1.98E-06	1.42E-07	0.00E+00	7.09E-04	2.37E-02	1.01E-01	1.25E-01
	Molybdenum	7.63E-05	6.83E-06	8.18E-08	6.68E-06	8.01E-08	0.00E+00	4.54E-07	5.20E-03	2.73E-01	2.79E-01
	Selenium	9.65E-05	2.66E-05	3.19E-07	5.15E-05	6.17E-07	0.00E+00	2.89E-02	1.87E-02	7.51E-01	7.99E-01
	Uranium	8.23E-04	8.71E-04	1.04E-04	4.39E-04	5.26E-05	0.00E+00	9.75E-04	1.04E-01	1.52E-01	2.59E-01
	Vanadium	1.14E-03	3.13E-03	3.76E-04	2.43E-03	2.92E-04	0.00E+00	6.45E-03	6.21E-03	4.18E-01	4.38E-01
	Zinc	2.28E-05	1.48E-05	1.78E-06	9.24E-06	1.11E-06	0.00E+00	2.71E-03	5.01E-02	5.63E-01	6.16E-01
		Project Total HQ - Future Centuries									
	Cadmium	4.76E-04	6.17E-04	7.39E-06	1.93E-04	2.31E-06	0.00E+00	8.49E-05	1.97E-02	6.29E-01	6.50E-01
	Chromium	5.69E-06	3.02E-06	3.62E-07	1.78E-06	2.14E-07	0.00E+00	1.87E-05	1.72E-05	1.18E-05	5.87E-05
	Cobalt	1.67E-04	3.63E-05	4.35E-07	1.16E-05	1.39E-07	0.00E+00	1.22E-04	1.46E-02	3.78E-02	5.27E-02
	Copper	2.39E-05	4.67E-06	3.36E-07	1.98E-06	1.42E-07	0.00E+00	7.14E-04	2.37E-02	1.01E-01	1.25E-01
	Molybdenum	7.75E-05	6.83E-06	8.18E-08	6.79E-06	8.13E-08	0.00E+00	4.77E-07	5.20E-03	2.73E-01	2.79E-01

Human Receptor	COPC	HQ during Future Centuries									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Selenium	1.01E-04	2.66E-05	3.19E-07	5.40E-05	6.47E-07	0.00E+00	3.31E-02	1.87E-02	7.51E-01	8.03E-01
	Uranium	8.50E-04	8.74E-04	1.05E-04	4.53E-04	5.43E-05	0.00E+00	1.08E-03	1.05E-01	1.52E-01	2.61E-01
	Vanadium	1.14E-03	3.13E-03	3.76E-04	2.43E-03	2.92E-04	0.00E+00	6.47E-03	6.21E-03	4.18E-01	4.38E-01
	Zinc	2.31E-05	1.48E-05	1.78E-06	9.36E-06	1.12E-06	0.00E+00	2.83E-03	5.01E-02	5.63E-01	6.16E-01
		Project Incremental HQ - Future Centuries									
	Cadmium	4.21E-07	1.75E-10	2.27E-12	1.71E-07	2.04E-09	0.00E+00	2.50E-07	1.86E-08	2.03E-06	2.89E-06
	Chromium	1.16E-08	0.00E+00	0.00E+00	3.64E-09	4.36E-10	0.00E+00	1.26E-07	0.00E+00	3.87E-08	1.81E-07
	Cobalt	1.51E-06	6.37E-10	7.67E-12	1.05E-07	1.25E-09	0.00E+00	3.60E-06	8.43E-07	7.26E-06	1.33E-05
	Copper	5.40E-08	4.68E-11	3.38E-12	4.48E-09	3.22E-10	0.00E+00	5.36E-06	7.13E-07	2.56E-06	8.69E-06
	Molybdenum	1.18E-06	0.00E+00	0.00E+00	1.03E-07	1.23E-09	0.00E+00	2.33E-08	0.00E+00	8.05E-07	2.11E-06
	Selenium	4.69E-06	3.64E-12	5.68E-14	2.50E-06	3.00E-08	0.00E+00	4.20E-03	1.12E-08	4.52E-04	4.66E-03
	Uranium	2.69E-05	3.39E-06	4.06E-07	1.43E-05	1.72E-06	0.00E+00	1.06E-04	1.31E-03	3.75E-05	1.50E-03
	Vanadium	8.65E-07	4.66E-09	5.53E-10	1.85E-06	2.21E-07	0.00E+00	1.63E-05	2.05E-08	1.01E-05	2.94E-05
	Zinc	3.02E-07	2.55E-11	2.96E-12	1.22E-07	1.47E-08	0.00E+00	1.19E-04	2.38E-07	2.99E-05	1.50E-04
Seasonal Resident Adult (Russell Lake)		Baseline HQ									
	Cadmium	4.26E-04	9.44E-06	4.32E-06	2.95E-06	1.35E-06	0.00E+00	8.94E-05	8.78E-03	2.48E-01	2.57E-01
	Chromium	5.09E-06	4.62E-08	2.11E-07	2.73E-08	1.25E-07	0.00E+00	1.96E-05	7.43E-06	2.02E-05	5.27E-05
	Cobalt	1.49E-04	5.55E-07	2.54E-07	1.76E-07	8.04E-08	0.00E+00	1.25E-04	6.29E-03	1.77E-02	2.42E-02
	Copper	2.13E-05	7.15E-08	1.96E-07	3.02E-08	8.31E-08	0.00E+00	7.49E-04	1.03E-02	5.98E-02	7.08E-02
	Molybdenum	5.61E-05	8.58E-08	3.93E-08	8.40E-08	3.85E-08	0.00E+00	3.94E-07	1.85E-03	8.62E-02	8.81E-02
	Selenium	8.34E-05	3.93E-07	1.80E-07	7.61E-07	3.48E-07	0.00E+00	2.94E-02	7.70E-03	2.89E-01	3.26E-01
	Uranium	7.37E-04	1.33E-05	6.10E-05	6.72E-06	3.08E-05	0.00E+00	1.03E-03	4.55E-02	5.86E-02	1.06E-01
	Vanadium	1.02E-03	4.80E-05	2.20E-04	3.72E-05	1.70E-04	0.00E+00	6.81E-03	3.43E-03	1.72E-01	1.83E-01
	Zinc	1.76E-05	1.95E-07	8.92E-07	1.22E-07	5.56E-07	0.00E+00	2.46E-03	1.88E-02	2.34E-01	2.55E-01
		Project Total HQ - Future Centuries									
	Cadmium	4.26E-04	9.44E-06	4.32E-06	2.95E-06	1.35E-06	0.00E+00	8.94E-05	8.78E-03	2.48E-01	2.57E-01
	Chromium	5.10E-06	4.62E-08	2.11E-07	2.73E-08	1.25E-07	0.00E+00	1.96E-05	7.43E-06	2.02E-05	5.28E-05
	Cobalt	1.50E-04	5.55E-07	2.54E-07	1.77E-07	8.11E-08	0.00E+00	1.26E-04	6.29E-03	1.77E-02	2.42E-02

Human Receptor	COPC	HQ during Future Centuries									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Copper	2.14E-05	7.15E-08	1.96E-07	3.03E-08	8.32E-08	0.00E+00	7.50E-04	1.03E-02	5.98E-02	7.08E-02
	Molybdenum	5.70E-05	8.58E-08	3.93E-08	8.53E-08	3.90E-08	0.00E+00	4.00E-07	1.85E-03	8.62E-02	8.81E-02
	Selenium	8.75E-05	3.93E-07	1.80E-07	7.98E-07	3.65E-07	0.00E+00	3.07E-02	7.70E-03	2.89E-01	3.28E-01
	Uranium	7.61E-04	1.34E-05	6.12E-05	6.94E-06	3.18E-05	0.00E+00	1.06E-03	4.57E-02	5.87E-02	1.06E-01
	Vanadium	1.02E-03	4.80E-05	2.20E-04	3.73E-05	1.71E-04	0.00E+00	6.82E-03	3.43E-03	1.72E-01	1.83E-01
	Zinc	1.78E-05	1.95E-07	8.92E-07	1.23E-07	5.64E-07	0.00E+00	2.49E-03	1.88E-02	2.34E-01	2.55E-01
		Project Incremental HQ - Future Centuries									
	Cadmium	3.77E-07	2.73E-12	9.09E-13	2.61E-09	1.19E-09	0.00E+00	7.91E-08	2.79E-09	9.09E-07	1.37E-06
	Chromium	1.04E-08	0.00E+00	0.00E+00	5.57E-11	2.55E-10	0.00E+00	4.00E-08	0.00E+00	1.90E-08	6.98E-08
	Cobalt	1.35E-06	9.78E-12	4.46E-12	1.60E-09	7.32E-10	0.00E+00	1.14E-06	1.08E-07	3.73E-06	6.33E-06
	Copper	4.84E-08	7.18E-13	1.99E-12	6.85E-11	1.88E-10	0.00E+00	1.70E-06	9.13E-08	1.23E-06	3.07E-06
	Molybdenum	8.64E-07	0.00E+00	0.00E+00	1.29E-09	5.92E-10	0.00E+00	6.06E-09	0.00E+00	3.50E-07	1.22E-06
	Selenium	4.05E-06	8.53E-14	2.84E-14	3.70E-08	1.69E-08	0.00E+00	1.28E-03	1.40E-09	2.14E-04	1.50E-03
	Uranium	2.41E-05	5.19E-08	2.37E-07	2.20E-07	1.00E-06	0.00E+00	3.36E-05	1.67E-04	1.57E-05	2.42E-04
	Vanadium	7.74E-07	7.28E-11	3.20E-10	2.83E-08	1.29E-07	0.00E+00	5.17E-06	2.56E-09	6.32E-06	1.24E-05
	Zinc	2.32E-07	3.27E-13	1.53E-12	1.61E-09	7.36E-09	0.00E+00	3.25E-05	2.61E-08	1.69E-05	4.97E-05
Seasonal Resident One-year-old (Russell Lake)		Baseline HQ									
	Cadmium	4.76E-04	6.17E-04	7.39E-06	1.93E-04	2.31E-06	0.00E+00	8.46E-05	1.97E-02	6.29E-01	6.50E-01
	Chromium	5.68E-06	3.02E-06	3.62E-07	1.78E-06	2.13E-07	0.00E+00	1.86E-05	1.72E-05	1.17E-05	5.85E-05
	Cobalt	1.66E-04	3.63E-05	4.35E-07	1.15E-05	1.38E-07	0.00E+00	1.18E-04	1.46E-02	3.78E-02	5.27E-02
	Copper	2.38E-05	4.67E-06	3.36E-07	1.98E-06	1.42E-07	0.00E+00	7.09E-04	2.37E-02	1.01E-01	1.25E-01
	Molybdenum	7.63E-05	6.83E-06	8.18E-08	6.68E-06	8.01E-08	0.00E+00	4.54E-07	5.20E-03	2.73E-01	2.79E-01
	Selenium	9.65E-05	2.66E-05	3.19E-07	5.15E-05	6.17E-07	0.00E+00	2.89E-02	1.87E-02	7.51E-01	7.99E-01
	Uranium	8.23E-04	8.71E-04	1.04E-04	4.39E-04	5.26E-05	0.00E+00	9.75E-04	1.04E-01	1.52E-01	2.59E-01
	Vanadium	1.14E-03	3.13E-03	3.76E-04	2.43E-03	2.92E-04	0.00E+00	6.45E-03	6.21E-03	4.18E-01	4.38E-01
	Zinc	2.28E-05	1.48E-05	1.78E-06	9.24E-06	1.11E-06	0.00E+00	2.71E-03	5.01E-02	5.63E-01	6.16E-01
		Project Total HQ - Future Centuries									
	Cadmium	4.76E-04	6.17E-04	7.39E-06	1.93E-04	2.31E-06	0.00E+00	8.47E-05	1.97E-02	6.29E-01	6.50E-01

Human Receptor	COPC	HQ during Future Centuries									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Chromium	5.69E-06	3.02E-06	3.62E-07	1.78E-06	2.14E-07	0.00E+00	1.86E-05	1.72E-05	1.18E-05	5.86E-05
	Cobalt	1.67E-04	3.63E-05	4.35E-07	1.16E-05	1.39E-07	0.00E+00	1.19E-04	1.46E-02	3.78E-02	5.27E-02
	Copper	2.39E-05	4.67E-06	3.36E-07	1.98E-06	1.42E-07	0.00E+00	7.11E-04	2.37E-02	1.01E-01	1.25E-01
	Molybdenum	7.75E-05	6.83E-06	8.18E-08	6.79E-06	8.13E-08	0.00E+00	4.61E-07	5.20E-03	2.73E-01	2.79E-01
	Selenium	1.01E-04	2.66E-05	3.19E-07	5.40E-05	6.47E-07	0.00E+00	3.02E-02	1.87E-02	7.51E-01	8.00E-01
	Uranium	8.50E-04	8.74E-04	1.05E-04	4.53E-04	5.43E-05	0.00E+00	1.01E-03	1.05E-01	1.52E-01	2.60E-01
	Vanadium	1.14E-03	3.13E-03	3.76E-04	2.43E-03	2.92E-04	0.00E+00	6.46E-03	6.21E-03	4.18E-01	4.38E-01
	Zinc	2.31E-05	1.48E-05	1.78E-06	9.36E-06	1.12E-06	0.00E+00	2.74E-03	5.01E-02	5.63E-01	6.16E-01
		Project Incremental HQ - Future Centuries									
	Cadmium	4.21E-07	1.75E-10	2.27E-12	1.71E-07	2.04E-09	0.00E+00	7.49E-08	5.59E-09	5.96E-07	1.27E-06
	Chromium	1.16E-08	0.00E+00	0.00E+00	3.64E-09	4.36E-10	0.00E+00	3.79E-08	0.00E+00	1.21E-08	6.57E-08
	Cobalt	1.51E-06	6.37E-10	7.67E-12	1.05E-07	1.25E-09	0.00E+00	1.08E-06	2.52E-07	2.08E-06	5.03E-06
	Copper	5.40E-08	4.68E-11	3.38E-12	4.48E-09	3.22E-10	0.00E+00	1.61E-06	2.14E-07	7.38E-07	2.62E-06
	Molybdenum	1.18E-06	0.00E+00	0.00E+00	1.03E-07	1.23E-09	0.00E+00	6.99E-09	0.00E+00	2.38E-07	1.52E-06
	Selenium	4.69E-06	3.64E-12	5.68E-14	2.50E-06	3.00E-08	0.00E+00	1.26E-03	1.86E-09	1.39E-04	1.41E-03
	Uranium	2.69E-05	3.39E-06	4.06E-07	1.43E-05	1.72E-06	0.00E+00	3.19E-05	3.93E-04	1.10E-05	4.83E-04
	Vanadium	8.65E-07	4.66E-09	5.53E-10	1.85E-06	2.21E-07	0.00E+00	4.90E-06	6.05E-09	3.55E-06	1.14E-05
	Zinc	3.02E-07	2.55E-11	2.96E-12	1.22E-07	1.47E-08	0.00E+00	3.58E-05	7.08E-08	1.04E-05	4.67E-05
Fisher/Trapper Adult (Russell Lake)		Baseline HQ									
	Cadmium	4.26E-04	9.44E-06	4.32E-06	2.95E-06	1.35E-06	0.00E+00	6.15E-04	0.00E+00	2.01E-01	2.02E-01
	Chromium	5.09E-06	4.62E-08	2.11E-07	2.73E-08	1.25E-07	0.00E+00	1.35E-04	0.00E+00	5.51E-04	6.92E-04
	Cobalt	1.49E-04	5.55E-07	2.54E-07	1.76E-07	8.04E-08	0.00E+00	8.61E-04	0.00E+00	7.79E-03	8.80E-03
	Copper	2.13E-05	7.15E-08	1.96E-07	3.02E-08	8.31E-08	0.00E+00	5.15E-03	0.00E+00	2.80E-02	3.32E-02
	Molybdenum	5.61E-05	8.58E-08	3.93E-08	8.40E-08	3.85E-08	0.00E+00	2.71E-06	0.00E+00	4.58E-02	4.59E-02
	Selenium	8.34E-05	3.93E-07	1.80E-07	7.61E-07	3.48E-07	0.00E+00	2.03E-01	0.00E+00	2.77E-01	4.80E-01
	Uranium	7.37E-04	1.33E-05	6.10E-05	6.72E-06	3.08E-05	0.00E+00	7.09E-03	0.00E+00	3.64E-02	4.44E-02
	Vanadium	1.02E-03	4.80E-05	2.20E-04	3.72E-05	1.70E-04	0.00E+00	4.69E-02	0.00E+00	3.68E-01	4.16E-01
	Zinc	1.76E-05	1.95E-07	8.92E-07	1.22E-07	5.56E-07	0.00E+00	1.69E-02	0.00E+00	5.41E-01	5.57E-01

Human Receptor	COPC	HQ during Future Centuries									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
		Project Total HQ - Future Centuries									
	Cadmium	4.26E-04	9.44E-06	4.32E-06	2.95E-06	1.35E-06	0.00E+00	6.17E-04	0.00E+00	<u>2.01E-01</u>	2.02E-01
	Chromium	5.11E-06	4.62E-08	2.11E-07	2.73E-08	1.25E-07	0.00E+00	1.36E-04	0.00E+00	5.51E-04	6.93E-04
	Cobalt	1.51E-04	5.55E-07	2.54E-07	1.78E-07	8.16E-08	0.00E+00	8.87E-04	0.00E+00	7.79E-03	8.83E-03
	Copper	2.14E-05	7.15E-08	1.96E-07	3.04E-08	8.34E-08	0.00E+00	5.19E-03	0.00E+00	2.80E-02	3.32E-02
	Molybdenum	5.76E-05	8.58E-08	3.93E-08	8.62E-08	3.94E-08	0.00E+00	2.85E-06	0.00E+00	4.58E-02	4.59E-02
	Selenium	9.02E-05	3.93E-07	1.80E-07	8.22E-07	3.76E-07	0.00E+00	<u>2.32E-01</u>	0.00E+00	<u>2.79E-01</u>	5.12E-01
	Uranium	7.77E-04	1.34E-05	6.14E-05	7.09E-06	3.24E-05	0.00E+00	7.86E-03	0.00E+00	3.65E-02	4.53E-02
	Vanadium	1.02E-03	4.80E-05	2.20E-04	3.73E-05	1.71E-04	0.00E+00	4.70E-02	0.00E+00	<u>3.68E-01</u>	4.16E-01
	Zinc	1.80E-05	1.95E-07	8.92E-07	1.24E-07	5.69E-07	0.00E+00	1.77E-02	0.00E+00	<u>5.41E-01</u>	5.59E-01
		Project Incremental HQ - Future Centuries									
	Cadmium	6.28E-07	4.55E-12	1.82E-12	4.35E-09	1.99E-09	0.00E+00	1.82E-06	0.00E+00	8.06E-06	1.05E-05
	Chromium	1.73E-08	0.00E+00	0.00E+00	9.28E-11	4.25E-10	0.00E+00	9.19E-07	0.00E+00	2.51E-07	1.19E-06
	Cobalt	2.26E-06	1.63E-11	7.45E-12	2.67E-09	1.22E-09	0.00E+00	2.61E-05	0.00E+00	2.61E-06	3.10E-05
	Copper	8.06E-08	1.20E-12	3.31E-12	1.14E-10	3.14E-10	0.00E+00	3.89E-05	0.00E+00	2.52E-06	4.15E-05
	Molybdenum	1.44E-06	0.00E+00	0.00E+00	2.16E-09	9.87E-10	0.00E+00	1.39E-07	0.00E+00	6.59E-07	2.24E-06
	Selenium	6.76E-06	1.14E-13	5.68E-14	6.16E-08	2.82E-08	0.00E+00	2.94E-02	0.00E+00	2.30E-03	3.17E-02
	Uranium	4.01E-05	8.65E-08	3.96E-07	3.66E-07	1.67E-06	0.00E+00	7.72E-04	0.00E+00	9.41E-05	9.09E-04
	Vanadium	1.29E-06	1.20E-10	5.38E-10	4.71E-08	2.16E-07	0.00E+00	1.19E-04	0.00E+00	1.50E-04	2.70E-04
	Zinc	3.87E-07	5.40E-13	2.56E-12	2.68E-09	1.23E-08	0.00E+00	7.46E-04	0.00E+00	3.13E-04	1.06E-03

<u>Underlined values</u> indicate exceedance of the HQ of 0.2 for a given exposure pathway; **Bolded** values indicate exceedance of the HQ of 1 for all exposure pathways.
HQ = hazard quotient; COPC = constituent of potential concern.

4.4.1.2 Carcinogen Risk

The arsenic ILCR was not predicted to exceed the negligible cancer risk level of 1 in 100,000 for the camp worker, recreational fisher/hunter, and seasonal resident at any locations during the Project phases, as shown in Table 4-17. The recreational fisher/hunter, and seasonal resident were assessed as composite receptors throughout all life stages. The arsenic ILCR is essentially equal to the negligible cancer risk level of 1 in 100,000 for the adult fisher/trapper at Russell Lake during the Project phases. In the future centuries, a permanent resident was assessed instead of a camp worker – the cancer risk was not predicted to exceed the negligible cancer risk level for any of the receptors assessed in the future centuries (Table 4-17).

The main ingestion exposure pathway for arsenic for all human receptors was consumption of local terrestrial animals including muskrat, goose, mallard, moose, moose organs, and caribou, as well as locally caught fish represented in the HHRA by northern pike and white sucker.

The main contribution to the arsenic cancer risk for the fisher/trapper at Russell Lake is from ingestion of caribou. The predicted tissue concentration of arsenic in caribou in the Russell Lake area was 0.07 mg/kg fw, (see Appendix B) compared to a measured average value in barren-ground caribou of 0.02 mg/kg fw or maximum of 0.04 mg/kg fw from the Eastern Athabasca Regional Monitoring Program from 2011 to 2017 (CanNorth, 2018).

The diet assumptions for the fisher/trapper are conservative and are based on engagement with a local fisher/trapper. The diet of the fisher/trapper is representative of one person, who consumes a unique composition and quantity of traditional foods (e.g., ingestion rate of 175 kg/yr of caribou, equivalent to approximately 2 to 3 servings per day). Most people fishing, hunting, and trapping in the LSA and RSA would consume traditional foods more consistent with the average traditional foods consumer diet which was developed from the ERFN country foods study. In comparison, the ERFN country foods study (Table 4-4) indicates a caribou ingestion rate of 2.6 kg/yr (1 to 2 servings per month) and a total game ingestion rate of 21.3 kg/yr. The First Nations Food, Nutrition and Environment Study for Saskatchewan (Chan et al., 2018) indicates a total game ingestion rate of 54.4 kg/yr for the high consumer for the boreal shield. Overall, other local fisher/trappers may prefer consumption of moose over caribou.

The potential for arsenic to represent health risks for consumers of Traditional Foods was assessed for the Eastern Athabasca Region and for the Boreal Shield region of Saskatchewan by CanNorth (2018) and Chan et al. (2018), respectively. The Eastern Athabasca Region HHRA used a high consumer of traditional foods with a caribou ingestion rate of approximately 132 kg/yr (from the Hatchet Lake Dietary Survey [(CanNorth, 2000)]) and concluded that arsenic did not pose a significant risk to consumers of Traditional Foods.

Table 4-17: Estimated Incremental Lifetime Cancer Risk from Arsenic to Human Receptors

Human Receptor	Project Phases Cancer Risk (per 100,000)	Future Centuries Cancer Risk (per 100,000)
Camp Worker	0.1	N/A
Recreational Fisher/Hunter (LA-1)	0.4	0.1
Recreational Fisher/Hunter (Russell Lake)	0.3	0.04
Seasonal Resident (Russell Lake)	0.1	0.01
Fisher/Trapper (Russell Lake)	1.2	0.2
Permanent Resident	N/A	0.1

4.4.1.3 Radiological Risk

The incremental radiation dose to all human receptors in the Project area, LSA, or RSA during all phases of the Project was predicted to be below the dose limit of 1 mSv/yr, as shown in Table 4-18. If a dose constraint of 0.3 mSv/yr is applied, the predicted radiation dose to all human receptors during all phases of the Project was predicted to remain below the dose constraint. Therefore, it is unlikely that there would be significant adverse effects on human receptors as a result of radionuclide releases from the Project.

The predicted highest dose during the Project phases would be to the fisher/trapper at Russell Lake (0.06 mSv/yr for the adult, as shown in Table 4-19). The main contributor to total dose would be from Po-210 due to ingestion of fish from Russell Lake (inlet) and ingestion of animals (mallard and woodland caribou) harvested in the area around Russell Lake who eat from the aquatic environment. The mallard consumes benthic invertebrates and aquatic plants (macrophytes). The woodland caribou consumes aquatic plants (macrophytes) as the aquatic component of its diet.

During the future centuries, the predicted highest dose would be 0.04 mSv/yr to the permanent resident (one-year old) at Whitefish Lake, as shown in Table 4-18.

Overall, since the radiation dose estimates were below the dose limit, no discernable health effects would be anticipated due to exposure of these receptors to radioactive releases from the Project. The presence and concentrations of radionuclides in the receiving environment would be monitored and the associated radiation dose estimates would be periodically reassessed in accordance with the processes outlined in the Environmental Protection Program.

Table 4-18: Summary of All Radiation Doses to Human Receptors during Project Phases

Human Receptor	Location	Maximum Total Incremental Dose (mSv/yr)	% of Dose Limit	% of Dose Constraint
Camp Worker (Adult)	Whitefish Lake	0.03	3%	8%
Recreational Fisher/Hunter (Adult)	McGowan Lake	0.04	4%	12%
Recreational Fisher/Hunter (One-year-old)	McGowan Lake	0.05	5%	16%
Recreational Fisher/Hunter (Adult)	Russell Lake	0.02	2%	8%
Recreational Fisher/Hunter (One-year-old)	Russell Lake	0.03	3%	10%
Seasonal Resident (Adult)	Russell Lake	0.01	1%	4%
Seasonal Resident (One-year-old)	Russell Lake	0.02	2%	6%
Fisher/Trapper (Adult)	Russell Lake	0.06	6%	19%

Note: The dose limit and dose limit for a non-NEW is 1 mSv/yr and the dose constraint is 0.3 mSv/yr. The camp worker is not assessed in the future centuries.

Table 4-19: Summary of Radiation Dose to Limiting Human Receptor – Project Phases

Maximum Incremental Dose (mSv/yr)	Receptor	Location	Largest Contributor to Dose
0.06	Fisher/Trapper	Russell Lake	Po-210 Aquatic Animals

Table 4-20: Summary of All Radiation Doses to Human Receptors during Future Centuries

Human Receptor	Location	Maximum Total Incremental Dose (mSv/yr)	% of Dose Limit	% of Dose Constraint
Permanent Resident (Adult)	Whitefish Lake	0.03	3%	9%
Permanent Resident (One-year-old)	Whitefish Lake	0.04	4%	12%
Recreational Fisher/Hunter (Adult)	McGowan Lake	0.01	1%	3%
Recreational Fisher/Hunter (One-year-old)	McGowan Lake	0.01	1%	5%
Recreational Fisher/Hunter (Adult)	Russell Lake	0.01	1%	2%

Human Receptor	Location	Maximum Total Incremental Dose (mSv/yr)	% of Dose Limit	% of Dose Constraint
Recreational Fisher/Hunter (One-year-old)	Russell Lake	0.01	1%	3%
Seasonal Resident (Adult)	Russell Lake	0.002	0%	1%
Seasonal Resident (One-year-old)	Russell Lake	0.003	0%	1%
Fisher/Trapper (Adult)	Russell Lake	0.01	1%	4%

Note: The public dose limit is 1 mSv/yr and the dose constraint is 0.3 mSv/yr. The camp worker is not assessed in the future centuries.

4.4.1.4 Radon Risk

The maximum incremental radon dose to the camp worker was estimated to be 0.13 mSv/yr during operation. The assessment is conservative in that it assumes that the camp worker spends 100% of the time indoors.

The total incremental dose to the camp worker from all radionuclides in the U-238 decay chain including radon would be 0.16 mSv/year, which is below the dose limit for a non-NEW of 1 mSv/yr (Table 4-21). The estimate of total dose including radon is conservative based on the following assumptions:

- the camp worker spends 100% of their time indoors when on site for exposure to radon (Section 4.2.5.3).
- receptors are exposed to the maximum exposure concentrations at their location for each model scenario and Project phase (Section 4.2.6).
- For radionuclides in the U-238 decay chain (other than radon), the camp worker is also exposed to radionuclides through ingestion (water and food) pathways resulting in a conservative dose when also factoring in the dose from radon indoors.

Table 4-21: Total Radiation Dose to Camp Worker from all Radionuclides including Radon Progeny – Project Phases

Human Receptor	Location	Maximum Total Incremental Dose - U-238 decay chain (mSv/yr)	Maximum Radon Dose (mSv/yr)	Maximum Total Dose (mSv/yr)	% of Dose Limit for non-NEW
Camp Worker (Adult)	Whitefish Lake	0.03	0.13	0.16	16%

4.4.2 Uncertainties in the Risk Characterization

The problem formulation and toxicity and exposure information are combined in the risk characterization step to estimate the potential for human health effects. The uncertainties associated with each of the previous steps of the HHRA are discussed in Section 4.1.6, Uncertainty in Problem Formulation, Section 4.2.6, Uncertainty in Exposure Assessment, and Section 4.3.3, Uncertainty in the Toxicity Assessment. In each step of the HHRA, conservative assumptions were used to address uncertainties. The use of this approach is far more likely to overestimate potential risk than to underestimate risk.

5.0 Ecological Risk Assessment

5.1 Problem Formulation

The problem formulation includes identification of ecological receptors (i.e., VCs) and their characteristics, selection of COPCs (radiological and non-radiological) and other stressors, identification of assessment and measurement endpoints and exposure pathways, and an overall conceptual model for the EcoRA.

5.1.1 Receptor Selection

It is generally an impractical task to assess the effect of radiological and non-radiological emissions on all the species within a natural ecosystem, and specifically within the ecosystem around the Project. Therefore, a representative group of organisms were selected for dose and risk analysis. The organisms were selected as ecological receptors because they are known to exist at the site and in the local study area, are representative of major taxonomic groups or exposure pathways, are listed federally and/or provincially, and/or have a special importance or value to people or other ecological factors.

A preliminary list of ecological receptors for the Project was compiled from the species identified in the Aquatic Baseline Report (Ecometrix, 2020) and Terrestrial Environment, Wildlife and Vegetation Baseline Inventory Report (Omnia, 2020). Species were included in the preliminary list if they were quantified and/or incidentally observed through respective survey methods, except for birds, where only the ten most abundant song birds and area waterfowl, or sensitive bird species are included in the preliminary list.

A representative subset of organisms was selected from each major plant or animal group to be carried forward as ecological receptors. Several factors were considered in the selection process, following the criteria provided in Table 7.1 of CSA N288.6 (2022):

- Availability of chemical analyses for radiological and non-radiological parameters for the species. For example, the southern red-backed vole was selected on this basis;
- Abundance of the species in the study area relative to other species;
- Value or importance to Indigenous communities, based on information from Denison's meeting notes with a local fisher/trapper Mr. Bobby John (KPI Program, 2019);
- Classification as threatened or species of special concern identified by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and listed under the federal Species at Risk Act (SARA) (e.g., woodland caribou);
- Representing a potential exposure pathway to COPCs through releases to the environment; and,

- Availability of scientific information for the receptor that can be used in risk analysis. For example, amphibian and reptiles are relatively less characterized. Therefore, frogs were not included on the ecological receptor list on the basis of limited scientific information for risk assessment. However, the assessment of a fish receptor is considered to be protective of the most sensitive life stage of frogs, which is the tadpole.

The major plant and animal groups were defined based on taxonomy and ecology, so as to represent the different possible pathways of exposure to COPCs. The organisms selected to represent each major group were either individual species of vertebrate organisms, or generic types of plants or invertebrates such as aquatic macrophytes or zooplankton.

Table 5-1 below summarizes the selected ecological receptors for the Denison Project, and the key information used in the selection process. A finalized summary table of all ecological receptors selected for the EcoRA can be found in Table 5-3.

5.1.1.1 Consideration of Species at Risk

Species at Risk (SAR) often lack the information needed for risk assessment, because they are difficult to study. However, some SAR can be represented by other more common species that have similar diets and exposure pathways. For example, the olive-sided flycatcher (SAR) was selected to represent other aerial insectivores, which include the SAR common nighthawk and barn swallow.

Table 5-2 lists the SAR or species of conservation concern that may potentially interact with the Project, which are listed by COSEWIC or under SARA, or ranked “imperiled” or “vulnerable” by the Saskatchewan Conservation Data Centre (SKCDC). The SKCDC rankings are intended to provide support in conservation planning and monitoring of SAR, but protection of species on the list is not regulated. Surrogate species selected to represent each listed species are also provided in Table 5-2.

Table 5-1: List of Ecological Receptors for Wheeler River Project

Representative Species	Selection Criteria					Selection Rationale and Applicable Criteria[1,2,3]
	1	2	3	4	5	
	Major Plant/Animal Group	Facility or Stakeholder Importance*	Ecological Significance**	Socio-Economic Significance***	Exposed to and/or Sensitive to Stressor	
Terrestrial Invertebrates						
Terrestrial Invertebrates (general category)	Terrestrial Invertebrates	Habitat identified in the baseline study.	Food source for other receptors	Not identified	Exposed to atmospheric release through soil	**Selected as VC: 1,2,5**
Aquatic Invertebrates						
Zooplankton (general category)	Zooplankton	Present in lakes / potential discharge locations	Food source for other receptors	Not identified	Exposed to aquatic release through water	**Selected as VC: 1,2,5**
Benthic invertebrates (general category)	Benthic invertebrates	Taxonomy was classified in most lakes surveyed in the studied area. Whole body tissue was collected and analyzed for metal and radionuclides.	Food source for other receptors	Not identified	Exposed to aquatic release through water and sediment.	**Selected as VC: 1,2,5**
Aquatic Plants						
Macrophyte (e.g., *Carex sp.*) (general category)	Aquatic Macrophyte	Present in most surface water bodies.	Food source for other receptors. Provides spawning substrate for some fish species (e.g. Northern Pike)	Provides habitat and food for traditional food fish and animals	Exposed to aquatic release through water and sediment.	**Selected as VC: 1,2,3,4,5**
Phytoplankton (general category)	Phytoplankton	Present in lakes / potential discharge locations	Food source for other receptors	Provides food for traditional food fish	Exposed to aquatic release through water.	**Selected as VC: 1,2,3,4,5**
Terrestrial Plants						
Lichen	Lichen	Observed in the study area. Sampled and analyzed for metals and radionuclides in terrestrial baseline studies.	Primary food source for woodland caribou. Some lichen species are provincially rare.	Provides food for caribou, a species of socio-economic significance.	Exposed to atmospheric release through soil	**Selected as VC: 1,2,3,4,5**
Blueberry (*Vaccinium myrtilloides*)	Shrub	Observed in the study area. Fruit, leaves and stems collected and analyzed for metals and radionuclides.	Food source for other receptors.	Regional traditional food item.	Exposed to atmospheric release through soil	**Selected as VC: 1,2,3,4,5**

Representative Species	Selection Criteria					Selection Rationale and Applicable Criteria[1,2,3]
	1 Major Plant/Animal Group	2 Facility or Stakeholder Importance*	3 Ecological Significance**	4 Socio-Economic Significance***	5 Exposed to and/or Sensitive to Stressor	
Labrador tea (*Rhododendron groenlandicum*)	Shrub	Observed in the study area.	Food source for other receptors. Surrogate for leafy plants used in the human diet and rare species observed in the area such as Alaskan clubmoss (ranked S2) and three-seeded sedge (ranked S3).	Harvested regionally for medicinal use (tea)	Exposed to atmospheric release through soil	**Selected as VC: 1,2,3,4,5**
Browse	Shrub	Observed in the study area.	Food source for other receptors.	Not identified	Exposed to atmospheric release through soil	Not selected as a VC, but it is a component of the food web.
Terrestrial Mammals						
Woodland caribou (*Rangifer tarandus caribou*)	Terrestrial herbivore	Observed in the study area.	Threatened status under COSEWIC and SARA for broader regional study area	Harvested regionally as a traditional food item and for fur.	Exposed to atmospheric and aquatic releases through consumption of food (plants and lichens), water and soil.	**Selected as VC: 1,2,3,4,5**
Snowshoe hare (*Lepus americanus*)	Terrestrial herbivore	Observed in the study area.	Food source for other receptors.	Regional traditional food item. Harvested regionally for fur.	Exposed to atmospheric and aquatic releases through food (upland plants), water and soil.	**Selected as VC: 1,2,3,4,5**
Moose (*Alces americanus*)	Terrestrial herbivore	Observed in the study area.	Food source for other receptors.	Regional traditional food item.	Exposed to atmospheric and aquatic releases through food (upland and aquatic plants), water and soil.	**Selected as VC: 1,2,3,4,5**
Red-backed vole (*Myodes gapperi*)	Terrestrial omnivore	Observed in the study area. 124 specimens were analyzed for metals and radionuclides. Surrogate for other small mammals such as dusky shrews, meadow vole.	Food source for other receptors.	Food source for other species. Regional traditional food items and/or traditionally harvested for fur.	Exposed to atmospheric and aquatic releases through food (plants, insects and invertebrates), water and soil	**Selected as VC: 1,2,3,4,5**
Meadow vole (*Microtus pennsylvanicus*)	Terrestrial herbivore	Observed in the study area.	Food source for other receptors.	Traditionally harvested for fur.	Exposed to atmospheric release through food (plants) and soil	Not Selected. Assessment of Red-backed vole is expected to be protective of this species.
Red squirrel	Terrestrial omnivore	Observed in the study area.	Food source for other receptors	Trapped for fur/meat and hunted by indigenous people	Exposed to atmospheric release through food (plants) and soil	

Representative Species	Selection Criteria					Selection Rationale and Applicable Criteria[1,2,3]
	1	2	3	4	5	
	Major Plant/Animal Group	Facility or Stakeholder Importance*	Ecological Significance**	Socio-Economic Significance***	Exposed to and/or Sensitive to Stressor	
Dusky Shrews (*Sorex monticolus*)	Terrestrial omnivore	Observed in the study area.	Food source for other receptors	Not identified	Exposed to atmospheric release through food (plants) and soil	
Black bear (*Ursus americanus*)	Terrestrial omnivore	Observed in the study area.	Top Omnivore	Regional traditional food item. Harvested regionally for fur.	Exposed to atmospheric and aquatic releases through food (berries, nuts, small mammals, fish, birds), water, sediment and soil.	**Selected as VC: 1,2,3,4,5**
Canada Lynx (*Lynx canadensis*)	Terrestrial carnivore	Observed in the study area.	Top carnivore. Surrogate for other carnivores such as wolf, marten, fisher, and ermine.	Harvested regionally for fur. Small lynx is also consumed as traditional food item.	Exposed to atmospheric and aquatic releases through food (small mammals), water and soil	**Selected as VC: 1,2,3,4,5**
American marten (*Martes americana*)	Terrestrial carnivore	Observed in the study area.	Small mammal, carnivore.	Regional traditional food item. Harvested regionally for fur.	Exposed to atmospheric release through food (small mammals) and soil	Not selected. Assessment of the Canada Lynx is expected to be protective of this species.
Fisher (*Pekania pennanti*)	Terrestrial carnivore	Observed in the study area.	Small mammal, carnivore.	Trapped for fur/meat.	Exposed to atmospheric release through food (small mammals) and soil	
Red fox	Terrestrial carnivore	Observed in the study area.	Small mammal, carnivore.	Trapped for fur/meat and hunted by indigenous people	Exposed to atmospheric release through food (small mammals) and soil	
Ermine (*Mustela erminea*)	Terrestrial carnivore	Observed in the study area.	Small mammal, carnivore.	Trapped for fur/meat.	Exposed to atmospheric release through food (small mammals) and soil	
Grey wolf (*Canis lupus*)	Terrestrial carnivore	Observed in the study area.	Large mammal, top carnivore.	Trapped for fur/meat.	Exposed to atmospheric release through food (small mammals) and soil	
Riparian Mammals						
Muskrat (*Ondatra zibethicus*)	Riparian herbivore	Observed in the study area.	Surrogate for other riparian herbivores such as the beaver.	Regional traditional food item. Harvested regionally for fur.	Exposed to aquatic release through food (aquatic vegetation), water and sediment	**Selected as VC: 1,2,3,4,5**
North American beaver (*Castor canadensis*)	Riparian herbivore	Observed in the study area.	Food source for other receptors	Trapped for fur/meat and hunted by indigenous people	Exposed to aquatic release through food (aquatic vegetation), water and sediment	Not selected. Assessment of the Muskrat is expected to be protective of this species.

Representative Species	Selection Criteria					Selection Rationale and Applicable Criteria[1,2,3]
	1	2	3	4	5	
	Major Plant/Animal Group	Facility or Stakeholder Importance*	Ecological Significance**	Socio-Economic Significance***	Exposed to and/or Sensitive to Stressor	
American Mink (*Neovison vison*)	Riparian carnivore	Observed in the study area.	Surrogate for other riparian carnivores such as river otter.	Harvested regionally for fur.	Exposed to atmospheric and aquatic releases through food (small mammals, fish, amphibians, insects), water, sediment, and soil.	**Selected as VC: 1,2,3,4,5**
River otter (*Lontra canadensis*)	Riparian carnivore	Observed in the study area.	Small riparian carnivore. SKCDC status S3.	Trapped for fur/meat and hunted by indigenous people	Exposed to atmospheric and aquatic releases through food (small mammals, fish, amphibians, insects), water, sediment, and soil.	Not selected. Assessment of the American Mink is expected to be protective of this species.
Terrestrial Birds*****						
Olive-sided flycatcher (*Contopus cooperi*)	Aerial insectivore	Observed in the study area.	Special concern (COSEWIC) and threatened status (SARA). Surrogate for other small birds and at-risk species, such as barn swallow and common nighthawk.	Not identified	Exposed to atmospheric and aquatic releases through food (flying insects) and water.	**Selected as VC: 1,2,4,5**
Barn swallow (*Hirundo rustica*)	Aerial insectivore	Observed in the study area.	SB, S5M, threatened (COSEWIC)	Not identified	Exposed to atmospheric and aquatic releases through food (flying insects) and water.	Not selected. Assessment of the Olive-sided flycatcher is expected to be protective of this species.
Common Nighthawk (*Chordeiles minor*)	Aerial Insectivore	Observed in the study area.	S4B, S4M, COSEWIC Special Concern, SARA Status Threatened.	Not identified	Exposed to atmospheric and aquatic releases through food (flying insects) and water.	
Bald Eagle (*Haliaeetus leucocephalus*)	Terrestrial carnivore	Observed in the study area.	Surrogate of other raptors	Not identified	Exposed to atmospheric and aquatic releases through food (fish and small mammals), water, sediment, and soil.	**Selected as VC: 1,2, 5**
American Robin (*Turdus migratorius*)	Ground feeding omnivore	Observed in the study area.	Surrogate for other insectivores and ground-feeding birds, such as dark-eyed junco, Hermit thrush, and yellow-rumped warbler.	Not identified	Exposed to atmospheric and aquatic releases through food (seeds, fruits, terrestrial invertebrates), water and soil.	**Selected as VC: 1,2,5**

Representative Species	Selection Criteria					Selection Rationale and Applicable Criteria[1,2,3]
	1 Major Plant/Animal Group	2 Facility or Stakeholder Importance*	3 Ecological Significance**	4 Socio-Economic Significance***	5 Exposed to and/or Sensitive to Stressor	
Dark-eyed junco (*Junco hyemalis*)	Ground feeding omnivore	Observed in the study area.	Breeds within the study area.	Not identified	Exposed to atmospheric release through food (terrestrial invertebrates) and soil	Not selected. Assessment of the American Robin is expected to be protective of this species.
Chipping sparrow (*Spizella passerina*)	Ground feeding omnivore	Observed in the study area.	Breeds within the study area.	Not identified	Exposed to atmospheric release through food (terrestrial invertebrates) and soil	
Yellow-rumped warbler (*Setophaga coronata*)	Tree/shrub feeding insectivore	Observed in the study area.	Breeds within the study area.	Not identified	Exposed to atmospheric release through food (terrestrial invertebrates) and soil	
Fox sparrow (*Passerella iliaca*)	Ground feeding omnivore	Observed in the study area.	Breeds within the study area.	Not identified	Exposed to atmospheric release through food (terrestrial invertebrates) and soil	
Gray jay (*Perisoreus canadensis*)	Ground feeding omnivore	Observed in the study area.	Breeds within the study area.	Not identified	Exposed to atmospheric release through food (terrestrial invertebrates) and soil	
Hermit thrush (*Catharus guttatus*)	Ground feeding omnivore	Observed in the study area.	Breeds within the study area.	Not identified	Exposed to atmospheric release through food (terrestrial invertebrates) and soil	
Lincoln's sparrow (*Melospiza lincolnii*)	Ground feeding omnivore	Observed in the study area.	Breeds within the study area.	Not identified	Exposed to atmospheric release through food (terrestrial invertebrates) and soil	
Ruby-crowned kinglet (*Regulus calendula*)	Tree/shrub feeding insectivore	Observed in the study area.	Breeds within the study area.	Not identified	Exposed to atmospheric release through food (terrestrial invertebrates) and soil	
Canada Goose (*Branta canadensis*)	Ground feeding herbivore	Observed in the study area.	Breeds within the study area.	Regional traditional food item.	Exposed to atmospheric and aquatic releases through food (grass, sedges, berries, seeds), water and soil.	**Selected as VC: 1,2,3,4,5**
Riparian Birds*****						

Representative Species	Selection Criteria					Selection Rationale and Applicable Criteria[1,2,3]
	1	2	3	4	5	
	Major Plant/Animal Group	Facility or Stakeholder Importance*	Ecological Significance**	Socio-Economic Significance***	Exposed to and/or Sensitive to Stressor	
Lesser Scaup (*Aythya affinis*)	Riparian omnivore	Observed in the study area.	Surrogate for other omnivore ducks and gulls (e.g. bufflehead, mew gull, herring gull, bonaparte's gull, and horned grebe).	Not identified	Exposed to aquatic release through water, food (invertebrates) and sediment.	**Selected as VC: 1,2,5**
Ring-necked duck (*Aythya collaris*)	Riparian omnivore	Observed in the study area.	Food source for other receptors.	Not identified.	Exposed to aquatic release through water, food (invertebrates) and sediment.	Not selected. Assessment of the a Lesser Scaup is expected to be protective of this species.
Bufflehead (*Bucephala albeola*)	Diving bird, riparian omnivore	Observed in the study area.	Food source for other receptors.	Not identified	Exposed to aquatic release through water, food and sediment.	
Herring Gull (*Larus argentatus*)	Gull (riparian omnivore)	Observed in the study area.	S5B, S5M, not threatened. Breeds in the study area.	Hunted by indigenous people.	Exposed to aquatic release through water and food (fish and aquatic invertebrates)	
Bonaparte's Gull (*Chroicocephalus philadelphia*)	Gull (riparian omnivore)	Observed in the study area.	S4B, S4M, not threatened.	Not identified.	Exposed to aquatic release through water and food (fish and aquatic invertebrates)	
Common Tern (*Sterna hirundo*)	Riparian omnivore	Observed in the study area.	S5B, S5M, Not at risk	Not identified.	Exposed to aquatic release through water and aquatic food (fish) and invertebrates.	
Horned Grebe (*Podiceps auritus*)	Diving bird, riparian omnivore	Incidental observation in the study area.	S5B, S5M, COSEWIC Special Concern, SARA Special Concern	Not identified.	Exposed to aquatic release through water, food and sediment.	
Mew Gull (Larus canus)	Gull (riparian omnivore)	Observed in the study area.	S4B, S4M, Not threatened. Breeds in the study area.	Hunted by indigenous people.	Exposed to aquatic release through water, food and sediment.	
Mallard (*Anas platyrhynchos*)	Riparian herbivore	Observed in the study area.	Surrogate for other herbivore duck species (e.g. ring-necked duck).	Regional traditional food item.	Exposed to aquatic release through water, food (aquatic plants and invertebrates) and sediment	**Selected as VC: 1,2,3,4,5**
Common loon (*Gavia immer*)	Piscivore	Observed in the study area.	Surrogate for other fish-eating birds (e.g. common tern, common merganser, and osprey).	Regional traditional food item.	Exposed to aquatic release through water and aquatic food (fish)	**Selected as VC: 1,2,3,4,5**

Representative Species	Selection Criteria					Selection Rationale and Applicable Criteria[1,2,3]
	1 Major Plant/Animal Group	2 Facility or Stakeholder Importance*	3 Ecological Significance**	4 Socio-Economic Significance***	5 Exposed to and/or Sensitive to Stressor	
Common merganser (*Mergus merganser*)	Piscivore	Observed in the study area.	Prey on other receptors.	Not identified.	Exposed to aquatic release through water and aquatic food (fish)	Not selected. Assessment of a Loon is expected to be protective of this species.
Osprey (*Pandion haliaetus*)	Piscivore	Observed in the study area (including the nest).	S2B, S2M, not threatened.	Not identified	Exposed to atmospheric and aquatic releases through food (fish and small mammals), water, sediment, and soil.	
Fish****						
Northern Pike (*Esox lucius*)	Pelagic predator fish (Piscivore)	Present in most area lakes and surrounding surface water bodies. Spawning habitat has also been identified within the study area. Fish flesh and bone were analyzed for metal and radionuclides. Age determination has also been done.	Food source for other receptors. Surrogate for all predator fish.	Regional traditional food item. Recreational and commercial fishing documented at Russell Lake.	Exposed to aquatic release through food (fish and other aquatic biota) and water.	**Selected as VC: 1,2,3,4,5**
Lake Trout (*Salvelinus namaycush*)	Pelagic predator fish	Observed in McGowan Lake and Russell Lake. Spawning habitat was observed in the study area.	Food source for other receptors.	Regional traditional food item. Recreational and commercial fishing documented at Russell Lake.	Exposed to aquatic release through food (fish and other aquatic biota) and water.	Not selected. Assessment of the Northern Pike is expected to be protective of this species.
Walleye (*Sander vitreus*)	Pelagic predator fish	Present in most area lakes and streams within the study area. Spawning habitat has also been identified within the study area.	Food source for other receptors.	Regional traditional food item. Commercial fishing is documented at Russell Lake.	Exposed to aquatic release through food (fish and other aquatic biota) and water.	
Yellow Perch (*Perca flavescens*)	Pelagic predator fish	Observed in McGowan Lake and the regional study area.	Food source for other receptors.	Regional traditional food item.	Exposed to aquatic release through food (fish and other aquatic biota) and water.	
White Sucker (*Catostomus commersoni*)	Benthic forage fish	Present in most area lakes and surrounding surface water bodies. Spawning habitat has also been identified within the study area. Fish flesh and bone were analyzed for metal and radionuclides. Age determination has also been done.	Food source for other receptors. Surrogate for all foraging fish.	Regional traditional food item. Recreational and commercial fishing documented at Russell Lake.	Exposed to aquatic release through food (aquatic invertebrates and aquatic plants).	**Selected as VC: 1,2,3,4,5**
Lake Whitefish (*Coregonus clupeaformis*)	Benthopelagic fish	Present in most area lakes and surrounding surface water bodies.	Food source for other receptors.	Regional traditional food item. Commercial fishing is documented at Russell Lake.	Exposed to aquatic release through food (aquatic	Not selected. Assessment of the White Sucker is

Representative Species	Selection Criteria					Selection Rationale and Applicable Criteria[1,2,3]
	1 Major Plant/Animal Group	2 Facility or Stakeholder Importance*	3 Ecological Significance**	4 Socio-Economic Significance***	5 Exposed to and/or Sensitive to Stressor	
					invertebrates and aquatic plants).	expected to be protective of this species.
Slimy Sculpin (representative small fish)	Benthopelagic forage fish	Observed in the Icelander River and other streams within the study area.	Food source for other receptors.	Not identified.	Exposed to aquatic release through food (aquatic invertebrates and aquatic plants).	
Arctic Grayling (*Thymallus arcticus*)	Benthopelagic forage fish	Observed in the Icelander River and other streams within the study area.	Food source for other receptors.	Regional traditional food item.	Exposed to aquatic release through food (aquatic invertebrates and aquatic plants).	
Longnose Sucker (*Catostumus catostumus*)	Benthic forage fish	Observed in McGowan Lake, Icelander River and other streams within the study area.	Food source for other receptors.	Regional traditional food item.	Exposed to aquatic release through food (aquatic invertebrates and aquatic plants).	
Lake Chub (*Couesius plumbeus*)	Benthopelagic forage fish	Observed in Icelander River and other streams within the study area. Spawning habitat has also been identified within the study area.	Food source for other receptors.	Not identified	Exposed to aquatic release through food (aquatic invertebrates and aquatic plants).	
Spottail Shiner (*Notropis hudsonius*)	Benthopelagic forage fish	Present in most area lakes and other surface water bodies in the study area.	Food source for other receptors.	Not identified	Exposed to aquatic release through food (aquatic invertebrates and aquatic plants).	
Ninespine Stickleback (*Pungitius pungitius*)	Benthopelagic forage fish	Observed in the Whitefish Lake, south basin (LA-5), and streams within the study area.	Food source for other receptors.	Not identified	Exposed to aquatic release through food (aquatic invertebrates and aquatic plants).	
Burbot (*Lota lota*)	Benthic predator fish	Observed in Russell Lake and other streams within the study area.	Food source for other receptors.	Regional traditional food item.	Exposed to aquatic release through food (fish and other aquatic biota) and water.	
Amphibians and Reptiles						
Northern Leopard frog (*Lithobates pipiens*)	Frog	Present in the study area.	Listed as a species of concern under SARA and COSEWIC, and is provincially ranked S3 (vulnerable/rare to uncommon)	Not identified	Exposed to aquatic release through surface water, sediment, and prey.	Not selected. A fish model will be used to represent the early sensitive life stages of amphibians (egg and tadpole).
Canadian toad (*Anaxyrus hemiphrys*)	Toad	Present in the study area.	Food source for other receptors.	Not identified	Exposed to aquatic release through surface water, sediment, and prey.	

Representative Species	Selection Criteria					Selection Rationale and Applicable Criteria[1,2,3]
	1	2	3	4	5	
	Major Plant/Animal Group	Facility or Stakeholder Importance*	Ecological Significance**	Socio-Economic Significance***	Exposed to and/or Sensitive to Stressor	
Wood Frogs (*Lithobates sylvaticus*)	Frog	Present in the study area.	Food source for other receptors.	Not identified	Exposed to aquatic release through surface water, sediment, and prey.	
Boreal chorus frogs (*Pseudacris maculata*)	Frog	Present in the study area.	Food source for other receptors.	Not identified	Exposed to aquatic release through surface water, sediment, and prey.	

Notes:
* Information from EcoMetrix (2020) and Omnia (2020).
** Information from EcoMetrix (2020) and Omnia (2020).
***FNFNES (First Nations Food, Nutrition and Environment Study), Hatchet Lake and Uranium City food study results were used to identify VECs that are part of the human traditional/subsistence diet and characterize regional socio-economic significance. Partial information is also from the meeting notes Denison provided with local trapper/fisher Mr. Bobby John.
**** Amphibian species such as wood frogs and boreal chorus frogs were not specified on the list on the basis of limited scientific information for amphibian risk assessment. Amphibian species will be assessed qualitatively in the EcoRA.
***** As there are many birds observed in the study area (36 song birds and 20 water fowls), only the ten most abundant breeding songbirds and aerial waterfowls, as well as all sensitive bird species are included in this table.
Species names that are highlighted and underlined are sensitive or threatened species at risk observed at the Wheeler River Project.
SKCDC: Saskatchewan Conservation Data Center.
COSWIC: Committee on the Status of Endangered Wildlife in Canada.
No observation of bat is documented in the terrestrial baseline report (Omnia, 2019).

References:
1. Omnia Ecological Services (Omnia). 2020. Denison Mines Corporation Wheeler River Project - Terrestrial Environment Wildlife and Vegetation Baseline Inventory.
2. Denison Mines Corp (Denison). 2019. Wheeler River Project Provincial Technical Proposal and Federal Project Description. May.
3. Denison Mines Corp (Denison). 2019. Denison Mines Wheeler River Project Key Person Interview with Bobby John - Meeting Notes. October.

Table 5-2: Species at Risk for the Wheeler River Project and Associated Surrogates

Common Name	Scientific Name	Feeding Behaviour	SKCDC Status	COSEWIC Status	SARA Status	Field Observations	Surrogate species, if not selected as a VC
Mammals							
Woodland Caribou	*Rangifer tarandus caribou*	Terrestrial herbivore	S3	Threatened	Threatened	Only observed in the Regional Study Area	Selected
River Otter	*Lontra canadensis*	Riparian carnivore	S3	N/A	N/A	Eleven observations.	American Mink
Wolverine	*Gulo gulo*	Terrestrial carnivore	S2	Special Concern	Special Concern	Not observed	Canada Lynx
Birds							
Osprey	*Pandion haliaetus*	Piscivore	S2B, S2M	N/A	N/A	8 pairs observed.	Common Loon
Common Nighthawk	*Chordeiles minor*	Aerial insectivore	S4B, S4M	Special Concern	Threatened	Incidentally observed.	Olive-sided Flycatcher
Olive-sided Flycatcher	*Contopus cooperi*	Aerial insectivore	S4B, S4M	Threatened	Threatened	8 pairs observed.	Selected
Barn Swallow	*Hirundo rustica*	Aerial insectivore	S5B, S5M	Threatened	Threatened	4 pairs observed.	Olive-sided Flycatcher
Horned Grebe	*Podiceps auritus*	Aquatic invertebrates/ piscivore	S5B, S5M	Special Concern	Special Concern	One incidental observation.	Lesser Scaup
Short-eared Owl	*Asio flammeus*	Terrestrial carnivore	S3B, S2N	Threatened	Special Concern	Not observed	Bald Eagle
Yellow Rail	*Coturnicops noveboracensis*	Aquatic invertebrates	S3B	Special Concern	Special Concern	Not observed	Lesser Scaup
Rusty Blackbird	*Euphagus carolinus*	Aerial insectivore	S3B, SUN	Special Concern	Special Concern	Not observed	Olive-sided Flycatcher

Notes:
Modified from Table 3-1 (Omnia, 2020)
'N/A' denotes species status not assessed.
SKCDC Rankings:
2: Imperiled/Very rare

3: Vulnerable/Rare to uncommon
4: Apparently secure
5: Secure/Common
M: for a migratory species, rank applies to the transient (migrant) population
B: for a migratory species, applies to the breeding population in the province
N: for a migratory species, applies to the non-breeding population in the province
U: status is uncertain in Saskatchewan because of limited or conflicting information (unrankable)

Table 5-3: List of Ecological Receptors for Wheeler River Project

Category	Representative Species
Terrestrial Invertebrates	Terrestrial Invertebrates
Terrestrial Plants	Lichen
	Blueberry (*Vaccinium myrtilloides*)
	Labrador tea (*Rhododendron groenlandicum*)
Aquatic Invertebrates	Zooplankton (general category)
	Benthic invertebrates
Aquatic Plants	Macrophyte (*e.g., Carex sp.)*
	Phytoplankton
Fish	Northern Pike *(Esox lucius*)
	White Sucker (*Catostomus commersoni*)
Terrestrial Mammals	Woodland caribou (*Rangifer tarandus caribou*)
	Snowshoe hare (*Lepus americanus*)
	Moose (*Alces americanus*)
	Red-backed vole (*Myodes gapperi*)
	Black bear (*Ursus americanus*)
	Canada Lynx (*Lynx canadensis*)
Riparian Mammals	Muskrat (*ondatra zibethicus*)
	American Mink (*Neovision vision*)
Terrestrial Birds	Olive-sided flycatcher (*Contopus cooperi*)
	Bald Eagle (*Haliaeetus leucocephalus*)
	American Robin (*Turdus migratorius*)
	Canada Goose (*Branda canadensis*)
Riparian Birds	Lesser Scaup (*Aythya affinis*)
	Mallard (*Anas platyrhynchos*)
	Common loon (*Gavia immer*)

5.1.2 Receptor Characterization

The following section provides a brief summary of the ecological receptors selected for the EcoRA. For additional information regarding ecological characteristics relevant to receptor exposures, refer to Appendix C of this report.

5.1.2.1 Terrestrial Invertebrates

Soil invertebrates such as earthworms, grubs, arthropods, etc. are important components of terrestrial ecosystems. Invertebrates provide a food source to mammals and birds and the community can reflect the health of the environment.

5.1.2.2 Terrestrial Plants

Lichens are a complex life form that is a symbiotic partnership of two separate organisms, a fungus and an alga. The dominant partner is the fungus, which gives the lichen the majority of its characteristics. The alga can be either a green alga or a blue-green alga, also known as cyanobacteria. Lichen are important indicator species of environmental conditions, as they can absorb atmospheric pollutants, including heavy metals (USFS, 2021).

Blueberries and Labrador Tea are important terrestrial plant species consumed by humans for food or for medicinal purposes (CanNorth, 2017). Berries are also an important food source for many terrestrial bird and mammal species, offering a reliable source of carbohydrates, vitamins and antioxidants.

5.1.2.3 Aquatic Invertebrates

Aquatic invertebrates are an important food item for many species of fish and waterfowl. Benthic invertebrates are often found living on or within sediment. Benthic invertebrates can be used to provide an indication of habitat quality in aquatic environments.

Zooplankton are aquatic microorganisms that include crustaceans, rotifers, insect larvae and aquatic mites. The zooplankton community is composed of both primary consumers, which eat free-floating algae, and secondary consumers, which feed on other zooplankton and microorganisms. Zooplankton are particularly sensitive to changes in the aquatic environment. The effects of environmental disturbances can be perceived through changes in species composition, abundance and body size (US EPA, 2021a).

5.1.2.4 Aquatic Plants

Macrophytes are aquatic plants that grow within or in close proximity to water. They may be emergent (i.e., portions of the plant exist above the water surface), fully submerged or floating. Examples of macrophytes include cattails, hydrilla, water hyacinth and duckweed. Macrophytes provide habitat for fish and other aquatic organisms. They also produce oxygen and are an important food source for fish and wildlife. Macrophytes are an important indicator species, as they tend to quickly respond to changing environmental conditions (US EPA, 2021b).

Phytoplankton are free-floating algae that inhabit the upper sunlit layers of most freshwater and marine environments. They are often associated with freshwater water quality characteristics such as colour and clarity. Phytoplankton are primary producers, and convert solar energy into biologically-useable energy through photosynthesis. They are an important food source for higher organisms, including zooplankton and small fish. Phytoplankton can be used to assess an ecosystem's environmental condition by examining their abundance and community richness (US EPA, 2021c).

5.1.2.5 Fish

The Northern Pike (*Esox lucius*) is a cool-water fish, and tends to live in slower-moving, heavily vegetated rivers or lake bays. Spawning occurs in the spring, immediately following the seasonal ice melt. Northern pike are opportunistic feeders, targeting smaller fish, crayfish, frogs, mice, muskrats and young waterfowl for food. In many regions across Canada, northern pike are considered an important commercial and sport fish species (DFO, 2018).

The White Sucker (*Catostomus commersoni*) is a bottom-feeding, freshwater fish common to North America. They tend to live in shallow lakes and rivers, where they feed on benthic invertebrates, clams, insect larvae and fish eggs. They are an important prey species of northern pike (DFO, 2016).

5.1.2.6 Terrestrial Mammals

The Woodland Caribou (*Rangifer tarandus caribou*) is a herbivorous mammal found in Canada's boreal and open taiga forests. They consume plant materials for sustenance, including tree and ground lichens in winter, and lichens, grasses, sedges, forbs, horsetails and shrub leaves in summer. Woodland caribou are threatened by habitat degradation and fragmentation, and have been classified as "threatened" under the federal *Species at Risk Act, 2002* (NRC, 2021).

The Snowshoe Hare (*Lepus americanus*) is a herbivorous mammal found in coniferous and boreal forests throughout Canada and the United States. They often forage through brush, consuming plant materials such as grasses, flowers, and new growth from trees. Snowshoe hares breed rapidly, and thus maintain a relatively stable population throughout their range. They are an important prey item for larger carnivorous birds and mammals, such as the bald eagle and lynx (NWF, 2021a).

Moose (*Alces americanus*) are the largest members of the deer family, and are common in forested regions across Canada and the United States. In the winter, moose will eat various shrubs and pinecones for sustenance. In summer, moose feed on aquatic plants (macrophytes) both on and below the water's surface. Moose are potentially threatened by habitat degradation and fragmentation, but are not a federally-recognized species at risk (NCC, 2022).

The Red-backed Vole (*Myodes gapperi*) is a small, herbivorous mammal common across forested areas of Canada and the United States. They often consume vegetation, seeds, nuts and fungi, but will occasionally prey on soil invertebrates depending on food availability. They are an important prey item for larger carnivorous birds and mammals (BC Conservation Data Centre, 1993).

The Black Bear (*Ursus americanus*) is a large, omnivorous mammal, and can be found across almost the entirety of the North American continent. They can survive in a variety of habitat types, including both coniferous and deciduous forests and mountainous terrain. Their diet typically consists of plant materials (roots, berries, grass, succulents), fish, invertebrates, and meat, often of young deer, elk or moose (NWF, 2021b).

The Canada Lynx (*Lynx canadensis*) is a medium-sized carnivorous mammal found across Canada's boreal forests. The snowshoe hare composes the majority of the lynx's diet, particularly during the winter months. In summer, lynx will supplement their diet by preying on other small mammals and birds, such as grouse, voles, mice and squirrels. Lynx are resilient and well-adapted to living in areas close to human settlements (CWF, 2022).

5.1.2.7 Riparian Mammals

The Muskrat (*Ondatra zibethicus*) is a semi-aquatic herbivorous mammal well adapted to swimming. Muskrats can occur in high densities in suitable areas with appropriate food and shelter (i.e., cattail marshes). Muskrats are an important prey species of predatory birds and mammals (US EPA, 1993).

The American Mink (*Neovision vision*) is the most abundant carnivorous mammal in North America. They are mostly nocturnal hunters and are opportunistic feeders, preferring small mammals as their main prey, including muskrat. They are often found near aquatic habitats such as streams, rivers and lakes (US EPA, 1993).

5.1.2.8 Terrestrial Birds

The Bald Eagle (*Haliaeetus leucocephalus*) is a carnivorous terrestrial bird of prey. They are primarily carrion feeders, and will consume dead or dying prey species. Bald eagles are opportunistic feeders, scavenging different foods based on their availability and hunting easily-captured prey, such as fish, mammals, and other birds. Bald eagles generally are restricted to coastal areas, lakes, and rivers, although some may winter in areas not associated with water (US EPA, 1993).

The American Robin (*Turdus migratorius*) is a common, medium-sized terrestrial bird. They often consume worms, insects and fruit. They are found living in a variety of habitats, including woodlands, swamps, suburbs, and parks (US EPA, 1993).

The Olive-sided Flycatcher (*Contopus cooperi*) is a medium-sized songbird and aerial insectivore, consuming flying insects over both land and water. It is a migratory species, with approximately half of its breeding range across most of forested Canada, and the remainder in the western and northeastern United States. Olive-sided Flycatcher is a designated threatened species, largely due to its susceptibility to habitat loss, a decline in prey species (insects) from pesticide use, and climate change (COSEWIC, 2018).

The Canada Goose (*Branda canadensis*) is a common herbivorous bird, native to both Arctic and temperate regions of North America. They are a migratory bird species, and tend to overwinter in the United States. They often consume grass, seeds, berries and other terrestrial and aquatic plant materials as food. Canada geese tend to build their nests near water, and prefer secluded areas. They are highly adapted to living near humans and can be often found in parks and greenspaces in urban and suburban areas (ECCC, 2018).

5.1.2.9 Riparian Birds

The Mallard (*Anas platyrhynchos*) is an omnivorous waterfowl species, and primarily feeds on aquatic vegetation, seeds, acorns and grains, and occasionally on fish and other aquatic organisms. While common across North America, populations have experienced a marked declined in the last few decades, primarily due to habitat degradation and drought (US EPA, 1993).

The Lesser Scaup (*Aythya affinis*) is one of the most abundant North American ducks. Lesser scaup are found on larger lakes and bays during the fall and winter but are more common on smaller bodies of water (e.g., ponds) during the spring. Most populations of lesser scaup primarily consume aquatic invertebrates, but are known to consume aquatic plant materials (often seeds) as food availability changes seasonally (US EPA, 1993).

The Common Loon (*Gavia immer*) is a riparian bird that primarily feeds on fish and aquatic invertebrates, and to a lesser extent aquatic vegetation. They are well adapted to swimming and diving to catch and consume prey. Populations of common loon are generally considered to be stable across North America. They require clean and largely undisturbed freshwater lakes for their survival, and thus are potentially susceptible to pollution and human disturbances. Adult loons are occasionally preyed upon by larger raptors such as the bald eagle and osprey. Their eggs and chicks are an important food source for a variety of other birds, mammals and some predatory fish (NWF, 2021c).

5.1.3 Assessment and Measurement Endpoints

Assessment endpoints for the EcoRA are explicit expressions of the environmental values that are to be protected (FCSAP, 2012). Assessment endpoints for the EcoRA should include the ecological receptor and the attribute of the ecological receptor that is to be protected (e.g., abundance, viability of the population) (FCSAP, 2012). The EcoRA assessment endpoints to be evaluated are presented in Table 5-4.

Measurement endpoints for the EcoRA are conceptually related to assessment endpoints and are defined as the specific measures that would be used to judge potential for effect on the attribute of an assessment endpoint (e.g., if we predict an effect on organism growth or reproduction, we can infer a potential for effect on abundance). Measurement endpoints for the EcoRA may include endpoints such as survival, growth, or reproduction. Measurement endpoints for the EcoRA are the foundation for the lines of evidence that are used to estimate risks to ecological receptors (FCSAP, 2012).

In this EcoRA, the assessment endpoints are at the population or community level; however, for species at risk, the assessment endpoint is at the individual level. While exposure and risk estimates always pertain to individuals, for most receptors, when effects on individuals are predicted from constituent levels in a certain location, further discussion of population or community effects (or lack thereof) is appropriate. For species at risk, it is considered that effects on even a single individual represent an effect on the population.

Table 5-4: Assessment Endpoints, Measurement Endpoints, and Lines of Evidence

Ecological Receptor	Level of Protection	Protection Goal	Assessment Endpoint	Lines of Evidence	
				Line of Evidence	Measurement Endpoints and their Interpretation
Fish	Population	Maintenance of fish populations as a source of food for piscivorous fish and wildlife.	Viability of fish populations.	Water chemistry	COPC concentrations in water. Compare to toxicological reference values (low-effect threshold concentrations) for effect on survival, growth, or reproduction.
				Radiological dose	Compare estimated doses of COPCs to growth, survival, and reproduction benchmark values (low-effect threshold doses) relevant to the assessment endpoint.
Aquatic Vegetation	Population	Maintenance of aquatic plant populations as a source of food and cover for wildlife.	Viability of aquatic plant populations.	Water chemistry	COPC concentrations in water. Compare to toxicological reference values (low-effect threshold concentrations) for aquatic plants for effect on survival, growth, or reproduction.
				Radiological dose	Compare estimated doses of COPCs to growth, survival, and reproduction benchmark values (low-effect threshold doses) relevant to the assessment endpoint.

Ecological Receptor	Level of Protection	Protection Goal	Assessment Endpoint	Lines of Evidence	
				Line of Evidence	Measurement Endpoints and their Interpretation
Zooplankton	Community	Maintenance of a diverse zooplankton community as a source of food for fish.	Density, richness, and diversity of zooplankton community.	Water chemistry	COPC concentrations in water. Compare to toxicological reference values (low-effect threshold concentrations) for zooplankton for effect on survival, growth, or reproduction.
				Radiological dose	Compare estimated doses of COPCs to growth, survival, and reproduction benchmark values (low-effect threshold doses) relevant to the assessment endpoint.
Benthic Invertebrates	Community	Maintenance of a diverse benthic invertebrate community as a source of food for fish and wildlife.	Richness, diversity, abundance of benthic invertebrates.	Water chemistry	Compare COPC concentrations to water quality guidelines.
				Sediment chemistry	Compare COPC concentrations to sediment quality guidelines.
				Radiological dose	Compare estimated doses of COPCs to growth, survival, and reproduction benchmark values (low-effect threshold doses) relevant to the assessment endpoint.

Ecological Receptor	Level of Protection	Protection Goal	Assessment Endpoint	Lines of Evidence	
				Line of Evidence	Measurement Endpoints and their Interpretation
Riparian Birds	Population	Maintenance of riparian bird populations.	Viability of riparian bird populations.	Radiological and toxicological doses	Compare estimated doses of COPCs to growth, survival, and reproduction benchmark values (low-effect threshold doses) relevant to the assessment endpoint.
Riparian Mammals	Population	Maintenance of riparian mammal populations.	Viability of riparian mammal populations.	Radiological and toxicological doses	Compare estimated doses of COPCs to growth, survival, and reproduction benchmark values (low-effect threshold doses) relevant to the assessment endpoint.
Terrestrial Invertebrates	Population	Maintenance of terrestrial invertebrate population as a source of food for wildlife.	Viability of terrestrial invertebrate populations.	Soil chemistry	COPC concentrations in soil. Compare COPC concentrations to soil quality guidelines.
				Radiological dose	Compare estimated doses to growth, survival, and reproduction benchmark values (low-effect threshold doses) relevant to the assessment endpoint.
Terrestrial Plants	Population	Maintenance of terrestrial plant	Viability of terrestrial plant populations.	Soil chemistry	COPC concentrations in soil. Compare COPC concentrations to soil quality guidelines.

Ecological Receptor	Level of Protection	Protection Goal	Assessment Endpoint	Lines of Evidence	
				Line of Evidence	Measurement Endpoints and their Interpretation
		population as a source of food for wildlife.		Radiological dose	Compare estimated doses to growth, survival, and reproduction benchmark values (low-effect threshold doses) relevant to the assessment endpoint.
Terrestrial Birds	Population	Maintenance of terrestrial bird populations.	Viability of terrestrial bird populations.	Radiological and toxicological doses	Compare estimated doses of COPCs to growth, survival, and reproduction benchmark values (low-effect threshold doses) relevant to the assessment endpoint.
Terrestrial Mammals	Population	Maintenance of terrestrial mammal populations.	Viability of terrestrial mammal populations.	Radiological and toxicological doses	Compare estimated doses of COPCs to growth, survival, and reproduction benchmark values (low-effect threshold doses) relevant to the assessment endpoint.

Note:
For species at risk, protection is at the individual level, recognizing that effects on even a few individuals represent an effect on the population.
COPC = constituent of potential concern

5.1.4 Selection of Chemical, Radiological, and Other Stressors

The selection of COPCs retained for the EcoRA is presented in Section 3.0 of this report. Chloride and sulphate were identified as COPCs in the aquatic environment, but not in the terrestrial environment. The selection of chemical stressors to evaluate in the EcoRA followed a tiered screening approach to reduce the risk of overlooking any COPCs relevant to ecological health. The selection of COPCs in water was based on the assumption that the main source of aquatic release to Whitefish Lake Middle part will be from the effluent monitoring and release ponds during operation and decommissioning phases. The list of water COPCs is composed of constituents expected to potentially be operational issues or to result in changes to water quality in Whitefish Lake (LA-5) and the downstream environment.

The screening involved a conservative process of comparing the expected treated effluent quality against the selected water quality guidelines protective of ecological health (refer to Table 3-1 in Section 3.0).

No formal screening was conducted for radionuclides. However, since radiation dose to ecological receptors is of public and regulatory interest, the radionuclides in the uranium-238 decay series are carried forward as COPCs for further assessment.

No specific COPCs were identified in air; however, to be sure that exposures were not underestimated in the multi-media pathways analysis, evaluation of potential ecological risk via indirect exposures such as air to soil deposition, soil contact and exposure through the food chain was included for all COPCs identified in water. Exposure to constituents that may deposit from air to surface water was not considered, as that pathway is considered negligible according to CSA N288.1-20.

5.1.5 Selection of Exposure Pathways

Exposure pathways consider the various routes by which radionuclides and/or chemicals may enter the body of the receptor, or for radionuclides, may exert effects from outside the body. Exposures to environmental media may be direct (i.e., by contact) or indirect (i.e., via constituent transport through the food chain).

For each type of ecological receptor, Table 5-5 summarizes the relevant exposure pathways to various environmental media including air, surface water, soil, and sediment. Direct contact or uptake exposure pathways associated with groundwater are assumed to be incomplete, as it is assumed that groundwater is inaccessible to ecological receptors, or negligible relative to other pathways.

Airborne COPCs partition to soil and plants. For most COPCs, ingestion pathways dominate over inhalation and air immersion. The latter pathways are considered minor pathways in the EcoRA, but inhalation was included in the IMPACT model and is thus included in Table 5-5.

For fish, aquatic plants, and aquatic invertebrates, contact with water and constituent uptake from water via bioaccumulation represents the main exposure pathway. Direct contact or uptake from sediment are also considered for benthic invertebrates and bottom-feeding fish. Individual food chain transport pathways are not calculated by the IMPACT model for aquatic organisms because exposures for aquatic receptors are determined using bioaccumulation factors (BAFs) based on surface water concentrations; these BAFs represent all operable exposure pathways. The CSA N288.6-22 recommends the use of BAFs for the estimation of COPC concentrations in plant, invertebrate, and fish tissues based on concentrations in ambient media.

For soil invertebrates and terrestrial plants, the main exposure pathway is through contact with soil and constituent uptake from soil via bioaccumulation. Earthworms and plant roots may have the potential to be exposed to groundwater when groundwater levels are high; however, both earthworms and plants would only be exposed to groundwater occasionally as they do not reside in the saturated zone. Therefore, direct contact with groundwater (for soil invertebrates) and uptake of groundwater (for terrestrial plants) are not quantified in IMPACT.

The dominant exposure pathways for birds and mammals are expected to include uptake of constituents via the ingestion of water, direct contact with or incidental ingestion of soil and/or sediment, and ingestion of food/prey. Direct contact with surface water is also considered to be a complete exposure pathway for riparian mammals and birds.

Table 5-5: Complete Exposure Pathways for All Selected Ecological Receptors to be Assessed using the IMPACT Model

Category	Ecological Receptor	Exposure Pathways	Environmental Media
Terrestrial invertebrates	Terrestrial invertebrates	Direct contact	In Soil
Aquatic invertebrates	Benthic invertebrates	Uptake	In water On sediment
Zooplankton	Zooplankton	Direct contact	In water
Terrestrial plants	Lichen	Direct contact	Air
	Blueberry	Direct contact	In soil
	Labrador tea	Direct contact	In soil
Aquatic plants	Macrophytes	Direct contact	In water On sediment
	Phytoplankton	Direct contact	In water
Fish	Northern pike	Direct contact	In water
	White sucker	Direct contact	In water On sediment
Terrestrial mammals	Woodland caribou	Direct contact	On soil
		Inhalation	Air
		Ingestion	Water Soil

Category	Ecological Receptor	Exposure Pathways	Environmental Media
			Sediment Browse Lichen Macrophytes
	Snowshoe hare	Direct contact	On soil
		Inhalation	Air
		Ingestion	Water Soil Browse Blueberries
	Moose	Direct contact	On soil
		Inhalation	Air
		Ingestion	Water Soil Sediment Browse Macrophytes
	Red-backed vole	Direct contact	On soil
		Inhalation	Air
		Ingestion	Water Soil Browse Blueberries
	Black bear	Direct contact	On soil
		Inhalation	Air
		Ingestion	Water Soil Blueberries Fish (Northern pike)
	Canada lynx	Direct contact	On soil
		Inhalation	Air
		Ingestion	Water Soil Snowshoe hare Red-backed Vole Canada Goose
Riparian mammals	Muskrat	Direct contact	In water On sediment

Category	Ecological Receptor	Exposure Pathways	Environmental Media
		Inhalation	Air
		Ingestion	Water Sediment Benthic invertebrates Macrophytes
	American mink	Direct contact	In water On soil On sediment
		Inhalation	Air
		Ingestion	Water Soil Sediment Benthic invertebrates Muskrat Fish (Northern pike) Mallard
Terrestrial birds	Olive-sided flycatcher	Direct contact	On soil
		Inhalation	Air
		Ingestion	Water Soil Benthic invertebrates Soil invertebrates
	Bald eagle	Direct contact	On soil
		Inhalation	Air
		Ingestion	Water Soil Fish (Northern pike) Mallard
	American robin	Direct contact	On soil
		Inhalation	Air
		Ingestion	Water Soil Soil invertebrates Blueberries
	Canada goose	Direct contact	On soil
		Inhalation	Air
		Ingestion	Water Soil Browse

Category	Ecological Receptor	Exposure Pathways	Environmental Media
Riparian birds	Lesser scaup	Direct contact	In water On sediment
		Inhalation	Air
		Ingestion	Water Sediment Benthic invertebrates Macrophytes
	Mallard	Direct contact	In water On sediment
		Inhalation	Air
		Ingestion	Water Sediment Benthic invertebrates Macrophytes
	Common loon	Direct contact	In water
		Inhalation	Air
		Ingestion	Water Benthic invertebrates Fish (Northern pike)

5.1.6 Ecological Health Conceptual Model

The ecological conceptual site model (CSM) illustrates how receptors are exposed to COPCs. It identifies the source of constituents, constituent transport mechanisms, environmental media, and the exposure pathways to be considered in the assessment for each receptor. Exposure pathways represent the various routes by which radionuclides and/or chemicals may enter the body of the receptor, or (for radionuclides) how they may exert effects from outside the body.

The conceptual site model for the EcoRA is illustrated below in Figure 5-1.

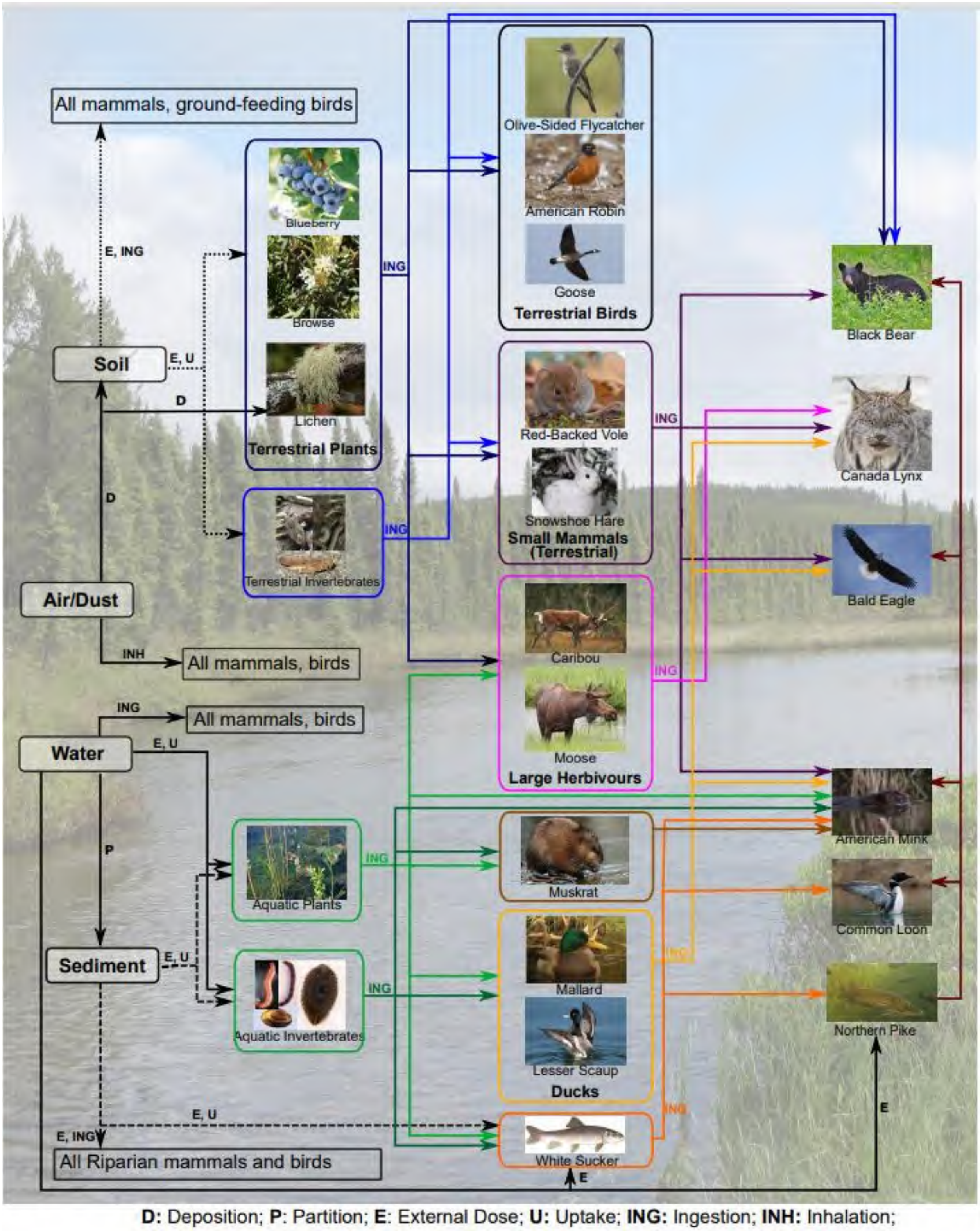


Figure 5-1: Ecological CSM for the Wheeler River Project

5.2 Exposure Assessment

The exposure assessment includes identification of exposure locations and exposure factors for each receptor, explanation of dispersion models, and presentation of exposure concentrations and doses (radiological and non-radiological). Uncertainties are discussed. This section presents the information used in the IMPACT model at a high-level; however, the details of the model will be included in Appendix A to the ERA.

5.2.1 Exposure Locations

The conceptual model assumes that all terrestrial and aquatic receptors are present at Whitefish Lake (LA-5 North), McGowan Lake (LA-1) and the inlet to Russell Lake (Figure 5-2). All terrestrial and aquatic receptors were also assumed to be at Kratchkowsky Lake, which was chosen as a reference location. Separate exposure values were estimated for each receptor in the locations where they were assumed to be present.

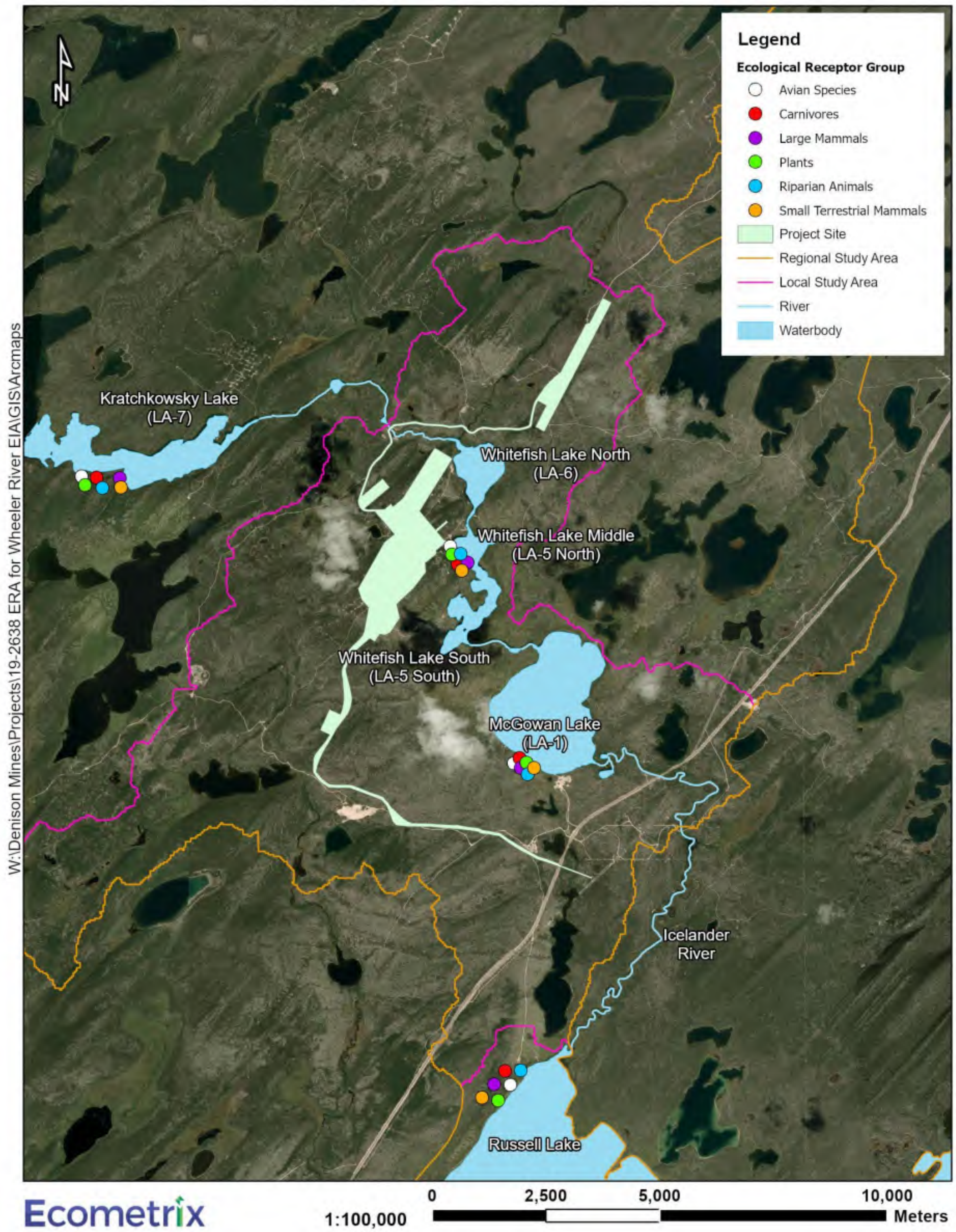


Figure 5-2: Locations of Ecological Receptors Assessed in the Ecological Risk Assessment

5.2.2 Exposure Averaging

Most ecological receptors were assessed assuming 100% residency at the exposure point location. This was the case for aquatic biota, immobile terrestrial biota such as plants and soil invertebrates, and mobile terrestrial mammals and birds that have small home ranges. This assumption was also applied to migratory ecological receptors, such as waterfowl and passerine birds, that spend part of the year away from the LSA and RSA, or ecological receptors that have a small home range while nesting or rearing young. For instance, mallards are not present in the LSA and RSA for over half the year due to migration, but have a small home range during the nesting and rearing season. Therefore, it was conservatively assumed that the mallard has a 100% residency factor on one lake where the young are hatched and reared. Similarly, moose have large annual home ranges but generally remain within small seasonal home ranges of 5 km^2 to 10 km^2 during the summer and winter. For modelling purposes, these animals were associated with one location.

Animals with large home ranges (i.e., greater than 10 km^2), such as the woodland caribou, black bear and bald eagle, interact with several different exposed polygon locations for feeding and water intake. All other receptors have relatively small home ranges (i.e., less than 10 km^2) and were assumed to reside in the same polygon year-round. For modelling purposes, the large home range animals were associated with a central location but with residency factors applied to other adjacent locations depending on the size of their home range. In some cases, a portion of their time in the LSA or RSA may be attributed to time spent at unexposed (reference) locations. For example, due to its large home range of 314 km^2, the bald eagle located near Whitefish Lake was assumed to spend 12.2% of its time at exposed locations and 87.8% of its time at unexposed locations. Further details are provided in Appendix A. The residency assumptions for ecological receptors with large home ranges are summarized in Table 5-6.

Table 5-6: Residency Factors for Terrestrial Ecological Receptors with Potentially Larger Home Ranges

Ecological Receptors	Home Polygon	Waterbody Surface Area (ha)	Total Waterbody Surface Area (ha)	Residency Factor	Water and Feed Source Polygon
Woodland Caribou	LA-7 South	323	323	1	LA-7 South
	LA-5	59	1111	0.06	LA-5
		149		0.13	LA-1
		512		0.46	Russell Lake
		392		0.35	Unexposed Locations
Moose	LA-7 South	-	-	1	LA-7 South
	LA-5	-	-	1	LA-5
	LA-1	-	-	1	LA-1
	Russell Lake	-	-	1	Russell Lake
Black Bear	LA-7 South	323	323	1	LA-7 South
	LA-5	59	1111	0.06	LA-5
		149		0.13	LA-1

Ecological Receptors	Home Polygon	Waterbody Surface Area (ha)	Total Waterbody Surface Area (ha)	Residency Factor	Water and Feed Source Polygon
		512		0.46	Russell Lake
		392		0.35	Unexposed Locations
Mink	LA-7 South	-	-	1	LA-7 South
	LA-5			1	LA-5
	LA-1	-	-	1	LA-1
	Russell Lake	-	-	1	Russell Lake
Bald Eagle	LA-7 South	323	323	1	LA-7 South
	LA-5	59	5872	0.010	LA-5
		149		0.025	LA-1
		512		0.087	Russell Lake
		5153		0.878	Unexposed Locations

5.2.3 Exposure and Dose Calculations

Exposure and dose calculations for ecological receptors were completed using IMPACT version 5.6.0. IMPACT is consistent with the COPC transport equations outlined in CSA N288.1-20 and with the methods of biota dose calculation outlined in CSA N288.6-22 for both non-radiological and radiological COPCs. The equations are presented in Appendix A.

Assessment of radiation exposures to ecological receptors is commonly based on estimation of the effects of the project or site. Assessments consider the radiation dose received from external exposure to radiation as well as the dose received from inhalation and ingestion of radionuclides. The radionuclide intake by ecological receptors from various pathways is converted into a dose that is presented in milligrays per day (mGy/d). The dose for each radionuclide is comprised of an internal dose component, and an external dose component, which is driven by water and sediment.

Assessment of non-radiological exposures to ecological receptors considers the dose received from ingestion of COPCs. This is presented as a dose in mg/kg/d for each pathway. Inhalation for non-radionuclides is not included as no non-radiological air COPCs were identified for further assessment. Additionally, this is consistent with guidance in CSA N288.6-22 which indicates that inhalation exposure is usually minor compared to soil and food ingestion.

The inputs and assumptions used in the IMPACT model for the Project, including receptor characteristics, exposure pathways, and the derivation and identification of site-specific information used in the model are provided in Appendix A. Relevant to the exposure and dose calculations, the IMPACT model report:

- describes the model structure for ecological receptor assessment, specific assumptions made for the Project, and the generic equations used to calculate the transfer of constituents between environmental media and the receptors; and
- presents the development of input parameters and describes the approach used for calibration and validation based on regional monitoring data.

5.2.4 Exposure Factors

Exposure estimates rely on several COPC- and biota-specific exposure factors for the dose calculations. These parameters include body weights and intake rates as well as occupancy factors (OFs), DCFs, BAFs, and transfer factors (TFs).

5.2.4.1 Body Weights and Intake Rates for Ecological Receptors

The body weight and intake rates are required for the calculation of exposure to birds and mammals (Table 5-7). Body weights and intake rates were obtained, in order of preference, from CSA N288.1-20, the US Environmental Protection Agency (USEPA) *Wildlife Exposure Factors Handbook* (US EPA, 1993), and the Federal Contaminated Sites Action Plan *Module 3: Standardization of Wildlife Receptor Characteristics* (FCSAP, 2012). For species not represented in the above sources, additional sources as identified in Table 5-7 were consulted to identify representative body weights, and then feed intake rates were calculated using allometric equations from the USEPA (1993).

Water intake and inhalation rates were determined using allometric equations from the USEPA (1993) for birds and mammals. The incidental ingestion of soil and/or sediment was estimated from feed intake. Incidental ingestion varied from 2% to 10.4% of food intake as dry weight, depending on the biota (Beyer et al., 1994). However, no incidental soil or sediment ingestion was assumed for the common loon, which feeds from the water column.

Table 5-7: Bird and Mammal Body Weights and Intake Rates

Receptor	Body Weight		Total Feed Intake				Dietary Components	Feed Type Fraction		Feed Intake Rate		Dry Weight Fraction [g]	IMPACT Intake Group	Feed Intake by Group		Intake of Soil [m]	Intake of Sediment [m]	Intake of Soil & Sediment [j]	Basis of the Soil and Sediment Intake Value	Total Soil/ Sediment Intake [k]	Water Intake [l]	Inhalation Rate	
	kg	Source	kg dw/d	Source	kg fw/d	Source		fw	dw	kg dw/d	kg fw/d	unitless		kg dw/d	kg fw/d	%	%	%		kg dw/d	L/d	m^3/d	source
Woodland Caribou	180.0	e	3.817	l	11.327	-	Browse	0.50	0.30	1.133	5.664	0.20	Terrestrial Plants	2.968	7.929	5.3	1.5	6.8	Bison	0.260	10.602	34.774	l
							Lichen	0.20	0.48	1.835	2.265	0.81											
							Macrophytes	0.30	0.22	0.850	3.398	0.25	Aquatic Plants	0.850	3.398								
Snowshoe Hare	1.8	c	0.110	c	0.475	-	Browse	0.90	0.78	0.086	0.428	0.20	Terrestrial Plants	0.110	0.475	3.7	0	3.7	Average of small mammals	0.004	0.168	0.900	c,l
							Berries (Blueberry)	0.10	0.22	0.024	0.048	0.52											
Moose	400.0	b	8.000	b	38.095	-	Browse	0.80	0.76	6.095	30.476	0.20	Terrestrial Plants	6.095	30.476	1.5	0.5	2.0	Moose	0.160	21.751	65.869	l
							Macrophytes	0.20	0.24	1.905	7.619	0.25	Aquatic Plants	1.905	7.619								
Southern Red-Backed Vole	0.03	a, i	0.004	-	0.012	a, i	Berries (Blueberry)	0.60	0.79	0.004	0.007	0.52	Terrestrial Plants	0.004	0.012	2.4	0	2.4	Meadow vole	0.0001	0.005	0.048	a
							Browse	0.40	0.21	0.001	0.005	0.20											
Black Bear	102.5	f	3.075	b	7.053	-	Berries (Blueberry)	0.70	0.83	2.546	4.937	0.52	Terrestrial Plants	2.546	4.937	2.9	0	2.9	Average of large mammals	0.090	6.387	22.162	l
							Fish (Northern Pike)	0.30	0.17	0.529	2.116	0.25	Aquatic Animals	0.529	2.116								
Canada Lynx	14.0	n	0.601	l	2.038	-	Showshoe hare	0.80	0.81	0.489	1.630	0.30	Terrestrial Animals	0.601	2.038	2.8	0	2.8	Red fox	0.017	1.065	4.508	l
							Small Mammals (represented by Vole)	0.15	0.14	0.082	0.306	0.27											
							Terrestrial Birds (Goose)	0.05	0.05	0.031	0.102	0.30											
Muskrat	1.2	a	0.088	-	0.352	a	Macrophytes	0.80	0.80	0.070	0.282	0.25	Aquatic Plants	0.070	0.282	0	3.3	3.3	Mallard	0.003	0.114	0.590	a
							Benthic Invertebrates	0.20	0.20	0.018	0.070	0.25	Aquatic Animals	0.018	0.070								
Mink	1.0	a	0.045	-	0.161	a	Fish (Northern Pike)	0.30	0.27	0.012	0.048	0.25	Aquatic Animals	0.018	0.072	2.6	0.4	3.1	Average of mallard and Lynx	0.001	0.101	0.440	a
							Benthic Invertebrates	0.15	0.14	0.006	0.024	0.25											
							Small Mammals (Muskrat)	0.45	0.49	0.022	0.072	0.30	Terrestrial Animals	0.026	0.088								
							Birds (Mallard)	0.10	0.11	0.005	0.016	0.30											
Canada Goose	3.7	c	0.023	-	0.115	a	Browse	1.00	1.00	0.023	0.115	0.20	Terrestrial Plants	0.023	0.115	8.2	0	8.2	Canada goose	0.002	0.142	0.082	c
Olive-Sided Flycatcher	0.03	d	0.008	-			Soil Invertebrates (Earthworms)	0.90	0.86	0.007	0.039	0.17	Terrestrial Plants	0.007	0.039	8.9	1.5	10.4	American woodcock	0.001	0.006	0.058	l
							Benthic Invertebrates	0.10	0.14	0.001	0.004	0.25	Aquatic Animals	0.001	0.004								
Bald Eagle	5.8	a		-	0.691	a	Fish (Northern Pike)	0.80	0.77	0.138	0.553	0.25	Aquatic Animals	0.138	0.553	9.3	0	9.3	Wild turkey	0.051	0.191	1.310	a
							Riparian birds (Mallard)	0.20	0.23	0.041	0.138	0.30	Terrestrial Animals	0.041	0.138								
American Robin	0.1	a			0.202	a, h	Fruit (Berries)	0.60	0.82	0.062	0.121	0.52	Terrestrial Plants	0.076	0.202	10.4	0	10.4	American woodcock	0.008	0.013	0.142	l
							Soil Invertebrates (Earthworms)	0.40	0.18	0.014	0.081	0.17											
Lesser Scaup	0.8	a	0.063	a			Benthic Invertebrates	0.90	0.90	0.056	0.226	0.25	Aquatic Animals	0.056	0.226	0	3.3	3.3	Mallard	0.002	0.051	0.350	a
							Macrophytes	0.10	0.10	0.006	0.025	0.25	Aquatic Plants	0.006	0.250								
Mallard	1.1	c	0.060	c	0.240	-	Macrophytes	0.25	0.25	0.015	0.060	0.25	Aquatic Plants	0.015	0.060	0	3.3	3.3	Mallard	0.002	0.064	0.020	c
							Benthic Invertebrates	0.75	0.75	0.045	0.180	0.25	Aquatic Animals	0.045	0.180								
Common Loon	5.3	b	0.159	b	0.636	-	Fish (Northern Pike)	0.90	0.90	0.143	0.572	0.25	Aquatic Animals	0.159	0.636	0	0	0	negligible	0	0.180	1.477	l
							Benthic Invertebrates	0.10	0.10	0.016	0.064	0.25											

Notes:

[a] USEPA (1993). Body weights, ingestion rates and inhalation rates of adults or all groups (adults and juveniles) are an average of the listed values. If only a range is given, the upper limit of the range is used. Values for the southern red-backed vole was based on the meadow vole

[b] FCSAP Ecological Risk Assessment Guidance, Module 3: Standardization of Wildlife Receptor Characteristics (March 2012)

[c] CSA Standard N288.1-20 (March 2020), Clause 7.7.4.2, and Table A.5d

[d] Environment Canada. 2015. Recovery Strategy for Olive-sided Flycatcher (*Contopus cooperi*) in Canada; average for adult male/female weight range of 31 to 34 g.

[e] COSEWIC Assessment and Update Status Report on the Woodland Caribou (2002). Body weight calculated as a mean of the male and female upper range.

[f] Hinterland Who's Who. 2007. Average of males and females from http://www.hww.ca/en/wildlife/mammals/black-bear.html

[g] Moisture/dry weight fraction values are based on Beresford *et al,* 2008 (soil invertebrate - assume earthworm); Omnia 2019 (blueberries, lichen and small mammal - assuming vole); and CSA Standard N288.1-20 (all other receptors). The blueberry value is based on the fruit only.

[h] The total feed intake for the American Robin was used in the absence of a species-specific value.

[i] The body weight and total feed intake for the Meadow Vole was used in the absence of a species-specific value.

[j] Beyer *et al*, 1994

[k] Intake of Soil & Sediment (kg dw/d) = Total Feed Intake (kg dw/d) x Intake of Soil & Sediment (%)/100.

[l] Calculated using allometric equations in USEPA (1993)

[m] The % intake of soil or sediment is calculated from the combined % intake of soil and sediment, weighted to the relative proportions of terrestrial vs. aquatic dietary components for each receptor, based on the following equations.
Intake of Soil (%) = Total Intake of Soil & Sediment (%) x Feed Type Fraction Terrestrial. Intake of Sediment (%) = Total Intake of Soil & Sediment (%) x Feed Type Fraction Aquatic.

[n] U.S.FWS (Fish and Wildlife Service), 2017. Species Status Assessment for the Canada Lynx (Lynxcanadensis), Contiguous United States Distinct Population Segment. Version 1.0 - Final, October 2017. Lakewood, Colorado.

fw = fresh weight; dw = dry weight

5.2.4.2 Occupancy Factors, Dose Coefficients, Bioaccumulation Factors, and Transfer Factors

Short descriptions of the role of OFs, DCFs, BAFs, and TFs are provided in Table 5-8. Additional details and the numeric factors are presented in Appendix A.

Table 5-8: Exposure Factors Used in the IMPACT Model for the Wheeler River ERA

Exposure Factor	Description	Appendix A
OFs	An OF is defined as the fraction of time the receptor species spends in or on various media. The OFs are based on the experience and judgment of the risk assessor and the known behaviour of the receptor. The OFs for air, soil/sediment, soil/sediment surface, and water were used in the model.	Section 2.3.3.2, Occupancy Factor
DCFs	The DCFs represent the dose-equivalent rate per unit concentration of a radionuclide in the environment (or tissue) for a particular mode of exposure. The model used DCFs for external and internal exposures to radionuclides. Aquatic DCFs were based on values published by the ICRP for aquatic plants and northern pike (ICRP 2008), and were calculated with the ERICA Tool (Brown et al. 2008) for benthic invertebrates, zooplankton, and whitefish DCFs. Terrestrial plant and invertebrate DCFs were based on values published by the ICRP (ICRP 2008). Terrestrial animal DCFs follow the approach of ICRP (ICRP 2008).	Section 3.6.3, Dose Coefficients for Aquatic Receptors Section 3.7.3, Dose Coefficients for Terrestrial Plants and Invertebrates Section 3.7.6, Dose Coefficients for Terrestrial Animals, Birds, and Humans
TFs and BAFs	The TFs are the ratio of concentration in an animal to the animal's daily intake of a COPC. BAFs are the ratio of concentration in an organism to the concentration in an environmental medium. The TFs and BAFs are generally COPC- and biota-specific. Aquatic BAFs were generally obtained from CSA N288.1-20 and IAEA (2010), and from publicly available regional data from other uranium mine sites in northern Saskatchewan. The soil-to-plant BAFs were derived from regional data from Northern Saskatchewan. An allometric equation (transfer proportional to a -3/4 power of body weight) (CSA N288.6-22) was applied to transfer factors available for beef and poultry from CSA N288.1-20, IAEA (2010), or NCRP (1996) to estimate the	Section 3.6.1, Aquatic Bioaccumulation Factors Section 3.7.1, Soil-to-Plant Transfer Section 3.7.4, Ingestion Transfer Factors for Terrestrial Receptors Section 3.7.5, Inhalation Transfer Factors for Terrestrial Receptors

Exposure Factor	Description	Appendix A
	ingestion transfer factors for the mammal and bird receptors, respectively. Inhalation TFs for terrestrial receptors were calculated from the ingestion transfer factor by adjusting the ingestion transfer factor by a COPC-specific inhalation/ingestion ratio (II) from CSA N288.1-20.	

IAEA = International Atomic Energy Agency; BAF = bioaccumulation factor; OF = occupancy factor; TF = transfer factor; DCF = dose coefficient factor; NCRP = National Council on Radiation Protection and Measurements; ICRP = International Commission on Radiological Protection; CSA = Canadian Standards Association; COPC = constituent of potential concern.

5.2.5 Exposure Point Concentrations and Doses

This subsection presents the estimated non-radiological and radiological doses to aquatic and terrestrial ecological receptors due to releases from the Project during all phases of the Project. The results are presented as a total dose which includes both baseline and Project contributions. While non-radiological and radiological doses were predicted in IMPACT over the life of the Project, the maximum doses are represented in this section. The estimated non-radiological and radiological concentrations in environmental media and biota tissue concentrations are shown in Appendix B.

5.2.5.1 Non-radiological Dose

Non-radiological dose was only calculated for birds and mammals, as effects to aquatic animals (fish and invertebrates) and plants and soil invertebrates are assessed based on concentrations and not doses.

The estimated non-radiological doses to the selected birds and mammals during the Project phases are shown by COPC in Table 5-9. The doses shown represent the maximum dose by COPC over the assessment period, which is during the operation phase for the Project. The results are presented as a total dose which includes both baseline and Project contributions. The non-radiological dose to birds and mammals during the future centuries is also shown in Table 5-9.

Table 5-9: Estimated Non-radiological Project Total Doses to Ecological Receptors – Project Phases and Future Centuries

Biota		Location	Maximum Non-radiological Dose During Project Phases (mg/kg/d)											
			As	Cd	Cl-	Co	Cr	Cu	Mo	SO4	Se	U	V	Zn
			Arsenic	Cadmium	Chloride	Cobalt	Chromium	Copper	Molybdenum	Sulphate	Selenium	Uranium	Vanadium	Zinc
Terrestrial Animals	Black Bear	Reference (Kratchkowsky Lake)	4.84E-03	5.32E-04	2.01E-02	2.27E-03	3.90E-03	1.47E-01	1.75E-03	4.28E-02	5.43E-03	1.20E-03	4.72E-03	3.69E-01
		Whitefish Lake	4.86E-03	5.33E-04	1.57E-01	2.27E-03	3.97E-03	1.48E-01	2.32E-03	9.39E-01	1.52E-02	2.07E-03	4.89E-03	3.73E-01
	Canada Lynx	Reference (Kratchkowsky Lake)	1.61E-02	2.50E-03	2.44E-02	5.64E-04	6.54E-03	3.38E-01	5.49E-04	5.20E-02	2.87E-02	5.81E-04	1.02E-02	1.43E+01
		Whitefish Lake	1.62E-02	2.50E-03	4.65E-01	5.70E-04	6.64E-03	3.48E-01	2.43E-03	2.93E+00	2.91E-02	6.46E-03	1.04E-02	1.43E+01
		McGowan Lake	1.61E-02	2.50E-03	3.18E-01	5.66E-04	6.56E-03	3.39E-01	1.76E-03	1.97E+00	2.88E-02	1.37E-03	1.02E-02	1.43E+01
		Russell Lake Inlet	1.61E-02	2.50E-03	2.47E-01	5.65E-04	6.55E-03	3.38E-01	1.46E-03	1.51E+00	2.88E-02	8.02E-04	1.02E-02	1.43E+01
	Mink	Reference (Kratchkowsky Lake)	1.05E-02	7.71E-04	3.25E-02	1.04E-03	1.37E-02	1.46E-01	6.42E-04	6.81E-02	1.44E-02	7.02E-04	1.39E-02	3.17E-01
		Whitefish Lake	1.33E-02	9.39E-04	6.18E-01	1.20E-03	1.68E-02	1.83E-01	8.68E-02	3.83E+00	1.26E-01	6.74E-03	3.43E-02	4.62E-01
		McGowan Lake	1.16E-02	8.80E-04	4.23E-01	1.15E-03	1.57E-02	1.72E-01	6.23E-02	2.58E+00	8.23E-02	3.00E-03	2.19E-02	4.01E-01
		Russell Lake Inlet	1.11E-02	8.51E-04	3.29E-01	1.12E-03	1.52E-02	1.66E-01	4.74E-02	1.97E+00	6.45E-02	2.20E-03	1.89E-02	3.77E-01
	Moose	Reference (Kratchkowsky Lake)	2.47E-03	1.06E-03	1.78E-02	1.18E-03	1.84E-03	5.89E-02	7.36E-04	3.75E-02	5.98E-04	6.51E-04	4.20E-03	1.68E-01
		Whitefish Lake	2.82E-03	1.10E-03	3.40E-01	1.28E-03	2.08E-03	6.12E-02	1.06E-02	2.11E+00	2.44E-03	1.80E-02	9.84E-03	1.73E-01
		McGowan Lake	2.60E-03	1.08E-03	2.33E-01	1.24E-03	1.98E-03	5.96E-02	7.49E-03	1.42E+00	1.67E-03	3.48E-03	6.25E-03	1.70E-01
		Russell Lake Inlet	2.55E-03	1.08E-03	1.81E-01	1.22E-03	1.95E-03	5.94E-02	5.84E-03	1.08E+00	1.37E-03	1.73E-03	5.49E-03	1.70E-01
	Moose Organs	Reference (Kratchkowsky Lake)	2.47E-03	1.06E-03	1.78E-02	1.18E-03	1.84E-03	5.89E-02	7.36E-04	3.75E-02	5.98E-04	6.51E-04	4.20E-03	1.68E-01
		McGowan Lake	2.60E-03	1.08E-03	2.33E-01	1.24E-03	1.98E-03	5.96E-02	7.49E-03	1.42E+00	1.67E-03	3.48E-03	6.25E-03	1.70E-01
		Russell Lake Inlet	2.55E-03	1.08E-03	1.81E-01	1.22E-03	1.95E-03	5.94E-02	5.84E-03	1.08E+00	1.37E-03	1.73E-03	5.49E-03	1.70E-01
	Muskrat	Reference (Kratchkowsky Lake)	2.56E-02	1.21E-03	3.84E-02	4.50E-03	1.59E-02	3.72E-02	1.02E-03	6.70E-02	2.98E-03	1.81E-03	4.09E-02	1.20E-01
		Whitefish Lake	3.34E-02	1.86E-03	7.31E-01	5.67E-03	2.07E-02	4.88E-02	1.84E-01	3.77E+00	3.21E-02	2.48E-02	1.45E-01	1.78E-01
		McGowan Lake	2.87E-02	1.62E-03	5.00E-01	5.26E-03	1.91E-02	4.47E-02	1.29E-01	2.54E+00	2.03E-02	1.60E-02	8.07E-02	1.53E-01
		Russell Lake Inlet	2.75E-02	1.51E-03	3.89E-01	5.06E-03	1.82E-02	4.28E-02	9.81E-02	1.94E+00	1.55E-02	1.21E-02	6.61E-02	1.43E-01
	Snowshoe Hare	Reference (Kratchkowsky Lake)	6.76E-03	3.71E-03	3.04E-02	4.09E-03	8.23E-03	2.53E-01	3.19E-03	6.49E-02	2.24E-03	2.73E-03	1.30E-02	6.87E-01
		Whitefish Lake	6.78E-03	3.72E-03	5.80E-01	4.13E-03	8.31E-03	2.60E-01	5.51E-03	3.65E+00	2.30E-03	5.98E-02	1.32E-02	6.89E-01
		McGowan Lake	6.76E-03	3.71E-03	3.97E-01	4.09E-03	8.25E-03	2.54E-01	4.67E-03	2.46E+00	2.27E-03	1.02E-02	1.30E-02	6.88E-01
		Russell Lake Inlet	6.76E-03	3.71E-03	3.08E-01	4.09E-03	8.24E-03	2.53E-01	4.30E-03	1.88E+00	2.26E-03	4.75E-03	1.30E-02	6.87E-01
	Southern Red-Backed Vole	Reference (Kratchkowsky Lake)	1.58E-01	2.40E-02	4.49E-02	9.13E-02	2.70E-02	6.31E+00	7.48E-02	9.57E-02	6.19E-02	4.17E-02	3.16E-02	1.56E+01
		Whitefish Lake	1.58E-01	2.40E-02	8.55E-01	9.18E-02	2.73E-02	6.52E+00	7.87E-02	5.38E+00	6.23E-02	5.43E-01	3.23E-02	1.57E+01
		McGowan Lake	1.58E-01	2.40E-02	5.85E-01	9.13E-02	2.70E-02	6.33E+00	7.70E-02	3.62E+00	6.20E-02	1.08E-01	3.17E-02	1.56E+01
		Russell Lake Inlet	1.58E-01	2.40E-02	4.54E-01	9.13E-02	2.70E-02	6.31E+00	7.65E-02	2.77E+00	6.19E-02	5.93E-02	3.17E-02	1.56E+01
	WoodLand Caribou	Reference (Kratchkowsky Lake)	5.33E-03	1.60E-03	1.99E-02	2.17E-03	2.09E-02	4.10E-02	1.35E-03	4.05E-02	1.53E-03	1.74E-03	1.70E-02	2.12E-01
		Whitefish Lake	5.55E-03	1.63E-03	1.56E-01	2.22E-03	2.12E-02	4.24E-02	1.04E-02	8.87E-01	2.52E-03	5.15E-02	1.96E-02	2.14E-01
	Canada Goose	Reference (Kratchkowsky Lake)	7.66E-04	5.49E-04	1.24E-02	4.51E-04	1.78E-03	2.35E-02	3.28E-04	2.64E-02	2.16E-04	3.80E-04	2.73E-03	6.71E-02
		Whitefish Lake	7.63E-04	5.49E-04	0.00E+00	4.51E-04	1.77E-03	2.41E-02	3.27E-04	0.00E+00	2.16E-04	7.94E-03	2.74E-03	6.72E-02
		McGowan Lake	7.66E-04	5.49E-04	1.61E-01	4.52E-04	1.78E-03	2.35E-02	9.29E-04	9.99E-01	2.25E-04	1.38E-03	2.74E-03	6.71E-02
		Russell Lake Inlet	7.66E-04	5.49E-04	1.25E-01	4.52E-04	1.78E-03	2.35E-02	7.78E-04	7.63E-01	2.22E-04	6.53E-04	2.74E-03	6.71E-02
	Bald Eagle	Reference (Kratchkowsky Lake)	1.01E-02	3.34E-03	1.07E-02	2.67E-03	3.40E-02	6.28E-02	1.05E-03	2.28E-02	2.18E-02	3.52E-03	4.53E-02	1.91E-01
		Whitefish Lake	1.01E-02	3.34E-03	2.43E-02	2.67E-03	3.40E-02	6.36E-02	1.45E-03	1.12E-01	3.07E-02	3.98E-03	4.55E-02	1.95E-01
	Olive-Sided Flycatcher	Reference (Kratchkowsky Lake)	2.82E-02	1.72E-01	5.95E-02	1.27E-02	1.34E-01	1.02E+00	1.53E-02	1.27E-01	4.15E-02	1.28E-02	1.25E-01	2.35E+00
		Whitefish Lake	3.01E-02	1.73E-01	0.00E+00	1.33E-02	1.41E-01	1.17E+00	3.72E-01	0.00E+00	7.37E-02	2.75E-01	1.40E-01	2.49E+00
		McGowan Lake	2.90E-02	1.72E-01	7.76E-01	1.31E-02	1.39E-01	1.12E+00	2.74E-01	4.81E+00	6.19E-02	4.93E-02	1.31E-01	2.44E+00
		Russell Lake Inlet	2.87E-02	1.72E-01	6.02E-01	1.30E-02	1.37E-01	1.10E+00	2.12E-01	3.67E+00	5.64E-02	2.38E-02	1.29E-01	2.42E+00
		Reference (Kratchkowsky Lake)	4.43E-03	7.86E-05	1.09E-02	3.76E-04	5.54E-03	9.10E-02	2.11E-04	2.33E-02	2.08E-02	1.03E-04	2.33E-03	1.85E-01

Biota		Location	Maximum Non-radiological Dose During Project Phases (mg/kg/d)											
			As	Cd	Cl-	Co	Cr	Cu	Mo	SO4	Se	U	V	Zn
			Arsenic	Cadmium	Chloride	Cobalt	Chromium	Copper	Molybdenum	Sulphate	Selenium	Uranium	Vanadium	Zinc
	Common Loon	Whitefish Lake	5.49E-03	1.17E-04	2.09E-01	4.63E-04	7.52E-03	1.16E-01	3.60E-02	1.31E+00	1.73E-01	1.69E-03	8.94E-03	2.76E-01
		McGowan Lake	4.73E-03	1.03E-04	1.43E-01	4.35E-04	6.75E-03	1.08E-01	2.58E-02	8.84E-01	1.13E-01	1.02E-03	4.58E-03	2.37E-01
		Russell Lake Inlet	4.57E-03	9.68E-05	1.11E-01	4.21E-04	6.41E-03	1.04E-01	1.96E-02	6.75E-01	8.96E-02	7.68E-04	3.75E-03	2.22E-01
	Mallard	Reference (Kratchkowsky Lake)	2.33E-02	1.61E-03	2.32E-02	4.50E-03	4.22E-02	7.73E-01	3.38E-03	3.89E-02	6.71E-03	1.57E-03	3.04E-02	4.91E-01
		Whitefish Lake	3.07E-02	2.39E-03	4.42E-01	5.50E-03	5.47E-02	9.67E-01	5.76E-01	2.19E+00	6.05E-02	2.00E-02	1.03E-01	6.77E-01
		McGowan Lake	2.64E-02	2.12E-03	3.02E-01	5.20E-03	5.06E-02	9.12E-01	4.13E-01	1.47E+00	4.07E-02	1.32E-02	6.01E-02	6.12E-01
		Russell Lake Inlet	2.52E-02	1.98E-03	2.35E-01	5.03E-03	4.84E-02	8.79E-01	3.14E-01	1.13E+00	3.15E-02	1.00E-02	4.92E-02	5.80E-01
	American Robin	Reference (Kratchkowsky Lake)	1.39E-01	1.34E-01	4.07E-02	7.19E-02	2.86E-01	3.73E+00	5.54E-02	8.67E-02	6.44E-02	5.27E-02	3.83E-01	9.73E+00
		Whitefish Lake	1.39E-01	1.34E-01	0.00E+00	7.23E-02	2.86E-01	3.86E+00	5.57E-02	0.00E+00	6.47E-02	5.22E-01	3.83E-01	9.76E+00
		McGowan Lake	1.39E-01	1.34E-01	5.31E-01	7.20E-02	2.86E-01	3.75E+00	5.74E-02	3.29E+00	6.45E-02	1.14E-01	3.83E-01	9.74E+00
		Russell Lake Inlet	1.39E-01	1.34E-01	4.12E-01	7.19E-02	2.86E-01	3.74E+00	5.69E-02	2.51E+00	6.44E-02	6.92E-02	3.83E-01	9.74E+00
	Lesser Scaup	Reference (Kratchkowsky Lake)	4.05E-02	2.95E-03	2.72E-02	1.11E-02	7.12E-02	1.37E+00	5.83E-03	4.27E-02	1.26E-02	2.76E-03	5.85E-02	9.28E-01
		Whitefish Lake	5.30E-02	4.43E-03	5.19E-01	1.37E-02	9.24E-02	1.71E+00	1.00E+00	2.40E+00	1.18E-01	3.71E-02	2.06E-01	1.29E+00
		McGowan Lake	4.55E-02	3.90E-03	3.54E-01	1.29E-02	8.54E-02	1.61E+00	7.17E-01	1.62E+00	7.83E-02	2.40E-02	1.16E-01	1.16E+00
		Russell Lake Inlet	4.35E-02	3.64E-03	2.76E-01	1.24E-02	8.17E-02	1.55E+00	5.45E-01	1.24E+00	6.04E-02	1.82E-02	9.46E-02	1.10E+00

Biota		Location	Maximum Non-radiological Dose During Future Centuries (mg/kg/d)											
			As	Cd	Cl-	Co	Cr	Cu	Mo	SO4	Se	U	V	Zn
			Arsenic	Cadmium	Chloride	Cobalt	Chromium	Copper	Molybdenum	Sulphate	Selenium	Uranium	Vanadium	Zinc
Terrestrial Animals	Black Bear	Reference (Kratchkowsky Lake)	4.74E-03	5.32E-04	2.01E-02	2.27E-03	3.88E-03	1.47E-01	1.75E-03	4.28E-02	5.31E-03	1.20E-03	4.68E-03	3.68E-01
		Whitefish Lake	4.74E-03	5.32E-04	2.26E-02	2.27E-03	3.89E-03	1.47E-01	1.75E-03	4.37E-02	5.69E-03	1.25E-03	4.68E-03	3.69E-01
	Canada Lynx	Reference (Kratchkowsky Lake)	1.61E-02	2.50E-03	2.44E-02	5.64E-04	6.54E-03	3.38E-01	5.49E-04	5.20E-02	2.87E-02	5.81E-04	1.02E-02	1.43E+01
		Whitefish Lake	1.61E-02	2.50E-03	3.14E-02	5.66E-04	6.54E-03	3.38E-01	5.50E-04	5.46E-02	2.87E-02	7.82E-04	1.02E-02	1.43E+01
		McGowan Lake	1.61E-02	2.50E-03	2.97E-02	5.65E-04	6.54E-03	3.38E-01	5.50E-04	5.40E-02	2.87E-02	6.07E-04	1.02E-02	1.43E+01
		Russell Lake Inlet	1.61E-02	2.50E-03	2.85E-02	5.64E-04	6.54E-03	3.38E-01	5.50E-04	5.35E-02	2.87E-02	5.88E-04	1.02E-02	1.43E+01
	Mink	Reference (Kratchkowsky Lake)	1.01E-02	7.70E-04	3.25E-02	1.04E-03	1.37E-02	1.46E-01	6.42E-04	6.81E-02	1.40E-02	7.00E-04	1.36E-02	3.11E-01
		Whitefish Lake	1.05E-02	7.72E-04	4.18E-02	1.08E-03	1.38E-02	1.47E-01	6.88E-04	7.14E-02	1.81E-02	9.24E-04	1.37E-02	3.38E-01
		McGowan Lake	1.03E-02	7.72E-04	3.96E-02	1.07E-03	1.38E-02	1.47E-01	6.76E-04	7.06E-02	1.67E-02	7.59E-04	1.37E-02	3.30E-01
		Russell Lake Inlet	1.02E-02	7.71E-04	3.79E-02	1.06E-03	1.37E-02	1.47E-01	6.68E-04	7.00E-02	1.60E-02	7.33E-04	1.37E-02	3.25E-01
	Moose	Reference (Kratchkowsky Lake)	2.42E-03	1.06E-03	1.78E-02	1.18E-03	1.84E-03	5.89E-02	7.36E-04	3.75E-02	5.94E-04	6.50E-04	4.06E-03	1.68E-01
		Whitefish Lake	2.46E-03	1.06E-03	2.30E-02	1.20E-03	1.85E-03	5.90E-02	7.41E-04	3.93E-02	6.50E-04	7.86E-04	4.08E-03	1.68E-01
		McGowan Lake	2.43E-03	1.06E-03	2.17E-02	1.19E-03	1.84E-03	5.89E-02	7.40E-04	3.89E-02	6.31E-04	6.78E-04	4.07E-03	1.68E-01
		Russell Lake Inlet	2.43E-03	1.06E-03	2.08E-02	1.19E-03	1.84E-03	5.89E-02	7.39E-04	3.85E-02	6.21E-04	6.63E-04	4.07E-03	1.68E-01
	Moose Organs	Reference (Kratchkowsky Lake)	2.42E-03	1.06E-03	1.78E-02	1.18E-03	1.84E-03	5.89E-02	7.36E-04	3.75E-02	5.94E-04	6.50E-04	4.06E-03	1.68E-01
		McGowan Lake	2.43E-03	1.06E-03	2.17E-02	1.19E-03	1.84E-03	5.89E-02	7.40E-04	3.89E-02	6.31E-04	6.78E-04	4.07E-03	1.68E-01
		Russell Lake Inlet	2.43E-03	1.06E-03	2.08E-02	1.19E-03	1.84E-03	5.89E-02	7.39E-04	3.85E-02	6.21E-04	6.63E-04	4.07E-03	1.68E-01
	Muskrat	Reference (Kratchkowsky Lake)	2.50E-02	1.20E-03	3.84E-02	4.48E-03	1.58E-02	3.70E-02	1.02E-03	6.70E-02	2.93E-03	1.80E-03	3.92E-02	1.17E-01
		Whitefish Lake	2.59E-02	1.21E-03	4.94E-02	4.72E-03	1.60E-02	3.75E-02	1.11E-03	7.02E-02	3.90E-03	2.20E-03	3.96E-02	1.27E-01
		McGowan Lake	2.54E-02	1.21E-03	4.68E-02	4.66E-03	1.60E-02	3.73E-02	1.09E-03	6.95E-02	3.57E-03	2.07E-03	3.94E-02	1.24E-01
		Russell Lake Inlet	2.52E-02	1.21E-03	4.48E-02	4.62E-03	1.59E-02	3.73E-02	1.07E-03	6.89E-02	3.40E-03	2.00E-03	3.93E-02	1.22E-01
	Snowshoe Hare	Reference (Kratchkowsky Lake)	6.75E-03	3.71E-03	3.04E-02	4.09E-03	8.23E-03	2.53E-01	3.19E-03	6.49E-02	2.24E-03	2.73E-03	1.30E-02	6.87E-01
		Whitefish Lake	6.75E-03	3.71E-03	3.92E-02	4.10E-03	8.23E-03	2.53E-01	3.19E-03	6.81E-02	2.24E-03	3.46E-03	1.30E-02	6.88E-01
		McGowan Lake	6.75E-03	3.71E-03	3.71E-02	4.09E-03	8.23E-03	2.53E-01	3.19E-03	6.73E-02	2.24E-03	2.83E-03	1.30E-02	6.87E-01
		Russell Lake Inlet	6.75E-03	3.71E-03	3.56E-02	4.09E-03	8.23E-03	2.53E-01	3.19E-03	6.68E-02	2.24E-03	2.76E-03	1.30E-02	6.87E-01

Biota	Location	Maximum Non-radiological Dose During Future Centuries (mg/kg/d)											
		As	Cd	Cl-	Co	Cr	Cu	Mo	SO4	Se	U	V	Zn
		Arsenic	Cadmium	Chloride	Cobalt	Chromium	Copper	Molybdenum	Sulphate	Selenium	Uranium	Vanadium	Zinc
Southern Red-Backed Vole	Reference (Kratchkowsky Lake)	1.58E-01	2.40E-02	4.49E-02	9.13E-02	2.70E-02	6.31E+00	7.48E-02	9.57E-02	6.19E-02	4.17E-02	3.16E-02	1.56E+01
	Whitefish Lake	1.58E-01	2.40E-02	5.77E-02	9.15E-02	2.70E-02	6.31E+00	7.48E-02	1.00E-01	6.19E-02	5.56E-02	3.16E-02	1.56E+01
	McGowan Lake	1.58E-01	2.40E-02	5.47E-02	9.13E-02	2.70E-02	6.31E+00	7.48E-02	9.92E-02	6.19E-02	4.35E-02	3.16E-02	1.56E+01
	Russell Lake Inlet	1.58E-01	2.40E-02	5.24E-02	9.13E-02	2.70E-02	6.31E+00	7.48E-02	9.84E-02	6.19E-02	4.22E-02	3.16E-02	1.56E+01
WoodLand Caribou	Reference (Kratchkowsky Lake)	5.27E-03	1.60E-03	1.99E-02	2.17E-03	2.09E-02	4.10E-02	1.35E-03	4.05E-02	1.52E-03	1.74E-03	1.68E-02	2.12E-01
	Whitefish Lake	5.30E-03	1.60E-03	2.23E-02	2.18E-03	2.09E-02	4.10E-02	1.36E-03	4.13E-02	1.56E-03	1.77E-03	1.69E-02	2.12E-01
Canada Goose	Reference (Kratchkowsky Lake)	7.65E-04	5.49E-04	1.24E-02	4.51E-04	1.78E-03	2.35E-02	3.28E-04	2.64E-02	2.16E-04	3.80E-04	2.73E-03	6.71E-02
	Whitefish Lake	7.61E-04	5.48E-04	0.00E+00	4.48E-04	1.76E-03	2.35E-02	3.24E-04	0.00E+00	2.14E-04	4.82E-04	2.72E-03	6.71E-02
	McGowan Lake	7.65E-04	5.49E-04	1.51E-02	4.51E-04	1.78E-03	2.35E-02	3.28E-04	2.74E-02	2.16E-04	3.93E-04	2.73E-03	6.71E-02
	Russell Lake Inlet	7.65E-04	5.49E-04	1.44E-02	4.51E-04	1.78E-03	2.35E-02	3.28E-04	2.71E-02	2.16E-04	3.84E-04	2.73E-03	6.71E-02
Bald Eagle	Reference (Kratchkowsky Lake)	9.63E-03	3.34E-03	1.07E-02	2.67E-03	3.39E-02	6.26E-02	1.05E-03	2.28E-02	2.13E-02	3.52E-03	4.51E-02	1.88E-01
	Whitefish Lake	9.64E-03	3.34E-03	1.09E-02	2.67E-03	3.39E-02	6.27E-02	1.06E-03	2.29E-02	2.17E-02	3.54E-03	4.51E-02	1.89E-01
Olive-Sided Flycatcher	Reference (Kratchkowsky Lake)	2.82E-02	1.72E-01	5.95E-02	1.27E-02	1.34E-01	1.02E+00	1.53E-02	1.27E-01	4.15E-02	1.28E-02	1.25E-01	2.35E+00
	Whitefish Lake	2.84E-02	1.72E-01	0.00E+00	1.28E-02	1.34E-01	1.03E+00	1.55E-02	0.00E+00	4.28E-02	1.63E-02	1.25E-01	2.39E+00
	McGowan Lake	2.83E-02	1.72E-01	7.25E-02	1.28E-02	1.34E-01	1.02E+00	1.55E-02	1.32E-01	4.24E-02	1.33E-02	1.25E-01	2.38E+00
	Russell Lake Inlet	2.83E-02	1.72E-01	6.95E-02	1.28E-02	1.34E-01	1.02E+00	1.54E-02	1.31E-01	4.21E-02	1.30E-02	1.25E-01	2.37E+00
Common Loon	Reference (Kratchkowsky Lake)	3.91E-03	7.84E-05	1.09E-02	3.75E-04	5.47E-03	9.09E-02	2.11E-04	2.33E-02	2.02E-02	1.01E-04	2.11E-03	1.81E-01
	Whitefish Lake	4.06E-03	7.89E-05	1.41E-02	3.95E-04	5.54E-03	9.21E-02	2.30E-04	2.45E-02	2.56E-02	1.23E-04	2.13E-03	1.97E-01
	McGowan Lake	3.97E-03	7.87E-05	1.33E-02	3.90E-04	5.52E-03	9.18E-02	2.25E-04	2.42E-02	2.39E-02	1.16E-04	2.11E-03	1.92E-01
	Russell Lake Inlet	3.95E-03	7.86E-05	1.28E-02	3.87E-04	5.51E-03	9.16E-02	2.22E-04	2.40E-02	2.29E-02	1.12E-04	2.11E-03	1.89E-01
Mallard	Reference (Kratchkowsky Lake)	2.32E-02	1.61E-03	2.32E-02	4.50E-03	4.22E-02	7.73E-01	3.38E-03	3.89E-02	6.70E-03	1.57E-03	3.00E-02	4.90E-01
	Whitefish Lake	2.40E-02	1.62E-03	2.99E-02	4.73E-03	4.27E-02	7.83E-01	3.68E-03	4.08E-02	8.93E-03	1.91E-03	3.03E-02	5.33E-01
	McGowan Lake	2.35E-02	1.62E-03	2.83E-02	4.67E-03	4.26E-02	7.81E-01	3.61E-03	4.04E-02	8.18E-03	1.80E-03	3.01E-02	5.19E-01
	Russell Lake Inlet	2.34E-02	1.62E-03	2.71E-02	4.63E-03	4.25E-02	7.79E-01	3.55E-03	4.00E-02	7.79E-03	1.74E-03	3.01E-02	5.12E-01
American Robin	Reference (Kratchkowsky Lake)	1.39E-01	1.34E-01	4.07E-02	7.19E-02	2.86E-01	3.73E+00	5.54E-02	8.67E-02	6.44E-02	5.27E-02	3.83E-01	9.73E+00
	Whitefish Lake	1.39E-01	1.34E-01	0.00E+00	7.21E-02	2.86E-01	3.74E+00	5.54E-02	0.00E+00	6.44E-02	7.14E-02	3.83E-01	9.74E+00
	McGowan Lake	1.39E-01	1.34E-01	4.96E-02	7.19E-02	2.86E-01	3.73E+00	5.54E-02	9.00E-02	6.44E-02	5.51E-02	3.83E-01	9.73E+00
	Russell Lake Inlet	1.39E-01	1.34E-01	4.75E-02	7.19E-02	2.86E-01	3.73E+00	5.54E-02	8.92E-02	6.44E-02	5.33E-02	3.83E-01	9.73E+00
Lesser Scaup	Reference (Kratchkowsky Lake)	3.97E-02	2.94E-03	2.72E-02	1.10E-02	7.11E-02	1.37E+00	5.83E-03	4.27E-02	1.25E-02	2.74E-03	5.64E-02	9.25E-01
	Whitefish Lake	4.12E-02	2.96E-03	3.51E-02	1.16E-02	7.20E-02	1.38E+00	6.35E-03	4.48E-02	1.67E-02	3.35E-03	5.69E-02	1.00E+00
	McGowan Lake	4.03E-02	2.95E-03	3.32E-02	1.15E-02	7.18E-02	1.38E+00	6.22E-03	4.43E-02	1.53E-02	3.15E-03	5.66E-02	9.80E-01
	Russell Lake Inlet	4.01E-02	2.95E-03	3.18E-02	1.14E-02	7.16E-02	1.38E+00	6.13E-03	4.40E-02	1.45E-02	3.04E-03	5.65E-02	9.66E-01

5.2.5.2 Radiological Dose

The estimated radiation doses to aquatic and terrestrial ecological receptors during the Project phases and the future centuries are shown in Table 5-10. The doses shown represent the maximum total dose from all radionuclides over the assessment period. The dose breakdown by radionuclide is shown in Appendix B. The results are presented as a total dose which includes both baseline and Project contributions.

The maximum predicted dose during the Project phases for terrestrial and riparian biota is to lichen near Whitefish Lake (0.99 mGy/d), and the main contributors to total dose are from uranium-234 and uranium-238 in air that deposits to lichen. The maximum predicted dose for aquatic biota is to zooplankton at Whitefish Lake (0.10 mGy/d), and the main contributor to total dose is from polonium-210 in water.

The maximum predicted dose during the future centuries to aquatic biota is to zooplankton (0.08 mGy/d) in Whitefish Lake from polonium-210 in water. The maximum predicted dose during the future centuries to terrestrial and riparian biota is to the scaup (0.05 mGy/d) who eats aquatic animals from Whitefish Lake. For terrestrial plants the dose during the future centuries is 0.22 mGy/d for lichen at all locations, due to background concentrations of polonium-210 in lichen.

Table 5-10: Estimated Radiological Project Total Doses to Ecological Receptors – Project Phases and Future Centuries

Biota		Location	Maximum Radiological Dose During Project Phases (mGy/d)							Maximum Radiological Dose During Future Centuries (mGy/d)						
			Uranium-238	Uranium-234	Thorium-230	Radium-226	Lead-210	Polonium-210	Total Dose	Uranium-238	Uranium-234	Thorium-230	Radium-226	Lead-210	Polonium-210	Total Dose
Aquatic Plants	Macrophytes	Reference (Kratchkowsky Lake)	1.13E-05	1.28E-05	1.53E-03	3.08E-03	6.21E-05	1.35E-03	**6.04E-03**	1.09E-05	1.24E-05	1.52E-03	3.01E-03	5.27E-05	1.15E-03	**5.75E-03**
		Whitefish Lake North (LA-6)	1.10E-05	1.25E-05	1.53E-03	3.04E-03	5.68E-05	1.23E-03	**5.88E-03**	1.09E-05	1.24E-05	1.52E-03	3.01E-03	5.27E-05	1.15E-03	**5.75E-03**
		Whitefish Lake Middle (LA-5 North)	2.06E-04	2.35E-04	2.82E-03	3.71E-03	8.35E-05	1.43E-03	**8.48E-03**	1.33E-05	1.51E-05	1.56E-03	3.45E-03	6.05E-05	1.31E-03	**6.42E-03**
		Whitefish Lake South (LA-5 South)	1.96E-04	2.23E-04	2.80E-03	3.63E-03	8.24E-05	1.54E-03	**8.47E-03**	1.32E-05	1.50E-05	1.56E-03	3.44E-03	5.91E-05	1.29E-03	**6.37E-03**
		McGowan Lake (LA-1)	1.21E-04	1.38E-04	2.37E-03	3.41E-03	6.67E-05	1.33E-03	**7.44E-03**	1.25E-05	1.42E-05	1.55E-03	3.32E-03	5.56E-05	1.21E-03	**6.16E-03**
		Russell Lake Inlet	9.04E-05	1.03E-04	2.16E-03	3.31E-03	6.40E-05	1.32E-03	**7.04E-03**	1.20E-05	1.37E-05	1.55E-03	3.24E-03	5.45E-05	1.18E-03	**6.05E-03**
	Phytoplankton	Reference (Kratchkowsky Lake)	1.13E-05	1.28E-05	1.53E-03	3.07E-03	6.15E-05	1.35E-03	**6.04E-03**	1.09E-05	1.24E-05	1.52E-03	3.01E-03	5.21E-05	1.15E-03	**5.75E-03**
		Whitefish Lake North (LA-6)	1.10E-05	1.25E-05	1.53E-03	3.03E-03	5.62E-05	1.23E-03	**5.87E-03**	1.09E-05	1.24E-05	1.52E-03	3.01E-03	5.21E-05	1.15E-03	**5.75E-03**
		Whitefish Lake Middle (LA-5 North)	2.06E-04	2.35E-04	2.82E-03	3.70E-03	8.26E-05	1.43E-03	**8.47E-03**	1.33E-05	1.51E-05	1.56E-03	3.45E-03	5.98E-05	1.31E-03	**6.41E-03**
		Whitefish Lake South (LA-5 South)	1.96E-04	2.23E-04	2.80E-03	3.63E-03	8.15E-05	1.54E-03	**8.47E-03**	1.32E-05	1.50E-05	1.56E-03	3.43E-03	5.84E-05	1.29E-03	**6.37E-03**
		McGowan Lake (LA-1)	1.21E-04	1.38E-04	2.37E-03	3.41E-03	6.60E-05	1.33E-03	**7.43E-03**	1.25E-05	1.42E-05	1.55E-03	3.31E-03	5.50E-05	1.21E-03	**6.16E-03**
		Russell Lake Inlet	9.04E-05	1.03E-04	2.16E-03	3.31E-03	6.33E-05	1.32E-03	**7.04E-03**	1.20E-05	1.37E-05	1.55E-03	3.24E-03	5.39E-05	1.18E-03	**6.04E-03**
Aquatic Animals	Benthic Invertebrate	Reference (Kratchkowsky Lake)	4.94E-09	6.45E-09	2.00E-08	8.13E-05	3.95E-05	1.79E-09	**1.21E-04**	4.94E-09	6.44E-09	2.00E-08	8.13E-05	3.95E-05	1.79E-09	**1.21E-04**
		Whitefish Lake North (LA-6)	4.94E-09	6.44E-09	2.00E-08	8.13E-05	3.95E-05	1.79E-09	**1.21E-04**	4.94E-09	6.44E-09	2.00E-08	8.13E-05	3.95E-05	1.79E-09	**1.21E-04**
		Whitefish Lake Middle (LA-5 North)	6.10E-08	7.96E-08	3.31E-08	9.45E-05	5.88E-05	2.62E-09	**1.53E-04**	6.04E-09	7.88E-09	2.06E-08	9.32E-05	4.53E-05	2.05E-09	**1.39E-04**
		Whitefish Lake South (LA-5 South)	5.84E-08	7.62E-08	3.29E-08	9.39E-05	5.49E-05	2.45E-09	**1.49E-04**	5.99E-09	7.82E-09	2.06E-08	9.28E-05	4.43E-05	2.01E-09	**1.37E-04**
		McGowan Lake (LA-1)	4.06E-08	5.30E-08	2.95E-08	9.02E-05	4.67E-05	2.10E-09	**1.37E-04**	5.67E-09	7.40E-09	2.04E-08	8.96E-05	4.17E-05	1.89E-09	**1.31E-04**
		Russell Lake Inlet	3.10E-08	4.04E-08	2.72E-08	8.79E-05	4.37E-05	1.98E-09	**1.32E-04**	5.47E-09	7.15E-09	2.03E-08	8.75E-05	4.08E-05	1.85E-09	**1.28E-04**
	Northern pike	Reference (Kratchkowsky Lake)	4.47E-06	5.09E-06	3.96E-05	2.29E-04	2.20E-06	6.93E-04	**9.74E-04**	4.31E-06	4.90E-06	3.94E-05	2.24E-04	1.87E-06	5.87E-04	**8.62E-04**
		Whitefish Lake North (LA-6)	4.38E-06	4.98E-06	3.94E-05	2.26E-04	2.01E-06	6.33E-04	**9.10E-04**	4.31E-06	4.90E-06	3.94E-05	2.24E-04	1.87E-06	5.87E-04	**8.62E-04**
		Whitefish Lake Middle (LA-5 North)	8.18E-05	9.31E-05	7.28E-05	2.76E-04	2.96E-06	7.35E-04	**1.26E-03**	5.27E-06	6.00E-06	4.04E-05	2.57E-04	2.14E-06	6.74E-04	**9.84E-04**
		Whitefish Lake South (LA-5 South)	7.79E-05	8.87E-05	7.23E-05	2.70E-04	2.92E-06	7.90E-04	**1.30E-03**	5.23E-06	5.95E-06	4.04E-05	2.56E-04	2.09E-06	6.59E-04	**9.68E-04**
		McGowan Lake (LA-1)	4.81E-05	5.48E-05	6.12E-05	2.54E-04	2.37E-06	6.82E-04	**1.10E-03**	4.95E-06	5.63E-06	4.02E-05	2.47E-04	1.97E-06	6.20E-04	**9.20E-04**
		Russell Lake Inlet	3.59E-05	4.08E-05	5.58E-05	2.46E-04	2.27E-06	6.75E-04	**1.06E-03**	4.78E-06	5.44E-06	4.00E-05	2.41E-04	1.93E-06	6.06E-04	**8.99E-04**
	White sucker	Reference (Kratchkowsky Lake)	3.33E-06	3.89E-06	2.96E-05	1.91E-04	2.02E-06	5.30E-05	**2.83E-04**	3.21E-06	3.74E-06	2.94E-05	1.87E-04	1.76E-06	4.49E-05	**2.70E-04**
		Whitefish Lake North (LA-6)	3.26E-06	3.80E-06	2.95E-05	1.88E-04	1.88E-06	4.84E-05	**2.75E-04**	3.21E-06	3.74E-06	2.94E-05	1.87E-04	1.76E-06	4.49E-05	**2.70E-04**
		Whitefish Lake Middle (LA-5 North)	6.10E-05	7.11E-05	5.45E-05	2.29E-04	2.76E-06	5.61E-05	**4.75E-04**	3.93E-06	4.58E-06	3.02E-05	2.14E-04	2.02E-06	5.15E-05	**3.06E-04**
		Whitefish Lake South (LA-5 South)	5.80E-05	6.77E-05	5.41E-05	2.25E-04	2.70E-06	6.04E-05	**4.68E-04**	3.90E-06	4.54E-06	3.02E-05	2.13E-04	1.98E-06	5.04E-05	**3.04E-04**
		McGowan Lake (LA-1)	3.59E-05	4.18E-05	4.57E-05	2.12E-04	2.21E-06	5.21E-05	**3.89E-04**	3.68E-06	4.30E-06	3.00E-05	2.06E-04	1.86E-06	4.74E-05	**2.93E-04**
		Russell Lake Inlet	2.67E-05	3.12E-05	4.17E-05	2.05E-04	2.11E-06	5.16E-05	**3.59E-04**	3.56E-06	4.15E-06	2.99E-05	2.01E-04	1.82E-06	4.63E-05	**2.87E-04**
	Zooplankton	Reference (Kratchkowsky Lake)	2.22E-05	2.59E-05	3.29E-03	4.70E-03	3.44E-05	7.43E-02	**8.24E-02**	2.14E-05	2.50E-05	3.27E-03	4.60E-03	2.91E-05	6.30E-02	**7.09E-02**
		Whitefish Lake North (LA-6)	2.17E-05	2.53E-05	3.28E-03	4.64E-03	3.14E-05	6.79E-02	**7.59E-02**	2.14E-05	2.50E-05	3.27E-03	4.60E-03	2.91E-05	6.30E-02	**7.09E-02**
		Whitefish Lake Middle (LA-5 North)	4.06E-04	4.74E-04	6.05E-03	5.66E-03	4.62E-05	7.88E-02	**9.14E-02**	2.62E-05	3.05E-05	3.36E-03	5.27E-03	3.34E-05	7.22E-02	**8.10E-02**
		Whitefish Lake South (LA-5 South)	3.87E-04	4.51E-04	6.01E-03	5.55E-03	4.56E-05	8.48E-02	**9.72E-02**	2.60E-05	3.03E-05	3.36E-03	5.25E-03	3.27E-05	7.07E-02	**7.93E-02**
		McGowan Lake (LA-1)	2.39E-04	2.79E-04	5.08E-03	5.22E-03	3.69E-05	7.31E-02	**8.40E-02**	2.46E-05	2.87E-05	3.34E-03	5.07E-03	3.07E-05	6.65E-02	**7.50E-02**
		Russell Lake Inlet	1.78E-04	2.08E-04	4.63E-03	5.06E-03	3.54E-05	7.23E-02	**8.25E-02**	2.37E-05	2.77E-05	3.32E-03	4.95E-03	3.01E-05	6.50E-02	**7.33E-02**
Terrestrial Plants	Blueberries	Reference (Kratchkowsky Lake)	2.46E-04	2.80E-04	2.11E-04	1.62E-02	6.20E-05	9.60E-03	**2.66E-02**	2.46E-04	2.80E-04	2.11E-04	1.62E-02	6.20E-05	9.60E-03	**2.66E-02**
		Whitefish Lake (LA-5)	2.05E-03	2.33E-03	2.11E-04	1.62E-02	6.20E-05	9.60E-03	**3.04E-02**	3.36E-04	3.83E-04	2.11E-04	1.62E-02	6.20E-05	9.60E-03	**2.68E-02**
		McGowan Lake (LA-1)	4.83E-04	5.49E-04	2.11E-04	1.62E-02	6.20E-05	9.60E-03	**2.71E-02**	2.58E-04	2.93E-04	2.11E-04	1.62E-02	6.20E-05	9.60E-03	**2.66E-02**
		Russell Lake Inlet	3.09E-04	3.52E-04	2.11E-04	1.62E-02	6.20E-05	9.60E-03	**2.67E-02**	2.49E-04	2.83E-04	2.11E-04	1.62E-02	6.20E-05	9.60E-03	**2.66E-02**
	Browse	Reference (Kratchkowsky Lake)	2.16E-04	2.46E-04	1.03E-04	6.74E-03	3.16E-04	3.69E-03	**1.13E-02**	2.16E-04	2.46E-04	1.03E-04	6.74E-03	3.16E-04	3.69E-03	**1.13E-02**
		Whitefish Lake (LA-5)	7.48E-03	8.52E-03	1.03E-04	6.74E-03	3.16E-04	3.69E-03	**2.69E-02**	2.52E-04	2.87E-04	1.03E-04	6.74E-03	3.16E-04	3.69E-03	**1.14E-02**
		McGowan Lake (LA-1)	1.17E-03	1.33E-03	1.03E-04	6.74E-03	3.16E-04	3.69E-03	**1.34E-02**	2.20E-04	2.51E-04	1.03E-04	6.74E-03	3.16E-04	3.69E-03	**1.13E-02**
		Russell Lake Inlet	4.70E-04	5.35E-04	1.03E-04	6.74E-03	3.16E-04	3.69E-03	**1.19E-02**	2.17E-04	2.47E-04	1.03E-04	6.74E-03	3.16E-04	3.69E-03	**1.13E-02**

Biota		Location	Maximum Radiological Dose During Project Phases (mGy/d)							Maximum Radiological Dose During Future Centuries (mGy/d)						
			Uranium-238	Uranium-234	Thorium-230	Radium-226	Lead-210	Polonium-210	Total Dose	Uranium-238	Uranium-234	Thorium-230	Radium-226	Lead-210	Polonium-210	Total Dose
	Labrador Tea	Reference (Kratchkowsky Lake)	1.21E-03	1.38E-03	1.03E-04	6.74E-03	3.16E-04	3.69E-03	**1.34E-02**	1.21E-03	1.38E-03	1.03E-04	6.74E-03	3.16E-04	3.69E-03	**1.34E-02**
		Whitefish Lake (LA-5)	6.49E-02	7.39E-02	1.03E-04	6.74E-03	3.16E-04	3.69E-03	**1.50E-01**	1.25E-03	1.42E-03	1.03E-04	6.74E-03	3.16E-04	3.69E-03	**1.35E-02**
		McGowan Lake (LA-1)	9.57E-03	1.09E-02	1.03E-04	6.74E-03	3.16E-04	3.69E-03	**3.13E-02**	1.22E-03	1.39E-03	1.03E-04	6.74E-03	3.16E-04	3.69E-03	**1.35E-02**
		Russell Lake Inlet	3.45E-03	3.92E-03	1.03E-04	6.74E-03	3.16E-04	3.69E-03	**1.82E-02**	1.22E-03	1.38E-03	1.03E-04	6.74E-03	3.16E-04	3.69E-03	**1.35E-02**
	Lichen	Reference (Kratchkowsky Lake)	6.37E-04	7.24E-04	7.32E-04	9.05E-03	1.81E-03	2.03E-01	**2.16E-01**	6.37E-04	7.24E-04	7.32E-04	9.05E-03	1.81E-03	2.03E-01	**2.16E-01**
		Whitefish Lake (LA-5)	3.62E-01	4.11E-01	7.32E-04	9.05E-03	1.81E-03	2.03E-01	**9.88E-01**	6.37E-04	7.24E-04	7.32E-04	9.05E-03	1.81E-03	2.03E-01	**2.16E-01**
		McGowan Lake (LA-1)	4.80E-02	5.46E-02	7.32E-04	9.05E-03	1.81E-03	2.03E-01	**3.18E-01**	6.37E-04	7.24E-04	7.32E-04	9.05E-03	1.81E-03	2.03E-01	**2.16E-01**
		Russell Lake Inlet	1.33E-02	1.51E-02	7.32E-04	9.05E-03	1.81E-03	2.03E-01	**2.43E-01**	6.37E-04	7.24E-04	7.32E-04	9.05E-03	1.81E-03	2.03E-01	**2.16E-01**
	Terrestrial Invertebrate	Reference (Kratchkowsky Lake)	1.41E-04	1.61E-04	1.15E-04	4.85E-03	1.22E-05	1.33E-03	**6.61E-03**	1.41E-04	1.61E-04	1.15E-04	4.85E-03	1.22E-05	1.33E-03	**6.61E-03**
		Whitefish Lake (LA-5)	6.92E-03	7.88E-03	1.15E-04	4.85E-03	1.22E-05	1.33E-03	**2.11E-02**	1.50E-04	1.71E-04	1.15E-04	4.85E-03	1.22E-05	1.33E-03	**6.62E-03**
		McGowan Lake (LA-1)	1.03E-03	1.17E-03	1.15E-04	4.85E-03	1.22E-05	1.33E-03	**8.51E-03**	1.43E-04	1.62E-04	1.15E-04	4.85E-03	1.22E-05	1.33E-03	**6.61E-03**
		Russell Lake Inlet	3.79E-04	4.31E-04	1.15E-04	4.85E-03	1.22E-05	1.33E-03	**7.11E-03**	1.42E-04	1.61E-04	1.15E-04	4.85E-03	1.22E-05	1.33E-03	**6.61E-03**
Terrestrial Animals	**Black Bear**	Reference (Kratchkowsky Lake)	2.15E-06	2.45E-06	2.09E-06	8.38E-04	2.10E-06	9.90E-04	**1.84E-03**	2.15E-06	2.45E-06	2.09E-06	8.38E-04	2.09E-06	9.86E-04	**1.83E-03**
		Whitefish Lake (LA-5)	3.68E-06	4.19E-06	2.13E-06	8.38E-04	2.10E-06	9.90E-04	**1.84E-03**	2.23E-06	2.54E-06	2.10E-06	8.38E-04	2.09E-06	9.87E-04	**1.83E-03**
	Canada Lynx	Reference (Kratchkowsky Lake)	3.96E-07	4.60E-07	1.08E-06	6.67E-04	3.40E-06	3.42E-04	**1.01E-03**	3.96E-07	4.60E-07	1.08E-06	6.67E-04	3.40E-06	3.42E-04	**1.01E-03**
		Whitefish Lake (LA-5)	4.39E-06	5.06E-06	1.11E-06	6.67E-04	3.40E-06	3.42E-04	**1.02E-03**	5.33E-07	6.19E-07	1.08E-06	6.67E-04	3.40E-06	3.42E-04	**1.02E-03**
		McGowan Lake (LA-1)	9.31E-07	1.08E-06	1.10E-06	6.67E-04	3.40E-06	3.42E-04	**1.02E-03**	4.14E-07	4.81E-07	1.08E-06	6.67E-04	3.40E-06	3.42E-04	**1.01E-03**
		Russell Lake Inlet	5.46E-07	6.33E-07	1.09E-06	6.67E-04	3.40E-06	3.42E-04	**1.02E-03**	4.01E-07	4.65E-07	1.08E-06	6.67E-04	3.40E-06	3.42E-04	**1.01E-03**
	Mink	Reference (Kratchkowsky Lake)	2.40E-07	2.73E-07	2.76E-06	6.46E-05	2.77E-07	8.90E-04	**9.59E-04**	2.39E-07	2.72E-07	2.76E-06	6.45E-05	2.74E-07	8.87E-04	**9.55E-04**
		Whitefish Lake (LA-5)	2.32E-06	2.64E-06	4.29E-06	7.32E-05	3.89E-07	1.28E-03	**1.36E-03**	3.15E-07	3.59E-07	2.82E-06	7.21E-05	3.08E-07	1.01E-03	**1.09E-03**
		McGowan Lake (LA-1)	1.02E-06	1.17E-06	3.86E-06	7.03E-05	3.17E-07	1.04E-03	**1.11E-03**	2.59E-07	2.95E-07	2.81E-06	6.98E-05	2.87E-07	9.35E-04	**1.01E-03**
		Russell Lake Inlet	7.48E-07	8.52E-07	3.60E-06	6.88E-05	3.01E-07	9.75E-04	**1.05E-03**	2.51E-07	2.85E-07	2.80E-06	6.85E-05	2.82E-07	9.16E-04	**9.88E-04**
	Moose	Reference (Kratchkowsky Lake)	3.71E-06	4.22E-06	5.20E-06	8.25E-04	2.52E-06	9.41E-04	**1.78E-03**	3.70E-06	4.22E-06	5.18E-06	8.24E-04	2.44E-06	9.30E-04	**1.77E-03**
		Whitefish Lake (LA-5)	1.23E-04	1.40E-04	8.41E-06	8.39E-04	2.73E-06	9.78E-04	**2.09E-03**	4.36E-06	4.97E-06	5.29E-06	8.34E-04	2.51E-06	9.49E-04	**1.80E-03**
		McGowan Lake (LA-1)	2.02E-05	2.30E-05	7.29E-06	8.33E-04	2.57E-06	9.52E-04	**1.84E-03**	3.80E-06	4.33E-06	5.26E-06	8.31E-04	2.47E-06	9.37E-04	**1.78E-03**
		Russell Lake Inlet	8.61E-06	9.80E-06	6.77E-06	8.31E-04	2.54E-06	9.46E-04	**1.80E-03**	3.74E-06	4.26E-06	5.24E-06	8.29E-04	2.46E-06	9.34E-04	**1.78E-03**
	Moose Organs	Reference (Kratchkowsky Lake)	6.55E-06	7.46E-06	1.40E-03	5.97E-04	4.25E-05	9.41E-06	**2.07E-03**	6.55E-06	7.45E-06	1.40E-03	5.97E-04	4.00E-05	9.31E-06	**2.06E-03**
		McGowan Lake	3.58E-05	4.07E-05	1.98E-03	6.02E-04	4.41E-05	9.53E-06	**2.71E-03**	6.73E-06	7.66E-06	1.42E-03	6.01E-04	4.09E-05	9.38E-06	**2.09E-03**
		Russell Lake Inlet	1.52E-05	1.73E-05	1.83E-03	6.01E-04	4.32E-05	9.47E-06	**2.52E-03**	6.61E-06	7.53E-06	1.41E-03	6.00E-04	4.06E-05	9.35E-06	**2.08E-03**
	Muskrat	Reference (Kratchkowsky Lake)	6.39E-07	7.27E-07	1.18E-05	2.92E-04	2.02E-06	6.38E-04	**9.46E-04**	6.34E-07	7.21E-07	1.17E-05	2.89E-04	1.80E-06	6.07E-04	**9.10E-04**
		Whitefish Lake (LA-5)	8.72E-06	9.92E-06	2.15E-05	3.47E-04	2.80E-06	8.52E-04	**1.24E-03**	7.75E-07	8.82E-07	1.20E-05	3.31E-04	2.06E-06	6.96E-04	**1.04E-03**
		McGowan Lake (LA-1)	5.59E-06	6.36E-06	1.81E-05	3.24E-04	2.23E-06	7.11E-04	**1.07E-03**	7.28E-07	8.28E-07	1.19E-05	3.18E-04	1.90E-06	6.40E-04	**9.74E-04**
		Russell Lake Inlet	4.24E-06	4.82E-06	1.65E-05	3.15E-04	2.13E-06	6.77E-04	**1.02E-03**	7.03E-07	8.00E-07	1.19E-05	3.11E-04	1.86E-06	6.27E-04	**9.53E-04**
	Snowshoe Hare	Reference (Kratchkowsky Lake)	3.45E-06	3.93E-06	1.96E-06	1.07E-03	4.05E-06	8.65E-04	**1.95E-03**	3.45E-06	3.93E-06	1.96E-06	1.07E-03	4.05E-06	8.65E-04	**1.95E-03**
		Whitefish Lake (LA-5)	1.02E-04	1.17E-04	1.98E-06	1.07E-03	4.05E-06	8.65E-04	**2.16E-03**	4.16E-06	4.75E-06	1.96E-06	1.07E-03	4.05E-06	8.65E-04	**1.95E-03**
		McGowan Lake (LA-1)	1.64E-05	1.87E-05	1.97E-06	1.07E-03	4.05E-06	8.65E-04	**1.97E-03**	3.54E-06	4.04E-06	1.96E-06	1.07E-03	4.05E-06	8.65E-04	**1.95E-03**
		Russell Lake Inlet	6.92E-06	7.89E-06	1.97E-06	1.07E-03	4.05E-06	8.65E-04	**1.95E-03**	3.47E-06	3.96E-06	1.96E-06	1.07E-03	4.05E-06	8.65E-04	**1.95E-03**
	Southern Red-Backed Vole	Reference (Kratchkowsky Lake)	1.47E-05	1.67E-05	6.56E-06	3.88E-03	8.24E-06	5.81E-03	**9.74E-03**	1.47E-05	1.67E-05	6.56E-06	3.88E-03	8.24E-06	5.81E-03	**9.74E-03**
		Whitefish Lake (LA-5)	2.65E-04	3.01E-04	6.57E-06	3.88E-03	8.24E-06	5.81E-03	**1.03E-02**	1.90E-05	2.17E-05	6.56E-06	3.88E-03	8.24E-06	5.81E-03	**9.75E-03**
		McGowan Lake (LA-1)	4.75E-05	5.41E-05	6.57E-06	3.88E-03	8.24E-06	5.81E-03	**9.81E-03**	1.53E-05	1.74E-05	6.56E-06	3.88E-03	8.24E-06	5.81E-03	**9.74E-03**
		Russell Lake Inlet	2.35E-05	2.67E-05	6.56E-06	3.88E-03	8.24E-06	5.81E-03	**9.76E-03**	1.48E-05	1.69E-05	6.56E-06	3.88E-03	8.24E-06	5.81E-03	**9.74E-03**
	Woodland Caribou	Reference (Kratchkowsky Lake)	3.34E-06	3.81E-06	6.25E-06	6.81E-04	1.20E-05	6.24E-03	**6.95E-03**	3.34E-06	3.81E-06	6.24E-06	6.80E-04	1.19E-05	6.23E-03	**6.94E-03**
		Whitefish Lake (LA-5)	8.19E-05	9.32E-05	7.30E-06	6.86E-04	1.20E-05	6.26E-03	**7.14E-03**	3.40E-06	3.87E-06	6.28E-06	6.85E-04	1.19E-05	6.24E-03	**6.95E-03**
	Canada Goose	Reference (Kratchkowsky Lake)	1.39E-05	1.59E-05	4.00E-07	5.61E-04	3.17E-06	7.77E-04	**1.37E-03**	1.39E-05	1.59E-05	4.00E-07	5.61E-04	3.17E-06	7.77E-04	**1.37E-03**
		Whitefish Lake (LA-5)	4.23E-04	4.82E-04	3.95E-07	5.61E-04	3.17E-06	7.76E-04	**2.25E-03**	1.67E-05	1.90E-05	3.95E-07	5.61E-04	3.17E-06	7.76E-04	**1.38E-03**
		McGowan Lake (LA-1)	6.78E-05	7.72E-05	4.04E-07	5.61E-04	3.17E-06	7.77E-04	**1.49E-03**	1.43E-05	1.63E-05	4.01E-07	5.61E-04	3.17E-06	7.77E-04	**1.37E-03**

Biota	Location	Maximum Radiological Dose During Project Phases (mGy/d)							Maximum Radiological Dose During Future Centuries (mGy/d)						
		Uranium-238	Uranium-234	Thorium-230	Radium-226	Lead-210	Polonium-210	Total Dose	Uranium-238	Uranium-234	Thorium-230	Radium-226	Lead-210	Polonium-210	Total Dose
	Russell Lake Inlet	2.84E-05	3.23E-05	4.03E-07	5.61E-04	3.17E-06	7.77E-04	**1.40E-03**	1.40E-05	1.60E-05	4.00E-07	5.61E-04	3.17E-06	7.77E-04	**1.37E-03**
Bald Eagle	Reference (Kratchkowsky Lake)	4.93E-05	5.61E-05	3.13E-06	3.72E-05	5.32E-07	7.06E-03	**7.21E-03**	4.93E-05	5.61E-05	3.13E-06	3.72E-05	5.27E-07	6.99E-03	**7.14E-03**
	Whitefish Lake (LA-5)	5.58E-05	6.35E-05	3.14E-06	3.73E-05	5.32E-07	7.12E-03	**7.28E-03**	4.96E-05	5.64E-05	3.13E-06	3.72E-05	5.27E-07	7.02E-03	**7.17E-03**
Olive-Sided Flycatcher	Reference (Kratchkowsky Lake)	1.29E-04	1.47E-04	5.91E-06	1.59E-04	1.07E-06	1.23E-02	**1.28E-02**	1.29E-04	1.47E-04	5.91E-06	1.59E-04	1.07E-06	1.23E-02	**1.28E-02**
	Whitefish Lake (LA-5)	4.95E-03	5.64E-03	7.77E-06	1.61E-04	1.16E-06	1.59E-02	**2.67E-02**	1.47E-04	1.67E-04	5.98E-06	1.61E-04	1.10E-06	1.35E-02	**1.40E-02**
	McGowan Lake (LA-1)	7.70E-04	8.76E-04	7.27E-06	1.61E-04	1.11E-06	1.37E-02	**1.55E-02**	1.32E-04	1.50E-04	5.97E-06	1.60E-04	1.08E-06	1.28E-02	**1.32E-02**
	Russell Lake Inlet	3.05E-04	3.47E-04	6.94E-06	1.60E-04	1.09E-06	1.31E-02	**1.40E-02**	1.30E-04	1.48E-04	5.96E-06	1.60E-04	1.08E-06	1.26E-02	**1.30E-02**
Common Loon	Reference (Kratchkowsky Lake)	1.43E-06	1.63E-06	1.11E-06	1.90E-05	1.82E-07	3.14E-03	**3.16E-03**	1.40E-06	1.59E-06	1.11E-06	1.90E-05	1.77E-07	3.07E-03	**3.10E-03**
	Whitefish Lake (LA-5)	2.39E-05	2.72E-05	1.86E-06	2.22E-05	2.66E-07	4.42E-03	**4.49E-03**	1.70E-06	1.94E-06	1.14E-06	2.17E-05	2.03E-07	3.53E-03	**3.55E-03**
	McGowan Lake (LA-1)	1.41E-05	1.60E-05	1.65E-06	2.11E-05	2.11E-07	3.60E-03	**3.65E-03**	1.60E-06	1.82E-06	1.14E-06	2.09E-05	1.87E-07	3.24E-03	**3.27E-03**
	Russell Lake Inlet	1.05E-05	1.20E-05	1.52E-06	2.05E-05	1.99E-07	3.41E-03	**3.45E-03**	1.55E-06	1.76E-06	1.13E-06	2.04E-05	1.83E-07	3.18E-03	**3.20E-03**
Mallard	Reference (Kratchkowsky Lake)	1.46E-05	1.66E-05	1.09E-05	7.92E-05	1.33E-06	2.66E-02	**2.67E-02**	1.46E-05	1.66E-05	1.09E-05	7.90E-05	1.28E-06	2.65E-02	**2.66E-02**
	Whitefish Lake (LA-5)	1.85E-04	2.11E-04	1.82E-05	9.24E-05	1.93E-06	3.88E-02	**3.93E-02**	1.79E-05	2.03E-05	1.12E-05	9.05E-05	1.47E-06	3.04E-02	**3.05E-02**
	McGowan Lake (LA-1)	1.22E-04	1.39E-04	1.61E-05	8.78E-05	1.54E-06	3.12E-02	**3.15E-02**	1.68E-05	1.91E-05	1.11E-05	8.71E-05	1.35E-06	2.80E-02	**2.81E-02**
	Russell Lake Inlet	9.31E-05	1.06E-04	1.49E-05	8.55E-05	1.45E-06	2.93E-02	**2.96E-02**	1.62E-05	1.84E-05	1.10E-05	8.50E-05	1.32E-06	2.74E-02	**2.75E-02**
American Robin	Reference (Kratchkowsky Lake)	4.34E-04	4.93E-04	1.29E-05	1.28E-03	8.36E-06	3.62E-02	**3.84E-02**	4.34E-04	4.93E-04	1.29E-05	1.28E-03	8.36E-06	3.62E-02	**3.84E-02**
	Whitefish Lake (LA-5)	6.70E-03	7.62E-03	1.29E-05	1.28E-03	8.36E-06	3.62E-02	**5.18E-02**	5.70E-04	6.48E-04	1.29E-05	1.28E-03	8.36E-06	3.62E-02	**3.87E-02**
	McGowan Lake (LA-1)	1.26E-03	1.43E-03	1.29E-05	1.28E-03	8.36E-06	3.62E-02	**4.01E-02**	4.51E-04	5.14E-04	1.29E-05	1.28E-03	8.36E-06	3.62E-02	**3.84E-02**
	Russell Lake Inlet	6.53E-04	7.43E-04	1.29E-05	1.28E-03	8.36E-06	3.62E-02	**3.89E-02**	4.38E-04	4.99E-04	1.29E-05	1.28E-03	8.36E-06	3.62E-02	**3.84E-02**
Lesser Scaup	Reference (Kratchkowsky Lake)	2.37E-05	2.70E-05	2.25E-05	1.45E-04	3.17E-06	4.30E-02	**4.32E-02**	2.36E-05	2.68E-05	2.24E-05	1.44E-04	2.91E-06	4.27E-02	**4.29E-02**
	Whitefish Lake (LA-5)	3.19E-04	3.62E-04	3.85E-05	1.71E-04	4.47E-06	6.24E-02	**6.33E-02**	2.89E-05	3.28E-05	2.30E-05	1.65E-04	3.34E-06	4.90E-02	**4.93E-02**
	McGowan Lake (LA-1)	2.06E-04	2.34E-04	3.36E-05	1.61E-04	3.57E-06	5.02E-02	**5.08E-02**	2.71E-05	3.08E-05	2.29E-05	1.59E-04	3.07E-06	4.51E-02	**4.53E-02**
	Russell Lake Inlet	1.56E-04	1.78E-04	3.09E-05	1.57E-04	3.38E-06	4.72E-02	**4.77E-02**	2.62E-05	2.98E-05	2.28E-05	1.55E-04	3.01E-06	4.41E-02	**4.44E-02**

5.2.6 Uncertainties in Exposure Assessment

For the exposure assessment it was conservatively assumed that ecological receptors would be exposed to the maximum exposure concentrations at their location. The duration of exposure was assumed to be sufficient for each receptor to be in equilibrium with their environment. This resulted in conservatively high:

- direct exposure estimates for aquatic biota exposed to COPCs in water, and terrestrial plants and soil invertebrates exposed to COPCs in soil;
- predicted uptakes of COPCs by ecological receptors in the food chain; and
- estimated doses of COPCs to ecological receptors through the food chain.

The assumptions to address uncertainties in the exposure assessment are anticipated to produce conservative exposure estimates for ecological receptors. The risk that the exposure assessment underestimates potential exposure of ecological receptors to COPCs from the Project is low. That said, the following provides more detail about assessment uncertainty and how it was addressed.

5.2.6.1 Uncertainties in Uptake and Exposure Factors

Wildlife exposure factors, such as intake rates and diets, are a potential source of uncertainty. Reputable sources were used for these factors, and the factors are considered to be representative of the organisms assessed. Feed, water, and inhalation intake rates were obtained or calculated based on the following primary sources: Federal Contaminated Sites Action Plan (FCSAP, 2012; Sample and Suter, 1994; US EPA, 1993). These documents have undergone several stages of review and are considered appropriate literature values for use in this assessment; therefore, the uncertainty in these values is considered acceptable.

Bioaccumulation factors were used to calculate uptake into tissues (fish, invertebrates, plants). The BAFs were derived from regional biota and water data for a number of aquatic biota in this assessment. There is inherent uncertainty in using field data to calculate BAFs from metal concentrations in tissues of aquatic biota and surface water concentrations, because the actual exposure history of the organisms is unknown. Unless it is known that a metal concentration in surface water is at a steady state for an extended period of time, the use of tissue and water concentrations sampled at the same time from the same location may not reflect the average exposure of an organism. In addition, as a result of physiological control, intracellular storage and different excretion mechanisms, biota have an ability to actively regulate the body burden of many metals and maintain homeostatic control over a range of exposures (Chapman et al., 1996; Hamilton and Mehrle, 1986; Wood and Port, 2000). These homeostatic controls can produce a non-linear relationship between the steady-state tissue concentration and the environmental exposure (Newman and Unger, 2002). As a result, the validity of assuming a linear relationship between water and tissue concentrations is an area of uncertainty. In most cases it is difficult to assess whether non-linear relationships may exist; therefore, linear relationships are assumed by default (with the exception of selenium where a non-linear BAF was used). These complicating issues do not diminish the importance of BAFs in assessing the environmental hazard associated with metals.

5.2.6.2 Uncertainties in Dose Coefficients

Dose coefficients were obtained from reputable sources for reference organisms, but have not been derived specifically for all the organisms assessed. Dose coefficients for surrogate organisms were often used. They were selected with attention to similar body size and exposure habits and are believed to adequately represent the organism assessed. Dose coefficients for each receptor were not adjusted for body size and dimensions, which represents a possible source of uncertainty. For the maximum exposed receptors, the dose is primarily delivered through alpha emissions as over 95% of the dose can be attributed to polonium-210 in tissue. The geometry-scaling factor of alpha particles is 1 for all organisms and geometries; as such, geometry assumptions are expected to have very little effect on the total radiation dose.

5.3 Effects Assessment

5.3.1 Toxicological Benchmarks

For assessment of non-radiological COPCs, a TRV was used. A TRV is a toxicological index associating specific effects with a level of exposure to a chemical. The TRVs for aquatic biota are based on concentrations in water, while TRVs for mammals and birds are weight-normalized daily oral doses.

Arsenic, cadmium, chloride, chromium, cobalt, copper, molybdenum, selenium, sulphate, uranium, and zinc were identified as COPCs for further evaluation in the EcoRA for aquatic biota Arsenic, cadmium, chromium, cobalt, copper, molybdenum, selenium, uranium, and zinc were also evaluated in the EcoRA for terrestrial biota.

No COPCs in air were identified for further evaluation of potential risks for ecological health; therefore, TRVs for direct contact with air were not included in the toxicity assessment. Deposition of COPCs in dust to soil was evaluated; however, no COPCs in soil were identified for further evaluation; therefore, toxicity via direct contact with COPCs in soil for plants and soil invertebrates was not included in the toxicity assessment.

5.3.1.1 Toxicity Reference Values for Aquatic Biota

Water concentration-based TRVs for aquatic biota are based on chronic effects from long-term exposures. They are concentrations below which health risks to receptors are not anticipated. The TRVs were derived for aquatic biota in six categories: forage fish (lake whitefish), predator fish (northern pike), zooplankton, benthic invertebrates, phytoplankton, and aquatic plants.

The selected TRVs were 20% Effect Concentrations (i.e., EC_{20} values), which are concentrations at which only 20% of the test organisms respond. The EC_{20} value was preferred because 20% is near the level at which effects become statistically discernible or measurable in both laboratory and field studies (EC and HC, 2003; Suter, 1996), and therefore can be reliably reproduced.

However, chronic EC_{20} values are not always readily available; therefore, a protocol shown in Table 5-11 was established to derive chronic EC_{20} values from available data.

Table 5-11: Procedure for Adjusting Test Endpoints to Chronic 20% Effect Concentration

Test Endpoint [(a)]	Adjustment to Chronic EC_{20}
Chronic EC_{10}	Multiply by 2
Chronic EC_{25}	Multiply by 2/2.5
Chronic EC_{30}	Multiply by 2/3
Chronic EC_{50}	Multiply by 2/5
Chronic LC_{25}	Multiply by 0.5
Chronic LC_{50}	Divide by 4

a) IC endpoints were treated as EC endpoints.
EC = effect concentration; LC = lethal concentration; IC = inhibition concentration.

Toxicity data for effect endpoints involving growth, reproduction, and survival were selected because they are considered to be relevant to the persistence of aquatic populations. Chronic toxicity data were preferred, and acute data were only considered when chronic data were not sufficient (a minimum of 2 values required). If 20 or more chronic EC_{20} values were available in each taxonomic group, a 5th percentile of the EC_{20} values was used as a selected TRV. If there were less than 20 chronic EC_{20} values, the lowest EC_{20} was used as a selected TRV for the taxonomic category. Calculated values that fell below the CCME or provincial guideline were not considered appropriate as TRVs for aquatic biota and the CCME or provincial values were selected in their place. The selected TRVs for aquatic biota groups are summarized in Table 5-12. For aquatic TRVs that were based on the lowest chronic EC_{20} value, the reference is provided in Table 5-12.

In some cases, site-specific modifying factors (ambient conditions) may influence the toxicity of a chemical. For example, these modifying factors include water hardness for copper. In these cases, the TRV must be appropriate to the ambient condition.

The USEPA Ecotoxicology Database (ECOTOX) was generally used for the selection of TRVs for aquatic organisms. There were sufficient data available from ECOTOX to derive TRVs for arsenic, cadmium, copper and zinc. There were limited data available in the ECOTOX database pertaining to the effects of the other COPCs on aquatic biota. The TRVs for chloride and chromium were obtained from the CCME (CCME, 2011a, 2008). The TRVs for cobalt were selected from a recently published review of toxicological data (Stubblefield et al., 2020), in which a species sensitivity distribution approach was used. The TRVs for molybdenum were obtained from the Saskatchewan Water Quality Guideline (WSA, 2017). The TRVs for selenium in fish were estimated using the US EPA criteria of 11.3 mg/kg dw muscle (US EPA, 2021d) and converting to a water based TRV using a species-specific water to fish bioaccumulation factor. The TRVs for selenium for zooplankton and benthic invertebrates were the lowest observed ECs obtained from literature (Crane et al., 1992). The TRVs for sulphate were obtained from the BC MOE (BC MOE, 2013). The TRVs for uranium were derived from data available from toxicological reports (Liber et al., 2007; VST, 2004).

Table 5-12: Selected Toxicity Reference Values for Aquatic Biota

COPC	Biotic Group	TRV	Unit	Rationale	Data Source
Arsenic	Forage fish	0.123	mg/L	Lowest estimated chronic EC_{20} (survival)	ECOTOX (Birge et al., 1979)
	Predator fish	0.630	mg/L	5th percentile of estimated chronic EC_{20} distribution (n=50)	ECOTOX
	Zooplankton	0.340	mg/L	Lowest estimated chronic EC_{20} (intoxication)	ECOTOX (May-Passino and Novak, 1987)
	Benthic invertebrates	0.122	mg/L	5th percentile of estimated chronic EC_{20} distribution (n=27)	ECOTOX
	Phytoplankton	0.0192	mg/L	Lowest estimated chronic EC_{20} (growth)	ECOTOX (Vocke et al., 1980)
	Aquatic plants	0.252	mg/L	Lowest estimated chronic EC_{20} (population)	ECOTOX (Jenner and Janssen-Mommen, 1993)
Cadmium[(b)]	Forage Fish	0.00029	mg/L	5th percentile of estimated chronic EC_{20} (n=35)	ECOTOX
	Predator Fish	0.00036	mg/L	5th percentile of estimated chronic EC_{20} (n=73)	ECOTOX
	Zooplankton	0.00015	mg/L	5th percentile of estimated chronic EC_{20} (n=25)	ECOTOX
	Benthic Invertebrates	0.00048	mg/L	5th percentile of estimated chronic EC_{20} (n=49)	ECOTOX
	Phytoplankton	0.0025	mg/L	lowest estimated EC_{20} value	ECOTOX
	Aquatic Plants[(a)]	0.00763	mg/L	LOEC	ECOTOX (Sajwan and Ornes, 1994)
Chloride	Forage fish	693	mg/L	Chronic LOEC (survival)	(Birge et al., 1985; CCME, 2011a)
	Predator fish	989	mg/L	Chronic EC_{25} (reproduction)	(Beak International Inc, 1999; CCME, 2011a)
	Zooplankton	421	mg/L	Chronic EC_{25} (reproduction)	(CCME, 2011a; J. R. F. Elphick et al., 2011)
	Benthic invertebrates	421	mg/L	Chronic EC_{25} (growth)	(Bartlett, 2009; CCME, 2011a)
	Phytoplankton	6,066	mg/L	Chronic MATC (growth)	(CCME, 2011a; Kessler, 1974)
	Aquatic plants	3,150	mg/L	Chronic EC_{50} (population)	(Buckley et al., 1996; CCME, 2011a)
Chromium	Forage Fish	0.53	mg/L	Chronic value for the fathead minnow in hard water of 0.53 mg/L	(US EPA, 1985) cited in (CCME, 2008)
	Predator Fish	0.105	mg/L	60-day post hatch study with rainbow trout (*Oncorhynchus mykiss*)	(Sauter et al., 1976) cited in (CCME, 2008)
	Zooplankton	0.01	mg/L	Significant reduction in reproduction of Daphnia magna after 96-hours	(Trabalka and Gehrs, 1977) cited in (CCME, 2008)
	Benthic Invertebrates	2.2	mg/L	96-h LC_{50} with the mayfly (*Ephemerella subvaria*)	(CCME, 2008)
	Phytoplankton	0.02	mg/L	Photosynthesis inhibition in natural populations of river algae (*Chlorella pyrenoidosa, Chlamydomonas reinhardii*)	(Zarafonetis and Hampton, 1974) cited in (CCME, 2008)

COPC	Biotic Group	TRV	Unit	Rationale	Data Source
	Aquatic Plants	0.02	mg/L	TRV for phytoplankton used as surrogate for aquatic plants	
Cobalt	Forage fish	0.409	mg/L	Lowest chronic EC_{20} (survival)	(Stubblefield et al., 2020)
	Predator fish	2.495	mg/L	Lowest chronic EC_{20} (biomass)	(Stubblefield et al., 2020)
	Zooplankton	0.0111	mg/L	Lowest chronic EC_{20} (reproduction)	(Stubblefield et al., 2020)
	Benthic invertebrates	0.0176	mg/L	Lowest chronic EC_{20} (growth)	(Stubblefield et al., 2020)
	Phytoplankton	0.046	mg/L	Lowest estimated EC_{20} (growth)	(Stubblefield et al., 2020)
	Aquatic plants	0.0098	mg/L	lowest estimated EC_{20} (growth)	(Stubblefield et al., 2020)
Copper[b,c,d,f]	Forage fish	0.002	mg/L	5th percentile of estimated chronic EC_{20} distribution (n=237)	ECOTOX
	Predator fish	0.003	mg/L	5th percentile of estimated chronic EC_{20} distribution (n=89)	ECOTOX
	Zooplankton	*0.002*	mg/L	5th percentile of estimated chronic EC_{20} distribution (n=117)	ECOTOX; CCME
	Benthic invertebrates	*0.002*	mg/L	5th percentile of estimated chronic EC_{20} distribution (n=264)	ECOTOX; CCME
	Phytoplankton[a]	0.0092	mg/L	5th percentile of estimated chronic EC_{20} distribution (n=101)	ECOTOX
	Aquatic plants[a]	0.038	mg/L	5th percentile of estimated chronic EC_{20} distribution (n=28)	ECOTOX
Molybdenum	Forage fish	31	mg/L	Saskatchewan Water Quality Guideline	(WSA, 2017)
	Predator fish	80	mg/L	lowest estimated EC_{20} value	ECOTOX; (Goettl et al., 1976; McConnell, 1977)
	Zooplankton	31	mg/L	Saskatchewan Water Quality Guideline	(WSA, 2017)
	Benthic invertebrates	31	mg/L	Saskatchewan Water Quality Guideline	(WSA, 2017)
	Phytoplankton	31	mg/L	Saskatchewan Water Quality Guideline	(WSA, 2017)
	Aquatic plants	31	mg/L	Saskatchewan Water Quality Guideline	(WSA, 2017)
Selenium[g]	Forage Fish	0.00063 842	mg/L	TRV for White Sucker was estimated using the US EPA (2021) criteria of 11.3 mg/kg dw muscle and converted to a waterbase TRV using a species-specific water to fish bioaccumulation factor of 4425 and a default dry content of 0.25.	(US EPA, 2021d)
	Predator Fish	0.00088 163	mg/L	TRV for Northern Pike was estimated using the US EPA (2021) criteria of 11.3 mg/kg dw muscle and	(US EPA, 2021d)

COPC	Biotic Group	TRV	Unit	Rationale	Data Source
				converted to a waterbase TRV using a species-specific water to fish bioaccumulation factor of 949 and a default dry content of 0.25.	
	Zooplankton	0.01	mg/L	LOEC	(Crane et al., 1992)
	Benthic Invertebrates	0.01	mg/L	LOEC	(Crane et al., 1992)
	Phytoplankton	0.0797	mg/L	5th percentile of estimated chronic EC_{20} (n=25)	ECOTOX
	Aquatic Plants	0.68	mg/L	lowest estimated EC_{20} value	ECOTOX; (Jenner and Janssen-Mommen, 1993)
Sulphate	Forage fish	2,999	mg/L	Lowest chronic EC_{25} (biomass)	(BC MOE, 2013); PESC data
	Predator fish	502	mg/L	Lowest chronic LC_{25} (survival)	(BC MOE, 2013); PESC data
	Zooplankton	425	mg/L	Lowest chronic EC_{25} (reproduction)	(BC MOE, 2013; J. R. Elphick et al., 2011)
	Benthic invertebrates	730	mg/L	Lowest chronic LC_{25} (survival)	(BC MOE, 2013); PESC data
	Phytoplankton	2,660	mg/L	Lowest chronic EC_{25} (cell yield)	(BC MOE, 2013; J. R. Elphick et al., 2011)
	Aquatic plants	2,310	mg/L	Lowest chronic EC_{10} (frond increase)	(BC MOE, 2013); PESC data
Uranium[(e)]	Forage fish	1.50	mg/L	Lowest estimated chronic EC_{20} (growth)	(Liber et al., 2007; VST, 2004)
	Predator fish	0.550	mg/L	Lowest estimated chronic EC_{20} (growth)	(Liber et al., 2007; VST, 2004)
	Zooplankton	0.060	mg/L	Lowest estimated chronic EC_{20} (growth)	(Liber et al., 2007; VST, 2004)
	Benthic invertebrates	0.027	mg/L	Lowest estimated chronic EC_{20} (growth)	(Liber et al., 2007; VST, 2004)
	Phytoplankton	0.440	mg/L	Geometric mean of 2 EC_{25} values	(Liber et al., 2007; VST, 2004)
	Aquatic plants	5.50	mg/L	Geometric mean of 2 EC_{25} values	(Liber et al., 2007; VST, 2004)
Vanadium	Forage Fish	0.08	mg/L	lowest chronic value for all aquatic organisms	(Suter and Tsao, 1996)
	Predator Fish	0.08	mg/L	lowest chronic value for all aquatic organisms	(Suter and Tsao, 1996)
	Zooplankton	1.9	mg/L	lowest chronic value for Daphnids	(Suter and Tsao, 1996)
	Benthic Invertebrates	0.08	mg/L	lowest chronic value for all aquatic organisms	(Suter and Tsao, 1996)
	Phytoplankton	0.08	mg/L	lowest chronic value for all aquatic organisms	(Suter and Tsao, 1996)
	Aquatic Plants	0.08	mg/L	lowest chronic value for all aquatic organisms	(Suter and Tsao, 1996)
Zinc[(b,d)]	Forage Fish	0.035	mg/L	Lowest estimated chronic EC_{20}	ECOTOX
	Predator Fish	*0.032*	mg/L	5th percentile of estimated chronic EC_{20} (n=39)	ECOTOX
	Zooplankton	*0.03*	mg/L	Lowest estimated chronic EC_{20}	ECOTOX

COPC	Biotic Group	TRV	Unit	Rationale	Data Source
	Benthic Invertebrates	*0.03*	mg/L	Lowest estimated chronic EC_{20}	ECOTOX
	Phytoplankton[(a)]	*0.03*	mg/L	5th percentile of estimated chronic EC_{20} (n=46)	ECOTOX
	Aquatic Plants	0.116	mg/L	Lowest estimated chronic EC_{20}	ECOTOX

a) Study specific hardness data was not available for the adjustment of TRVs.
b) The TRV is hardness dependent and is presented as dissolved metal in soft water (hardness of 25 mg $CaCO_3$/L).
c) Hardness dependent TRVs are presented for hardness of 25 mg $CaCO_3$/L and may be converted to reflect specific site hardness conditions using the equations presented.
d) The TRVs presented in italics are CCME guidelines used as a default when estimated TRVs are below the recommended guideline.
e) The TRVs are based on hardness of 60 mg/L, other than phytoplankton which is based on hardness of 120 mg/L.
f) Copper TRVs, calculated using the Federal Environmental Quality Guideline (FEQG) are included in Section 6.3.2.
g) Selenium TRVs for fish calculated using the Federal Environmental Quality Guideline (FEQG) are included in Section 6.3.1.EC_{XX} = effect concentration for XX% response; LOEC = lowest observed effect concentration; MATC = maximum acceptable toxicant concentration; $CaCO_3$ = calcium carbonate; TRV = toxicity reference value; PESC = Pacific Environmental Science Centre; CCME = Canadian Council of Ministers of the Environment.

5.3.1.1.1 Arsenic

The TRVs for arsenic were estimated chronic EC_{20} values that were selected based on EC_{50} and lethal concentration (LC_{50}) values obtained from the USEPA ECOTOX database (Table 5-12). The minimum adjusted EC_{20} value was selected as the TRV for aquatic plants, phytoplankton, zooplankton and forage fish. For benthic invertebrates and predator fish, the TRV was selected as the 5th percentile of the adjusted chronic EC20 values. The results suggest that phytoplankton, benthic invertebrates, and forage fish are the aquatic organisms most sensitive to arsenic exposure while predator fish are the least sensitive.

5.3.1.1.2 Cadmium

Water hardness can have a major influence on cadmium toxicity to aquatic biota. The toxicity data were adjusted to chronic EC_{20} and were hardness adjusted to soft water (hardness of 25 mg $CaCO_3$/L) with equations from the U.S. Geological Survey (USGS, 2006). According to the USGS (2006), the cadmium hardness-dependent criterion continuous concentration (CCC) can be calculated from the following:

$$CC = e^{0.6247 \times ln(hardness) - 3.384} \times (1.101672 - ln(hardness) \times 0.041838)$$

The second term in the equation above is a conversion factor (CF) which converts the total metal concentration to a dissolved metal concentration. For studies on chronic toxicity of cadmium to aquatic biota that reported the hardness of the water, H1 (in mg/L $CaCO_3$), the CCC for the hardness used in the study was calculated. The CCC values for two hardness levels provide a ratio that can be used to adjust an EC_{20} at the test hardness (H1) to an EC_{20} at some standard hardness (H2), which is relevant to the site, using the following relationship:

$$EC_{20}H2 = \frac{CCC_{H2}}{CCC_{H1}} \times EC_{20}H1$$

The lowest hardness adjusted chronic EC_{20} values are considered conservative and are deemed appropriate as TRVs at different hardness levels. Therefore, the TRVs for forage fish, predator fish, freshwater zooplankton, benthic invertebrates and phytoplankton are presented as dissolved cadmium in soft water with hardness of 25 mg $CaCO_3$/L (Table 5-12). No study specific hardness data were available for TRV adjustment for aquatic plants. A lower LOEC of 0.00763 mg/L for cadmium was applied based on a chronic study of duckweed growth (Sajwan and Ornes, 1994). The more conservative LOEC value is considered appropriate as the TRV for aquatic plants.

The results suggest that zooplankton is the aquatic organism most sensitive to cadmium exposure while aquatic plants are the least sensitive.

5.3.1.1.3 Chloride

Toxicity records were taken from data selected by CCME (CCME, 2011a) to derive the Canadian Water Quality Guideline value for the protection of freshwater aquatic life. The studies met the minimum primary or secondary requirements for data quality. No EC_{20} concentrations were available from the CCME data. Low effect levels including EC_{25}, LOEC, and maximum acceptable toxicant concentration were selected preferentially, and the lowest for each aquatic group were selected (Table 5-12). The results suggest that benthic invertebrates and zooplankton are the most sensitive to chloride exposure while phytoplankton are the least sensitive.

5.3.1.1.4 Chromium

Limited data were available in the USEPA ECOTOX database pertaining to the effects of chromium exposure on aquatic biota. The toxicity data for chromium was obtained from the CCME (CCME, 2008) which provides guidelines for the protection of freshwater aquatic life. Based on U.S. EPA data (US EPA, 1985) cited in CCME (CCME, 2008), the chronic value for the fathead minnow (*Pimephales promelas*) in hard water was selected as the TRV for forage fish. A maximum acceptable concentration of 0.105 mg/L based on a 60-day post hatch study with rainbow trout (*Oncorhynchus mykiss*) (Sauter et al., 1976) was selected as the TRV for predator fish. The TRV for zooplankton was based on the chromium exposure resulting in significant reduction in reproduction of *Daphnia magna* after 96-hours (Trabalka and Gehrs, 1977). The lowest 96-h LC_{50} value for mayfly (*Ephemerella subvaria*) was selected as the TRV for benthic invertebrates, without adjustment, based on CCME (CCME, 2008). The TRVs for phytoplankton and aquatic plants were selected based on the chromium concentration at which the photosynthesis in natural populations of river algae (*Chlorella pyrenoidosa, Chlamydomonas reinhardii*) was inhibited (Zarafonetis and Hampton, 1974).

The results suggest that zooplankton, phytoplankton and aquatic plants are the aquatic organisms most sensitive to chromium exposure while benthic invertebrates are the least sensitive.

5.3.1.1.5 Cobalt

The TRVs for cobalt are chronic EC_{20} values for aquatic animal groups and estimated chronic EC_{20} values for aquatic plant groups from (Stubblefield et al., 2020). Stubblefield et at. (2020) conducted a series of acute and chronic toxicity tests with the primary objective to generate data needed to derive international water quality guidelines for cobalt based on USEPA and European Union requirements. Early life stage tests were conducted on three fish species, one zooplankton species, three aquatic invertebrate species, one alga, and one aquatic macrophyte. The study produced chronic EC_{20} values for the aquatic animal species and chronic EC_{10} values for aquatic plants. The TRVs for phytoplankton and aquatic plants were derived from EC_{10} values using a factor of 2 to adjust to an EC_{20} (Table 5-12). The results suggest that zooplankton, benthic invertebrates, and macrophytes are among the most sensitive to cobalt and fish is the least sensitive.

5.3.1.1.6 Copper

The TRVs for copper for forage fish, predator fish, phytoplankton, and aquatic plants are estimated chronic EC_{20} values. They were estimated based on EC_{10}, EC_{25}, EC_{30}, EC_{50}, LC_{25}, LC_{50}, inhibition concentration (IC_{10}), IC_{25}, and IC_{50} values obtained from the USEPA ECOTOX database. In the case of zooplankton and benthic invertebrates, the derived TRVs were lower than the existing CCME guideline values; therefore, the CCME values were selected as the TRVs because the CCME guidelines are considered protective of all life forms of aquatic species in Canada.

According to the U.S. EPA (US EPA, 2007a), the copper hardness-dependent criterion continuous concentration (CCC) can be calculated from the following:

$$CCC = e^{0.8545 \times ln(hardness) - 1.702} \times 0.96$$

A conversion factor of 0.96 was used to convert the total mean concentration of copper to a dissolved copper concentration. The selected TRVs are summarized in Table 5-12 for dissolved copper in soft water conditions (hardness of 25 mg $CaCO_3$/L) using the same equation describing the relationship of the CCC values for two hardness levels which is discussed above for cadmium TRV adjustment. No study specific hardness data was available for TRV adjustment for phytoplankton and aquatic plants.

The EC_{20} values derived for copper, based on a hardness of 25 mg $CaCO_3$/L, were compared to the CCME water quality guidelines for the same hardness condition prior to selecting the appropriate TRVs (Table 5-12). The results suggest that zooplankton, benthic invertebrates, forage fish, and predator fish are the aquatic organisms most sensitive to copper exposure while aquatic plants are the least sensitive.

Additional copper TRVs, calculated using the Federal Environmental Guideline (FEQG), are included in Section 6.3.2.

5.3.1.1.7 Molybdenum

For forage fish, zooplankton, benthic invertebrates, phytoplankton, and aquatic plants, the Saskatchewan Water Security Agency water quality objective (WQO) for the protection of aquatic life (WSA, 2017) was selected as the TRV for molybdenum. The WQO is based on current understanding of aquatic toxicity of molybdenum to fresh-water aquatic organisms as discussed in Section 3.1.1. The TRV for predator fish is the lowest of three estimated chronic EC_{20} values, derived from LC_{50} values for rainbow trout (*Oncorhynchus mykiss),* obtained from the USEPA ECOTOX database. The selected TRV is from (Goettl et al., 1976) and was republished in 1977 by McConnell (McConnell, 1977), who provided detailed documentation as to the methods used to generate the data (cited in (Tetra Tech Inc., 2008)).

5.3.1.1.8 Selenium

The TRVs for selenium for fish were estimated using the US EPA criteria of 11.3 mg/kg dw muscle (US EPA, 2021d) and converting to a water based TRV using a species-specific water to fish bioaccumulation factor. The LOEC of 0.01 mg/L based on multi-generational mesocosm studies (Crane et al., 1992) is recommended as the TRV for zooplankton and benthic invertebrates. There were 25 chronic toxicity records for phytoplankton obtained from the USEPA ECOTOX database. The 5^{th} percentile of estimated chronic EC_{20} values (derived from EC_{50} values) is deemed appropriate as a TRV for freshwater phytoplankton. The lowest estimated chronic EC_{20} for aquatic plants is derived from EC_{50} values based on a 14-day laboratory test on duckweed (Jenner and Janssen-Mommen, 1993). The results suggest that forage fish and predator fish are the aquatic organisms most sensitive to selenium exposure while aquatic plants are the least sensitive.

Additional selenium TRVs were considered for whole body fish and egg-ovary using the ECCC (2022) published FEQG in Section 6.3.1.

5.3.1.1.9 Sulphate

Toxicity records were taken from data selected by the British Columbia Ministry of Environment (BC MOE, 2013) to derive British Columbia's Ambient Water Quality Guideline value for sulphate for the protection of freshwater aquatic life. The BC MOE used data from the Pacific Environmental Science Centre and Dr. Chris Kennedy (Simon Fraser University) and Elphick et al. ((J. R. Elphick et al., 2011)). The tests selected by BC MOE were conducted over a range of hardness levels. The BC MOE determined that, though dose-response curves of many organisms were influenced by water hardness, a consistent relationship among the species could not be established. The selected TRVs are LC_{25} or EC_{25} values, except for the aquatic plant TRV, which is an EC_{10} value (Table 5-12). The results suggest that aquatic animals are generally more sensitive to sulphate exposure than aquatic plants.

5.3.1.1.10 Uranium

Limited data were available in the USEPA ECOTOX database pertaining to the effects of uranium exposure on aquatic biota. Data were instead obtained from two reports (Liber et al., 2007; VST, 2004) that investigated the toxicity of uranium to aquatic biota in Northern Saskatchewan. The TRVs for uranium are all estimated chronic EC_{20} values, derived from EC_{25}, EC_{50} and LC_{25}, LC_{50}, IC_{25}, and IC_{50} values.

While uranium speciation and toxicity in fresh water are strongly determined by water characteristics such as hardness, pH, and temperature, the CCME (CCME, 2011b) does not consider that there is sufficient information available to quantitatively evaluate the influence of these factors. Therefore, the CCME recommends a water quality guideline for uranium that is not hardness dependent. The TRVs in Table 5-12 are therefore considered appropriate for use across a range of hardness and may be conservative for hard water environments because they were derived from tests conducted under soft water conditions (water hardness of 60 mg $CaCO_3$/L),except for phytoplankton which was based on a study using water hardness of 120 mg/L. The results suggest that zooplankton and benthic invertebrates are more sensitive to uranium exposure, and phytoplankton and aquatic plants are less sensitive.

5.3.1.1.11 Vanadium

Limited data were available in the USEPA ECOTOX database pertaining to the effects of vanadium exposure on aquatic biota. The toxicity data for vanadium was obtained from a report that recommends toxicological benchmarks for screening COPCs for effects on aquatic biota (Suter and Tsao, 1996). Based on the recommendation by Suter and Tsao (1996), the lowest chronic value for Daphnids was selected as the vanadium TRV for zooplankton, and the lowest chronic value for all aquatic organisms was conservatively selected as the vanadium TRV for the other aquatic groups.

5.3.1.1.12 Zinc

The TRVs for zinc were the lowest or 5th percentile of estimated chronic EC_{20} values, which were based on EC_{50} and LC_{50} values obtained from the USEPA ECOTOX database (Table 5-12).

Hardness is known to affect zinc toxicity. An increase in hardness results in a decrease in zinc toxicity. For zinc, the effect of hardness on fish toxicity may be due to changes in fish gills rather than metal speciation. According to the U.S. EPA, the zinc hardness-dependent criterion continuous concentration (CCC) can be calculated from the following:

$$CCC = e^{0.8473 \times ln(hardness) + 0.884} \times 0.986$$

A conversion factor of 0.986 was used to convert the total mean concentration of zinc to a dissolved zinc concentration. The selected TRVs are summarized in Table 5-12 for dissolved copper in soft water conditions (hardness of 25 mg $CaCO_3$/L) using the same equation describing the relationship of the CCC values for two hardness levels which is discussed above for cadmium TRV adjustment. No study specific hardness data were available for TRV adjustment for phytoplankton.

In the case of predator fish, zooplankton, benthic invertebrates and phytoplankton, the derived TRVs were lower than the existing CCME guideline values; therefore, the CCME values were selected as the TRVs because the CCME guidelines are considered protective of all life forms of aquatic species in Canada.

5.3.1.2 Toxicity Reference Values for Terrestrial Biota

Chronic dose-based TRVs for non-radiological COPCs were derived for birds and mammals based on endpoints (i.e., growth and reproduction) considered relevant for assessing the health of wildlife populations. Lowest observed adverse effect levels (LOAEL) were selected for each COPC. The LOAEL is the lowest exposure level at which the response of a test species in a toxicity study was statistically discernible. The LOAELs were used in the ERA to identify a threshold of exposure below which adverse effects are not expected. Exceeding a LOAEL does not mean that effects would necessarily occur; rather, it means that effects may occur. Particularly in large populations, localized effects on a few individuals can be compensated such that there is no discernible effect on the population as a whole.

The selected TRVs, shown in Table 5-13, are chronic daily intakes that are not expected to cause adverse effects to a particular ecological receptor. Where the TRV is based a single LOAEL, the specific reference is provided in Table 5-14 to Table 5-23.

Toxicity data for bird and mammal species were preferentially selected from the USEPA ecological soil screening levels (Eco-SSL) database (US EPA, 2005a). There were no data available in the USEPA Eco-SSL database pertaining to the effects of uranium exposure, so TRVs were derived from data available in toxicological reports previously used in risk assessments for uranium mines in northern Saskatchewan. Toxicity reference values were derived from the selected data for several test species of avian and mammalian wildlife. When possible, a test species was selected with a close taxonomic relationship to the ecological receptor in the risk assessment, such as within the same order, family, genus, or species. If there were several potential test species relevant to an ecological receptor, consideration was given to similar diet and body size. A sensitive test species of the same class was selected to represent an ecological receptor when no data were available for species with a closer taxonomic relationship.

Table 5-13: Selected Toxicity Reference Values for Terrestrial Biota

Ecological Receptor	Constituent of Potential Concern (mg/kg/d)									
	Arsenic	Cadmium	Chromium	Cobalt	Copper	Molybdenum	Selenium	Uranium	Vanadium	Zinc
Mammals										
Black bear	3.1	103	91.1	13.4	11.5	2.6	0.21	5.6	2.18	35
Woodland caribou	14.4	5.7	91.1	13.4	1.5	4.1	0.33	5.6	2.18	76
Snowshoe hare	3.0	0.9	91.1	13.4	45.7	30.0	0.21	5.6	2.18	35
Lynx	3.1	103	91.1	13.4	11.5	2.6	0.21	5.6	2.18	35
Mink	3.1	103	91.1	13.4	11.5	2.6	0.21	5.6	2.18	35
Moose	14.4	5.7	91.1	13.4	1.5	4.1	0.33	5.6	2.18	76
Muskrat	14.2	6.8	91.1	13.4	119	3.8	0.63	5.6	2.18	249
Meadow vole	20.7	1.9	91.1	27.9	296	2.6	0.77	5.6	2.18	4395
Birds										
Bald eagle	3.6	4.4	75.4	14.1	27.0	20.8	0.68	16	0.49	123
Common loon	3.6	4.4	75.4	14.1	27.0	20.8	0.59	16	0.49	123
Mallard	5.1	25.6	2.8	14.1	75.2	20.8	1.29	16	0.49	63
Canada goose	3.6	4.4	75.4	14.1	27.0	20.8	0.59	16	0.49	123
Olive-sided Flycatcher	3.6	4.4	75.4	14.1	27.0	20.8	0.59	16	0.49	123
American Robin	3.6	4.4	75.4	14.1	27.0	20.8	0.59	16	0.49	123
Scaup	5.1	25.6	2.8	14.1	75.2	20.8	1.29	16	0.49	63

5.3.1.2.1 Arsenic

A summary of the TRVs selected for mammalian and avian species for arsenic is shown in Table 5-14.

Mammalian Toxicity Reference Values

Data for growth and reproduction for mammalian species were obtained from the Eco-SSL document for arsenic exposure (US EPA, 2005b). The data were based on a total of 14 LOAEL values from studies with dogs, goats, guinea pigs, mice, pigs, rabbits, and rats. The geometric means of the LOAELs within species ranged from 0.84 mg/kg/d for a guinea pig to 20.7 mg/kg/d for a mouse. Each of the species mean values of LOAEL can be considered as a TRV for arsenic for other mammals. In the event that a species has no closely related test species, the second lowest LOAEL value of 3.0 mg/kg/d for rabbit and dog can be used as a conservative default for the arsenic TRV. Although this LOAEL is not the minimum of the species LOAELs, it was selected over the minimum LOAEL of 0.84 mg/kg/d for guinea pig because the latter value was essentially at the same level as the minimum NOAEL from the same dataset. Of the total 14 LOAEL values used to derive the species LOAELs only two are below 3.0 mg/kg/d. As such, the LOAEL of 3.0 mg/kg/d was selected as the default LOAEL as it is more representative of the LOAEL data overall.

Avian Toxicity Reference Values

Data for growth and reproduction for avian species were obtained from the Eco-SSL document for arsenic exposure (US EPA, 2005b). The document was based on studies with chickens and ducks. After review of the data, two LOAEL values were retained for ducks and one was retained for chicken. The selected avian TRVs are 3.6 mg/kg/d for chickens based on a single LOAEL value, and 5.1 mg/kg/d for ducks based on the geometric mean of two LOAEL values.

Table 5-14: Summary of Selected Toxicity Reference Values for Mammal and Bird Test Species – Arsenic

Test Species	TRV (mg/kg/d)	Rationale
Mammal		
Dog (*Canis familiaris*)	3.1	Geometric mean of two LOAELs for the species
Goat (*Capra hircus*)	14.4	Geometric mean of two LOAELs for the species
Guinea pig (*Cavia porcellus*)	0.84	Single LOAEL for the species (Hunder et al., 1999)
Mouse (*Mus musculus*)	20.7	Geometric mean of three LOAELs for the species
Pig (*Sus scrofa*)	9.4	Single LOAEL for the species (Morrison and Chavez, 1983)
Rabbit (*Oryctolagus cuniculus*)	3.0	Single LOAEL for the species (Nemec et al., 1998)
Rat (*Rattus norvegicus*)	14.2	Geometric mean of four LOAELs for the species
Bird		
Mallard duck (*Anas platyrhynchos*)	5.1	Geometric mean of two LOAELs for the species
Chicken (*Gallus* sp.)	3.6	Single LOAEL for the species (Howell and Hill, 1978)

LOAEL = lowest observed adverse effect level; TRV = toxicity reference value.

5.3.1.2.2 Cadmium

A summary of the TRVs selected for mammalian and avian species for cadmium is shown in Table 5-15.

Mammalian Toxicity Reference Values

There were 7 mammal species represented in the Eco-SSL database with growth or reproduction endpoints, and with LOAEL only or LOAEL plus NOAEL reported (US EPA, 2005c). The species mean values of NOAELs were in the range of 0.45 mg/kg/day for sheep to 4.05 mg/kg/day for pig. The species mean values of LOAELs were in the range of 0.9 mg/kg/day for sheep to 103 mg/kg/day for shrew. Each of the species mean values of LOAEL (Table 5-15) can be used as a surrogate TRV for other similar species in ecological risk assessment. If none of the test species are similar to the wildlife species of interest, the lowest LOAEL of 0.9 mg/kg/day can be used as a conservative default mammalian TRV for cadmium.

Avian Toxicity Reference Values

There were 3 species of birds represented in the Eco-SSL database with growth and reproduction endpoints, and with only LOAELs or paired LOAELs and NOAELs reported (US EPA, 2005c). A geometric mean of NOAEL or LOAEL was calculated for each species. Each of the species mean values of LOAEL (Table 5-15) can be used as a surrogate TRV for other similar species in ecological risk assessment. If none of the test species are similar to species of interest, the minimum LOAEL of 4.38 mg/kg/day can be used as a conservative default avian TRV for cadmium.

Table 5-15: Summary of Selected Toxicity Reference Values for Mammal and Bird Test Species – Cadmium

Test Species	TRV (mg/kg/d)	Rationale
Mammal		
Bank vole *(Microtus* sp)	1.9	Single LOAEL for the species (Swiergosz et al., 1998)
Shrew (*Sorex araneus*)	103	Single LOAEL for the species (Dodds-Smith et al., 1992)
Pig (*Sus scrofa*)	10.5	Geometric mean of four LOAEL for the species
Rat (R*attus norvegicus*)	6.8	Geometric mean of fifty-one LOAEL for the species
Sheep (*Ovis aires*)	0.9	Single LOAEL for the species (Doyle et al., 1974)
Cattle (*Bos taurus*)	5.7	Single LOAEL for the species (Lynch et al., 1976)
Mouse (*Mus musculus*)	9.6	Geometric mean of ten LOAEL for the species
Bird		
Chicken (*Gallus sp*)	4.4	Geometric mean of nineteen LOAEL for the species
Japanese Quail (*Coturnix japonica*)	11.3	Geometric mean of five LOAEL for the species;
Mallard (*Anas platyrhynchos*)	25.6	Geometric mean of three LOAEL for the species

LOAEL = lowest observed adverse effect level; TRV = toxicity reference value.

5.3.1.2.3 Chromium

A summary of the TRVs selected for mammalian and avian species for trivalent chromium is shown in Table 5-16.

Mammalian Toxicity Reference Values

Data for reproduction for one mammalian species was obtained from the Eco-SSL document for chromium exposure (US EPA, 2005d). A single NOAEL value was provided, based studies with the mouse.

Avian Toxicity Reference Values

Data for reproduction for two avian species were obtained from the Eco-SSL document for chromium exposure (US EPA, 2005d). Two LOAEL values were provided, based on studies with chicken and duck, respectively.

Table 5-16: Summary of Selected Toxicity Reference Values for Mammal and Bird Test Species – Chromium

Test Species	TRV (mg/kg/d)	Rationale
Mammal		
Mouse (*Mus musculus*)	91.1	Single NOAEL for the species (Elbetieha and Al-Hamood, 1997)
Bird		
Black Duck *(Anas rubripes)*	2.8	Single LOAEL for the species (Haseltine et al., 1986)
Chicken (*Gallus sp*)	75.4	Single LOAEL for the species (Meluzzi et al., 1996)

LOAEL = lowest observed adverse effect level; TRV = toxicity reference value.

5.3.1.2.4 Cobalt

A summary of the TRVs selected for mammalian and avian species for cobalt is shown in Table 5-17.

Mammalian Toxicity Reference Values

Two mammal species were represented in the Eco-SSL database with growth or reproduction endpoints and with LOAEL values reported (US EPA, 2005e). The species geometric mean values of LOAELs ranged from 13 mg/kg/d for rat to 28 mg/kg/d for mouse, from 6 and 7 LOAEL values respectively.

Avian Toxicity Reference Values

Data for growth and reproduction for avian species were obtained from the Eco-SSL database for cobalt exposure (US EPA, 2005a). The document was based on studies with chickens and ducks. Eight LOAEL values were retained for chicken and no LOAELs were retained for ducks because the LOAEL value was associated with high mortality. The selected avian TRV is 14 mg/kg/d for chickens based on the geometric mean of eight LOAEL values.

Table 5-17: Summary of Selected Toxicity Reference Values for Mammal and Bird Test Species – Cobalt

Test Species	TRV (mg/kg/d)	Rationale
Mammal		
Mouse (*Mus musculus*)	27.9	Geometric mean of six LOAELs for the species
Rat (*Rattus norvegicus*)	13.4	Geometric mean of seven LOAELs for the species
Bird		
Chicken (*Gallus* sp.)	14.1	Geometric mean of eight LOAELs for the species

LOAEL = lowest observed adverse effect level; TRV = toxicity reference value.

5.3.1.2.5 Copper

A summary of the TRVs selected for mammalian and avian species for copper is shown in Table 5-18.

Mammalian Toxicity Reference Values

The mammalian data for growth and reproduction were obtained from the data presented in the Eco-SSL document for copper exposure (US EPA, 2007b). The data were based on studies with goats, minks, mice, pigs, rabbits, rats, and sheep. The TRVs for goat, rabbit, and sheep are each based on a single LOAEL value. The TRVs for mink, mouse, pig, and rat are geometric means of the LOAEL data for each test species. For rats, the geometric mean of the NOAEL values was larger than the geometric mean of the LOAEL values, due to the larger dataset for the LOAEL values. For this species, the LOAEL was therefore derived only from the studies that had both LOAEL and NOAEL values. The geometric mean of the LOAELs ranged from 1.47 mg/kg/d for a goat to 296 mg/kg/d for a mouse. In the event that a species had no closely related test species, the LOAEL of 8.8 mg/kg/d for pig was used as the default mammalian TRV. It is not the lowest LOAEL; however, it can be used as the default mammalian TRV as it is the lowest species LOAEL above the lowest NOAEL from the same dataset.

Avian Toxicity Reference Values

The avian data for growth and reproduction were obtained from the data presented in the Eco-SSL document for copper exposure (US EPA, 2007b). The data were based on studies with chickens, ducks, and turkeys. The geometric means of the LOAELs within species were selected to serve as the TRVs. The geometric means of the LOAELs for chickens, ducks, and turkeys were 34.9 mg/kg/d, 75.2 mg/kg/d, and 27 mg/kg/d respectively, based on 78, 3, and 9 LOAEL values, respectively. These values were used as TRVs for other similar species in the EcoRA.

Table 5-18: Summary of Selected Toxicity Reference Values for Mammal and Bird Test Species – Copper

Test Species	TRV (mg/kg/d)	Rationale
Mammal		
Goat (*Capra hircus*)	1.5	Single LOAEL for the species (Solaiman et al., 2001)
Mink (*Neovison vison*)	11.5	Geometric mean of two LOAELs for the species
Mouse (*Mus musculus*)	296	Geometric mean of five LOAELs for the species
Pig (*Sus scrofa*)	8.8	Geometric mean of four LOAELs for the species
Rabbit (*Oryctolagus cuniculus*)	45.7	Single LOAEL for the species (Grobner et al., 1986)
Rat (*Rattus norvegicus*)	119	Geometric mean of five LOAELs for the species
Sheep (*Ovis aires*)	3.0	Single LOAEL for the species (Ortolani et al., 2003)
Bird		
Chicken (*Gallus* sp.)	34.9	Geometric mean of 78 LOAELs for the species
Duck (*Anas platyrhynchos*)	75.2	Geometric mean of three LOAELs for the species
Turkey (*Meleagris gallopavo*)	27.0	Geometric mean of nine LOAELs for the species

LOAEL = lowest observed adverse effect level; TRV = toxicity reference value.

5.3.1.2.6 Molybdenum

A summary of the TRVs selected for mammalian and avian species for molybdenum is shown in Table 5-19.

Mammalian Toxicity Reference Values

The selected TRVs for mammals are from studies with reported LOAEL values for growth and reproduction endpoints. Relevant LOAEL values for molybdenum were obtained from literature for four mammal species: rabbit (*Oryctolagus cunculus*), mouse (*Mus musculus*), cow (*Bos taurus*), and rat (*Rattus norvegicus*). The TRVs for rabbit, mouse, and cow are based on one LOAEL value and the TRV for rat is the geometric mean of two LOAEL values. The TRVs range from 2.6 mg/kg/d for a mouse to 30 mg/kg/d for a rabbit. In the event that a species had no closely related test species, the LOAEL of 2.6 mg/kg/d for the mouse was used as the default mammalian TRV.

Avian Toxicity Reference Values

The selected TRVs for birds are from studies with reported LOAEL values for growth and reproduction endpoints. Relevant LOAEL values for molybdenum were obtained from literature for two avian species: chicken (*Gallus* sp.) and turkey (*Meleagris gallopavo*). The TRV for chicken is the geometric mean of three LOAEL values and the TRV for turkey is based on one LOAEL value from Underwood (1971). The TRVs range from 21 mg/kg/d for a turkey to 39 mg/kg/d for a chicken. In the event that a species had no closely related test species, the LOAEL of 21 mg/kg/d for turkey was used as the default avian TRV.

Table 5-19: Summary of Selected Toxicity Reference Values for Mammal and Bird Test Species – Molybdenum

Test Species	TRV (mg/kg/d)	Rationale
Mammal		
Rabbit (*Oryctolagus cunculus*)	30	Single LOAEL for the species (Arrington and Davis, 1953)
Mouse (*Mus musculus*)	2.6	Single LOAEL for the species (Schroeder and Mitchener, 1971)
Cow (*Bos taurus*)	4.1	Single LOAEL for the species (Thomas and Moss, 1951)
Rat (*Rattus norvegicus*)	3.8	Geometric mean of two LOAELs for the species
Bird		
Chicken (*Gallus domesticus*)	38.6	Geometric mean of three LOAELs for the species
Turkey (*Melagris gallopavo*)	20.8	Single LOAEL for the species (Underwood, 1971)

LOAEL = lowest observed adverse effect level; TRV = toxicity reference value.

5.3.1.2.7 Selenium

A summary of the TRVs selected for mammalian and avian species for selenium is shown in Table 5-20.

Mammalian Toxicity Reference Values

There were seven mammal species represented in the Eco-SSL database with growth or reproduction endpoints, and with LOAEL only or LOAEL plus NOAEL reported (US EPA, 2007c). The species mean values of NOAELs were in the range of 0.17 mg/kg/day for cattle and pig to 0.93 mg/kg/day for mouse. The species mean values of LOAELs were in the range of 0.21 mg/kg/day for dog to 1.53 mg/kg/day for mouse. Each of the species mean values of LOAEL (Table 5-20) can be used as a surrogate TRV for other similar species in ecological risk assessment. If none of the test species are similar to the wildlife species of interest, the lowest LOAEL of 0.21 mg/kg/day can be used as a conservative default mammalian TRV for selenium.

Avian Toxicity Reference Values

Five species of birds are represented in the Eco-SSL database with growth and reproduction endpoints, and with LOAEL only or paired LOAEL and NOAEL reported(US EPA, 2007c). A geometric mean of NOAEL or LOAEL for the records relating to growth and reproduction endpoints was calculated for each species. The geometric means of NOAEL were 0.36 and 1.18 mg/kg/day for chicken and mallard, respectively. The geometric means of LOAELs were in a range of 0.59 mg/kg/day for chicken to 4.49 mg/kg/day for owl. Each of the species mean values of LOAEL (Table 5-20) can be used as a surrogate TRV for other similar species. If none of the test species are similar to species of interest, the lowest LOAEL of 0.59 mg/kg/day can be used as a conservative default avian TRV for selenium.

Table 5-20: Summary of Selected Toxicity Reference Values for Mammal and Bird Test Species – Selenium

Test Species	TRV (mg/kg/d)	Rationale
Mammal		
Cattle (*Bos taurus*)	0.33	Single LOAEL for the species (Jenkins and Hidiroglou, 1986)
Dog (*Canis familiaris*)	0.21	Single LOAEL for the species (Rhian and Moxon, 1943)
Hamster (*Mesocricetus auratus*)	0.77	Geometric mean of seven LOAEL for the species
Mouse (*Mus musculus*)	1.53	Geometric mean of twenty-three LOAEL for the species
Pig (*Sus scrofa*)	0.33	Geometric mean of twenty-one LOAEL for the species
Pronghorn (*Antilocapra americana*)	0.49	Single LOAEL for the species (Raisbeck et al., 1996)
Rat (*Rattus norvegicus*)	0.63	Geometric mean of sixty-nine LOAEL for the species
Bird		
Black-crowned night-heron (*Nycticorax nycticorax*)	0.68	Single LOAEL for the species (Smith et al., 1988)
Chicken (*Gallus sp*)	0.59	Geometric mean of thirty-two LOAEL for the species
Japanese Quail (*Coturnix japonica*)	0.75	Geometric mean of six LOAEL for the species
Mallard (*Anas platyrhynchos*)	1.29	Geometric mean of twenty LOAEL for the species
Owl (*Megascops asio*)	4.49	Single LOAEL for the species (Wiemeyer and Hoffman, 1996)

LOAEL = lowest observed adverse effect level; TRV = toxicity reference value.

5.3.1.2.8 Uranium

A summary of the TRVs selected for mammalian and avian species for uranium is shown in Table 5-21.

Mammalian Toxicity Reference Values

There is no Eco-SSL document for uranium. Previous risk assessments have used TRVs for mammalian exposure to uranium derived from Oak Ridge National Laboratory (ORNL) data (Sample et al., 1996). The Sample et al. (1996) data for mammalian species were based on a study by (Paternain et al., 1989) related to reproduction in mice. Sample et al. derived a LOAEL of 6.13 mg/kg/d from the study. The TRV quoted by the authors contains a small unit conversion error. Instead of 6.13 mg/kg/d as reported, the value should be 5.6 mg/kg/d. The difference arises from Sample's use of uranyl acetate molecular weight rather that uranyl acetate dehydrates molecular weight in converting the molecular dose to uranium dose. The correct value (5.6 mg/kg/d) can be found in the ATSDR toxicity profile for uranium. It represents the oral dose (to parents) at which viability of F1 offspring was reduced. Since the LOAEL value from (Paternain et al., 1989) is the only mammalian data available, this LOAEL value of 5.6 mg/kg/d was selected for evaluating uranium toxicity to mammalian species.

Avian Toxicity Reference Values

No data were available in the Eco-SSL database related to uranium exposure in avian species. Previous risk assessments used TRVs for avian exposure to uranium derived from the ORNL data (Sample et al., 1996). The data were based on a previous study (Haseltine and Sileo, 1983) describing mortality, body weight, liver, and kidney effects in ducks; Sample et al. derived a NOAEL of 16 mg/kg/d, but no LOAEL from the study. There are no other avian data available for uranium. The study used powdered metallic uranium. Uranium in this form would likely be oxidized to ionic form in the gut since uranium is strongly reducing in aqueous systems (Durante and Pugliese, 2002). Uranium in the environment similarly exists in an oxidized ionic form. Solubility differences among ionic forms in the gut can be bounded. The ICRP (ICRP, 1994) has determined that some oxidized species in the gut may be an order of magnitude less soluble than the most soluble species. Any reduced solubility in the gut would be offset by the fact that a NOAEL value is used in the absence of a LOAEL value. Since the NOAEL value (Haseltine and Sileo, 1983) is the only avian data available, this NOAEL value of 16 mg/kg/d was selected as the TRV for evaluating uranium toxicity to avian species.

Table 5-21: Summary of Selected Toxicity Reference Values for Mammal and Bird Test Species – Uranium

Test Species	TRV (mg/kg/d)	Rationale
Mammal		
Mouse *(Mus musculus)*	5.6	(Paternain et al., 1989), from (Sample et al., 1996)
Bird		
Black duck (*Anas rubripes*)	16	(Haseltine and Sileo, 1983), from (Sample et al., 1996)

TRV = toxicity reference value.

5.3.1.2.9 Vanadium

A summary of the TRVs selected for mammalian and avian species for vanadium is shown in Table 5-22.

Mammalian Toxicity Reference Values

The data for Mammalian species were obtained from the data presented in the Eco-SSL document for vanadium exposure (US EPA, 2005f). The selected TRVs for mammals are from studies with rat with reported LOAEL values for reproduction endpoints.

Avian Toxicity Reference Values

The data for avian species were obtained from the data presented in the Eco-SSL document for vanadium exposure (US EPA, 2005f). The selected TRVs for avian species are from studies with chickens with reported LOAEL values for growth endpoints.

Table 5-22: Summary of Selected Toxicity Reference Values for Mammal and Bird Test Species – Vanadium

Test Species	TRV (mg/kg/d)	Rationale
Mammal		
Rat (*Rattus norvegicus*)	2.18	Single LOAEL for the species (Domingo et al., 1986)
Bird		
Chicken (*Gallus sp*)	0.49	Single LOAEL for the species (Phillips et al., 1982)

LOAEL = lowest observed adverse effect level; TRV = toxicity reference value.

5.3.1.2.10 Zinc

A summary of the TRVs selected for mammalian and avian species for zinc is shown in Table 5-23.

Mammalian Toxicity Reference Values

The data for growth and reproduction for mammalian species were obtained from the data presented in the Eco-SSL document for zinc exposure (US EPA, 2007d). The data were based on studies with cattle, mice, pigs, rats and sheep; these species served as the surrogates for mammalian wildlife. The geometric means of the NOAEL and LOAEL data were calculated for each surrogate species. The geometric mean of the NOAELs ranged from 15.5 mg/kg/day for a pig to 585 mg/kg/day for a mouse. The geometric mean of the LOAELs ranged from 35 mg/kg/day for sheep to 4,395 mg/kg/day for a mouse. Each of the species mean values of LOAEL (Table 5-23) can be used as a surrogate TRV for other similar species in ecological risk assessment. In the event that none of the species are similar, the lowest LOAEL of 35 mg/kg/day can be used as a conservative default for the zinc TRV for mammals.

Avian Toxicity Reference Values

The data for growth and reproduction for avian species were obtained from the data presented in the Eco-SSL document for zinc exposure (US EPA, 2007d). The data were based predominantly on studies with chickens, with some studies with Japanese quails, mallard ducks and turkeys; these four species served as the surrogates for avian wildlife. The geometric means of the LOAEL and NOAEL data were calculated for each species. None of the studies for ducks presented in the Eco-SSL document reported both LOAEL and NOAEL data; therefore, no NOAEL for ducks was calculated. The geometric means of the NOAELs ranged from 61 mg/kg/day for a Japanese quail to 148 mg/kg/day for a turkey, and the geometric means of the LOAELs ranged from 63 mg/kg/day for a duck to 297 mg/kg/day for a turkey. Each of the geometric mean values of LOAEL for zinc (Table 5-23) can be used as a surrogate TRV for other similar species. In the event that none of the species are similar, the LOAEL of 123 mg/kg/day can be selected as the default TRV for avian species. The minimum LOAEL of 63 mg/kg/day was not selected as the default TRV because this value is equivalent to the minimum NOAEL of 61 mg/kg/day. Of the 52 LOAEL values obtained from the Eco SSL data, only 12 (i.e., 23%) are below 100 mg/kg/day. Additionally, the minimum LOAEL is less than half of the LOAEL value derived by Sample et al. (Sample et al., 1996), therefore it was not selected as the default TRV.

Table 5-23: Summary of Selected Toxicity Reference Values for Mammal and Bird Test Species – Zinc

Test Species	TRV (mg/kg/d)	Rationale
Mammal		
Cattle (*Bos taurus*)	76	Single LOAEL for the species (Miller et al., 1989)
Mouse (*Mus musculus*)	4395	Geometric mean of five LOAEL for the species
Pig (*Sus scrofa*)	90	Geometric mean of four LOAEL for the species
Rat (*Rattus norvegicus*)	249	Geometric mean of seventeen LOAEL for the species
Sheep (*Ovis aries*)	35	Geometric mean of two LOAEL for the species
Bird		
Chicken (*Gallus sp*)	179	Geometric mean of forty-seven LOAEL for the species
Japanese quail (*Cotumix japonica*)	123	Geometric mean of two LOAEL for the species
Mallard duck (*Anas platyrhynchos*)	63	Geometric mean of two LOAEL for the species
Turkey (*Maleagris gallopavo*)	297	Single LOAEL for the species (Vohra and Kratzer, 1968)

LOAEL = lowest observed adverse effect level; TRV = toxicity reference value.

5.3.2 Radiation Benchmarks

Radiation dose benchmarks of 0.4 mGy/h (9.6 mGy/d) and 0.1 mGy/h (2.4 mGy/d) (UNSCEAR, 2008) were selected for the assessment of effects on aquatic biota and terrestrial biota, respectively, as recommended in the CSA N288.6-22 standard (CSA, 2022) . This is a total dose benchmark, therefore the dose to biota due to each radionuclide of concern is summed to compare against this benchmark.

The aquatic biota considered by United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) are organisms such as fish and benthic invertebrates that reside in water. Birds and mammals with riparian habits are considered to be terrestrial biota. Dose calculations in this ERA follow the same convention.

Exceedance of the aquatic or terrestrial dose benchmarks is considered to indicate the potential for adverse effects to occur, and the need for more detailed assessment.

5.3.3 Uncertainties in the Effects Assessment

Uncertainties associated with the estimation of ecotoxicological effect levels for COPCs are inherent in the ERA process. Many uncertainties are associated with the use of literature-based TRVs. These uncertainties may include: extrapolation of results from laboratory tests to the field, differences in sensitivity between the test organism and resident organisms, laboratory conditions that are not representative of field conditions, and the form of the COPC used in toxicity testing, which may not be representative of the form that would be found at the Project.

The use of TRVs from laboratory studies tends to be conservative because these studies are typically chemical-specific and use highly bioavailable forms of the COPC studied. In field situations, the chemical form of the same COPC may be less bioavailable, and toxicity-modifying factors may be present that were not acting in laboratory tests.

The EC_{20} values were used for aquatic biota to reduce uncertainty by representing a standard threshold level of low magnitude effects. Depending on the size of the available dataset, selection of the 5^{th} percentile or lowest EC_{20} value as the TRV for an aquatic biota group was intended to reduce the likelihood that risks would be underestimated.

There is inherent uncertainty associated with the use of LOAEL values as TRVs for birds and mammals as these values are not precisely related to a particular magnitude of effect. However, LOAEL values have widespread use in the risk assessment community and the science is not currently available to change this approach to TRVs. Defaulting to the most conservative TRV for ecological receptors that are not closely related taxonomically to the test species was meant to reduce the likelihood that risks would be underestimated.

5.4 Risk Characterization

Risk assessment is the process of estimating the likelihood of undesirable effects on ecological health resulting from exposure to chemical or radiological constituents. Three components must be present for risks to ecological health to exist:

- The COPC must be present at concentrations sufficient to cause a possible adverse effect.
- A receptor must be present.
- There must be a complete exposure pathway by which the receptor can come into contact with the COPC

5.4.1 Risk Estimation and Discussion

Risk characterization is the process in the EcoRA that integrates the results from the exposure and effects assessments to estimate the risk of adverse effects on ecological receptors. The risk characterization also evaluates the uncertainties associated with the overall conclusion of risk.

The hazard quotient (HQ) is a simple approach that provides a quantitative estimate of overall risk. The HQ is the ratio between the exposure estimate and a TRV:

$$HQ = \frac{Exposure\ (Dose)\ Estimate}{TRV}$$

If the HQ is less than or equal to 1, this suggests low risk to the ecological receptor because exposure estimates are below levels known to cause adverse effects. If the HQ is greater than 1, adverse effects may be possible, and further investigation of the assumptions of the exposure and effects assessments could be considered to reduce the conservatism inherent in the EcoRA. Risk assessment is often an iterative process of refining information, and the identified risk in the first iteration is often an artefact of conservative assumptions. If further evaluation under more realistic assumptions confirms the risk, this information can be used to inform mitigation to avoid, eliminate, or reduce the source of the risk.

5.4.1.1 Non-radiological Risk

The predicted total HQs (baseline and Project) for all aquatic and terrestrial ecological receptors at all assessed locations during the Project phases and in the future centuries are shown in Table 5-24. The HQs represent the maximum HQ over the life of the Project for relevant COPCs, which is a conservative representation of risk. Additional copper HQ values for some aquatic ecological receptors are presented in Section 6.3.2 using TRVs re-evaluated from the copper FEQG. Additional evaluation of selenium in fish (whole body and egg-ovary) is presented in Section 6.3.1 using TRVs from the selenium FEQG.

No significant adverse effect on either aquatic or terrestrial populations or communities as a result of releases from the Project are predicted during the Project phases.

The predicted total HQs are less than 1 for terrestrial and riparian receptors for all non-radiological COPCs during all phases of the Project and the future centuries, including for invertebrates, vegetation, mammals, and birds. This includes receptors residing and feeding in and around Whitefish Lake, McGowan Lake, and Russell Lake (exposure locations) as well as Kratchkowsky Lake (a reference location).

Since there are no exceedances of TRVs (all HQs less than 1) for birds and mammals, individual SAR would also be considered protected.

The predicted total HQs are less than 1 for aquatic receptors for all non-radiological COPCs, except copper, during all phases of the Project and the future centuries, including aquatic plants, invertebrates and fish (including northern pike and white sucker). This includes receptors at Whitefish Lake, McGowan Lake, and Russell Lake (exposure locations) as well as Kratchkowsky Lake (a reference location). When copper is re-evaluated using updated TRVs as shown in Section 6.3.2, under baseline conditions as well as the future centuries, copper HQs for all aquatic organisms are less than 1 with the exception of predator fish in Whitefish Lake, and benthic invertebrates at all locations where HQs are slightly above 1. Using predicted operational site conditions for hardness of 9 mg/L and pH of 7 during periods of treated effluent discharge, copper HQs for all aquatic organisms are less than 1 at all downstream locations, indicating no adverse effects to aquatic organisms from facility related copper (Section 6.3.2).

For assessment of risk to benthic invertebrates, risk was calculated based on toxicity benchmarks as water concentrations. However, considering that benthic invertebrates also reside in sediment, a comparison of predicted sediment concentrations against sediment toxicity benchmarks was warranted. This only applied to molybdenum and selenium in sediment, as no other COPC exceeded sediment screening values (Table 3-6). Molybdenum and selenium in sediment in Whitefish Lake (LA-5) were predicted to exceed the REF screening values from Burnett-Seidel and Liber (2013), but were predicted to be below the NE2 values in Whitefish Lake and all other downstream locations. Concentrations below the NE2 values indicate that benthic invertebrate community metrics (abundance, richness, and evenness) downstream of discharges are not expected to differ significantly (i.e., by 20%) from those observed at natural background conditions.

Table 5-24: Estimated Non-radiological Total Risk to Ecological Receptors – Project Phases and Future Centuries

Biota		Location	Maximum HQs during Project Phases											
			Arsenic	Cadmium	Chloride	Cobalt	Chromium	Copper	Molybdenum	Sulphate	Selenium	Uranium	Vanadium	Zinc
Aquatic Plants[(a)]	Macrophytes	Reference (Kratchkowsky Lake)	4.73E-04	3.13E-03	1.02E-04	1.04E-02	2.65E-02	1.64E-02	3.47E-06	2.98E-04	4.93E-05	5.67E-06	2.09E-03	6.03E-03
		Whitefish Lake North	4.37E-04	3.08E-03	1.02E-04	1.03E-02	2.62E-02	1.63E-02	3.46E-06	2.98E-04	4.83E-05	5.55E-06	1.93E-03	5.94E-03
		Whitefish Lake Middle	5.81E-04	5.23E-03	1.95E-03	1.31E-02	3.73E-02	2.16E-02	7.84E-04	1.67E-02	6.37E-04	1.04E-04	8.38E-03	9.16E-03
		Whitefish Lake South	5.91E-04	5.08E-03	1.94E-03	1.31E-02	3.65E-02	2.15E-02	7.73E-04	1.67E-02	6.07E-04	9.94E-05	7.06E-03	8.91E-03
		McGowan Lake	5.00E-04	4.31E-03	1.33E-03	1.21E-02	3.27E-02	1.97E-02	5.09E-04	1.13E-02	3.81E-04	6.14E-05	4.10E-03	7.77E-03
		Russell Lake Inlet	4.85E-04	3.96E-03	1.04E-03	1.17E-02	3.09E-02	1.89E-02	3.82E-04	8.61E-03	2.87E-04	4.57E-05	3.36E-03	7.24E-03
	Phytoplankton	Reference (Kratchkowsky Lake)	6.21E-03	9.53E-03	5.31E-05	2.21E-03	2.65E-02	6.76E-02	3.47E-06	2.58E-04	4.21E-04	7.09E-05	2.09E-03	2.33E-02
		Whitefish Lake North	5.73E-03	9.37E-03	5.31E-05	2.20E-03	2.62E-02	6.74E-02	3.46E-06	2.58E-04	4.12E-04	6.94E-05	1.93E-03	2.30E-02
		Whitefish Lake Middle	7.63E-03	1.59E-02	1.01E-03	2.80E-03	3.73E-02	8.94E-02	7.84E-04	1.45E-02	5.43E-03	1.31E-03	8.38E-03	3.54E-02
		Whitefish Lake South	7.76E-03	1.54E-02	1.01E-03	2.78E-03	3.65E-02	8.88E-02	7.73E-04	1.45E-02	5.18E-03	1.24E-03	7.06E-03	3.44E-02
		McGowan Lake	6.57E-03	1.31E-02	6.93E-04	2.59E-03	3.27E-02	8.15E-02	5.09E-04	9.78E-03	3.25E-03	7.68E-04	4.10E-03	3.00E-02
		Russell Lake Inlet	6.36E-03	1.20E-02	5.38E-04	2.49E-03	3.09E-02	7.79E-02	3.82E-04	7.47E-03	2.45E-03	5.72E-04	3.36E-03	2.80E-02
Aquatic Animals[(a)]	Benthic Invertebrate	Reference (Kratchkowsky Lake)	7.10E-04	4.68E-02	7.66E-04	5.70E-03	2.30E-04	3.07E-01	3.42E-06	9.42E-04	3.11E-03	1.07E-03	1.54E-03	2.20E-02
		Whitefish Lake North	7.10E-04	4.68E-02	7.66E-04	5.70E-03	2.30E-04	3.07E-01	3.42E-06	9.42E-04	3.11E-03	1.07E-03	1.54E-03	2.20E-02
		Whitefish Lake Middle	9.38E-04	6.89E-02	1.45E-02	6.90E-03	2.99E-04	3.84E-01	5.80E-04	5.28E-02	2.74E-02	1.33E-02	5.11E-03	3.02E-02
		Whitefish Lake South	8.96E-04	6.79E-02	1.45E-02	6.88E-03	2.96E-04	3.82E-01	5.70E-04	5.25E-02	2.63E-02	1.27E-02	4.58E-03	2.98E-02
		McGowan Lake	8.05E-04	6.13E-02	9.87E-03	6.57E-03	2.77E-04	3.62E-01	4.17E-04	3.52E-02	1.86E-02	8.84E-03	3.05E-03	2.74E-02
		Russell Lake Inlet	7.69E-04	5.75E-02	7.77E-03	6.36E-03	2.65E-04	3.49E-01	3.17E-04	2.73E-02	1.44E-02	6.75E-03	2.50E-03	2.60E-02
	Northern pike	Reference (Kratchkowsky Lake)	1.89E-04	6.62E-02	3.26E-04	4.07E-05	5.05E-03	2.07E-01	1.34E-06	1.37E-03	3.80E-02	5.67E-05	2.09E-03	2.19E-02
		Whitefish Lake North	1.75E-04	6.51E-02	3.26E-04	4.06E-05	4.99E-03	2.07E-01	1.34E-06	1.37E-03	3.72E-02	5.55E-05	1.93E-03	2.15E-02
		Whitefish Lake Middle	2.33E-04	1.10E-01	6.21E-03	5.16E-05	7.10E-03	2.74E-01	3.04E-04	7.70E-02	4.91E-01	1.04E-03	8.38E-03	3.32E-02
		Whitefish Lake South	2.36E-04	1.07E-01	6.18E-03	5.13E-05	6.95E-03	2.72E-01	3.00E-04	7.67E-02	4.68E-01	9.94E-04	7.06E-03	3.23E-02
		McGowan Lake	2.00E-04	9.10E-02	4.25E-03	4.77E-05	6.23E-03	2.50E-01	1.97E-04	5.18E-02	2.93E-01	6.14E-04	4.10E-03	2.82E-02
		Russell Lake Inlet	1.94E-04	8.37E-02	3.30E-03	4.59E-05	5.88E-03	2.39E-01	1.48E-04	3.96E-02	2.22E-01	4.57E-04	3.36E-03	2.63E-02
	White sucker	Reference (Kratchkowsky Lake)	9.03E-04	8.10E-02	4.65E-04	2.47E-04	9.90E-04	3.10E-01	3.46E-06	2.29E-04	5.16E-02	2.04E-05	1.95E-03	1.97E-02
		Whitefish Lake North	8.47E-04	8.00E-02	4.65E-04	2.47E-04	9.80E-04	3.09E-01	3.45E-06	2.29E-04	5.07E-02	2.01E-05	1.84E-03	1.95E-02
		Whitefish Lake Middle	1.13E-03	1.31E-01	8.85E-03	3.10E-04	1.37E-03	4.04E-01	7.33E-04	1.29E-02	6.16E-01	3.47E-04	7.56E-03	2.92E-02
		Whitefish Lake South	1.13E-03	1.28E-01	8.81E-03	3.09E-04	1.34E-03	4.02E-01	7.22E-04	1.28E-02	5.87E-01	3.31E-04	6.44E-03	2.85E-02
		McGowan Lake	9.69E-04	1.10E-01	6.05E-03	2.89E-04	1.21E-03	3.72E-01	4.86E-04	8.65E-03	3.77E-01	2.09E-04	3.84E-03	2.52E-02
		Russell Lake Inlet	9.35E-04	1.02E-01	4.71E-03	2.78E-04	1.15E-03	3.56E-01	3.66E-04	6.63E-03	2.86E-01	1.56E-04	3.14E-03	2.36E-02
	Zooplankton	Reference (Kratchkowsky Lake)	3.51E-04	1.59E-01	7.66E-04	9.14E-03	5.30E-02	3.11E-01	3.47E-06	1.62E-03	3.35E-03	5.20E-04	8.80E-05	2.33E-02
		Whitefish Lake North	3.24E-04	1.56E-01	7.66E-04	9.12E-03	5.24E-02	3.10E-01	3.46E-06	1.62E-03	3.28E-03	5.09E-04	8.14E-05	2.30E-02
		Whitefish Lake Middle	4.31E-04	2.65E-01	1.46E-02	1.16E-02	7.46E-02	4.11E-01	7.84E-04	9.10E-02	4.33E-02	9.57E-03	3.53E-04	3.54E-02
		Whitefish Lake South	4.38E-04	2.57E-01	1.45E-02	1.15E-02	7.30E-02	4.08E-01	7.73E-04	9.06E-02	4.12E-02	9.11E-03	2.97E-04	3.44E-02
		McGowan Lake	3.71E-04	2.18E-01	9.99E-03	1.07E-02	6.54E-02	3.75E-01	5.09E-04	6.12E-02	2.59E-02	5.63E-03	1.73E-04	3.00E-02
		Russell Lake Inlet	3.59E-04	2.01E-01	7.75E-03	1.03E-02	6.17E-02	3.58E-01	3.82E-04	4.68E-02	1.95E-02	4.19E-03	1.41E-04	2.80E-02

Biota		Location	Maximum HQs during Project Phases											
			Arsenic	Cadmium	Chloride	Cobalt	Chromium	Copper	Molybdenum	Sulphate	Selenium	Uranium	Vanadium	Zinc
Terrestrial Animals	Black Bear	Reference (Kratchkowsky Lake)	1.59E-03	5.16E-06	0.00E+00	1.70E-04	4.28E-05	1.27E-02	6.73E-04	0.00E+00	2.60E-02	2.15E-04	2.17E-03	1.06E-02
		Whitefish Lake	1.59E-03	5.17E-06	0.00E+00	1.70E-04	4.36E-05	1.28E-02	8.93E-04	0.00E+00	7.27E-02	3.70E-04	2.24E-03	1.07E-02
	Canada Lynx	Reference (Kratchkowsky Lake)	5.28E-03	2.43E-05	0.00E+00	4.21E-05	7.18E-05	2.94E-02	2.11E-04	0.00E+00	1.37E-01	1.04E-04	4.67E-03	4.09E-01
		Whitefish Lake	5.30E-03	2.43E-05	0.00E+00	4.25E-05	7.28E-05	3.03E-02	9.33E-04	0.00E+00	1.39E-01	1.15E-03	4.75E-03	4.10E-01
		McGowan Lake	5.28E-03	2.43E-05	0.00E+00	4.23E-05	7.20E-05	2.95E-02	6.78E-04	0.00E+00	1.38E-01	2.45E-04	4.68E-03	4.09E-01
		Russell Lake Inlet	5.28E-03	2.43E-05	0.00E+00	4.22E-05	7.19E-05	2.94E-02	5.61E-04	0.00E+00	1.38E-01	1.43E-04	4.67E-03	4.09E-01
	Mink	Reference (Kratchkowsky Lake)	3.43E-03	7.48E-06	0.00E+00	7.74E-05	1.51E-04	1.27E-02	2.47E-04	0.00E+00	6.87E-02	1.25E-04	6.37E-03	9.08E-03
		Whitefish Lake	4.38E-03	9.12E-06	0.00E+00	8.93E-05	1.84E-04	1.59E-02	3.34E-02	0.00E+00	6.04E-01	1.20E-03	1.57E-02	1.32E-02
		McGowan Lake	3.79E-03	8.54E-06	0.00E+00	8.58E-05	1.73E-04	1.50E-02	2.39E-02	0.00E+00	3.94E-01	5.36E-04	1.00E-02	1.15E-02
		Russell Lake Inlet	3.65E-03	8.26E-06	0.00E+00	8.38E-05	1.67E-04	1.44E-02	1.82E-02	0.00E+00	3.09E-01	3.92E-04	8.69E-03	1.08E-02
	Moose	Reference (Kratchkowsky Lake)	1.71E-04	1.85E-04	0.00E+00	8.80E-05	2.02E-05	3.93E-02	1.80E-04	0.00E+00	1.81E-03	1.16E-04	1.93E-03	2.21E-03
		Whitefish Lake	1.96E-04	1.92E-04	0.00E+00	9.53E-05	2.28E-05	4.08E-02	2.58E-03	0.00E+00	7.38E-03	3.21E-03	4.52E-03	2.27E-03
		McGowan Lake	1.81E-04	1.89E-04	0.00E+00	9.24E-05	2.18E-05	3.98E-02	1.83E-03	0.00E+00	5.05E-03	6.21E-04	2.87E-03	2.24E-03
		Russell Lake Inlet	1.77E-04	1.88E-04	0.00E+00	9.12E-05	2.14E-05	3.96E-02	1.42E-03	0.00E+00	4.15E-03	3.09E-04	2.52E-03	2.23E-03
	Moose Organs	Reference (Kratchkowsky Lake)	1.71E-04	1.85E-04	0.00E+00	8.80E-05	2.02E-05	3.93E-02	1.80E-04	0.00E+00	1.81E-03	1.16E-04	1.93E-03	2.21E-03
		McGowan Lake	1.81E-04	1.89E-04	0.00E+00	9.24E-05	2.18E-05	3.98E-02	1.83E-03	0.00E+00	5.05E-03	6.21E-04	2.87E-03	2.24E-03
		Russell Lake Inlet	1.77E-04	1.88E-04	0.00E+00	9.12E-05	2.14E-05	3.96E-02	1.42E-03	0.00E+00	4.15E-03	3.09E-04	2.52E-03	2.23E-03
	Muskrat	Reference (Kratchkowsky Lake)	1.81E-03	1.79E-04	0.00E+00	3.36E-04	1.74E-04	3.12E-04	2.69E-04	0.00E+00	4.75E-03	3.24E-04	1.88E-02	4.80E-04
		Whitefish Lake	2.35E-03	2.75E-04	0.00E+00	4.23E-04	2.27E-04	4.10E-04	4.84E-02	0.00E+00	5.13E-02	4.43E-03	6.64E-02	7.14E-04
		McGowan Lake	2.02E-03	2.39E-04	0.00E+00	3.93E-04	2.09E-04	3.76E-04	3.40E-02	0.00E+00	3.24E-02	2.85E-03	3.70E-02	6.14E-04
		Russell Lake Inlet	1.94E-03	2.22E-04	0.00E+00	3.78E-04	2.00E-04	3.59E-04	2.58E-02	0.00E+00	2.47E-02	2.16E-03	3.03E-02	5.74E-04
	Snowshoe Hare	Reference (Kratchkowsky Lake)	2.25E-03	4.08E-03	0.00E+00	3.05E-04	9.04E-05	5.53E-03	1.06E-04	0.00E+00	1.07E-02	4.88E-04	5.96E-03	1.97E-02
		Whitefish Lake	2.26E-03	4.09E-03	0.00E+00	3.08E-04	9.13E-05	5.69E-03	1.84E-04	0.00E+00	1.10E-02	1.07E-02	6.04E-03	1.97E-02
		McGowan Lake	2.25E-03	4.08E-03	0.00E+00	3.06E-04	9.06E-05	5.55E-03	1.56E-04	0.00E+00	1.08E-02	1.83E-03	5.97E-03	1.97E-02
		Russell Lake Inlet	2.25E-03	4.08E-03	0.00E+00	3.06E-04	9.05E-05	5.54E-03	1.43E-04	0.00E+00	1.08E-02	8.49E-04	5.97E-03	1.97E-02
	Southern Red-Backed Vole	Reference (Kratchkowsky Lake)	7.62E-03	1.28E-02	0.00E+00	3.27E-03	2.96E-04	2.13E-02	2.88E-02	0.00E+00	8.08E-02	7.45E-03	1.45E-02	3.56E-03
		Whitefish Lake	7.63E-03	1.28E-02	0.00E+00	3.29E-03	3.00E-04	2.20E-02	3.03E-02	0.00E+00	8.14E-02	9.70E-02	1.48E-02	3.57E-03
		McGowan Lake	7.62E-03	1.28E-02	0.00E+00	3.27E-03	2.97E-04	2.14E-02	2.96E-02	0.00E+00	8.09E-02	1.92E-02	1.45E-02	3.56E-03
		Russell Lake Inlet	7.62E-03	1.28E-02	0.00E+00	3.27E-03	2.96E-04	2.13E-02	2.94E-02	0.00E+00	8.08E-02	1.06E-02	1.45E-02	3.56E-03
	WoodLand Caribou	Reference (Kratchkowsky Lake)	3.70E-04	2.79E-04	0.00E+00	1.62E-04	2.30E-04	2.74E-02	3.30E-04	0.00E+00	4.63E-03	3.10E-04	7.79E-03	2.80E-03
		Whitefish Lake	3.85E-04	2.84E-04	0.00E+00	1.66E-04	2.33E-04	2.83E-02	2.54E-03	0.00E+00	7.65E-03	9.19E-03	8.98E-03	2.82E-03
	Canada Goose	Reference (Kratchkowsky Lake)	2.13E-04	1.25E-04	0.00E+00	3.19E-05	2.36E-05	8.69E-04	1.57E-05	0.00E+00	3.66E-04	2.37E-05	5.58E-03	5.45E-04
		Whitefish Lake	2.12E-04	1.25E-04	0.00E+00	3.20E-05	2.34E-05	8.91E-04	1.57E-05	0.00E+00	3.67E-04	4.96E-04	5.61E-03	5.46E-04

Biota		Location	Maximum HQs during Project Phases											
			Arsenic	Cadmium	Chloride	Cobalt	Chromium	Copper	Molybdenum	Sulphate	Selenium	Uranium	Vanadium	Zinc
		McGowan Lake	2.13E-04	1.25E-04	0.00E+00	3.20E-05	2.37E-05	8.72E-04	4.46E-05	0.00E+00	3.81E-04	8.65E-05	5.60E-03	5.46E-04
		Russell Lake Inlet	2.13E-04	1.25E-04	0.00E+00	3.20E-05	2.36E-05	8.70E-04	3.74E-05	0.00E+00	3.76E-04	4.08E-05	5.59E-03	5.46E-04
	Bald Eagle	Reference (Kratchkowsky Lake)	2.80E-03	7.63E-04	0.00E+00	1.89E-04	4.50E-04	2.33E-03	5.06E-05	0.00E+00	3.23E-02	2.20E-04	9.26E-02	1.56E-03
		Whitefish Lake	2.81E-03	7.64E-04	0.00E+00	1.89E-04	4.52E-04	2.36E-03	6.94E-05	0.00E+00	4.54E-02	2.49E-04	9.31E-02	1.58E-03
	Olive-Sided Flycatcher	Reference (Kratchkowsky Lake)	7.84E-03	3.93E-02	0.00E+00	8.99E-04	1.77E-03	2.92E-02	5.67E-04	0.00E+00	7.03E-02	8.03E-04	2.56E-01	1.91E-02
		Whitefish Lake	8.36E-03	3.94E-02	0.00E+00	9.43E-04	1.87E-03	3.36E-02	1.38E-02	0.00E+00	1.25E-01	1.72E-02	2.86E-01	2.02E-02
		McGowan Lake	8.05E-03	3.93E-02	0.00E+00	9.27E-04	1.84E-03	3.22E-02	1.02E-02	0.00E+00	1.05E-01	3.08E-03	2.68E-01	1.98E-02
		Russell Lake Inlet	7.97E-03	3.93E-02	0.00E+00	9.19E-04	1.82E-03	3.15E-02	7.84E-03	0.00E+00	9.56E-02	1.49E-03	2.64E-01	1.97E-02
	Common Loon	Reference (Kratchkowsky Lake)	1.23E-03	1.80E-05	0.00E+00	2.66E-05	7.35E-05	3.37E-03	1.01E-05	0.00E+00	3.53E-02	6.44E-06	4.77E-03	1.51E-03
		Whitefish Lake	1.52E-03	2.67E-05	0.00E+00	3.27E-05	9.98E-05	4.30E-03	1.73E-03	0.00E+00	2.93E-01	1.05E-04	1.83E-02	2.25E-03
		McGowan Lake	1.31E-03	2.36E-05	0.00E+00	3.08E-05	8.95E-05	4.01E-03	1.24E-03	0.00E+00	1.92E-01	6.40E-05	9.37E-03	1.93E-03
		Russell Lake Inlet	1.27E-03	2.21E-05	0.00E+00	2.98E-05	8.50E-05	3.85E-03	9.43E-04	0.00E+00	1.52E-01	4.80E-05	7.68E-03	1.80E-03
	Mallard	Reference (Kratchkowsky Lake)	4.57E-03	6.31E-05	0.00E+00	3.21E-04	1.51E-02	1.03E-02	1.62E-04	0.00E+00	5.20E-03	9.80E-05	6.22E-02	7.83E-03
		Whitefish Lake	6.02E-03	9.34E-05	0.00E+00	3.93E-04	1.95E-02	1.29E-02	2.76E-02	0.00E+00	4.69E-02	1.25E-03	2.10E-01	1.08E-02
		McGowan Lake	5.17E-03	8.28E-05	0.00E+00	3.71E-04	1.81E-02	1.21E-02	1.98E-02	0.00E+00	3.15E-02	8.24E-04	1.23E-01	9.76E-03
		Russell Lake Inlet	4.94E-03	7.76E-05	0.00E+00	3.59E-04	1.73E-02	1.17E-02	1.51E-02	0.00E+00	2.44E-02	6.27E-04	1.01E-01	9.25E-03
	American Robin	Reference (Kratchkowsky Lake)	3.87E-02	3.05E-02	0.00E+00	5.09E-03	3.79E-03	1.38E-01	2.66E-03	0.00E+00	1.09E-01	3.29E-03	7.82E-01	7.91E-02
		Whitefish Lake	3.87E-02	3.06E-02	0.00E+00	5.12E-03	3.80E-03	1.43E-01	2.68E-03	0.00E+00	1.10E-01	3.27E-02	7.84E-01	7.94E-02
		McGowan Lake	3.87E-02	3.05E-02	0.00E+00	5.09E-03	3.79E-03	1.39E-01	2.75E-03	0.00E+00	1.09E-01	7.15E-03	7.82E-01	7.92E-02
		Russell Lake Inlet	3.87E-02	3.05E-02	0.00E+00	5.09E-03	3.79E-03	1.38E-01	2.73E-03	0.00E+00	1.09E-01	4.32E-03	7.82E-01	7.91E-02
	Lesser Scaup	Reference (Kratchkowsky Lake)	7.95E-03	1.15E-04	0.00E+00	7.91E-04	2.54E-02	1.82E-02	2.80E-04	0.00E+00	9.74E-03	1.72E-04	1.20E-01	1.48E-02
		Whitefish Lake	1.04E-02	1.73E-04	0.00E+00	9.77E-04	3.30E-02	2.27E-02	4.81E-02	0.00E+00	9.17E-02	2.32E-03	4.21E-01	2.06E-02
		McGowan Lake	8.92E-03	1.52E-04	0.00E+00	9.18E-04	3.05E-02	2.14E-02	3.44E-02	0.00E+00	6.07E-02	1.50E-03	2.36E-01	1.85E-02
		Russell Lake Inlet	8.53E-03	1.42E-04	0.00E+00	8.86E-04	2.92E-02	2.06E-02	2.62E-02	0.00E+00	4.68E-02	1.14E-03	1.94E-01	1.75E-02

Biota		Location	Maximum HQs during Future Centuries											
			Arsenic	Cadmium	Chloride	Cobalt	Chromium	Copper	Molybdenum	Sulphate	Selenium	Uranium	Vanadium	Zinc
Aquatic Plants[(a)]	Macrophytes	Reference (Kratchkowsky Lake)	4.10E-04	3.05E-03	1.02E-04	1.03E-02	2.59E-02	1.63E-02	3.45E-06	2.98E-04	4.75E-05	5.46E-06	1.82E-03	5.87E-03
		Whitefish Lake North	4.10E-04	3.05E-03	1.02E-04	1.03E-02	2.59E-02	1.63E-02	3.45E-06	2.98E-04	4.75E-05	5.46E-06	1.82E-03	5.87E-03
		Whitefish Lake Middle	4.25E-04	3.07E-03	1.32E-04	1.09E-02	2.63E-02	1.65E-02	3.76E-06	3.12E-04	6.33E-05	6.68E-06	1.84E-03	6.38E-03
		Whitefish Lake South	4.23E-04	3.06E-03	1.31E-04	1.08E-02	2.63E-02	1.65E-02	3.75E-06	3.12E-04	6.26E-05	6.63E-06	1.83E-03	6.36E-03
		McGowan Lake	4.16E-04	3.06E-03	1.25E-04	1.07E-02	2.62E-02	1.64E-02	3.68E-06	3.09E-04	5.80E-05	6.28E-06	1.83E-03	6.22E-03
		Russell Lake Inlet	4.14E-04	3.06E-03	1.19E-04	1.06E-02	2.61E-02	1.64E-02	3.62E-06	3.06E-04	5.52E-05	6.06E-06	1.82E-03	6.13E-03
	Phytoplankton	Reference (Kratchkowsky Lake)	5.38E-03	9.26E-03	5.31E-05	2.20E-03	2.59E-02	6.72E-02	3.45E-06	2.58E-04	4.05E-04	6.83E-05	1.82E-03	2.27E-02

Biota		Location	Maximum HQs during Future Centuries											
			Arsenic	Cadmium	Chloride	Cobalt	Chromium	Copper	Molybdenum	Sulphate	Selenium	Uranium	Vanadium	Zinc
		Whitefish Lake North	5.38E-03	9.26E-03	5.31E-05	2.20E-03	2.59E-02	6.72E-02	3.45E-06	2.58E-04	4.05E-04	6.83E-05	1.82E-03	2.27E-02
		Whitefish Lake Middle	5.58E-03	9.32E-03	6.84E-05	2.31E-03	2.63E-02	6.81E-02	3.76E-06	2.71E-04	5.40E-04	8.36E-05	1.84E-03	2.47E-02
		Whitefish Lake South	5.55E-03	9.32E-03	6.82E-05	2.31E-03	2.63E-02	6.81E-02	3.75E-06	2.71E-04	5.34E-04	8.29E-05	1.83E-03	2.46E-02
		McGowan Lake	5.47E-03	9.30E-03	6.48E-05	2.28E-03	2.62E-02	6.79E-02	3.68E-06	2.68E-04	4.95E-04	7.84E-05	1.83E-03	2.40E-02
		Russell Lake Inlet	5.43E-03	9.29E-03	6.21E-05	2.26E-03	2.61E-02	6.77E-02	3.62E-06	2.66E-04	4.71E-04	7.57E-05	1.82E-03	2.37E-02
Aquatic Animals[a]	Benthic Invertebrate	Reference (Kratchkowsky Lake)	7.10E-04	4.68E-02	7.66E-04	5.70E-03	2.30E-04	3.07E-01	3.42E-06	9.42E-04	3.11E-03	1.07E-03	1.54E-03	2.20E-02
		Whitefish Lake North	7.10E-04	4.68E-02	7.66E-04	5.70E-03	2.30E-04	3.07E-01	3.42E-06	9.42E-04	3.11E-03	1.07E-03	1.54E-03	2.20E-02
		Whitefish Lake Middle	7.36E-04	4.71E-02	9.85E-04	6.00E-03	2.33E-04	3.11E-01	3.73E-06	9.87E-04	4.14E-03	1.31E-03	1.55E-03	2.39E-02
		Whitefish Lake South	7.33E-04	4.71E-02	9.83E-04	6.00E-03	2.33E-04	3.11E-01	3.73E-06	9.87E-04	4.09E-03	1.30E-03	1.55E-03	2.39E-02
		McGowan Lake	7.21E-04	4.70E-02	9.33E-04	5.93E-03	2.33E-04	3.10E-01	3.65E-06	9.77E-04	3.79E-03	1.23E-03	1.55E-03	2.33E-02
		Russell Lake Inlet	7.17E-04	4.70E-02	8.94E-04	5.88E-03	2.32E-04	3.09E-01	3.60E-06	9.68E-04	3.61E-03	1.19E-03	1.54E-03	2.30E-02
	Northern pike	Reference (Kratchkowsky Lake)	1.64E-04	6.43E-02	3.26E-04	4.05E-05	4.94E-03	2.06E-01	1.34E-06	1.37E-03	3.67E-02	5.46E-05	1.82E-03	2.13E-02
		Whitefish Lake North	1.64E-04	6.43E-02	3.26E-04	4.05E-05	4.94E-03	2.06E-01	1.34E-06	1.37E-03	3.67E-02	5.46E-05	1.82E-03	2.13E-02
		Whitefish Lake Middle	1.70E-04	6.47E-02	4.19E-04	4.26E-05	5.01E-03	2.09E-01	1.46E-06	1.44E-03	4.88E-02	6.68E-05	1.84E-03	2.31E-02
		Whitefish Lake South	1.69E-04	6.47E-02	4.18E-04	4.26E-05	5.00E-03	2.09E-01	1.45E-06	1.44E-03	4.83E-02	6.63E-05	1.83E-03	2.30E-02
		McGowan Lake	1.67E-04	6.46E-02	3.97E-04	4.21E-05	4.99E-03	2.08E-01	1.43E-06	1.42E-03	4.47E-02	6.28E-05	1.83E-03	2.25E-02
		Russell Lake Inlet	1.66E-04	6.45E-02	3.81E-04	4.17E-05	4.98E-03	2.08E-01	1.40E-06	1.41E-03	4.26E-02	6.06E-05	1.82E-03	2.22E-02
	White sucker	Reference (Kratchkowsky Lake)	8.06E-04	7.93E-02	4.65E-04	2.47E-04	9.74E-04	3.09E-01	3.44E-06	2.29E-04	5.01E-02	1.98E-05	1.75E-03	1.93E-02
		Whitefish Lake North	8.06E-04	7.93E-02	4.65E-04	2.47E-04	9.74E-04	3.09E-01	3.44E-06	2.29E-04	5.01E-02	1.98E-05	1.75E-03	1.93E-02
		Whitefish Lake Middle	8.36E-04	7.97E-02	5.99E-04	2.60E-04	9.86E-04	3.13E-01	3.75E-06	2.40E-04	6.68E-02	2.43E-05	1.77E-03	2.10E-02
		Whitefish Lake South	8.32E-04	7.97E-02	5.97E-04	2.59E-04	9.86E-04	3.13E-01	3.75E-06	2.40E-04	6.61E-02	2.41E-05	1.76E-03	2.09E-02
		McGowan Lake	8.19E-04	7.96E-02	5.67E-04	2.56E-04	9.82E-04	3.12E-01	3.67E-06	2.38E-04	6.12E-02	2.28E-05	1.76E-03	2.04E-02
		Russell Lake Inlet	8.14E-04	7.95E-02	5.43E-04	2.54E-04	9.80E-04	3.11E-01	3.62E-06	2.36E-04	5.82E-02	2.20E-05	1.75E-03	2.02E-02
	Zooplankton	Reference (Kratchkowsky Lake)	3.04E-04	1.54E-01	7.66E-04	9.10E-03	5.19E-02	3.09E-01	3.45E-06	1.62E-03	3.23E-03	5.01E-04	7.66E-05	2.27E-02
		Whitefish Lake North	3.04E-04	1.54E-01	7.66E-04	9.10E-03	5.19E-02	3.09E-01	3.45E-06	1.62E-03	3.23E-03	5.01E-04	7.66E-05	2.27E-02
		Whitefish Lake Middle	3.15E-04	1.55E-01	9.85E-04	9.58E-03	5.26E-02	3.13E-01	3.76E-06	1.70E-03	4.30E-03	6.13E-04	7.73E-05	2.47E-02
		Whitefish Lake South	3.14E-04	1.55E-01	9.83E-04	9.57E-03	5.26E-02	3.13E-01	3.75E-06	1.70E-03	4.26E-03	6.08E-04	7.72E-05	2.46E-02
		McGowan Lake	3.09E-04	1.55E-01	9.33E-04	9.46E-03	5.24E-02	3.12E-01	3.68E-06	1.68E-03	3.94E-03	5.75E-04	7.69E-05	2.40E-02
		Russell Lake Inlet	3.07E-04	1.55E-01	8.94E-04	9.37E-03	5.23E-02	3.11E-01	3.62E-06	1.66E-03	3.76E-03	5.55E-04	7.68E-05	2.37E-02
Terrestrial Animals	Black Bear	Reference (Kratchkowsky Lake)	1.55E-03	5.16E-06	0.00E+00	1.70E-04	4.26E-05	1.27E-02	6.73E-04	0.00E+00	2.54E-02	2.15E-04	2.15E-03	1.06E-02
		Whitefish Lake	1.55E-03	5.16E-06	0.00E+00	1.70E-04	4.27E-05	1.27E-02	6.73E-04	0.00E+00	2.72E-02	2.22E-04	2.15E-03	1.06E-02
	Canada Lynx	Reference (Kratchkowsky Lake)	5.28E-03	2.43E-05	0.00E+00	4.21E-05	7.18E-05	2.94E-02	2.11E-04	0.00E+00	1.37E-01	1.04E-04	4.67E-03	4.09E-01
		Whitefish Lake	5.28E-03	2.43E-05	0.00E+00	4.22E-05	7.18E-05	2.94E-02	2.11E-04	0.00E+00	1.37E-01	1.40E-04	4.67E-03	4.09E-01
		McGowan Lake	5.28E-03	2.43E-05	0.00E+00	4.22E-05	7.18E-05	2.94E-02	2.11E-04	0.00E+00	1.37E-01	1.08E-04	4.67E-03	4.09E-01
		Russell Lake Inlet	5.28E-03	2.43E-05	0.00E+00	4.21E-05	7.18E-05	2.94E-02	2.11E-04	0.00E+00	1.37E-01	1.05E-04	4.67E-03	4.09E-01
	Mink	Reference (Kratchkowsky Lake)	3.32E-03	7.48E-06	0.00E+00	7.74E-05	1.50E-04	1.27E-02	2.47E-04	0.00E+00	6.72E-02	1.25E-04	6.26E-03	8.92E-03

Biota		Location	Maximum HQs during Future Centuries											
			Arsenic	Cadmium	Chloride	Cobalt	Chromium	Copper	Molybdenum	Sulphate	Selenium	Uranium	Vanadium	Zinc
		Whitefish Lake	3.43E-03	7.50E-06	0.00E+00	8.03E-05	1.52E-04	1.28E-02	2.64E-04	0.00E+00	8.66E-02	1.65E-04	6.29E-03	9.68E-03
		McGowan Lake	3.37E-03	7.49E-06	0.00E+00	7.95E-05	1.51E-04	1.28E-02	2.60E-04	0.00E+00	8.01E-02	1.36E-04	6.27E-03	9.44E-03
		Russell Lake Inlet	3.35E-03	7.49E-06	0.00E+00	7.90E-05	1.51E-04	1.28E-02	2.57E-04	0.00E+00	7.67E-02	1.31E-04	6.27E-03	9.31E-03
	Moose	Reference (Kratchkowsky Lake)	1.68E-04	1.85E-04	0.00E+00	8.79E-05	2.02E-05	3.93E-02	1.80E-04	0.00E+00	1.80E-03	1.16E-04	1.86E-03	2.21E-03
		Whitefish Lake	1.71E-04	1.85E-04	0.00E+00	8.93E-05	2.03E-05	3.93E-02	1.81E-04	0.00E+00	1.97E-03	1.40E-04	1.87E-03	2.22E-03
		McGowan Lake	1.69E-04	1.85E-04	0.00E+00	8.89E-05	2.02E-05	3.93E-02	1.80E-04	0.00E+00	1.91E-03	1.21E-04	1.87E-03	2.22E-03
		Russell Lake Inlet	1.69E-04	1.85E-04	0.00E+00	8.87E-05	2.02E-05	3.93E-02	1.80E-04	0.00E+00	1.88E-03	1.18E-04	1.87E-03	2.21E-03
	Muskrat	Reference (Kratchkowsky Lake)	1.76E-03	1.78E-04	0.00E+00	3.35E-04	1.74E-04	3.11E-04	2.69E-04	0.00E+00	4.67E-03	3.22E-04	1.80E-02	4.69E-04
		Whitefish Lake	1.83E-03	1.79E-04	0.00E+00	3.52E-04	1.76E-04	3.15E-04	2.93E-04	0.00E+00	6.22E-03	3.93E-04	1.81E-02	5.10E-04
		McGowan Lake	1.79E-03	1.79E-04	0.00E+00	3.48E-04	1.75E-04	3.14E-04	2.87E-04	0.00E+00	5.70E-03	3.69E-04	1.81E-02	4.97E-04
		Russell Lake Inlet	1.78E-03	1.78E-04	0.00E+00	3.45E-04	1.75E-04	3.13E-04	2.83E-04	0.00E+00	5.42E-03	3.57E-04	1.80E-02	4.90E-04
	Snowshoe Hare	Reference (Kratchkowsky Lake)	2.25E-03	4.08E-03	0.00E+00	3.05E-04	9.04E-05	5.53E-03	1.06E-04	0.00E+00	1.07E-02	4.88E-04	5.96E-03	1.97E-02
		Whitefish Lake	2.25E-03	4.08E-03	0.00E+00	3.06E-04	9.04E-05	5.54E-03	1.06E-04	0.00E+00	1.07E-02	6.18E-04	5.96E-03	1.97E-02
		McGowan Lake	2.25E-03	4.08E-03	0.00E+00	3.05E-04	9.04E-05	5.53E-03	1.06E-04	0.00E+00	1.07E-02	5.05E-04	5.96E-03	1.97E-02
		Russell Lake Inlet	2.25E-03	4.08E-03	0.00E+00	3.05E-04	9.04E-05	5.53E-03	1.06E-04	0.00E+00	1.07E-02	4.93E-04	5.96E-03	1.97E-02
	Southern Red-Backed Vole	Reference (Kratchkowsky Lake)	7.62E-03	1.28E-02	0.00E+00	3.27E-03	2.96E-04	2.13E-02	2.88E-02	0.00E+00	8.08E-02	7.45E-03	1.45E-02	3.56E-03
		Whitefish Lake	7.62E-03	1.28E-02	0.00E+00	3.27E-03	2.96E-04	2.13E-02	2.88E-02	0.00E+00	8.08E-02	9.92E-03	1.45E-02	3.56E-03
		McGowan Lake	7.62E-03	1.28E-02	0.00E+00	3.27E-03	2.96E-04	2.13E-02	2.88E-02	0.00E+00	8.08E-02	7.77E-03	1.45E-02	3.56E-03
		Russell Lake Inlet	7.62E-03	1.28E-02	0.00E+00	3.27E-03	2.96E-04	2.13E-02	2.88E-02	0.00E+00	8.08E-02	7.54E-03	1.45E-02	3.56E-03
	WoodLand Caribou	Reference (Kratchkowsky Lake)	3.66E-04	2.79E-04	0.00E+00	1.62E-04	2.30E-04	2.74E-02	3.30E-04	0.00E+00	4.62E-03	3.10E-04	7.73E-03	2.79E-03
		Whitefish Lake	3.68E-04	2.79E-04	0.00E+00	1.63E-04	2.30E-04	2.74E-02	3.31E-04	0.00E+00	4.73E-03	3.16E-04	7.73E-03	2.80E-03
	Canada Goose	Reference (Kratchkowsky Lake)	2.13E-04	1.25E-04	0.00E+00	3.19E-05	2.36E-05	8.69E-04	1.57E-05	0.00E+00	3.65E-04	2.37E-05	5.58E-03	5.45E-04
		Whitefish Lake	2.11E-04	1.25E-04	0.00E+00	3.17E-05	2.33E-05	8.69E-04	1.55E-05	0.00E+00	3.63E-04	3.01E-05	5.57E-03	5.45E-04
		McGowan Lake	2.13E-04	1.25E-04	0.00E+00	3.20E-05	2.36E-05	8.69E-04	1.57E-05	0.00E+00	3.66E-04	2.46E-05	5.58E-03	5.45E-04
		Russell Lake Inlet	2.13E-04	1.25E-04	0.00E+00	3.20E-05	2.36E-05	8.69E-04	1.57E-05	0.00E+00	3.66E-04	2.40E-05	5.58E-03	5.45E-04
	Bald Eagle	Reference (Kratchkowsky Lake)	2.67E-03	7.63E-04	0.00E+00	1.89E-04	4.50E-04	2.32E-03	5.06E-05	0.00E+00	3.15E-02	2.20E-04	9.22E-02	1.53E-03
		Whitefish Lake	2.68E-03	7.63E-04	0.00E+00	1.89E-04	4.50E-04	2.32E-03	5.07E-05	0.00E+00	3.21E-02	2.21E-04	9.22E-02	1.53E-03
	Olive-Sided Flycatcher	Reference (Kratchkowsky Lake)	7.83E-03	3.93E-02	0.00E+00	8.99E-04	1.77E-03	2.92E-02	5.67E-04	0.00E+00	7.03E-02	8.03E-04	2.56E-01	1.91E-02
		Whitefish Lake	7.89E-03	3.93E-02	0.00E+00	9.08E-04	1.78E-03	2.94E-02	5.73E-04	0.00E+00	7.26E-02	1.02E-03	2.56E-01	1.94E-02
		McGowan Lake	7.86E-03	3.93E-02	0.00E+00	9.06E-04	1.78E-03	2.93E-02	5.72E-04	0.00E+00	7.18E-02	8.33E-04	2.56E-01	1.93E-02
		Russell Lake Inlet	7.85E-03	3.93E-02	0.00E+00	9.04E-04	1.78E-03	2.93E-02	5.71E-04	0.00E+00	7.14E-02	8.12E-04	2.56E-01	1.93E-02
	Common Loon	Reference (Kratchkowsky Lake)	1.09E-03	1.79E-05	0.00E+00	2.65E-05	7.26E-05	3.37E-03	1.01E-05	0.00E+00	3.43E-02	6.29E-06	4.31E-03	1.47E-03
		Whitefish Lake	1.13E-03	1.80E-05	0.00E+00	2.80E-05	7.35E-05	3.41E-03	1.10E-05	0.00E+00	4.35E-02	7.69E-06	4.35E-03	1.60E-03
		McGowan Lake	1.10E-03	1.80E-05	0.00E+00	2.76E-05	7.32E-05	3.40E-03	1.08E-05	0.00E+00	4.04E-02	7.22E-06	4.33E-03	1.56E-03

Biota		Location	Maximum HQs during Future Centuries											
			Arsenic	Cadmium	Chloride	Cobalt	Chromium	Copper	Molybdenum	Sulphate	Selenium	Uranium	Vanadium	Zinc
		Russell Lake Inlet	1.10E-03	1.80E-05	0.00E+00	2.74E-05	7.31E-05	3.39E-03	1.06E-05	0.00E+00	3.88E-02	6.97E-06	4.32E-03	1.54E-03
	Mallard	Reference (Kratchkowsky Lake)	4.54E-03	6.30E-05	0.00E+00	3.21E-04	1.51E-02	1.03E-02	1.62E-04	0.00E+00	5.19E-03	9.78E-05	6.14E-02	7.82E-03
		Whitefish Lake	4.72E-03	6.33E-05	0.00E+00	3.38E-04	1.53E-02	1.04E-02	1.77E-04	0.00E+00	6.92E-03	1.20E-04	6.19E-02	8.50E-03
		McGowan Lake	4.62E-03	6.32E-05	0.00E+00	3.34E-04	1.52E-02	1.04E-02	1.73E-04	0.00E+00	6.34E-03	1.12E-04	6.16E-02	8.28E-03
		Russell Lake Inlet	4.59E-03	6.31E-05	0.00E+00	3.31E-04	1.52E-02	1.04E-02	1.70E-04	0.00E+00	6.04E-03	1.08E-04	6.15E-02	8.16E-03
	American Robin	Reference (Kratchkowsky Lake)	3.87E-02	3.05E-02	0.00E+00	5.09E-03	3.79E-03	1.38E-01	2.66E-03	0.00E+00	1.09E-01	3.29E-03	7.82E-01	7.91E-02
		Whitefish Lake	3.87E-02	3.05E-02	0.00E+00	5.10E-03	3.79E-03	1.38E-01	2.66E-03	0.00E+00	1.09E-01	4.46E-03	7.82E-01	7.92E-02
		McGowan Lake	3.87E-02	3.05E-02	0.00E+00	5.09E-03	3.79E-03	1.38E-01	2.66E-03	0.00E+00	1.09E-01	3.45E-03	7.82E-01	7.91E-02
		Russell Lake Inlet	3.87E-02	3.05E-02	0.00E+00	5.09E-03	3.79E-03	1.38E-01	2.66E-03	0.00E+00	1.09E-01	3.33E-03	7.82E-01	7.91E-02
	Lesser Scaup	Reference (Kratchkowsky Lake)	7.78E-03	1.15E-04	0.00E+00	7.89E-04	2.54E-02	1.82E-02	2.80E-04	0.00E+00	9.69E-03	1.71E-04	1.15E-01	1.47E-02
		Whitefish Lake	8.08E-03	1.16E-04	0.00E+00	8.31E-04	2.57E-02	1.84E-02	3.05E-04	0.00E+00	1.29E-02	2.09E-04	1.16E-01	1.60E-02
		McGowan Lake	7.91E-03	1.15E-04	0.00E+00	8.21E-04	2.56E-02	1.83E-02	2.99E-04	0.00E+00	1.18E-02	1.97E-04	1.16E-01	1.56E-02
		Russell Lake Inlet	7.86E-03	1.15E-04	0.00E+00	8.13E-04	2.56E-02	1.83E-02	2.94E-04	0.00E+00	1.13E-02	1.90E-04	1.16E-01	1.54E-02

(a) - Aquatic receptor TRVs for copper have been calculated using the FEQG and are included in Section 6.3.2.
n/a = not applicable; HQ = hazard quotient.

5.4.1.2 Radiological Risk

An HQ is not typically calculated for radiological risk; however, a comparison of the total radiological dose (baseline plus Project) against the ecological dose benchmarks is presented.

There were no predicted exceedances of the 2.4 mGy/d radiation dose benchmark for terrestrial and riparian biota or the 9.6 mGy/d radiation dose benchmark for aquatic biota in the Project area, LSA, or RSA during any phase of the Project (Table 5-25) or in the future centuries (Table 5-26). This includes Whitefish Lake, McGowan Lake, and Russell Lake as exposure locations as well as Kratchkowsky Lake as a reference location. All predicted doses are well below the radiation dose benchmarks.

During the Project phases, the maximum predicted total dose for terrestrial and riparian biota is to lichen near Whitefish Lake (0.99 mGy/d), and the main contributors to total dose are from uranium-234 and uranium-238 in air that deposits to lichen. The maximum predicted total dose for aquatic biota is to zooplankton at Whitefish Lake (0.10 mGy/d), and the main contributor to total dose is from polonium-210 in tissue.

During the future centuries, the maximum predicted dose to aquatic biota is to zooplankton (0.08 mG/d) in Whitefish Lake from polonium-210 in water. The maximum predicted dose during the future centuries to terrestrial and riparian biota is to the scaup (0.05 mGy/d) who eats aquatic animals from Whitefish Lake. For terrestrial plants the dose during the future centuries is 0.22 mGy/d for lichen at all locations, due to background concentrations of polonium-210 in the soil.

Overall, it is unlikely that there would be significant adverse effects on terrestrial or aquatic populations or communities as a result of radionuclide releases from the Project.

Table 5-25: Summary of Total Radiation Doses to Limiting Ecological Receptors – Project Phases

Category	Maximum Total Dose [(a)] (mGy/d)	Receptor	Location	Largest Contributor and Pathway to Dose	Dose Benchmark (mGy/d)
Aquatic Plants	0.01	Macrophytes	Whitefish Lake Middle	Ra-226 Water to tissue (internal)	9.6
Aquatic Animals	0.10	Zooplankton	Whitefish Lake South	Po-210 Water to tissue (internal)	9.6
Terrestrial Plants	0.99	Lichen	On-site near Whitefish Lake	U-234 Soil to tissue (internal)	2.4
Terrestrial Animals	0.06	Lesser Scaup	Whitefish Lake	Po-210 Aquatic animals ingestion (internal)	2.4

Note:
(a) Total radiation dose includes the baseline dose and the Project dose combined.

Table 5-26: Summary of Total Radiation Doses to Limiting Ecological Receptors – Future Centuries

Category	Maximum Total Dose [(a)] (mGy/d)	Receptor	Location	Largest Contributor and Pathway to Dose	Dose Benchmark (mGy/d)
Aquatic Plants	0.01	Macrophytes	Whitefish Lake Middle	Ra-226 Water to tissue (internal)	9.6
Aquatic Animals	0.08	Zooplankton	Whitefish Lake Middle	Po-210 Water to tissue (internal)	9.6
Terrestrial Plants	0.22	Lichen	All locations	Po-210 tissue (internal)	2.4
Terrestrial Animals	0.05	Lesser Scaup	Whitefish Lake	Po-210 Aquatic animals ingestion (internal)	2.4

Note:
(a) Total radiation dose includes the baseline dose and the Project dose combined.

5.4.2 Uncertainties in the Risk Characterization

Since the risk characterization is dependent on the problem formulation and the exposure and effects assessments, any uncertainty identified in these assessments propagates uncertainty into the risk estimates. In general, the uncertainties are expected to cause an overestimation, not an underestimation of risk due to the conservative approaches employed in the ERA, including the use of:

- maximum predicted concentrations for COPCs in media for each exposure scenario;
- exposure of ecological receptors to COPCs in the environment for chronic periods of time and during sensitive life stages; and
- effect levels based on low-effect threshold concentrations and doses.

The assumptions to address uncertainties in the ERA are anticipated to produce overly conservative estimates of risk, as discussed below.

For the calculation of risk to environmental receptors, there are uncertainties associated with the use of literature-based TRVs. These uncertainties may include: extrapolation of results from laboratory tests to the field, differences in sensitivity between the test organism and resident organisms, laboratory conditions that are not representative of field conditions, and the form of the COPC used in toxicity testing which may not be representative of the form found at the site.

The use of TRVs from laboratory studies tends to be conservative because these studies are typically chemical-specific and use highly bioavailable forms of the COPC. In field situations, the chemical form of the COPC may be less bioavailable, and toxicity-modifying factors may be present that were not acting in laboratory tests.

There is inherent uncertainty associated with the use of LOAEL values as TRVs as these values are not precisely related to biologically relevant thresholds and do not provide information about the actual magnitude of effects in the reported studies. However, LOAEL values have widespread use in the risk assessment community and the science is not currently available to change this approach to TRVs.

Taken together, these approaches are anticipated to produce a risk characterization that has not underestimated risk; the resulting HQs are either overestimates or realistic estimates of risk, both of which are considered acceptable.

6.0 Quality Assurance and Updated Risk Characterization

6.1 Quality Assurance

Throughout the planning and preparation of the ERA, all staff worked under the Ecometrix ISO 9001:2015 certified Quality Management System. All work was internally reviewed and verified. Reviews included verification of input data in the IMPACT files against the source documents and verification of selected results with independent calculation spreadsheets, as well as review of report content. Comments have been addressed as appropriate by report revisions. The review process has been documented through a paper trail of review comments and responses. Examples of the independent calculation spreadsheets are provided in Appendix B.

The software used for the ERA was IMPACT 5.6.0, a dynamic version of the model and was tailored to align with the guidance in CSA standards N288.6-22 (CSA, 2022) and N288.1-20 (CSA, 2020). It contains differential equations for COPC transport, allowing for non-steady-state conditions, whereas N288.1 contains the corresponding steady-state equations. When utilizing IMPACT for this Project, all inputs to IMPACT were checked, along with an overall verification of IMPACT scenario files. Checks were performed on data and calculations to verify that transcription errors and formula errors, if any, were caught and addressed. Checks of the model structure, algorithms and functions have been made repeatedly throughout the model development history as it has been used in several related applications that underwent multiple layers of review.

The ERICA Tool, version 1.3.1, was used as a source of biota dose coefficients. Its parameters, including dose coefficients, have been subject to validation through numerous intercomparison exercises, as described by Brown et al., (Brown et al., 2016, 2003, 2008) and have generally compared well with other sources. The intercomparisons of dose coefficients are described by Vives I Batlle et al. (Vives i Batlle et al., 2011, 2007). The external dose predictions for small mammals have been validated against dosimetric measurements (Beresford et al., 2008). The code and database are updated from time to time, as described in its documented version history.

The ERA utilized environmental monitoring data collected as part of the baseline monitoring program which followed either Ecometrix' Quality Management System for the monitoring conducted by Ecometrix or the Quality Management System for Denison's other subcontractors. The data collected during the baseline monitoring program was considered valid and appropriate for use in the ERA. The ERA was reviewed and accepted by Denison in accordance with Denison's QA requirements.

6.2 Sensitivity Analysis

A sensitivity analysis of key model parameters was undertaken to understand the degree to which the results or conclusions of the risk assessment would vary if these parameters differed from what was assumed.

6.2.1 Woodland Caribou Diet

The food source for the woodland caribou in the winter is terrestrial or arboreal lichens; terrestrial and aquatic vegetation are also food sources in the remainder of the year. For the ecological risk assessment, a low lichen diet (LLD) comprised of 50% browse, 20% lichen and 30% macrophytes was assumed to represent the year-round diet for woodland caribou (woodland caribou LLD). Research has noted that arboreal lichen could make up 70% of the caribou's winter diet (MNRW, 2006). To ensure that woodland caribou who may have higher consumption rates of lichen remains protected, a high lichen diet (HLD) comprised of 70% lichen, 20% browse and 10% macrophytes was assumed as a sensitivity case for woodland caribou who may have higher consumption rates of lichen (woodland caribou HLD).

The predicted maximum HQs for non-radiological risk and the maximum radiological dose for radiological COPCs for both woodland caribou models are shown in Table 6-1 and Table 6-2. Compared with the woodland caribou LLD, the predicted maximum HQs for the woodland caribou HLD generally increased by 5 to 81% with the exception of copper and molybdenum where the HQ decreased by 4 to 22% due to the copper and molybdenum concentration in lichen being lower than in browse. However, all HQs for woodland caribou HLD are below the benchmark of 1 for all non-radiological COPCs. The predicted maximum total radiological dose for the woodland caribou HLD increased by 65% compared to that for the woodland caribou LLD. However, the total dose for woodland caribou HLD is still far below the radiation dose benchmark of 2.4 mGy/d for terrestrial biota, as recommended in CSA N288.6-22.

Table 6-1: Non-radiological Risk to Woodland Caribou during Project Phases

Biota	Location	Maximum HQs during Project Phases				
		Arsenic	Cadmium	Cobalt	Chromium	Copper
WoodLand Caribou LLD	Reference (Kratchkowsky Lake)	3.70E-04	2.79E-04	1.62E-04	2.30E-04	2.74E-02
	Whitefish Lake	3.85E-04	2.84E-04	1.66E-04	2.33E-04	2.83E-02
WoodLand Caribou HLD	Reference (Kratchkowsky Lake)	3.90E-04	3.28E-04	2.00E-04	3.72E-04	2.15E-02
	Whitefish Lake	4.06E-04	3.33E-04	2.04E-04	3.76E-04	2.29E-02
Biota	**Location**	**Molybdenum**	**Selenium**	**Uranium**	**Vanadium**	**Zinc**
WoodLand Caribou LLD	Reference (Kratchkowsky Lake)	3.30E-04	4.63E-03	3.10E-04	7.79E-03	2.80E-03
	Whitefish Lake	2.54E-03	7.65E-03	9.19E-03	8.98E-03	2.82E-03
WoodLand Caribou HLD	Reference (Kratchkowsky Lake)	4.50E-04	6.41E-03	4.20E-04	9.97E-03	3.53E-03
	Whitefish Lake	2.43E-03	8.40E-03	1.66E-02	1.10E-02	3.54E-03

Table 6-2: Maximum Radiological Doses to Woodland Caribou during Project Phases

Biota	Location	Maximum Radiological Dose During Project Phases (mGy/d)						
		Uranium-238	Uranium-234	Thorium-230	Radium-226	Lead-210	Polonium-210	Total Dose
WoodLand Caribou LLD	Reference (Kratchkowsky Lake)	3.34E-06	3.81E-06	6.25E-06	6.81E-04	1.20E-05	6.24E-03	**6.95E-03**
	Whitefish Lake	8.19E-05	9.32E-05	7.30E-06	6.86E-04	1.20E-05	6.26E-03	**7.14E-03**
WoodLand Caribou HLD	Reference (Kratchkowsky Lake)	3.61E-06	4.12E-06	4.44E-06	6.05E-04	1.99E-05	1.09E-02	**1.15E-02**
	Whitefish Lake	1.43E-04	1.62E-04	4.74E-06	6.09E-04	1.99E-05	1.09E-02	**1.18E-02**

6.2.2 Effluent Discharge Rate

One of the key model parameters is the effluent discharge rate. As described in Section 3.1, treated effluent will be released to Whitefish Lake Middle (LA-5) via a discharge line with a diffuser at the end to promote effluent mixing within the lake. Effluent will be released at a discharge rate of 36.5 m^3/hr (10.1 L/s) as the EA case. The maximum upper bound discharge rate is 81 m^3/hr (22.5 L/s). The reasonable upper bound effluent quality during the phases where effluent will be released is summarized in Table 3-2 – effluent quality is assumed to be constant over that time period.

In this ERA, surface water quality modeling was completed using IMPACT version 5.6.0 with treated effluent released to Whitefish Lake Middle at an expected discharge rate of 36.5 m^3/h during the operation and decommissioning phases of the Project. If the effluent was released at the maximum upper bound discharge rate of 81 m^3/hr, the maximum concentrations of COPCs in Whitefish Lake Middle and its downstream waterbodies will increase up to 120%.

*increase (%) = 100 * (modelled max concentration at upper bound discharge rate - modelled max concentration at expected discharge rate) / modelled max concentration at expected discharge rate.*

Figure 6-1 shows the maximum concentrations of COPCs in surface water at the expected and upper bound discharge rate. Compared to the maximum concentrations in surface water at the expected discharge rate, the maximum concentrations of COPCs in surface water at the upper bound discharge rate will increase 10 – 44% for arsenic, 29 – 51% for cadmium, 109 – 113% for chloride, 14 – 26% for cobalt, 20 – 38% for chromium, 17 – 30% for copper, 119 – 120% for molybdenum, 116 – 117% for sulphate, 101 – 111% for selenium, 107 – 113% for uranium, 53 – 95% for vanadium, 24 – 45% for zinc, 107 – 113% for uranium-238 and uranium-234, 36 – 55% for thorium-230, 12 – 24% for radium-226, 12 – 53% for lead-210, and 6 – 13% for polonium-210, respectively. If treated effluent is released at the maximum upper bound discharge rate, cadmium concentration in Whitefish Middle/South and McGowan Lake (LA-1) would exceed its surface water quality guideline of 0.00004 mg/L, and chromium concentration in Whitefish Middle/South would slightly exceed its surface water quality guideline of 0.001 mg/L. The modelled concentrations of other COPCs are expected to be below their corresponding surface water quality guidelines.

Figure 6-2 shows the resulting maximum concentrations of COPCs in sediment at the expected and upper bound discharge rate. Compared to the maximum concentrations in sediment at the expected discharge rate, the maximum concentrations of COPCs in sediment at the upper bound discharge rate will increase –10 - 30% for arsenic, 23 - 38% for cadmium, 13 - 21% for cobalt, 16 - 27% for chromium, 15 - 24% for copper, 119 -120% for molybdenum, 95 - 106% for selenium, 102 - 110% for uranium, 47 -84% for vanadium, 19 - 33% for zinc, 102 -110% for uranium-238 and uranium-234, 32 - 47% for thorium-230, 9 - 17% for radium-226, 12 - 40% for lead-210, and 12 - 39% for polonium-210, respectively. If treated effluent was released at the maximum upper bound discharge rate, the modelled concentrations of all COPCs are expected to be below their corresponding sediment quality guidelines, with the exception of cadmium, molybdenum, selenium and vanadium.

This is a conservative prediction as it assumes effluent is released during decommissioning at the same upper bound flow and quality as during operations. For cadmium, the predicted maximum sediment quality at the expected discharge rate is 0.497 mg/kg dw in Whitefish Lake Middle, which is below the selected interim sediment quality guideline (ISQG) value of 0.6 mg/kg dw. However, the predicted maximum sediment quality at the upper bound discharge rate is 0.688 mg/kg dw in Whitefish Lake Middle and 0.647 mg/kg dw in Whitefish Lake South, which exceeds the ISQG value but is below the probable effect level (PEL) of 3.5 mg/kg dw.

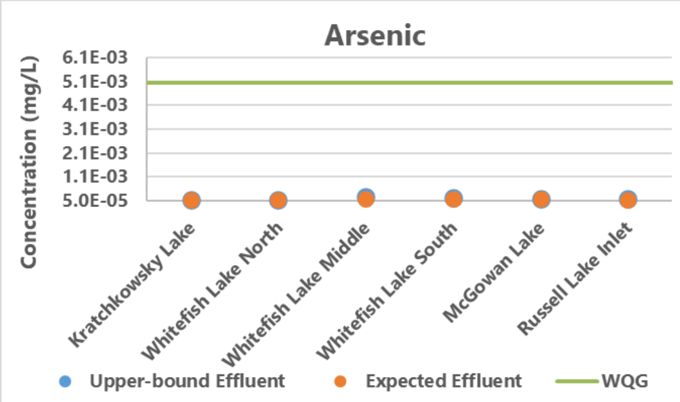
The predicted maximum molybdenum concentration in sediment is predicted to be 57.2 mg/kg dw in Whitefish Lake Middle at the expected discharge rate and 125 mg/kg dw in Whitefish Lake Middle at the upper bound discharge rate. Both values are above its reference (REF) value of 23 mg/kg dw, but below its no-effect (NE2) sediment quality benchmark of 245 mg/kg dw.

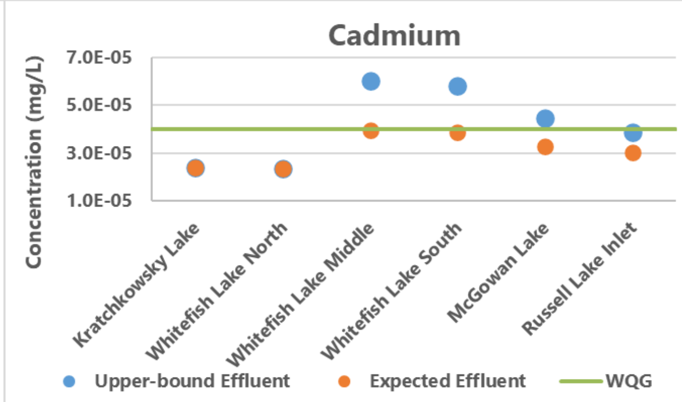
The maximum selenium concentration in sediment is 5.48 mg/kg dw in Whitefish Lake Middle at the expected discharge rate and 11.3 mg/kg dw in Whitefish Lake Middle at the upper bound discharge rate. Both values are above its REF value of 3.6 mg/kg dw, but below its NE2 value of 30 mg/kg dw.

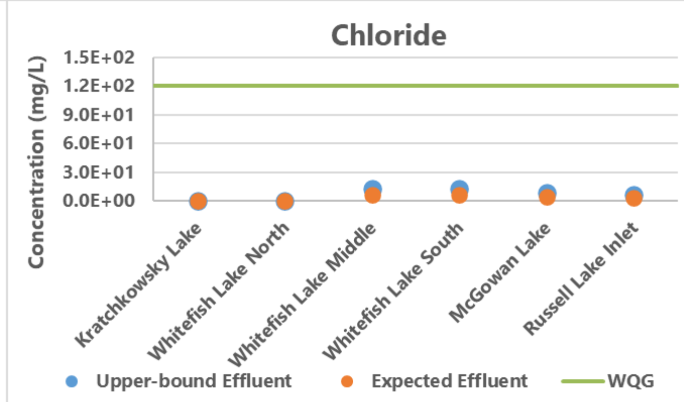
The predicted maximum concentration of vanadium in sediment at the end of decommissioning is 37.2 mg/kg dw in Whitefish Lake Middle at the expected discharge rate and 68.5 mg/kg dw in Whitefish Lake Middle at the upper bound discharge rate. Both values are higher than the REF value of 35.1 mg/kg dw and the lowest effect level (LEL) of 35.2 mg/kg dw but are well below the severe effect level (SEL) of 160 mg/kg dw.

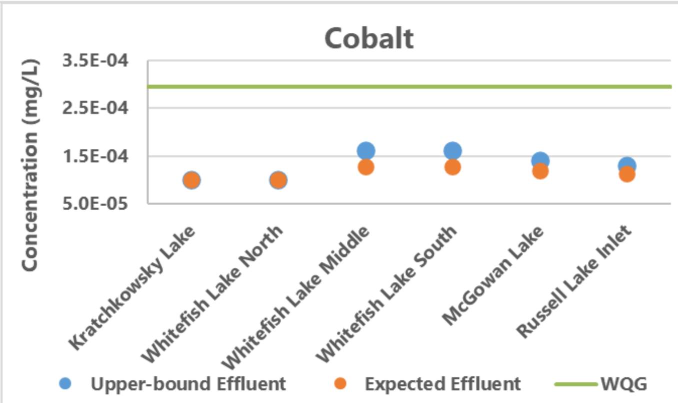
The REF values refer to locations upstream of mining or milling activities or located within separate but nearby drainages. Exceedance of a REF value indicates that sediment downstream of the proposed discharge is elevated compared to natural background (Burnett-Seidel and

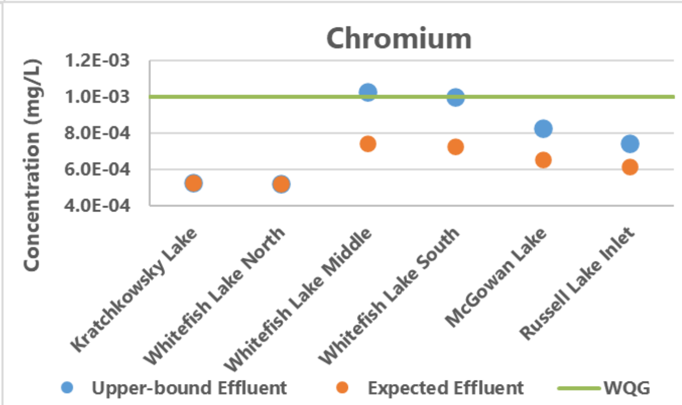
Liber, 2013). The predicted sediment concentration for exceedances of a REF or LEL value are not indicative of adverse effects to benthic communities but do suggest that further investigation may be warranted. The LEL represents a concentration in sediment that the majority of benthic organisms can tolerate, whereas the SEL represents a concentration in sediment that the majority of benthic organisms cannot tolerate (Persaud et al., 1993). The NE2 values refer to exposed (lightly contaminated) areas with elevated concentrations but no significant effect on benthic invertebrate abundance, richness, and evenness. Concentrations below the NE2 values indicate that benthic invertebrate community metrics (abundance, richness, and evenness) downstream of discharges are not expected to differ significantly (less than 20% difference) from those observed at natural background conditions. The predicted exceedances in sediment concentrations for cadmium, molybdenum, selenium and vanadium are all below their PEL or NE2 or SEL values, therefore, adverse effects to benthic communities are not anticipated under the upper bound discharge scenarios.

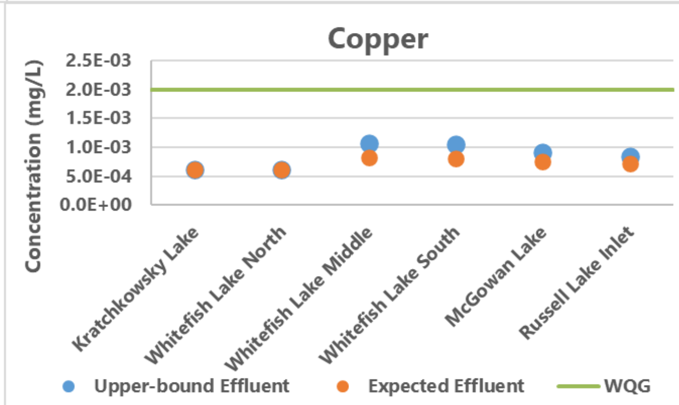

Arsenic
Concentration (mg/L)
6.1E-03
5.1E-03
4.1E-03
3.1E-03
2.1E-03
1.1E-03
5.0E-05
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Upper-bound Effluent
Expected Effluent
WQG

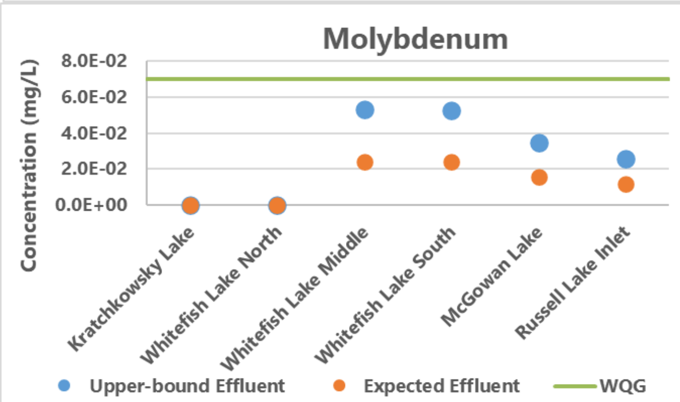

Cadmium
Concentration (mg/L)
7.0E-05
5.0E-05
3.0E-05
1.0E-05
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Upper-bound Effluent
Expected Effluent
WQG

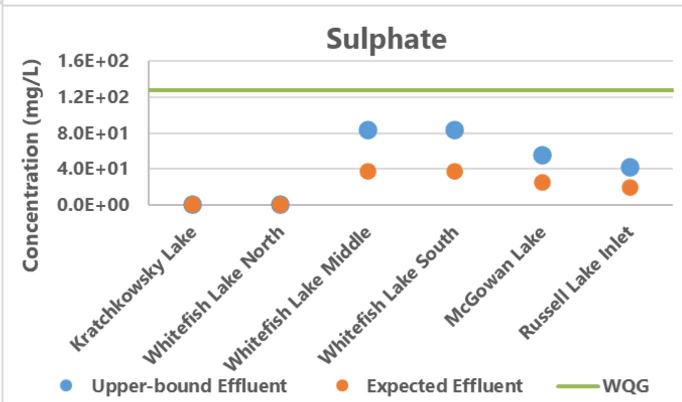

Chloride
Concentration (mg/L)
1.5E+02
1.2E+02
9.0E+01
6.0E+01
3.0E+01
0.0E+00
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Upper-bound Effluent
Expected Effluent
WQG

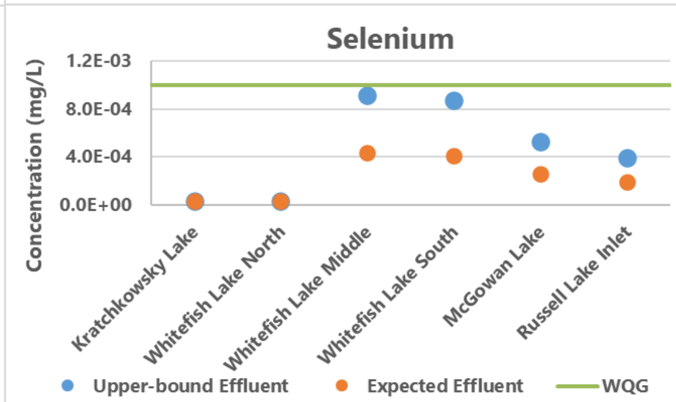

Cobalt
Concentration (mg/L)
3.5E-04
2.5E-04
1.5E-04
5.0E-05
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Upper-bound Effluent
Expected Effluent
WQG

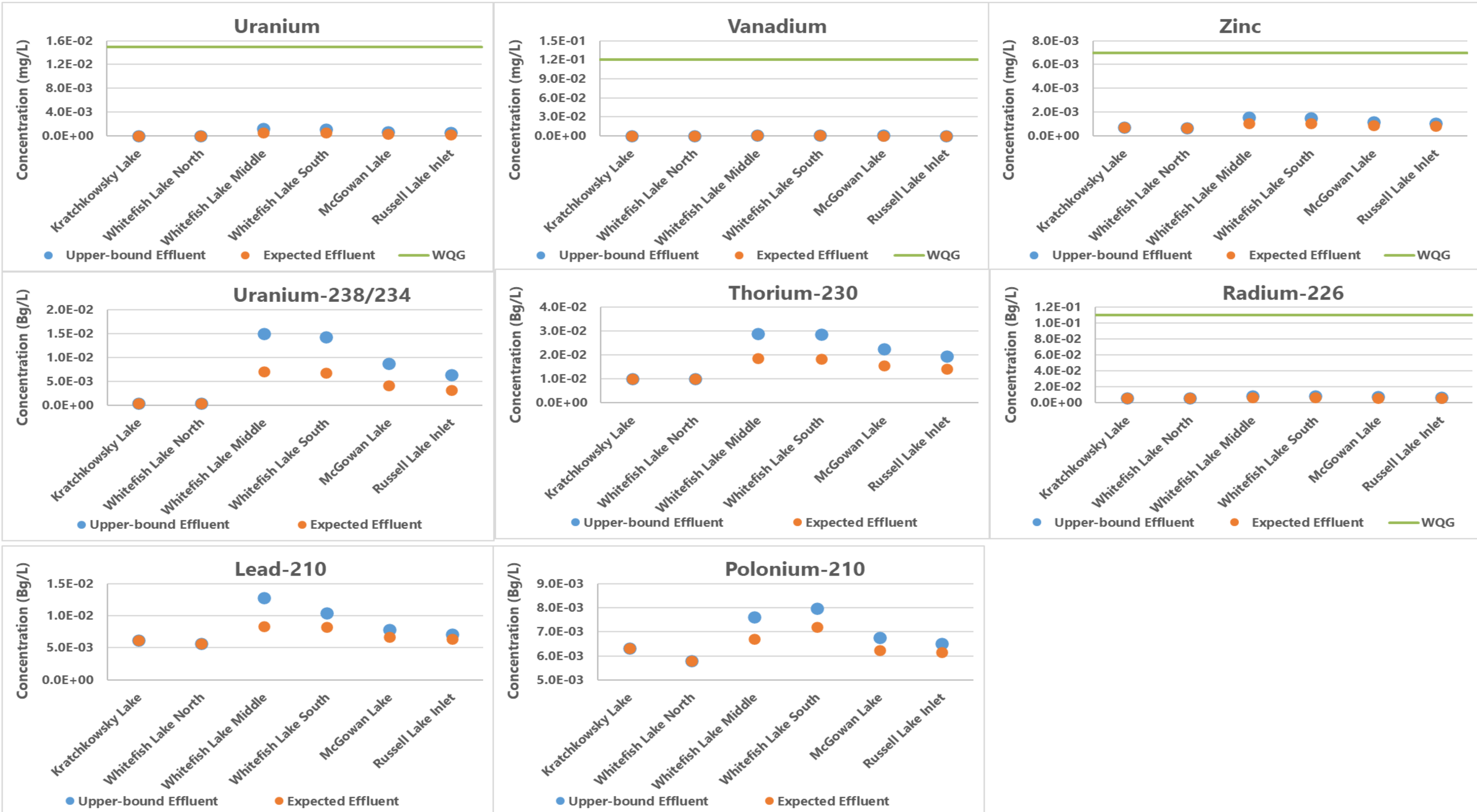

Chromium
Concentration (mg/L)
1.2E-03
1.0E-03
8.0E-04
6.0E-04
4.0E-04
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Upper-bound Effluent
Expected Effluent
WQG


Copper
Concentration (mg/L)
2.5E-03
2.0E-03
1.5E-03
1.0E-03
5.0E-04
0.0E+00
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Upper-bound Effluent
Expected Effluent
WQG


Molybdenum
Concentration (mg/L)
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Upper-bound Effluent
Expected Effluent
WQG

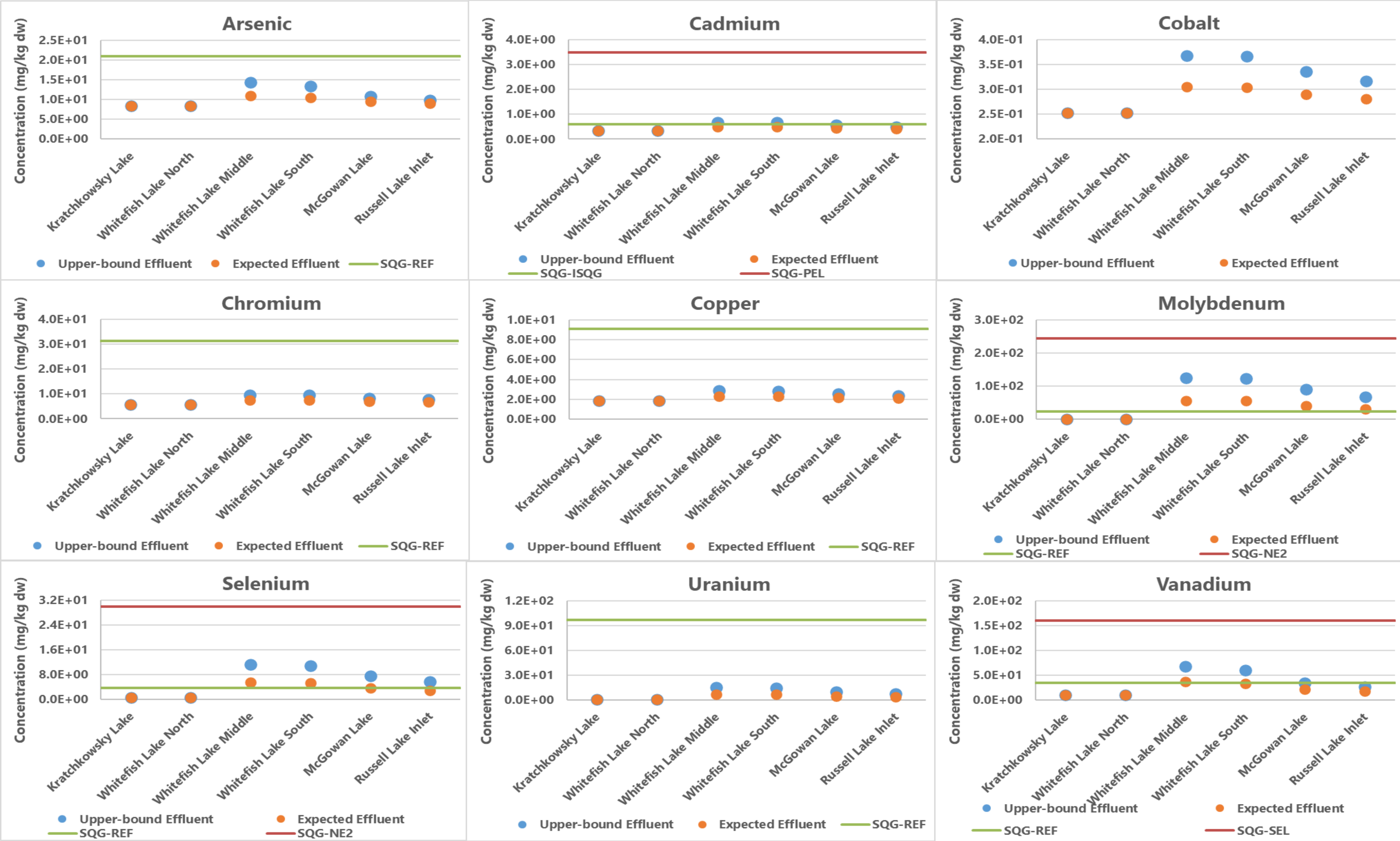

Sulphate
Concentration (mg/L)
1.6E+02
1.2E+02
8.0E+01
4.0E+01
0.0E+00
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Upper-bound Effluent
Expected Effluent
WQG

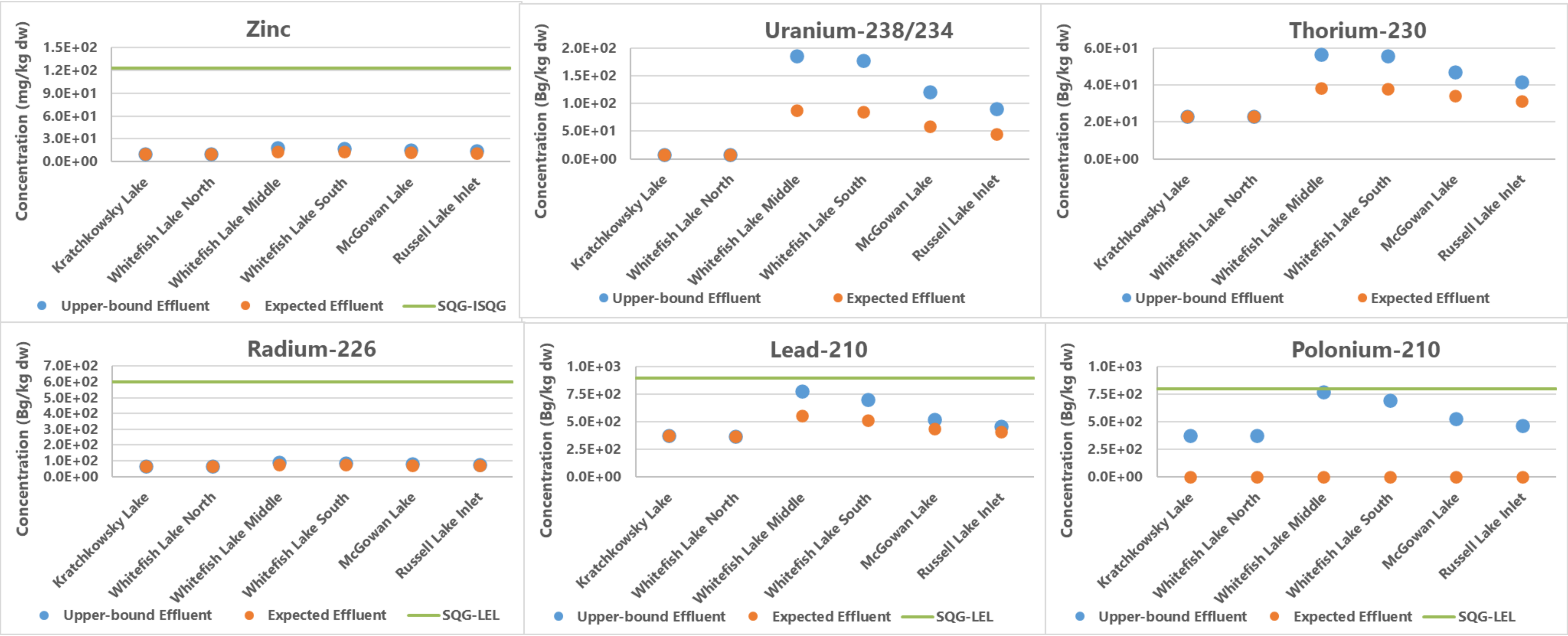

Selenium
Concentration (mg/L)
1.2E-03
8.0E-04
4.0E-04
0.0E+00
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Upper-bound Effluent
Expected Effluent
WQG



WQG = Water Quality Guideline. The WQG is the green line and is consistent with the selected screening values shown in Table 3-1.

Figure 6-1: Comparison of Maximum Concentrations of COPCs in Surface Water at the Expected and Upper Bound Discharge Rate


Arsenic
Concentration (mg/kg dw)
2.5E+01
2.0E+01
1.5E+01
1.0E+01
5.0E+00
0.0E+00
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Upper-bound Effluent
Expected Effluent
SQG-REF
Cadmium
4.0E+00
3.0E+00
2.0E+00
1.0E+00
0.0E+00
SQG-ISQG
SQG-PEL
Cobalt
4.0E-01
3.5E-01
3.0E-01
2.5E-01
2.0E-01
Chromium
4.0E+01
3.0E+01
2.0E+01
1.0E+01
0.0E+00
Copper
1.0E+01
8.0E+00
6.0E+00
4.0E+00
2.0E+00
0.0E+00
Molybdenum
3.0E+02
2.0E+02
1.0E+02
0.0E+00
SQG-NE2
Selenium
3.2E+01
2.4E+01
1.6E+01
8.0E+00
0.0E+00
Uranium
1.2E+02
9.0E+01
6.0E+01
3.0E+01
0.0E+00
Vanadium
2.0E+02
1.5E+02
1.0E+02
5.0E+01
0.0E+00
SQG-SEL



SQG = Sediment Quality Guideline. The SQG with the green line is consistent with the selected sediment screening values (REF or ISQG or LEL) shown in Table 3-6. The SQG with the red line is the upper sediment quality values (NE2 or SEL or PEL) shown in Table 3-6.

Figure 6-2: Comparison of maximum concentrations of COPCs in sediment at expected and upper bound discharge rate

6.3 Updated Risk Characterization for Selenium and Copper

An updated risk characterization for selenium and copper was undertaken due to additional evaluation criteria being published since the initiation of the ERA.

6.3.1 Selenium in Fish Tissue

The TRV for selenium in fish used in Section 5.3.1 was the US EPA criterion of 11.3 mg/kg dw muscle (US EPA, 2021d). ECCC has published a FEQG for selenium of 6.7 µg/g dw for whole body and 14.7 µg/g dw for egg-ovary. This section re-evaluates the assessment of selenium in fish tissue using the FEQG guidance (ECCC, 2022).

The whole-body concentrations were recalculated from the predicted selenium in muscle tissue concentrations (Appendix B, Table B.5), using site-specific moisture content and the species-specific US EPA (2021d) conversion factors. The values used for moisture content and conversion factors for muscle to whole body and egg-ovary to whole body are shown in Table 6-3 below. The resulting whole-body concentrations (Table 6-4) do not exceed either EPA (2021d) or ECCC (2022) guidelines for whole-body tissue, which are 8.5 µg/g dw and 6.7 µg/g dw, respectively, and therefore the conclusions of the ERA are unchanged.

Table 6-3: Moisture Content and Conversion Factors used for Selenium Calculations

Fish Species	Moisture Content (Aquatic Baseline Studies, Appendix 8-D, Table A-17)	Muscle:Whole Body (Table B-4, B-5, US EPA 2021d)	Egg-Ovary:Muscle (Table B-3, US EPA 2021d)
Northern Pike	77.98	1.27	1.88
White Sucker	76.55	1.34	1

Table 6-4: Calculated Whole Body and Egg-Ovary

			FEQG (µg/g dw)	6.7	14.7
Fish Species	Lake	Muscle µg/g fw	Muscle µg/g dw	Whole Body µg/g dw	Egg-Ovary µg/g dw
Northern Pike	Reference	1.89E-01	8.58E-01	0.68	1.61
	Whitefish Lake North	1.86E-01	8.45E-01	0.67	1.59
	Whitefish Lake Middle	1.57E+00	7.13E+00	5.61	13.40
	Whitefish Lake South	1.51E+00	6.86E+00	5.40	12.89
	McGowan Lake	1.02E+00	4.63E+00	3.65	8.71
	Russell Lake	8.12E-01	3.69E+00	2.90	6.93
White Sucker	Reference	1.46E-01	6.23E-01	0.46	0.62
	Whitefish Lake North	1.43E-01	6.10E-01	0.46	0.61
	Whitefish Lake Middle	1.74E+00	7.42E+00	5.54	7.42
	Whitefish Lake South	1.66E+00	7.08E+00	5.28	7.08
	McGowan Lake	1.06E+00	4.52E+00	3.37	4.52
	Russell Lake	8.06E-01	3.44E+00	2.57	3.44

6.3.1.1 Uncertainty Evaluation for Northern Pike Bioaccumulation Factor

Selenium BAFs were derived using regional data of measured fish tissue and water concentration data. Using measured fish tissue data and measured water concentrations to develop the BAF incorporates the selenium bioaccumulation through the food chain and would represent the transfer (enrichment function and trophic transfer).

Tissue data were available for northern pike, cisco, lake trout, longnose sucker, lake whitefish, white sucker, lake chub, and spottail shiner. The data comparisons resulted in the following conclusions:

- The same BAF can be applied to a fish species at different lakes;
- The BAF values for longnose sucker, cisco, and lake trout were not significantly different from those for northern pike; therefore; data from these species were combined to derive a BAF for northern pike;
- The BAF values for lake whitefish and white sucker were significantly different ($p<0.05$) from that for northern pike; and
- The BAF values for lake chub and spottail shiner were not significantly different ($p>0.05$) from each other; therefore, data for these two species were combined to derive a BAF for small-bodied fish.

Most of the data from fish species evaluated demonstrated a linear relationship between fish tissue and water concentrations. The linear regression line was shown to underestimate selenium in northern pike tissue at low water concentrations. Therefore, a non-linear relationship was adopted for northern pike, where the BAF = $949x^{0.827}$ (x is in units of µg/L). As shown in Figure 6-3, the linear (dotted line) and power function (solid red curve) are quite similar except where the water concentrations were less than 0.001 mg/L. The R^2 values for the linear and power function are similar but the better fit at the lower water concentration values provided a basis for selecting the power function as the preferred model for the northern pike. Correlation analyses of the tissue and water concentration data for selenium indicated that a significant relationship ($p<0.05$) existed between the water and tissue concentrations in northern pike, white sucker, lake whitefish and small-bodied fish.

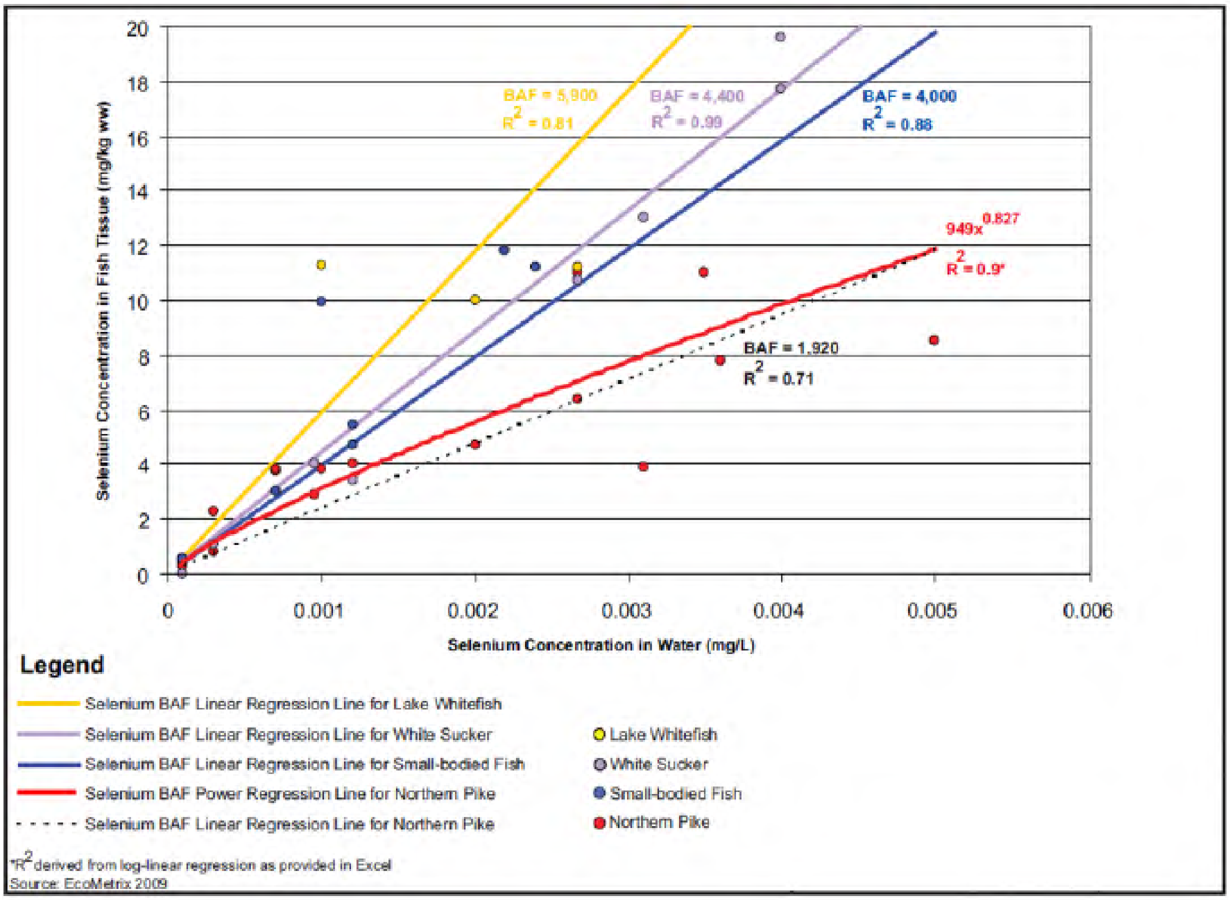


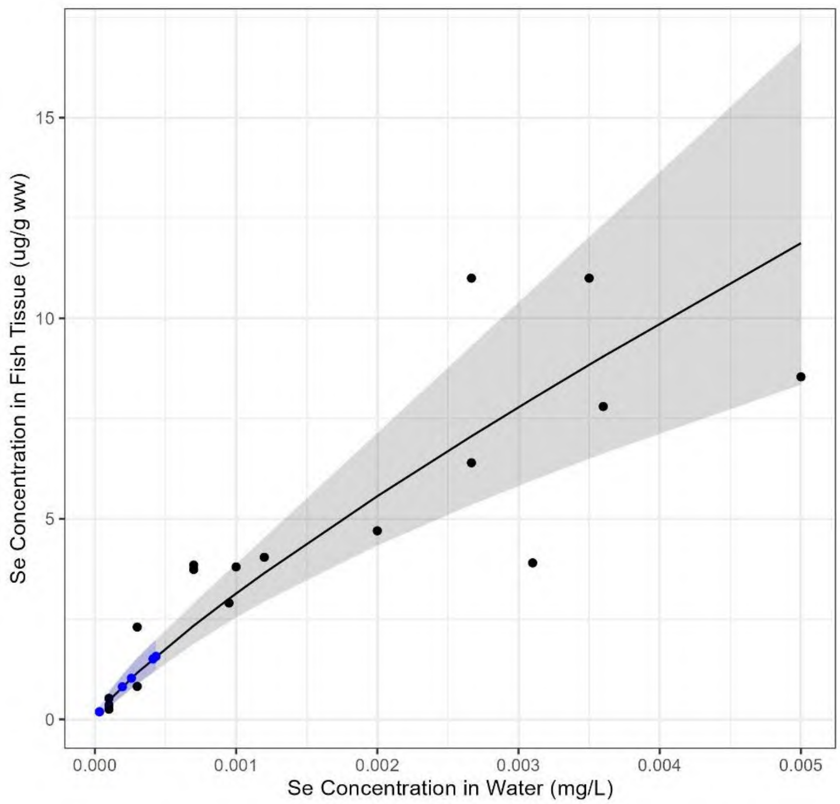
Figure 6-3: Development of Regional Fish BAFs for Selenium in Saskatchewan

To evaluate the range of uncertainty in the northern pike BAF, a power-regression (log-log) of the water and fish tissue selenium data was used to generate the expected relationship between selenium in water and selenium in tissue. The model was a good fit to the data (R^2 = 0.88). The regression equation ($y = ax^b$) was:

$Se_{[tissue;\ \mu g/g\ ww]} = a \times Se_{[water;\ mg/L]}{}^{b}$,

where the 95% confidence interval for '*a*' was 295–3060 and for '*b*' was 0.66–0.99.

The predicted mean response and confidence ribbon for those values are shown in Figure 6-4 and Table 6-5. Analysis was completed in *R v.* 4.4.4 using base functions (e.g., *lm()* and associated *predict()*). Plots were generated using *ggplot v.* 3.5.5.



Note: Blue dots are Wheeler River predictions, black dots are regional data

Figure 6-4: Predicted Mean Response and Confidence Ribbon – Selenium in Northern Pike

Table 6-5: Predicted Mean Lower and Upper Northern Pike Tissue Selenium Concentrations

	Water Concentration LA-5	Fish Muscle Tissue (Mean Value)	Fish Muscle Tissue (Low Value)	Fish Muscle Tissue (Upper Value)
Lake	**mg/L**	**µg/g fw**	**µg/g fw**	**µg/g fw**
Reference	3.35E-05	1.89E-01	1.06E-01	3.36E-01
Whitefish Lake North	3.28E-05	1.86E-01	1.04E-01	3.31E-01
Whitefish Lake Middle	4.33E-04	1.57E+00	1.23E+00	2.00E+00
Whitefish Lake South	4.12E-04	1.51E+00	1.18E+00	1.93E+00
McGowan Lake	2.59E-04	1.02E+00	7.65E-01	1.37E+00
Russell Lake	1.95E-04	8.12E-01	5.85E-01	1.12E+00

Using the range of the uncertainty in the northern pike BAF (from Table 6-5), fish muscle tissue selenium concentrations were calculated for the various lakes, using site-specific moisture content and the species-specific US EPA (2021d) conversion factors (see Table 6-3).

For reference, as indicated previously the whole body tissue and egg-ovary concentrations do not exceed the FEQGs (ECCC, 2022) for the mean BAF (Table 6-4). As shown in Table 6-6, the resulting whole-body tissue and egg-ovary concentrations do not exceed the FEQGs (ECCC, 2022) for the BAF lower range of uncertainty. At the upper range of the BAF, the egg-ovary concentration in Whitefish Lake exceeds the whole-body guideline of 6.7 µg/g dw and the egg-ovary guideline of 14.7 µg/g dw from ECCC (2022). At all other lakes the predicted whole-body and egg-ovary concentrations are below the selenium guidelines.

The results of the ERA and EIS are interpreted based on the expected mean BAF. Based on the expected selenium BAF, no significant adverse effects are predicted to northern pike from exposure to selenium. The uncertainty results provide a range (lower and upper) around the risk; however, there are numerous conservative assumptions in the overall assessment that would indicate the expected BAF is sufficiently conservative.

Table 6-6: Calculated Whole Body and Egg-Ovary Selenium Concentrations – Range of Uncertainty

FEQG (µg/g dw)						6.7	6.7	14.7	14.7
	Water Concent-ration	Fish Muscle Tissue (Lower Value)	Fish Muscle Tissue (Upper Value)	Fish Muscle Tissue (Lower Value)	Fish Muscle Tissue (Upper Value)	Whole Body (Lower Value) (b)	Whole Body (Upper Value) (b)	Egg-Ovary (Lower Value) (c)	Egg-Ovary (Upper Value) (c)
Lake	**mg/L**	**µg/g fw**	**µg/g fw**	**µg/g dw**	**µg/g dw**	**µg/g dw**	**µg/g dw**	**µg/g dw**	**µg/g dw**
Reference	3.35E-05	1.06E-01	3.36E-01	4.82E-01	1.53E+00	0.38	1.20	0.91	2.87
Whitefish Lake North	3.28E-05	1.04E-01	3.31E-01	4.72E-01	1.50E+00	0.37	1.18	0.89	2.83
Whitefish Lake Middle	4.33E-04	1.23E+00	2.00E+00	5.59E+00	9.07E+00	4.40	**7.14**	10.51	**17.06**
Whitefish Lake South	4.12E-04	1.18E+00	1.93E+00	5.35E+00	8.74E+00	4.21	**6.88**	10.05	**16.44**
McGowan Lake	2.59E-04	7.65E-01	1.37E+00	3.48E+00	6.24E+00	2.74	4.91	6.54	11.73
Russell Lake	1.95E-04	5.85E-01	1.12E+00	2.66E+00	5.10E+00	2.09	4.02	5.00	9.59

Notes:

(a) The site-specific moisture content for northern pike of 77.98% was used to convert from fresh weight to dry weight.

(b) A Muscle:Whole Body ratio of 1.27 was used for northern pike from Table B-4, B-5, US EPA 2021d.

(c) An Egg-Ovary:Muscle ratio of 1.88 was used for northern pike from Table B-3, US EPA 2021d.

Bold indicates exceedance of the selenium guideline.

6.3.2 Copper Aquatic Toxicity Reference Values

Since initiation of the ERA, ECCC has developed an updated FEQG for copper for protection of freshwater aquatic life based on the biotic ligand model (BLM) (ECCC, 2021). The FEQG is calculated based on site-specific concentrations of DOC, hardness, temperature and pH.

As identified in Section 5.3.1.1, TRVs for copper were obtained from the US EPA Ecotoxicology Database (ECOTOX) for aquatic organisms. The selected TRVs were 20% Effect Concentrations (i.e., EC_{20} values), which are concentrations at which only 20% of the test organisms respond. The TRVs used in the ERA for HQ calculations are shown in Table 5-12.

The TRVs for aquatic organisms have been re-evaluated using the FEQG and the BLM. The BLM was run based on baseline site-specific conditions (hardness of 5.26 mg/L, DOC of 2.24 mg/L, pH of 6.61, temperature of 13°C). The test species and concentrations identified as used to generate the BLM were evaluated to develop TRVs for the applicable biotic groups. The most restrictive effect concentration for each biotic group was identified. The test endpoint was either an EC_{10} or an IC_{10}. Based on the protocol identified in Table 5-11, the EC_{10} (or IC_{10}) was multiplied by 2 to obtain an EC_{20}, which was then utilized as the TRV. A summary of the TRVs for baseline conditions is identified in Table 6-7.

Considering that while the facility is in operation and during periods of treated effluent discharge it is expected that hardness in the receiving environment will increase to approximately 9 mg/L and pH will increase to approximately 7, the BLM was re-run under those conditions and the TRVs were re-evaluated based on the test species and concentrations used to generate the BLM. The copper TRVs under site conditions are presented in Table 6-8.

Table 6-7: Copper Toxicity Reference Values from Baseline Conditions BLM

COPC	Biotic Group	TRV	Unit	Rationale	Data Source
Copper	Forage fish	0.00517	mg/L	Fathead minnow, growth (IC_{10} = 0.0026 mg/L)	FEQG BLM
	Predator fish	0.000776	mg/L	White sturgeon, growth (EC_{10} = 0.0004 mg/L)	FEQG BLM
	Zooplankton	0.000886	mg/L	Daphnia magna, reproduction (EC_{10} = 0.0004 mg/L)	FEQG BLM
	Benthic invertebrates	0.000417	mg/L	Pond snail, growth (EC_{10} = 0.0002 mg/L)	FEQG BLM
	Phytoplankton	0.00913	mg/L	Rotifer, intrinsic (EC_{10} = 0.0046 mg/L)	FEQG BLM
	Aquatic plants	0.0212	mg/L	Duckweed, root length (EC_{10} = 0.01 mg/L)	FEQG BLM

Notes:
BLM based on hardness of 5.26 mg/L, DOC of 2.24 mg/L, pH of 6.61, temperature of 13°C.
TRV is an EC_{20}, adjusted from an EC_{10} or IC_{10}.

Table 6-8: Copper Toxicity Reference Values from Site Conditions BLM

COPC	Biotic Group	TRV	Unit	Rationale	Data Source
Copper	Forage fish	0.0104	mg/L	Fathead minnow, growth (IC_{10} = 0.005 mg/L)	FEQG BLM
	Predator fish	0.0018	mg/L	White sturgeon, growth (EC_{10} = 0.001 mg/L)	FEQG BLM
	Zooplankton	0.00205	mg/L	Daphnia magna, reproduction (EC_{10} = 0.001 mg/L)	FEQG BLM
	Benthic invertebrates	0.00098	mg/L	Pond snail, growth (EC_{10} = 0.0005 mg/L)	FEQG BLM
	Phytoplankton	0.0174	mg/L	Rotifer, intrinsic (EC_{10} = 0.009 mg/L)	FEQG BLM
	Aquatic plants	0.0153	mg/L	Duckweed, root length (EC_{10} = 0.008 mg/L)	FEQG BLM

Notes:
BLM based on hardness of 9 mg/L, DOC of 2.24 mg/L, pH of 7, temperature of 13°C.
TRV is an EC_{20}, adjusted from an EC_{10} or IC_{10}.

The hazard quotients (HQs) for aquatic organisms were re-evaluated using both sets of TRVs, baseline conditions and site conditions during operation where hardness and pH are increased (Table 6-9). Consistent with Section 5.4.1, an HQ less than or equal to 1 suggests low risk to the ecological receptor, and an HQ above 1 needs further investigation to determine if adverse effects are possible. Conservatively using baseline conditions, HQs for all aquatic organisms are less than 1 with the exception of predator fish in Whitefish Lake, and benthic invertebrates at all locations where HQs are slightly above 1. As such, further consideration was given to changes in site conditions when the facility is in operation.

Using predicted site conditions for hardness and pH, HQs for all aquatic organisms are less than 1 at all downstream locations, indicating no adverse effects to aquatic organisms from facility related copper during periods of treated effluent discharge. It is relevant to consider all aspects of the receiving environment, and this includes induced hardness and pH since the scenario being evaluated only occurs during periods of effluent discharge. This approach is used in other jurisdictions (e.g., water licences in northern Canada issued through local water boards) and therefore the concept of induced hardness is not unique.

The copper predictions are considered conservative based on the following assumptions:

- Baseline concentrations of copper are predominantly below the detection limit, indicating that baseline concentrations of copper are likely overestimated in the ERA.
- Based on the effluent quality and quantity released to Whitefish Lake, the maximum copper concentration in Whitefish Lake and downstream waterbodies was evaluated as part of the HQ. This is a conservative assumption.
- Once the facility is operational, site conditions will change which includes increased hardness and pH; therefore, the predicated HQs under baseline conditions are considered conservative and overestimate risk.

Table 6-9: Re-Evaluated Hazard Quotients for Copper in Aquatic Organisms

Location	Maximum Copper Concentration in Water (mg/L)	Hazard Quotients (unitless) – Baseline Conditions						Hazard Quotients (unitless) – Site Operation Conditions					
		Forage Fish	Predator Fish	Zooplankton	Benthic Invertebrate	Phyto-plankton	Aquatic Plants	Forage Fish	Predator Fish	Zooplankton	Benthic Invertebrate	Phytoplankton	Aquatic Plants
Kratchkowsky Lake (reference) [1]	6.22E-04	0.12	0.80	0.70	**1.49**	0.07	0.03	0.12	0.80	0.70	**1.49**	0.07	0.03
Whitefish Lake North	6.20E-04	0.12	0.80	0.70	**1.49**	0.07	0.03	0.06	0.34	0.30	0.63	0.04	0.04
Whitefish Lake Middle	8.22E-04	0.16	**1.06**	0.93	**1.97**	0.09	0.04	0.08	0.46	0.40	0.84	0.05	0.05
Whitefish Lake South	8.17E-04	0.16	**1.05**	0.92	**1.96**	0.09	0.04	0.08	0.45	0.40	0.83	0.05	0.05
McGowan Lake	7.50E-04	0.14	0.97	0.85	**1.80**	0.08	0.04	0.07	0.42	0.37	0.76	0.04	0.05
Icelander River	7.49E-04	0.14	0.97	0.84	**1.80**	0.08	0.04	0.07	0.42	0.37	0.76	0.04	0.05
Russell Lake Inlet	7.17E-04	0.14	0.92	0.81	**1.72**	0.08	0.03	0.07	0.40	0.35	0.73	0.04	0.05

Note:
Bold and shaded value indicates hazard quotient greater than 1.
[1] Kratchkowsky Lake is a reference lake located upstream of the effluent discharge point, and as such, the site operation conditions were the same as baseline conditions.

7.0 Conclusions and Recommendations

The selection of human and ecological receptors for inclusion in the ERA was informed by Indigenous and Local Knowledge, information from baseline studies, as well as professional judgement. The assumptions made for the Traditional Foods diet (i.e., amounts consumed and food types) was informed by an existing ERFN country foods study and through engagement with a local fisher/trapper.

The ERA focused on COPCs that exceeded screening values in air and water based on predicted atmospheric releases and aqueous releases (treated effluent) from the Wheeler River Project. The final list of COPCs included: arsenic, cadmium, chromium, cobalt, copper, molybdenum, selenium, uranium, vanadium, zinc, sulphate, chloride, and total dissolved solids.

Radionuclides of the uranium-238 series, including radon, were included as COPCs because these constituents are of public interest.

7.1 Human Health Risk Assessment

The HHRA estimated dose and risk during all Project phases to the following receptors: camp worker, seasonal resident, recreational fisher/hunter, fisher/trapper, and during future centuries to the future permanent resident. The future centuries reflect the time period over which the highest constituent concentrations in groundwater are predicted to migrate towards and interact with surface water post-restoration (i.e. beyond the Project timeline of 0-38 years).

During Post-Decommissioning, the Project area could be accessed intermittently by members of the public for various land use purposes. Any risks to these members of the public would be less than those assessed for the camp work and therefore the Project area would be safe for periodic land use during this period.

7.1.1 Non-radiological Human Health Risk Assessment

For assessment of non-carcinogens, risk was estimated based on Project total HQs (includes the Project risk in addition to the baseline risk) and Project incremental HQs (includes the Project risk only with baseline component removed). Project incremental HQs were compared to a benchmark HQ value of 0.2 because total background exposures (e.g. store-bought foods) were not included in the incremental HQ. This approach is consistent with Health Canada's guidance on human health preliminary quantitative risk assessment (Health Canada, 2021a).

The Project incremental HQ was predicted to remain below 0.2 for human receptors for all non-carcinogens and all pathways during all phases of the Project, with the exception of selenium for the fisher/trapper at Russell Lake from the fish ingestion pathway. The traditional foods diet for the fisher/trapper is conservative as it assumes a high annual fish consumption rate of 183 kg/yr (approximately 1 to 2 servings per day) and assumes that all fish consumed in the diet is obtained from the Project area. The diet of the fisher/trapper is representative of one person, who consumes a unique composition and quantity of traditional foods. Most people fishing, hunting, and trapping in the LSA and RSA would consume traditional foods more consistent with the average traditional foods consumer diet which was developed from the ERFN country foods study (CanNorth, 2017). During the future centuries there are no precited exceedances of the HQ benchmark (HQ<0.2) for human receptors, including the permanent resident, for any non-carcinogens.

The results are also discussed in terms of the total Project HQ (baseline plus Project). Since the Project total HQ includes background contributions from store-bought foods, a benchmark HQ value of 1 was considered. The Project total HQs for the fisher/trapper for selenium are predicted to be equal to or greater than 1. Since the Project incremental HQs for the fish ingestion pathway for selenium are predicted to be above 0.2, this indicates that the Project is expected to contribute to selenium in the environment and the food chain.

For assessment of risk for carcinogens (arsenic), the ILCR was estimated and compared against the cancer risk level of 1 in 100,000 recommended by Health Canada (Health Canada, 2021a). Incremental cancer risk was predicted to remain below the negligible cancer risk level of 1 in 100,000 for the camp worker, recreational fisher/hunter, and seasonal resident during the Project phases. The incremental cancer risk was predicted to be essentially equal to the negligible cancer risk level of 1 in 100,000 for the adult fisher/trapper at Russell Lake. These findings for the fisher/trapper are based on the conservative assumption of high consumption of Traditional Foods including fish and caribou in the LSA and RSA. As indicated above, the diet of the fisher/trapper is representative of one person, who consumes a unique composition and quantity of traditional foods. During the future centuries the cancer risk was not predicted to exceed the negligible cancer risk level of 1 in 100,000 for any human receptors, including the permanent resident.

7.1.2 Radiological Human Health Risk Assessment

The incremental radiation dose to all human receptors during all Project phases is predicted to be below the regulatory public dose limit of 1 mSv/yr and the dose constraint of 0.3 mSv/yr during all Project phases and in the future centuries. The maximum incremental radiological dose is predicted to be 0.06 mSv/yr to the fisher/trapper at Russell Lake. The total incremental dose to the camp worker from all radionuclides in the U-238 decay chain including radon would be 0.16 mSv/year, which is below the dose limit for a non-NEW of 1 mSv/yr.

Overall, since the radiation dose estimates would be below the dose limit, no discernable health effects are anticipated due to exposure of these receptors to radioactive releases from the Project.

7.2 Ecological Risk Assessment

The EcoRA estimated dose and risk to representative aquatic and terrestrial receptors during all Project phases and the future centuries. The future centuries reflect the time period over which the highest constituent concentrations in groundwater are predicted to migrate towards and interact with surface water post-restoration (i.e. beyond the Project timeline of 0-38 years).

Species at risk were either assessed directly or were represented by other more common species that have similar diets and exposure pathways.

7.2.1 Non-radiological Ecological Risk Assessment

The potential for ecological effects was assessed by comparing exposure levels to toxicological benchmarks and was characterized quantitatively in terms of total HQs. A total HQ greater than 1 indicates adverse effects may be possible for a given ecological receptor and further investigation would be warranted.

No significant adverse effect on either aquatic or terrestrial populations or communities, as a result of releases from the Project, are predicted during the Project phases or during the future centuries. All estimated total HQs for all COPCs, except copper, for all ecological receptors are predicted to remain below the HQ benchmark of 1. Under baseline conditions as well as the future centuries, copper HQs for all aquatic organisms are less than 1 with the exception of predator fish in Whitefish Lake, and benthic invertebrates at all locations where HQs are slightly above 1. Using operational site conditions for hardness and pH, copper HQs for all aquatic organisms are less than 1 at all downstream locations, indicating no adverse effects to aquatic organisms from facility related copper (Section 6.3.2). Since there are no total HQs above 1 for birds and mammals, individual species at risk would also be considered protected.

7.2.2 Radiological Ecological Risk Assessment

Radiation dose benchmarks of 9.6 mGy/d and 2.4 mGy/d (UNSCEAR, 2008) were selected for the assessment of effects on aquatic biota and terrestrial biota, respectively, as recommended in CSA N288.6-22.

There were no predicted exceedances of the 9.6 mGy/d radiation dose benchmark for aquatic biota or the 2.4 mGy/d radiation dose benchmark for terrestrial and riparian biota during any Project phase or during the future centuries.

Since there were no predicted exceedances of the respective dose benchmarks for any of the aquatic or terrestrial receptors, individual species at risk would also be considered protected.

Overall, it is unlikely that there would be potential adverse effects on terrestrial or aquatic populations or communities as a result of radionuclide releases from the Project.

7.3 Monitoring and Follow-up

The ERA was developed based on best available information for the Project, including baseline monitoring data, assumptions on source-terms, and Traditional Foods diet (intake rates and food types).

Monitoring should focus on collecting data to verify ERA model predictions, as well as provide data to improve model predictions as the Project begins. Recommended monitoring would support Denison's environmental protection framework with the goal of reducing uncertainty over time through an iterative process:

Air quality: With the exception of uranium, there were no predicted exceedances of annual screening values for any constituents, indicating that unacceptable chronic effects from direct exposure to air are not expected. Uranium exceeded its annual screening value at the on-site ecological receptor location, but not at the camp. Some short-term exceedances, based on maximum predicted concentrations, were predicted to occur at the camp and at the fence line for nitrogen dioxide (1 hour) and particulate matter (24 hour), and for uranium in TSP and PM_{10}. The predicted exceedances would be infrequent, short-term, and limited spatially. Any public visits to these locations would be very infrequent. Unacceptable levels of risk are not expected from infrequent, short-term exposures to these constituents in air. However, it is recommended that these constituents be monitored in accordance with provincial and federal guidelines and standards (i.e., CAAQS) as part of any Air Emissions Monitoring Plan. Additionally, for NO_2, monthly collection of passive samplers will be performed.

Environmental monitoring: Denison is implementing an Environmental Monitoring Program consistent with requirements and guidance in CSA N288.4-19: *Environmental monitoring programs at nuclear facilities and uranium mines and mills* (CSA, 2019). Monitoring would focus on providing data to verify the predictions made by the ERA, to refine the models used in the ERA, and to reduce the uncertainty in the predictions made by the ERA. The Environmental Monitoring Program should include collection of surface water, sediment, and soil samples as well as fish tissue samples, benthic invertebrate tissue samples, and country foods such as blueberries. Monitoring locations would be focused in the area of Whitefish Lake, McGowan Lake and Russell Lake. Monitoring constituents would include those identified as COPCs in the ERA, including metals and uranium-238 series radionuclides, and chloride and sulphate in lake waters. However, monitoring could extend to include other constituents for other purposes, such as meeting regulatory requirements for monitoring, or addressing constituents of public interest based on experience at other uranium mines and process plants.

8.0 References

Alberta, 2021. Alberta Ambient Air Quality Objectives [WWW Document]. Ambient Air Quality Objectives and supporting documents. URL https://www.alberta.ca/ambient-air-quality-objectives.aspx#jumplinks-5

Arrington, L.R., Davis, G.K., 1953. Molybdenum toxicity in the rabbit. J. Nutr. 51, 295–304.

ATSDR, 2007. Toxicological Profile for Arsenic.

ATSDR, 2004. Toxicological Profile for Cobalt [WWW Document]. URL http://www.atsdr.cdc.gov/toxprofiles/tp33.pdf

Bartlett, A., 2009. An assessment of the chronic toxicity of sodium chloride to Hyalella azteca (Unpublished data presented at the 1st International Conference on Urban Drainage and Road Salt Management in Cold Climates: Advances In Best Practices.). University of Waterloo.

BC Conservation Data Centre, 1993. Species Summary: Myodes gapperi [WWW Document]. BC Ministry of Environment.

BC MECCS, 2020. 2020. B.C. Source Drinking Water Quality Guidelines: Guideline Summary.

BC MOE, 2013. Ambient Water Quality Guideline for Sulphate. Technical Appendix. Update. BC Ministry of Environment. Water Protection & Sustainability Branch.

Beak International Inc, 1999. Ecotoxicology test results (Unpublished report for M.S. Evans). Environment Canada, National Water Research Institute.

Beresford, N.A., Gaschak, S., Barnett, C.L., Howard, B.J., Chizhevsky, I., Stromman, G., Oughton, D.H., Wright, S.M., Maksimenko, A., Copplestone, D., 2008. Estimating the exposure of small mammals at three sites within the Chernobyl exclusion zone – a test application of the ERICA Tool. Journal of Environmental Radioactivity. Journal of Environmental Radioactivity 1496–1502.

Beyer, W.N., Connor, E., Gerould, S., 1994. Estimates of Soil Ingestion by Wildlife. J. Wildl. Manage. 58.

Birge, W.J., Black, J.A., Westerman, A.G., Short, T.M., Taylor, S.B., Bruser, D.M., Wallingford, E.D., 1985. Recommendations on numerical values for regulating iron and chloride concentrations for the purpose of protecting warm water species of aquatic life in the Commonwealth of Kentucky. Memorandum of Agreement No. 5429. Kentucky Natural Resources and Environmental Protection Cabinet, Lexington.

Birge, W.J., Hudson, J.E., Black, J.A., Wasterman, A.G., 1979. Embryo-larval Bioassays on Inorganic Coal Elements and In Situ Biomonitoring of Coal-waste Effluents, in: Surface Mining and Fish/Wildlife Needs in the Eastern United States. Fish and Wildlife Service, Office of Biological Services, pp. 97–104.

Brown, J., Alfonso, B., Avila, R., Beresford, N.A., Copplestone, N.A., Hosseini, A., 2016. A new version of the ERICA tool to facilitate impact assessments of radioactivity on wild plants and animals. Journal of Environmental Radioactivity 153, 141–148.

Brown, J., Strand, P., Hosseini, A., Borretzen, P., 2003. Handbook for Assessment of the Exposure of Biota to Ionising Radiation from Radionuclides in the Environment.

Brown, J.E., Alfonso, B., Avila, R., Beresford, N.A., Copplestone, D., Prohl, G., Ulanovsky, A., 2008. The ERICA Tool. Journal of Environmental Radioactivity 99, 1371–1383.

Buckley, J.A., Rustagi, K.P., Laughlin, J.D., 1996. Response of Lemna minor to sodium chloride and a statistical analysis of continuous measurements for EC50 and 95% confidence limits calculation. Bulletin of Environmental Contamination and Toxicology 57, 1003–1008.

Burnett-Seidel, C., Liber, K., 2013. Derivation of no-effect and reference-level sediment quality values for application at Saskatchewan uranium operations. Environ. Monit. Assess. 185, 9481–9494.

Cal OEHHA, 2000. Proposed Action Level for Vanadium. California Office of Environmental Health Hazard Assessment.

CanNorth, 2018. Human Health Risk Assessment for the Eastern Athabasca Basin. Final Report. October.

CanNorth, 2017. English River First Nation Country Foods Study – Final Report (No. Project No. 2147). Canada North Environmental Services.

CanNorth, 2000. Hatchet Lake Dietary Survey – Field Report (No. Project No. 2147). Canada North Environmental Services.

CCME, 2020. Guidance Document on Achievement Determination for Canadian Ambient Air Quality Standards for Nitrogen Dioxide. PN 1608.

CCME, 2011a. Canadian Water Quality Guidelines for the Protection of Aquatic Life. Chloride Ion (Scientific Criteria Document No. PN 1460). Canadian Council of Mininsters of the Environment, Winnipeg.

CCME, 2011b. Canadian Water Quality Guideline for the Protection of Aquatic Life. Uranium. Canadian Council of Mininsters of the Environment.

CCME, 2008. Canadian Water Quality Guidelines.

CCME, 2007. A protocol for the derivation of water quality guidelines for the protection of aquatic life 2007. Canadian Council of Ministers of the Environment.

CCME, 1999a. Canadian Sediment Quality Guidelines for the Protection of Freshwater Aquatic Life (updated September 2007). Canadian Council of Ministers of the Environment.

CCME, 1999b. Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health: Thallium 1999. Canadian Council of Ministers of the Environment.

CCME, 1995. Protocol for the Derivation of Canadian Sediment Quality Guidelines for the Protection of Aquatic Life (No. CCME EPC-98E). Canadian Council of Ministers of the Environment.

Chan, L., Receveur, O., Sadik, T., Schwartz, H., Ing, A., Fediuk, K., Tikhonov, C., 2018. First Nations Food, Nutrition and Environment Study (FNFNES): Results from Saskatchewan (2015). University of Ottawa, Ottawa.

Chapman, P.M., Allen, H.E., Z'Graggen, M.N., 1996. Evaluation of bioaccumulation factors in regulating metals. Environ. Sci. Technol. 30, 448A-452A.

Chen, C.J., Chuang, Y.C., Lin, T.M., Wu, H.Y., 1985. Malignant neoplasms among residents of a blackfoot disease-endemic area in Taiwan: High-arsenic artesian well water and cancers. Cancer Research 45, 5895–5899.

CNSC, 2020. Environmental Protection. Environmental Principles, Assessments and Protection Measures. REGDOC-2.9.1, Version 1.2. Canadian Nuclear Safety Commission.

COSEWIC, 2018. Olive-sided Flycatcher (Contopus cooperi): COSEWIC Assessment and Status Report 2018. Committee on the Status of Endangered Wildlife in Canada, Ottawa.

Crane, M., Flower, T., Holmes, D., Watson, S., 1992. The toxicity of selenium in experimental freshwater ponds. Arch. Environ. Contam. Toxicol. 23, 440–452.

CSA, 2022. N288.6:22. Environmental risk assessments for nuclear facilities and uranium mines and mills. Canadian Standards Association.

CSA, 2020. Guidelines for modelling radionuclide environmental transport, fate, and exposure associated with the normal operation of nuclear facilities (No. CSA N288.1-20). Canadian Standards Association.

CSA, 2019. Environmental monitoring programs at nuclear facilities and uranium mines and mills. CSA N288.4-19.

CSA, 2012. Environmental risk assessments at Class I nuclear facilities and uranium mines and mills (No. CSA N288.6-12). Canadian Standards Association.

CWF, 2022. Canada Lynx [WWW Document]. The Canadian Wildlife Federation.

Davis, J.E., Fields, J.P., 1958. Experimental production of polycythemia in humans by administration of cobalt chloride. Proc Soc Exp Biol Med 99, 493–495.

Denison, 2019. Wheeler River Project - Provincial Technical Proposal and Federal Project Description. Denison Mines Corp.

DFO, 2018. Northern Pike [WWW Document]. Fisheries and Oceans Canada.

DFO, 2016. White Sucker [WWW Document]. Fisheries and Oceans Canada.

Dodds-Smith, M.E., Johnson, M.S., Thompson, D.J., 1992. Trace metal accumulation by the shrew sorex araneus. ii. tissue distribution in kidney and liver. Ecotoxicol Environ Saf. 24, 118–130.

Domingo, J.L., Paternain, J.L., Llobet, J.M., Corbella, J., 1986. Effects of vanadium on reproduction, gestation, parturition and lactation in rats upon oral administration. Life Sciences 39, 819–824.

Doyle, J.J., Pfander, W.H., Grebing, S.E., Pierce, J.O., 1974. Effect of dietary cadmium on growth, cadmium absorption and cadmium tissue levels in growing lambs. J. Nutr. 104, 160–166.

Durante, M., Pugliese, M., 2002. Estimates of radiological risk from depleted uranium weapons in war scenarios. Health Physics 82, 14–20.

EC and HC, 2003. Priority Substances List Assessment Report: Releases of Radionuclides from Nuclear Facilities (Impact on Non- Human Biota) (PSL2). Environment Canada and Health Canada.

EC and HC, 1993. Priority Substances List Assessment Report for Arsenic and its Compounds. Environment Canada and Health Canada, Ottawa.

ECCC, 2022. Federal Environmental Quality Guidelines Selenium. Environment and Climate Change Canada.

ECCC, 2021. Federal Environmental Quality Guidelines Copper. Environment and Climate Change Canada.

ECCC, 2018. Canada and Cackling Geese: Management and Population Control in Southern Canada. Canadian Wildlife Service, Environment Canada.

Ecometrix, 2022. Numerical Modelling: Post-Decommissioning Evaluation (Report prepared for Denison Mines Corporation). Ecometrix Incorporated.

Ecometrix, 2020. Wheeler River Project: Baseline Aquatic Environment Study (Report prepared for Denison Mines Corporation). Ecometrix Incorporated.

Elbetieha, A., Al-Hamood, M.H., 1997. Long-term exposure of male and female mice to trivalent and hexavalent chromium compounds: effect on fertility. Toxicology 116, 39–47.

Elphick, J.R., Davies, M., Gilron, G., Canaria, E.C., 2011. An aquatic toxicological evaluation of sulfate: The case for considering hardness as a modifying factor in setting water quality guidelines. Environ. Toxicol. Chem. 30, 247–253.

Elphick, J.R.F., Bergh, K.D., Bailey, H.C., 2011. Chronic toxicity of chloride to freshwater species: effects of hardness and implications for water quality guidelines. Environmental Toxicology and Chemistry 30, 239–249.

ERFN, 2011. English River First Nation, Aboriginal Traditional Knowledge Summary Report. Compiled by Environment Canada. English River First Nation.

ERFN, SVS, 2022a. Wheeler River Project – Summary of Health and Socio-Economic Study Results (Prepared for English River First Nation). English River First Nation (ERFN); Shared Value Solutions (SVS).

ERFN, SVS, 2022b. Wheeler River Project – Summary of Traditional Knowledge Study Results (Prepared for English River First Nation No. Project No. 2147). English River First Nation (ERFN); Shared Value Solutions (SVS).

FCSAP, 2012. Ecological Risk Assessment Guidance, Module 3: Standardization of Wildlife Receptor Characteristics. Environment Canada, Vancouver, B.C.

Gilman, A.P., Villeneuve, D.C., Secours, V.E., Yagminas, A.P., Tracy, B.L., Quinn, J.M., Valli, V.E., Wiles, R.J., Moss, M.A., 1998. Uranyl nitrate: 28-day and 91-day toxicity studies in the Sprague-Dawley rat. Toxicological Science 41, 117–128.

Goettl, J.P.Jr., Davies, P.H., Sinley, J.R., 1976. Water Pollution Studies, in: D.B.Cope (Ed.), Colorado Fish.Res.Rev.1972-1975, DOW-R-R-F72-75, Colorado Div.of Wildl. Boulder, pp. 68–75.

Government of Saskatchewan, 2015. Table 20: Saskatchewan Ambient Air Quality Standards.

Grobner, M.A., Cheeke, P.R., Patton, N.M., 1986. Effect of Dietary Copper and Oxytetracycline on Growth and Mortality of Weanling Rabbits. Journal of Applied Rabbit Research 9, 46–53.

Hamilton, S.J., Mehrle, P.M., 1986. Metallothionein in fish: review of its importance in assessing stress from metal contaminants. Transactions of the American Fisheries Society 115, 596–609.

Haseltine, S.D., Sileo, L., 1983. Response of American Black Ducks to Dietary Uranium: A Proposed Substitute for Lead Shot. Journal of Wildlife Management 47, 1124–1129.

Haseltine, S.D., Sileo, L., Hoffman, D.J., Mulhern, B.M., 1986. Effects of chromium on reproduction and growth of black ducks. Unpublished (Cited in Eisler, 1986 & Custer Et Al., 1986).

Health Canada, 2021a. Federal Contaminated Site Risk Assessment in Canada: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA). Version 3.0.

Health Canada, 2021b. Federal Contaminated Site Risk Assessment in Canada: Toxicological Reference Values (TRVs) Version 3.0.

Health Canada, 2020. Guidelines for Canadian Drinking Water Quality - Summary Table. September 2020.

Health Canada, 2019a. Guidelines for Canadian Drinking Water Quality: Guideline Technical Document—Copper. Health Canada, Ottawa.

Health Canada, 2019b. Guidelines for Canadian Drinking Water Quality: Guideline Technical Document—Uranium. Health Canada, Healthy Environments and Consumer Safety Branch, Ottawa.

Health Canada, 2018. Guidance for Evaluating Human Health Impacts in Environmental Assessments: Country Foods. Report No. H129- 54/5- 2018E-PDF.

Health Canada, 2016a. Guidance for evaluating Human Health Impacts in Environmental Assessment: Air Quality. Health Canada.

Health Canada, 2016b. Human Health Risk Assessment for Ambient Nitrogen Dioxide. Health Canada, Healthy Environments and Consumer Safety Branch.

Health Canada, 2016c. Human Health Risk Assessment for Coarse Particulate Matter. Health Canada. Healthy Environments and Consumer Safety Branch.

Health Canada, 2013. Interim Guidance on Human Health Risk Assessment for Short-Term Exposure to Carcinogens at Contaminated Sites. Federal Contaminated Sites Risk Assessment in Canada.

Health Canada, 2011. Canadian Guidelines for the Management of Naturally Occurring Radioactive Materials (NORM). Prepared by the Canadian NORM Working Group of the Federal Provincial Territorial Radiation Protection Committee.

Health Canada, 2010a. Federal Contaminated Site Risk Assessment in Canada, Part I: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA), Version 2.0. Contaminated Sites Program. Health Canada.

Health Canada, 2010b. Federal Contaminated Site Risk Assessment in Canada. Part VI: Guidance on Human Health Detailed Quantitative Radiological Risk Assessment (DQRARAD). Health Canada.

Health Canada, 2010c. Part II: Health Canada Toxicological Reference Values (TRVs) and Chemical-Specific Factors, Version 2.0. September.

Health Canada, 2006. Guidelines for Canadian Drinking Water Quality: Guideline Technical Document—Arsenic. Health Canada, Healthy Environments and Consumer Safety Branch, Ottawa.

Health Canada, 2004. Canadian Community Health Survey Cycle 2.2, Nutrition (2004) - A Guide to Accessing and Interpreting the Data (No. No. 4627). Office of Nutrition Policy and Promotion, Health Canada, Ottawa, ON.

Health Canada, 1998. National Ambient Air Quality Objectives for Particulate Matter. Executive Summary. Part 1: Science Assessment Document. Health Canada.

Health Canada, 1991. Guidelines for Canadian Drinking Water Quality: Guideline Technical Document—Total Dissolved Solids (TDS).

Hesterberg TW, Bunn WB, McClellan RO, Hamade AK, Long CM, Valberg PA, 2009. Critical review of the human data on short-term nitrogen dioxide (NO2) exposures: evidence for NO2 no-effect levels. Critical Reviews in Toxicology 39, 743–81.

Howell, G.O., Hill, C.H., 1978. Biological Interaction of Selenium with Other Trace Elements in Chicks. Environ. Health Perspect. 25, 147–150.

Hunder, G., Schaper, J., Ademuyiwa, O., Elsenhans, B., 1999. Species Differences in Arsenic-mediated Renal Copper Accumulation: A Comparison between Rats, Mice and Guinea Pigs. Hum. Exp. Toxicol. 18, 699–705.

ICRP, 2008. Environmental Protection - the Concept and Use of Reference Animals and Plants, ICRP Publication 108. International Commission on Radiological Protection.

ICRP, 2003. Basic Anatomical and Physiological Data for Use in Radiological Protection: Reference Values (No. Publication 89). International Commission on Radiological Protection.

ICRP, 1994. Dose Coefficients for Intakes of Radionuclides by Workers., Publication 68. Annals of the ICRP 24(4). International Commission on Radiological Protection.

IOM, 2001. Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc. Food and Nutrition Board of the Institute of Medicine of the National Academies, Washington, D.C.

IOM, 2000. Dietary Reference Intakes for Vitamin C, Vitamin E, Selenium and Carotenoids. Food and Nutrition Board of the Institute of Medicine of the National Academies, Washington, D.C.

Ivankovic, S., Preussmann, R., 1975. Absence of toxic and carcinogenic effects after administration of high doses of chromic oxide pigment in subacute and long-term feeding experiments in rats. Food and Cosmetics Toxicology 13, 347351.

Jenkins, K.J., Hidiroglou, M., 1986. Tolerance of the preruminant calf for selenium in milk replacer. J Dairy Sci. 69, 1865–1870.

Jenner, H.A., Janssen-Mommen, J.P.M., 1993. Duckweed Lemna minor as a tool for testing toxicity of coal residues and polluted sediments. Arch. Environ. Contam. Toxicol. 25, 3–11.

Kessler, E., 1974. Physiological and biochemical contributions to the taxonomy of the genus Chlorella. IX: Salt tolerance as a taxonomic character. Archives of Microbiology 100, 51–56.

KML, NVP, 2022a. Kineepik Métis Local #9 Kineepik Valued Ecosystem Components (KML Pre-statement for Denison EIS). Kineepik Métis Local (KML); Northern Village of Pinehouse Lake (NVP).

KML, NVP, 2022b. Response to the Environment Impact Assessment. (For the Proposed Ministry of Highways 914 Extension Project.). Kineepik Métis Local (KML); Northern Village of Pinehouse Lake (NVP).

KPI Program, 2020. Cabin owner survey conducted by Denison Mines. February 14-24, 2020. Key Person Interview Program (KPI Program).

KPI Program, 2019. Interview with the English River First Nation trapper conducted by Denison Mines (Notes finalized January 2, 2020.). Key Person Interview Program (KPI Program).

KPI Program, 2018. ERFN Patuanak Reserve workshop conducted by Denison Mines. Key Person Interview Program (KPI Program).

Laird, B.D., Chan, H.N., 2013. Bioacessibility of metals in fish, shellfish, wild game, and seaweed harvested in British Columbia, Canada. Food and Chemical Toxicology 58, 381–387.

Liber, K.S., deRosemond, S., Budnick, K., 2007. Uranium Toxicity to Regionally-Representative Algae and Invertebrate Species. Toxicology Centre, University of Saskatchewan, for AREVA Resources Inc. and Cameco Corporation.

Lynch, G.P., Smith, D.F., Fisher, M., Pike, T.L., Weinland, B.T., 1976. Physiological responses of calves to cadmium and lead. J. Anim. Sci. 42, 410–421.

May-Passino, D.R.M., Novak, A.J., 1987. Toxicity of arsenate and DDT to the Cladoceran Bosmina longirostris. Bull.Environ.Contam.Toxicol. 33, 325–329.

McConnell, R.P., 1977. Toxicity of molybdenum to rainbow trout under laboratory conditions., in: Chappell, W.R. and K.K. Peterson (Eds.). Molybdenum in the Environment. Volume 2. The Geochemistry, Cycling, and Industrial Uses of Molybdenum. Marcel Dekker, New York.

MECP, 2020. Ontario's Ambient Air Quality Criteria. Ministry of the Environment, Conservation and Parks.

MECP, 2011. Rationale for the Development of Soil and Ground Water Standards for Use at Contaminated Sites in Ontario. Standards Development Branch. Ontario Ministry of the Environment, Conservation and Parks.

Meluzzi, A., Simoncini, F., Sirri, F., Vandi, L., Giordani, G., 1996. Feeding hens diets supplemented with heavy metals (chromium, nickel and lead). Archiv Fuer Gefluegelkunde 60, 119–125.

Miller, W.J., Amos, H.E., Gentry, R.P., Blackmon, D.M., Durrance, R.M., Crowe, C.T., Fielding, A.S., Neathery, M.W., 1989. Long-term feeding of high zinc sulfate diets to lactating and gestating dairy cows. J. Dairy Sci. 72, 1499–1508.

Morales, K.H., Ryan, L., Kuo, T.L., Wu, M.M., Chen, C.J., 2000. Risk of internal cancers from arsenic in drinking water. Environmental Health Perspectives 108, 655–661.

Morrison, L.L., Chavez, E.R., 1983. Selenium-arsenic Interaction in the Weanling Pig. Canadian Journal of Animal Science 63, 239–246.

NCC, 2022. Moose [WWW Document]. Nature Conservancy Canada.

Nemec, M.D., Holson, J.F., Farr, C.H., Hood, R.D., 1998. Developmental Toxicity Assessment of Arsenic Acid in Mice and Rabbits. Reprod. Toxicol. 12, 647–658.

Newman, M.C., Unger, M.A., 2002. Fundamentals of Ecotoxicology, 2nd ed. CRC/Lewis Press, Boca Raton, FL.

NRC, 2021. Woodland caribou – boreal population [WWW Document]. Natural Resources Canada.

NWF, 2021a. Snowshoe Hare [WWW Document]. The National Wildlife Federation.

NWF, 2021b. Black Bear [WWW Document]. The National Wildlife Federation.

NWF, 2021c. Common Loon [WWW Document]. The National Wildlife Federation.

Olivares, M., Pizarro, F., Speisky, H., Lönnerdal, B., Uauy, R., 1998. Copper in Infant Nutrition: Safety of World Health Organization Provisional Guideline Value for Copper Content of Drinking Water. Journal of Pediatric Gastroenterology and Nutrition 26, 251–257.

Omnia, 2020. Denison Mines Corporation Wheeler River Project - Terrestrial Environment Wildlife and Vegetation Baseline Inventory. Omnia Ecological Services.

Ontario MOE, 2011. Ontario Air Standards for Uranium and Uranium Compounds. Ontario Ministry of Environment. Technical Assessment and Standards Development Branch.

Ortolani, E.L., Machado, C.H., Sucupira, M.C.A., 2003. Assessment of Some Clinical and Laboratory Variables for Early Diagnosis of Cumulative Copper Poisoning in Sheep. Vet. Hum. Toxicol. 45, 289.

Paternain, J.L., Domingo, J.L., Ortega, A., Llobet, J.M., 1989. The Effects of Uranium on Reproduction, Gestation, and Postnatal Survival in Mice. Ecotoxicol. Env. Saf. 17, 291–296.

Persaud, D., Jaagumagi, R., Hayton, A., 1993. Guidelines for the Protection and Management of Aquatic Sediment Quality of Ontario. Ministry of Environment and Energy. Ontario.

Phillips, T.D., Nechay, B.R., Neldon, S.L., Kubena, L.F., Heidelbaugh, N.D., Shepherd, E.C., Stein, A.F., Hayes, A.W., 1982. Vanadium-induced inhibition of renal sodium, potassium adenosinetriphosphatase in the chicken after chronic dietary exposure. J. Toxicol. Environ. Health 9, 651–661.

Raisbeck, M.F., O'toole, D., Schamber, R.A., Belden, E.L., Robinson, L.J., 1996. Toxicologic evaluation of a high-selenium hay diet in captive pronghorn antelope (Antilocapra americana). J. Wild. Dis. 32, 9–16.

Rhian, M., Moxon, A.L., 1943. Chronic selenium poisoning in dogs and its prevention by arsenic. J. Pharmacol. Exp. Ther. 78, 249.

Richardson, G.M., 1997. Compendium of Canadian Human Exposure Factors for Risk Assessment. Ottawa: O'Connor Associates Environmental Inc.

Sajwan, K.S., Ornes, W.H., 1994. Phytoavailability and bioaccumulation of cadmium in duckweed plants. J. Environ. Sci. Health. A 29, 1035–1044.

Sample, B.E., Opresko, D.M., Suter, G.W.I., 1996. Toxicological Benchmarks for Wildlife: 1996 Revision. United States Department of Energy.

Sample, B.E., Suter, G.W.I., 1994. Estimating Exposure of Terrestrial Wildlife to Contaminants (No. ES/ER/TM-125). Oak Ridges National Laboratory.

Sauter, S., Buxton, K.S., Macek, K.J., Petrocelli, S.R., 1976. Effects of Exposure to Heavy Metals on Selected Fresh Water Fish. Toxicity of Copper, Cadmium, Chromium and Lead to Eggs and Fry of Seven Fish Species (No. EPA-600/3-76-105). U.S. Environmental Protection Agency, Duluth, Minesota.

Schroeder, H.A., Mitchener, M., 1971. Toxic effects of trace elements on the reproduction of mice and rats. Arch. Environ. Health. 23, 102–106.

Smith, J.S., Heinz, G.H., Hoffman, D.J., Spann, J.W., Krynitsky, A.J., 1988. Reproduction in black-crowned night-herons fed selenium. Lake Reservoir Manage 4, 175–180.

Solaiman, S.G., Maloney, M.A., Qureshi, M.A., Davis, G., D'Andrea, G., 2001. Effects of High Copper Supplements on Performance, Health, Plasma Copper and Enzymes in Goats. Small Ruminant Research 41, 127–139.

Stubblefield, W.A., Van Genderen, E., Cardwell, A.S., Heijerick, D.G., Janssen, C.R., De Schamphelaere, A.C., 2020. Acute and Chronic Toxicity of Cobalt to Freshwater Organisms: Using a Species Sensitivity Distribution Approach to Establish International Water Quality Standards. Environmental Toxicology and Chemistry 39, 799–811.

Suter, G.W., Tsao, C.L., 1996. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota (No. ES/ER/TM-96/R2).

Suter, G.W.I., 1996. Risk Characterization for Ecological Risk Assessment of Contaminated Sites. Oak Ridge National Laboratory, Oak Ridge.

Swiergosz, R., Zakrzewska, M., Sawicka Kapusta, K., Bacia, K., Janowska, I., 1998. Accumulation of cadmium in and its effect on bank vole tissues after chronic exposure. Ecotoxicol. Environ. Saf. 41, 130–136.

TCEQ, 2016. Effects Screening Levels (ESLs) Used in the Review of Air Permitting Data [WWW Document]. Texas Commission on Environmental Quality. URL https://www.tceq.texas.gov/toxicology/esl/list_main.html (accessed 10.28.20).

Tetra Tech Inc., 2008. Aquatic Life Water Quality Criteria for Molybdenum, July 9, 2008. Prepared for Nevada Division of Environmental Protection. Bureau of Water Quality Planning.

Thomas, J.W., Moss, S., 1951. The effect of orally administered molybdenum on growth, spermatogenesis and testes histology of young dairy bulls. J. Dairy Sci. 34, 929–934.

Thompson, P.A., Kurias, J., Mihok, S., 2005. Derivation and use of sediment quality guidelines for ecological risk assessment of metals and radionuclides released to the environment from uranium mining and milling activities in Canada. Environ. Monit. Assess. 110, 71–85.

Trabalka, J.R., Gehrs, C.W., 1977. An observation on the toxicity of hexavalent chromium to Daphnia magna. Toxicol. Lett. 1, 131–134.

Underwood, E.J., 1971. Trace elements in human and animal nutrition, in: Molybdenum. Academic Press, New York, pp. 116–140.

UNSCEAR, 2008. Sources and Effects of Ionizing Radiation. Annex E. Effects of Ionizing Radiation on Non-human Biota., Report to the General Assembly with Scientific Annexes. United Nations Scientific Committee on Effects of Ionizing Radiation.

US EPA, 2021a. Indicators: Zooplankton [WWW Document]. National Aquatic Resource Surveys.

US EPA, 2021b. Indicators: Macrophytes [WWW Document]. National Aquatic Resource Surveys.

US EPA, 2021c. Indicators: Phytoplankton [WWW Document]. National Aquatic Resource Surveys.

US EPA, 2021d. 2021 Revision* to: Aquatic Life Ambient Water Quality Criterion for Selenium – Freshwater 2016 (No. EPA 822-R-21-006). United States Environmental Protection Agency.

US EPA, 2007a. Aquatic Life Ambient Freshwater Quality Criteria – Copper. United States Environmental Protection Agency.

US EPA, 2007b. Ecological Soil Screening Levels for Copper (Interim Final). United States Environmental Protection Agency.

US EPA, 2007c. Ecological Soil Screening Levels for Selenium– Interim Final. U.S. Environmental Protection Agency.

US EPA, 2007d. Ecological Soil Screening Levels for Zinc – Interim Final. U.S. Environmental Protection Agency.

US EPA, 2005a. Guidance for Developing Ecological Soil Screening Levels. OSWER Directive 9285.7-55 (Revised). United States Environmental Protection Agency.

US EPA, 2005b. Ecological Soil Screening Levels for Arsenic – Interim Final.

US EPA, 2005c. Ecological Soil Screening Levels for Cadmium – Interim Final. U.S. Environmental Protection Agency.

US EPA, 2005d. Ecological Soil Screening Levels for Chromium - Interim Final (No. OSWER Directive 9285.7-66). U.S. Environmental Protection Agency.

US EPA, 2005e. Ecological Soil Screening Levels for Cobalt– Interim Final (Interim Final).

US EPA, 2005f. Ecological Soil Screening Levels for Vanadium - Interim Final (No. OSWER Directive 9285.7-75). U.S. Environmental Protection Agency.

US EPA, 1998. Toxicological Review of Trivalent Chromium in Support of Summary Information on the Integrated Risk Information System (IRIS). Washington, DC.

US EPA, 1993. Wildlife Exposure Factors Handbook (No. EPA/600/R-93/187). Office of Health and Environmental Assessment, U.S. Environmental Protection Agency, Washington, D.C.

US EPA, 1985. Ambient Water Quality Criteria for Chromium - 1984 (No. EPA-440/5-84-029). Criteria and Standards Division, U.S. Environmental Protection Agency, Washington, D.C.

US EPA, 1980. Particle Size Distribution of Yellowcake Emissions at the United Nuclear-Churchrock Uranium Mill (No. ORP/LV-80-1). Office of Radiation Programs, U.S. Environmental Protection Agency, Las Vegas, NV.

USFS, 2021. About Lichens [WWW Document]. United States Forest Service.

USGS, 2006. Cadmium Risks to Freshwater Life: Derivation and Validation of Low-Effect Criteria Values using Laboratory and Field Studies. Scientific Investigations Report 2006-5245. U.S. Geological Survey, Department of the Interior.

Vives i Batlle, J., Balonov, M., Beaugelin-Seiller, K., Beresford, N.A., Brown, J., Cheng, J.-J., Copplestone, D., Doi, M., Filistovic, V., Golikov, V., Horyna, J., Hosseini, A., Howard, B.J., Jones, S.R., Kamboj, S., Kryshev, A., Nedvecaite, T., Olyslaegers, G., Prohl, G., Ulanovsky, A., Vives Lynch, S., Yankovic, T., Yu, C., 2007. Inter-comparison of absorbed dose rates for non-human biota 349–373.

Vives i Batlle, J., Beaugelin-Seiller, K., Beresford, N.A., Copplestone, D., 2011. The estimation of absorbed dose rates for non-human biota: an extended intercomparison. Radiation Environ. Biophys. 50, 231–251.

Vocke, R.W., Sears, K.L., O'Toole, J.J., Wildman, R.B., 1980. Growth responses of selected freshwater algae to trace elements and scrubber ash slurry generated by coal-fired power plants. Water. Res. 14, 141–150.

Vohra, P., Kratzer, F.H., 1968. Zinc, copper and manganese toxicities in turkey poults and their alleviation by EDTA. Poult. Sci. 47, 699.

VST, 2004. Final Report on the Toxicity Investigation of Uranium to Aquatic Organisms. Vizon SciTech Inc., for the Canadian Nuclear Safety Commission.

WHO, 2017. Guidelines for drinking-water quality. World Health Organization.

WHO, 2011. Evaluation of certain food additives and contaminants: seventy-third [73rd] report of the Joint FAO/WHO Expert Committee on Food Additives (No. No. 960), WHO Technical Report Series. World Health Organization, Food and Agriculture Organization of the United Nations & Joint FAO/WHO Expert Committee on Food Additives.

WHO, 2006. WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide Global update 2005, Summary of risk assessment.

Wiemeyer, S.N., Hoffman, D.J., 1996. Reproduction in eastern screech-owls fed selenium. Journal of Wildlife Management 60, 332–341.

Wood, C.M., Port, P., 2000. Intracellular pH regulation and buffer capacity in CO2/HCO3-buffered media in cultured epithelial cells from rainbow trout gills. J. Comp. Physiol. B. 170, 175–184.

WSA, 2017. Saskatchewan Water Quality Objective for the Protection of Aquatic Life – Molybdenum. Fact Sheet. (No. WSA 514). Saskatchewan Water Security Agency.

Wu, M.M., Kuo, T.L., Hwang, Y.H., Chen, C.J., 1989. Dose–response relation between arsenic concentration in well water and mortality from cancers and vascular diseases. American Journal of Epidemiology 130, 1123–1132.

YNLRO, 2022. An Exploration of Recorded Athabasca Denesųłiné Traditional Knowledge, Land Use and Occupancy Information in the Vicinity of Denison Mines Wheeler River Project. Ya'thi Néné Lands and Resources Office.

Zarafonetis, J.H., Hampton, R.E., 1974. Some effects of small concentrations of chromium on growth and photosynthesis in algae. Mich. Acad. 6, 417–421.

Appendix A Wheeler River Project IMPACT Model

Appendix B Model Results in Support of the ERA

Appendix C Ecological Receptor Profiles

APPENDIX 10-A: ENVIRONMENTAL RISK ASSESSMENT FOR WHEELER RIVER

TECHNICAL SUPPORT DOCUMENT

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APPENDIX 10-A: ENVIRONMENTAL RISK ASSESSMENT FOR WHEELER RIVER

TECHNICAL SUPPORT DOCUMENT

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EXECUTIVE SUMMARY

The Wheeler River Project (the Project) proposes the development of the high-grade Phoenix uranium deposit as an in-situ recovery (ISR) mining operation with on-site processing. The Project is located approximately 35 km north-northeast of Cameco's Key Lake Operation and 35 km southwest of Cameco's McArthur River Operation in the eastern portion of the Athabasca Basin region in northern Saskatchewan.

The proposed Project is subject to both federal and provincial Environmental Assessment (EA) processes, and the Environmental Impact Statement (EIS) was prepared to support the EA. This environmental risk assessment (ERA) encompasses a human health risk assessment (HHRA) and an ecological risk assessment (EcoRA), which have been prepared to be compliant with Canadian Standards Association Group (CSA) N288.6-22 *Environmental Risk Assessments at Nuclear Facilities and Uranium Mines and Mills* (CSA, 2022). It also meets the requirements for an ERA outlined in Section 4.1 of Regulatory Document-2.9.1, *Environmental Principles, Assessments and Protection Measures* (CNSC, 2020).

The ERA focused on constituents of potential concern (COPCs) that exceeded screening values in air and water based on predicted atmospheric releases and aqueous releases (e.g., treated effluent and groundwater solute releases) from the Project. Based on the screening of atmospheric releases, no COPCs in air were advanced for further quantitative assessment in the ERA. Based on the screening of aqueous releases, arsenic, cadmium, chromium, cobalt, copper, molybdenum, selenium, uranium, vanadium, zinc, sulphate, and chloride were advanced for further quantitative assessment in the ERA. Radionuclides, including the uranium-238 series and radon, were included as COPCs because these constituents are of public interest.

An environmental transport and pathways model (IMPACT) was used to evaluate the effects of COPCs on the local environment including human and ecological receptors.

The ERA estimated dose and risk to human and ecological receptors during all Project phases and in the future centuries. The future centuries reflect the time period over which the highest constituent concentrations in groundwater are predicted to migrate towards and interact with surface water post-restoration (i.e. beyond the Project timeline of 0-38 years).

The selection of human and ecological receptors was informed by Indigenous and Local Knowledge.

The HHRA focused on members of the public potentially exposed to low levels of airborne or waterborne constituents. The selected human health receptor groups included a camp worker, seasonal resident, recreational fisher/hunter, and fisher/trapper. In the future centuries a hypothetical permanent resident was assessed at the former mine site instead of a camp worker.

The ecological receptors selected for the EcoRA were a subset of valued components identified for the EA so that the results from the ERA could be used in the effects assessments for fish, vegetation, wildlife, human health, Indigenous land and resource use, and other land and resource uses.

Non-radiological Human Health Risk Assessment

The potential effects on human receptors were evaluated by comparing the non-radiological exposures of receptors to recognized benchmarks, a dose-based toxicity reference value in the same units, for each COPC.

For assessment of non-carcinogens, risk was estimated based on Project total HQs (includes the Project risk in addition to the baseline risk) and Project incremental HQs (includes the Project risk only with baseline component removed). Project incremental HQs were compared to a benchmark HQ value of 0.2 because total background exposures (e.g., store-bought foods) were not included in the incremental HQ. This approach is consistent with Health Canada's guidance on human health preliminary quantitative risk assessment (Health Canada, 2021a).

The Project incremental HQ was predicted to remain below 0.2 for human receptors for all non-carcinogens and all pathways during all phases of the Project, with the exception of selenium for fisher/trapper at Russell Lake from the fish ingestion pathway. The traditional foods diet for the fisher/trapper is conservative as it assumes a high annual fish consumption rate of 183 kg/yr (approximately 1 to 2 servings per day) and assumes that all fish consumed in the diet is obtained from Russell Lake, whereas it is likely that someone would fish from many different lakes including those outside of the RSA. The diet of the fisher/trapper is representative of one person, who consumes a unique composition and quantity of traditional foods. Most people fishing, hunting, and trapping in the LSA and RSA would consume traditional foods more consistent with the average traditional foods consumer diet which was developed from the ERFN country foods study (CanNorth, 2017). However, it is recognized that the ERFN considers the fisher/trapper's use of the area as representative of current and future land users and expects that their relationship to the Project Area will be continued and strengthened through generations of future use.

During the future centuries there are no predicted exceedances of the HQ benchmark (HQ<0.2) for any human receptors, including the permanent resident, for any non-carcinogens.

For the assessment of carcinogens (arsenic), the incremental risk of developing cancer over a lifetime (ILCR) was estimated and compared against the cancer risk level of 1 in 100,000 recommended by Health Canada (Health Canada, 2021a). The ILCR was predicted to remain below the negligible cancer risk level of 1 in 100,000 for the camp worker, recreational fisher/hunter, and seasonal resident during the Project phases. The ILCR was predicted to be essentially equal to the negligible cancer risk level of 1 in 100,000 for the adult fisher/trapper at Russell Lake. These findings for the fisher/trapper are based on the conservative assumption of high consumption of traditional foods including fish and caribou in the LSA and RSA. As indicated above, the diet of the fisher/trapper is representative of one person, who consumes a unique composition and quantity of traditional foods. During the future centuries, the cancer risk was not predicted to exceed the negligible cancer risk level of 1 in 100,000 for any human receptor, including the permanent resident.

Radiological Human Health Risk Assessment

The incremental radiation dose to all human receptors during all Project phases is predicted to be below the regulatory public dose limit of 1 mSv/yr and the dose constraint of 0.3 mSv/yr during all Project phases and in the future centuries. The maximum incremental radiological dose is predicted to be 0.06 mSv/yr to the fisher/trapper at Russell Lake. The total incremental dose to the camp worker from all radionuclides in the U-238 decay chain including radon would be 0.16 mSv/year, which is below the dose limit for a non-NEW of 1 mSv/yr.

Overall, since the radiation dose estimates were predicted to be below the public dose limit, no discernable health effects would be anticipated due to exposure of human receptors to radioactive releases from the Project.

Non-radiological Ecological Risk Assessment

The potential for ecological effects was assessed by comparing exposure levels to toxicological benchmarks and characterized quantitatively in terms of HQs. An HQ greater than 1 indicates adverse effects may be possible for a given ecological receptor and further investigation would be warranted. Species at risk were either assessed directly or were represented by other more common species that have similar diets and exposure pathways.

No significant adverse effect on either aquatic or terrestrial populations or communities, as a result of releases from the Project, are predicted during the Project phases or during the future centuries. Estimated total HQs for the COPCs arsenic, cadmium, chromium, cobalt, molybdenum, selenium, uranium, vanadium, zinc, chloride and sulphate, for all ecological receptors are predicted to remain below the HQ benchmark of 1. Under baseline conditions as well as the future centuries, copper HQs for all aquatic organisms are less than 1 with the exception of predator fish in Whitefish Lake, and benthic invertebrates at all locations where HQs are above 1.

Using predicted operational site conditions for hardness and pH, copper HQs for all aquatic organisms are less than 1 at all downstream locations, indicating no adverse effects to aquatic organisms from facility related copper.

Species at risk were assessed using surrogate species. Since there are no total HQs above 1 for birds and mammals, individual species at risk would also be considered protected.

Radiological Ecological Risk Assessment

Radiation dose benchmarks of 9.6 milligrays per day (mGy/d) and 2.4 mGy/d (UNSCEAR, 2008) were selected for the assessment of effects on aquatic biota and terrestrial biota, respectively, as recommended in CSA N288.6-22.

There were no predicted exceedances of the 9.6 mGy/d radiation dose benchmark for aquatic biota, or the 2.4 mGy/d radiation dose benchmark for terrestrial and riparian biota during any Project phase or during the future centuries.

Since there were no predicted exceedances of the respective dose benchmarks for any of the aquatic or terrestrial receptors, individual species at risk would also be considered protected.

Monitoring and Follow-up

The ERA was developed based on the best available information for the Project, including baseline monitoring data, assumptions on source-terms, and Traditional Foods diet (intake rates and food types).

Monitoring would focus on collecting data to verify ERA model predictions as well as providing data to improve model predictions as the Project begins. Recommended monitoring would support Denison's environmental protection framework with the goal of reducing uncertainty over time through an iterative process.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

AAAQO	Alberta Ambient Air Quality Objectives
AAQC	ambient air quality criteria
ATSDR	Agency for Toxic Substances and Disease Registry
BAF	bioaccumulation factor
BC MECCS	British Columbia Ministry of Environment and Climate Change Strategy
BC MOE	British Columbia Ministry of Environment
BLM	biotic ligand model
CAAQS	Canadian Ambient Air Quality Standards
CAC	criteria air contaminant
Cal OEHHA	California Office of Environmental Health Hazard Assessment
CCC	criterion continuous concentration
CCME	Canadian Council of Ministers of the Environment
CF	conversion factor
CNSC	Canadian Nuclear Safety Commission
COPC	constituent of potential concern
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CSA	Canadian Standards Association
CSM	conceptual site model
DCF	dose coefficient
DWWTP	domestic wastewater treatment plant
EA	Environmental Assessment
EC	effect concentration
EcoRA	ecological risk assessment
Eco-SSL	ecological soil screening level
ECOTOX	Ecotoxicology database
EIS	Environmental Impact Statement
ERA	environmental risk assessment
ERFN	English River First Nation
ESL	effects screening level
ESOD	erythrocyte superoxide dismutase
FEQG	federal environmental quality guidelines
FNFNES	First Nations Food, Nutrition and Environment Study
HC	Health Canada
HHRA	human health risk assessment
HQ	hazard quotient
IAEA	International Atomic Energy Agency
IC	inhibition concentration
ICRP	International Commission on Radiological Protection
ILCR	incremental lifetime cancer risk
IMPACT	Integrated Model for the Probabilistic Assessment of Contaminant Transport
ISQG	interim sediment quality guideline

ISR	in-situ recovery
IWWTP	industrial wastewater treatment plant
LC	lethal concentration
LEL	lowest effect level
LOAEL	lowest observed adverse effect level
LOEC	lowest observed effect concentration
LSA	local study area
MECP	Ministry of the Environment, Conservation and Parks
MOE	Ministry of Environment
MATC	maximum acceptable toxicant concentration
NCRP	National Council on Radiation Protection and Measurements
NOAEL	No-observed adverse effect level
OAAQC	Ontario Ambient Air Quality Criteria
OF	occupancy factor
ORNL	Oak Ridge National Laboratory
PEL	probable effect level
PESC	Pacific Environmental Science Centre
PM	particulate matter
PM_{10}	particulate matter with a diameter of 10 microns or less
$PM_{2.5}$	particulate matter with a diameter of 2.5 microns or less
RAF	relative absorption factors
Rec F/H	Recreational Fisher/Hunter
REF	reference
RSA	regional study area
SAAQS	Saskatchewan Ambient Air Quality Standards
SAR	Species at Risk
SARA	Species at Risk Act
SEL	severe effect level
SEQG	Saskatchewan environmental quality guidelines
SKCDC	Saskatchewan Conservation Data Centre
TDI	tolerable daily intake
TF	transfer factor
TRV	toxicity reference value
TSP	total suspended particulates
UL	upper intake level
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
USEPA	United States Environmental Protection Agency
VC	valued component
WHO	World Health Organization
WQO	water quality objective
YNLR	Ya'thi Néné Lands and Resources

Units of Measure

%	percent
µg/L	Micrograms per litre
µg/m^3	micrograms per cubic metre
µg/kg/d	micrograms per kilogram per day
Bq/g	becquerels per gram
Bq/kg	becquerels per kilogram
Bq/L	becquerels per litre
Bq/m^3	becquerels per cubic metre
dw	dry weight
fw	fresh weight
g/d	grams per day
g/m^2/yr	grams per square metre per year
h/yr	hours per year
kg/yr	kilograms per year
km	kilometre
km^2	square kilometre
L/d	Litre per day
m	metre
min	minute
m^3/h	cubic metre per hour
m/min	metres per minute
mg $CaCO_3$/L	milligrams of calcium carbonate per litre
mg/cm^2/30 days	milligrams per square centimetre per 30 days
mg/d	milligrams per day
mg/kg	milligrams per kilogram
mg/kg/d	milligrams per kilogram per day
mg/L	milligrams per litre
mGy/d	milligrays per day
mGy/h	milligrays per hour
mSv/yr	millisieverts per year

1.0 Introduction

1.1 Background and Regulatory Context

The Wheeler River Project (the Project) proposes the development of the high-grade Phoenix uranium deposit as an in-situ recovery (ISR) mining operation with on-site processing. Denison Mines Corp. (Denison) is the operator of the Wheeler River Joint Venture and holds a 90% interest (directly or through its subsidiaries). JCU (Canada) Exploration Company Ltd. owns the remaining 10% of the joint venture. The Project is located approximately 35 km north-northeast of Cameco's Key Lake Operation and 35 km southwest of Cameco's McArthur River Operation in the eastern portion of the Athabasca Basin region in northern Saskatchewan.

The proposed Project is subject to both federal and provincial Environmental Assessment (EA) processes, and the Environmental Impact Statement (EIS) was prepared to support the EA. This environmental risk assessment (ERA) encompasses a human health risk assessment (HHRA) and an ecological risk assessment (EcoRA), which have been prepared to be compliant with Canadian Standards Association Group (CSA) N288.6-22 *Environmental Risk Assessments at Nuclear Facilities and Uranium Mines and Mills* (CSA, 2022). It also meets the requirements for an ERA outlined in Section 4.1 of Regulatory Document-2.9.1, *Environmental Principles, Assessments and Protection Measures* (CNSC, 2020). The ERA has been developed with current science and current regulatory attitudes in mind.

The ERA is used to inform other EA disciplines and to support the conclusions made in the EIS. The regulatory and guidance documents applicable to the EIS are discussed in the EIS.

1.2 Objectives

The objectives of this ERA are to:

- Predict and assess the risk to representative human and ecological receptors resulting from exposure to radiological and non-radiological substances expected to be released throughout the Project Phases;
- Inform decision-making in the EIS; and
- Inform prioritization of monitoring and mitigation measures.

1.3 Scope

The scope of the ERA encompassed both human and ecological health risks, and radiological and non-radiological constituents of potential concern (COPCs).

The ERA used the expected sources of atmospheric and liquid releases to predict the transport of these constituents through the environment, exposure and dose to the public, and exposure and effects on representative ecological receptors.

1.3.1 Spatial Boundaries

The spatial boundaries of the ERA are generally consistent with the boundaries defined for the EIS for the aquatic and terrestrial environment. The study areas include the Project area, the local study area (LSA), and the regional study area (RSA). The spatial boundaries include the Icelander River drainage and major waterbodies along its course including Kratchkowsky Lake, Whitefish Lake, McGowan Lake, and parts of Russell Lake. The spatial boundaries for the ERA are shown on Figure 1-1.

The study areas for the ERA are defined as follows:

- **Project Area:** the area within which the Project and all components/activities are located (i.e., the Project footprint; the area of maximum physical disturbance).
- **Local Study Area (LSA):** the area that surrounds the Project Area where both direct and indirect effects resulting from Project activities can be reasonably measured. The LSA is established to assess the potential, largely direct effects of the Project and represents the extent to which there is a reasonable potential for the Project or Project-related activities to interact with and potentially adversely effect the valued components (VCs).
  - The LSA for the ERA represents the area where direct Project-related changes in air quality, sediment and water quality, and soil quality would likely occur. The LSA includes parts of the Icelander River drainage to its confluence with Russell Lake in the Wheeler River.
- **Regional Study Area (RSA):** the area that surrounds and includes the LSA, established to assess the potential, largely indirect effects of the Project in a regional context. The RSA is large enough to capture the extent of potential effects (i.e., zone of influence) on a VC and defines the area within which cumulative effects may occur (i.e., cumulative effects assessment boundary).
  - The RSA for the ERA includes parts of Russell Lake and the Wheeler River downstream of the Project.

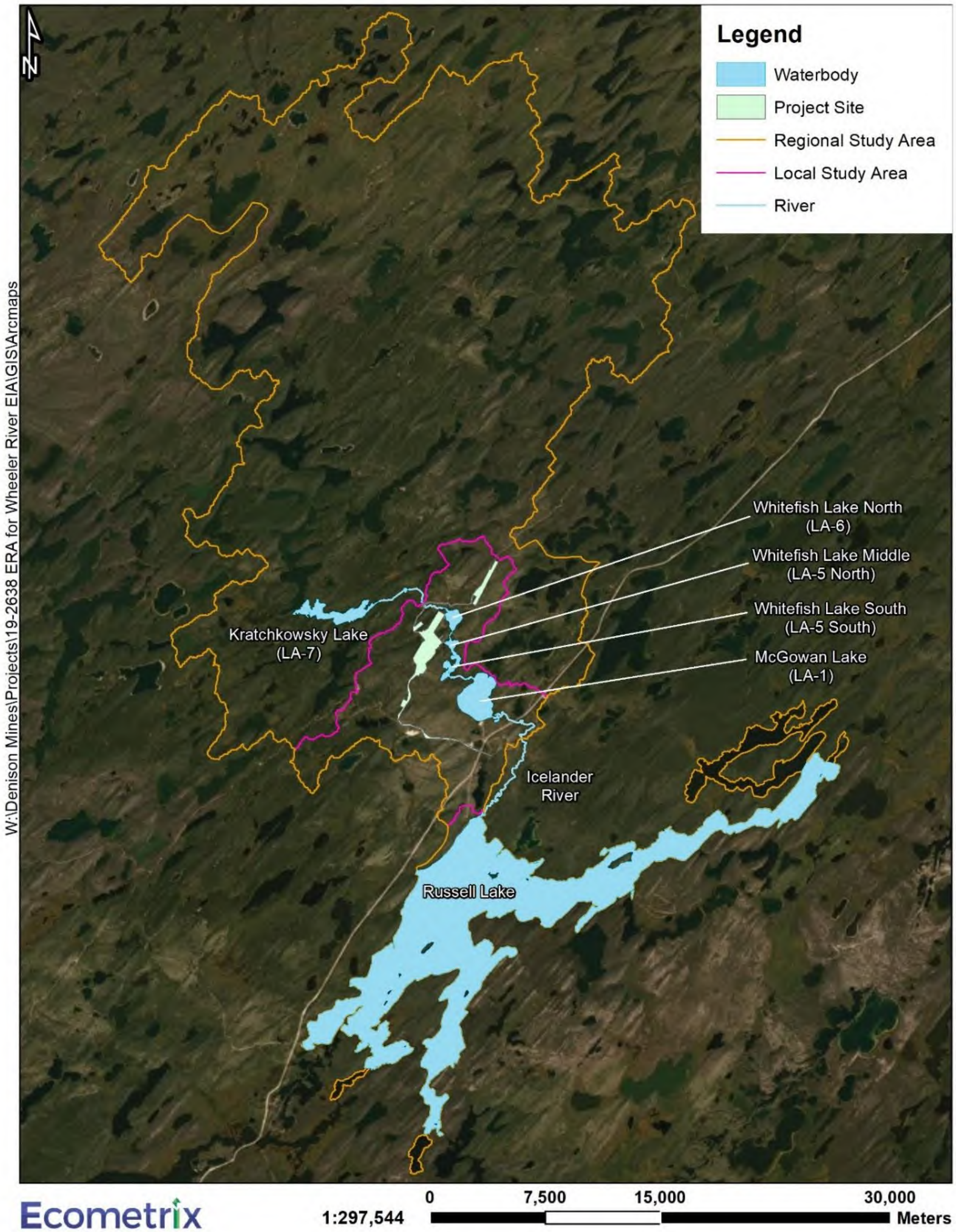


Figure 1-1: Spatial Boundaries of the ERA

1.3.2 Temporal Boundaries

Consistent with the Wheeler River Project EIS, the temporal boundaries of the assessment include the following Project phases: construction (which includes site preparation), operation, decommissioning, and post-decommissioning (Table 1-1). After post-decommissioning, the objective is to transfer the property to the province through the institutional control program or to direct the release of the land back to the Crown.

The temporal boundaries also include the "future centuries" period to assess the potential effects post-restoration (i.e. beyond the Project timeline of 0-38 years) and to reflect the time period over which the highest constituent concentrations in groundwater are predicted to migrate towards and interact with surface water.

This period represents the time where the highest constituent concentrations in groundwater are predicted to interact with surface water based on groundwater modelling. In this context, the future centuries scenario is considered with respect to the interaction of groundwater migration from the Project site and its potential influence on surface water in local water bodies. The future centuries projection encompasses the long-term period during which slow migration of groundwater from the Phoenix Ore Zone area to the surface water environment is anticipated, and it constitutes a bounding scenario of maximum concentrations of constituents of potential concern.

Table 1-1: Project Phases of the Wheeler River Environmental Risk Assessment

Phase and Year	Description of Activities	
Construction Year 1 to 3	• Development of access roads and air strip • Site preparation and earthworks; clearing, leveling and grading of the project area • Power generation – generators • Installation of main substation and distribution of power around site • Wellfield and freeze hole drilling; ground freezing • Batch plant operation (concrete); crusher at borrow area • Development of surface infrastructure (camp, operations centre, plants, ponds, pads and support facilities)	• Waste management (composting, domestic and industrial landfill operation, recycling) • Water management (including treatment and site run-off) • Groundwater supply • Surface water supply and release • Fuel management (e.g., propane for comfort heating; vehicle and aircraft fuel) • On-site and off-site operation of vehicles and transport of materials • Air transportation for workers • Regulatory site inspections • Engagement - site visit from Interested Parties
Operation Year 3 to 18	• Operation of the ISR wellfield • Wellfield and freeze wall drilling • Operation and expansion of freeze wall	• Storage and disposal of drill waste rock, process precipitates and industrial wastewater treatment plant precipitates

Phase and Year	Description of Activities	
	• Batch plant operation (grout and cement); crusher at borrow area • Expansion of pond and pads • Operation of the processing plant and production of uranium concentrate • Water withdrawal from groundwater or surface water body • Management of surface water (including seepage and site run-off) • Water treatment, both domestic and industrial • Water release to surface water body • Waste management (composting, domestic and industrial landfill operation, recycling) • Hazardous waste management (temporary storage, handling, and off-site transportation)	• On-site and off-site operation of vehicles and transport of materials • Power supply – primarily power from the grid, also generators and back-up generators • Package and transport of nuclear substances • Fuel management (e.g., propane for comfort heating; vehicle and aircraft fuel) • Air transportation for workers • Progressive decommissioning and reclamation • Regulatory site inspections • Engagement - site visit from Interested Parties
Decommissioning Year 18 to 23	• Site water management, treatment and release • Mining horizon remediation and thawing of freeze wall • Process water treatment and release • Closure of ISR and freeze wells and related infrastructure • Decontamination of surface facilities and injection, recovery and monitoring wells • Asset removal (including site power transmission lines and electrical infrastructure) • Demolition and disposal of non-salvageable surface infrastructure and materials • Remediation of contaminated areas (wellfield, pads, ponds, domestic wastewater treatment location, and process plant area)	• Power generation – generators • Waste management (composting and landfill operation) • Decommissioning of landfills; hazardous materials management (temporary storage and off-site disposal) • On-site and off-site operation of vehicles and transport of materials • Reclamation of disturbed areas • Regulatory site inspections • Engagement - site visit from Interested Parties
Post-Decommissioning Year 23 to 38	• Environmental monitoring • Regulatory site inspections	• Engagement - site visit from Interested Parties

2.0 Site Description

2.1 Project Description

The mining method proposed for the Project is in-situ recovery, and the process is shown on Figure 2-1.

A mining solution will be used to leach the uranium ore, similar to that used at other Athabasca Basin uranium mills: an acidic or low pH solution. The mining solution will be pumped underground to the uranium deposit via an injection well and recovered as uranium rich mining solution (i.e., mining solution now containing uranium) through a series of recovery wells. Once uranium rich mining solution is recovered to surface, it will be pumped from the pumphouses into the processing plant where uranium will be removed from the uranium rich solution. The mining solution will be refortified with reagents as required and pumped back into the mining horizon via an injection well. In this way, it is expected that the mining solution will be reused over and over again throughout the mining process. A small volume of make-up water will be added to the mining solution to replace moisture removed during the yellowcake precipitation and drying processes. This make-up water will be preferentially sourced from site runoff where possible; however, to be conservative, the assessment has included options for obtaining make-up water from either a shallow groundwater well or a nearby lake.

At the Project, the very low permeability basement rock below the uranium deposit serves as a natural aquitard; however, the sandstone hosting the uranium deposit is permeable and groundwater can flow horizontally through the deposit. To achieve containment at the Project, the uranium deposit will be surrounded by an engineered freeze wall that extends from the basement rock to surface, isolating the mining area from regional groundwater movement.

Processing or milling of the uranium rich solution and final processing to yellowcake will take place in the processing plant. Additionally, in the processing plant, the mining solution will be refortified for continued use in the ISR wellfield. An overview of the processing plant is shown in Figure 2-2. The anticipated production capacity of the Project is up to 12 Mlbs U_3O_8/year with a mine life of up to 15 years.

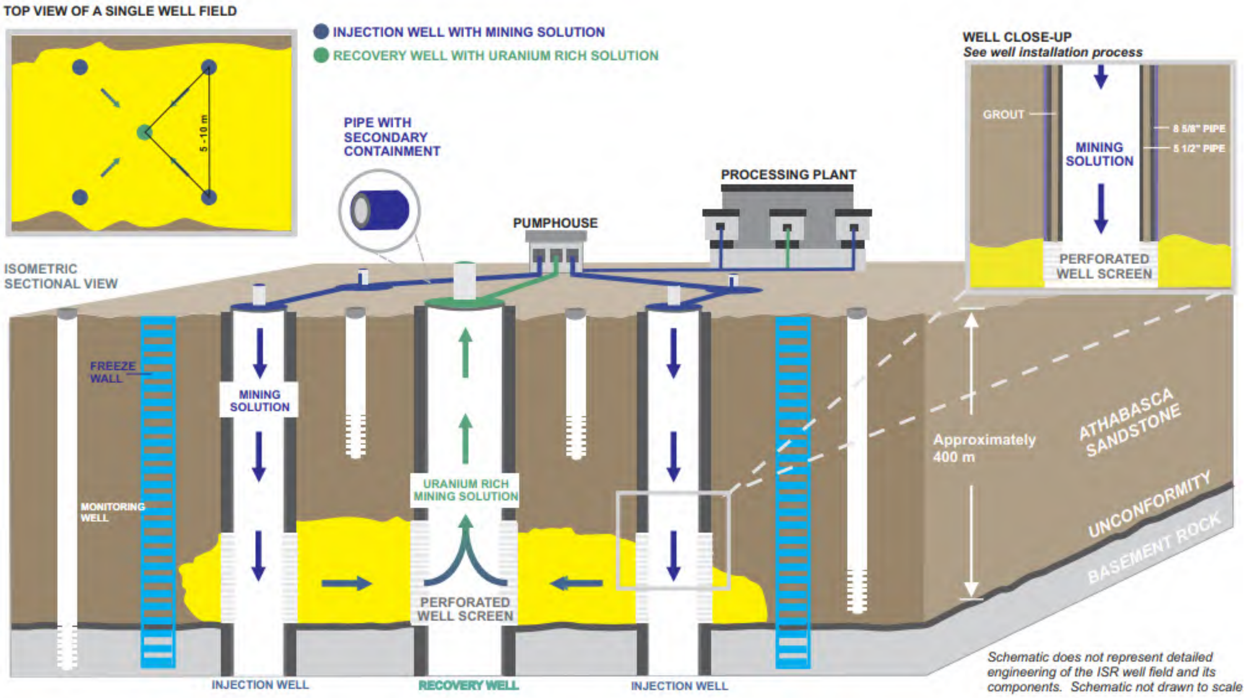


Figure 2-1: Overview of the ISR Process

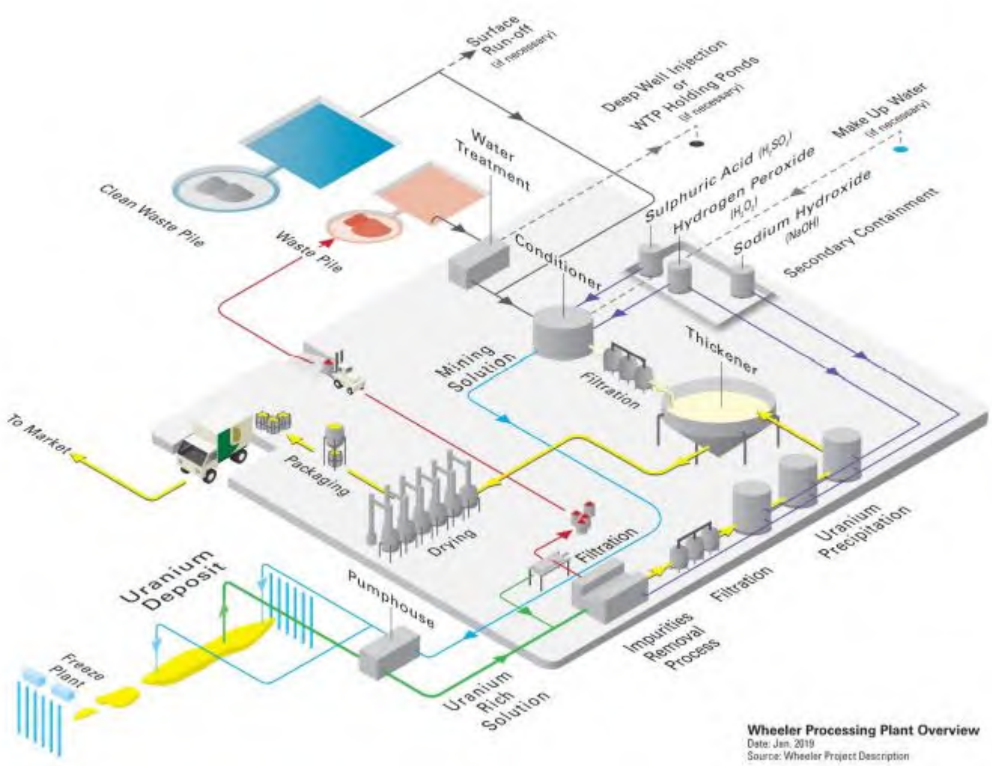


Figure 2-2: Overview of the Processing Plant Process

2.2 Description of the Natural and Physical Environment

The natural and physical environment is presented in the EIS and not reproduced in the ERA. Overall, the site is well characterized with regards to biophysical data and no residual uncertainties in the site characterization have been identified.

3.0 Source Term Characterization

3.1 Aqueous Sources

During construction, no effluent is expected to be released to the aquatic environment. Water management of runoff during construction will follow industry best management practices.

The following describes Denison's water management plan during operation.

Denison's approach to sustainable mining for the Project includes recycling as much process water as possible to reduce the need for fresh water supply.

When freshwater is needed, it would be obtained from a shallow groundwater well and/or from surface water, for a total maximum freshwater withdrawal of 81 m^3/h. Freshwater would be sent to the potable water treatment plant for treatment and distribution.

Domestic wastewater (which includes greywater and sewage) will be generated at the camp, processing plant, airstrip terminal, and the operations centre. Domestic wastewater from the central facilities will be piped directly to the on-site domestic wastewater treatment plant (DWWTP). Other sewage will be collected in septic tanks and transported via a vacuum truck to the DWWTP for treatment. Treated effluent from the DWWTP will be stored in a 5,000 m^3 pond prior to routing to the effluent monitoring and release ponds. Any reject solids from the DWWTP will be collected, dewatered, and disposed of at the site composting system, domestic landfill, or an approved off-site facility.

Contaminated water from the ISR process (e.g., backwash of sand filters, bleed solution) and various sources (e.g., wash bay sump water, leachate from the industrial landfill, wellfield runoff pond) will be treated in a three-stage industrial wastewater treatment plant (IWWTP). Water will be routed to the IWWTP via the process water pond. Treated water in the IWWTP will be routed back into the mining process, any excess treated water will be pumped to the effluent monitoring and release ponds. Any precipitates generated through the treatment process will be primarily comprised of gypsum and will be routed to the IWWTP precipitate pond.

There will be two effluent monitoring and release ponds, each with a composite liner and a capacity for 5,000 m^3 of water. The effluent monitoring and release ponds will primarily receive treated water from the DWWTP and IWWTP, but may also receive water from the process water pond, IWWTP precipitate pond, and wellfield runoff pond.

Effluent will be released to Whitefish Lake Middle (LA-5) via a discharge line with a diffuser at the end to promote effluent mixing within the lake. Effluent will be released at a discharge rate of 36.5 m^3/h as the EA case. The maximum upper bound discharge rate is 81 m^3/hr.

Surface runoff will generally be managed through collection in ponds. The wellfield runoff pond will capture runoff from the wellfield and the special waste pad. Any runoff from the process precipitate pond will be directed to the process water pond. A pond may be constructed beside the clean waste rock pad to collect runoff if required. Any runoff from the clean waste rock pad will be directed to the process water pond or to effluent monitoring and release ponds.

During decommissioning, mining area remediation will be initiated which will involve injecting water into the mining horizon via the injection wells and then recovering the water via the recovery wells. Water would be processed in the processing plant. This process would continue until the recovered water meets acceptable groundwater quality decommissioning objectives. After mining area remediation is complete, the freeze wall would be turned off, which would allow for gradual re-establishment of the pre-operational groundwater flow regime.

As such, during decommissioning effluent may be released to Whitefish Lake, but effluent is not expected to be released during post-decommissioning.

In summary, the main source of aquatic release to Whitefish Lake will be from the effluent monitoring and release ponds during operation and decommissioning. Effluent will undergo monitoring prior to discharge to ensure it meets federal and provincial regulatory discharge limits.

After all Project phases, in the future centuries, there is potential for leaching of post mining and residual mass into groundwater as part of natural groundwater evolution which can result in potential migration of constituents in groundwater into Whitefish Lake (LA-5) (see Section 3.1.2.2 for further details).

3.1.1 Screening for Constituents of Potential Concern

The list of constituents in liquid effluent started with a longer list, and this became more focused as more information became available. The larger list of constituents was based on constituents that:

- are known to be present in the treated effluent; and
- have existing water quality guidelines; or
- are identified in the Metal and Diamond Mining Effluent Regulations, SOR/2002-222, with the exception of cyanide which is considered not applicable.

The longer list of constituents was then reduced to those constituents expected to potentially be operational issues or result in changes to water quality in Whitefish Lake (LA-5) and the downstream environment.

3.1.1.1 Screening Value Selection

Screening values were selected based on the process shown in Figure 3-1. The most restrictive federal or provincial guideline for surface water quality, based on the Canadian Council of Ministers of the Environment (CCME) Canadian water quality guidelines for the protection of fresh water aquatic life, the federal environmental quality guidelines (FEQG), and the

Saskatchewan environmental quality guidelines (SEQG), was selected as the screening value for most surface water COPCs. Guidelines were adjusted for pre-operational hardness and pH, where applicable.

For molybdenum, the Saskatchewan Water Security Agency published an updated water quality objective for the protection of aquatic life based on current understanding of aquatic toxicity of molybdenum to fresh water aquatic organisms (WSA, 2017). This water quality objective of 31 mg/L is based on the 5th percentile of the species sensitivity distribution, and follows the CCME protocol (CCME, 2007). The British Columbia MOE has also published a water quality guideline for molybdenum of 7.6 mg/L (BC MOE, 2021). It was adopted for the Project for protection of aquatic life in preference over the CCME water quality objective of 0.073 mg/L. For protection of human health through the drinking water pathway, a value of 0.07 mg/L was used from the World Heath Organization (WHO, 2017).

Canadian drinking water quality guidelines were included for protection of human health (Health Canada, 2020). These guidelines are based on current, published scientific research related to human health effects, aesthetic effects, and operational considerations. Health-based guidelines are established on the basis of a comprehensive review of the known health effects associated with each constituent, on exposure levels, and on the availability of treatment and analytical technologies. Aesthetic effects (e.g., taste or odour) were taken into account when these play a role in determining whether consumers will consider the water drinkable, as is the case with copper. Where no Canadian drinking water quality guidelines were available, guidelines were obtained from the World Health Organization (WHO, 2017) or British Columbia Ministry of Environment and Climate Change Strategy (BC MECCS, 2020).

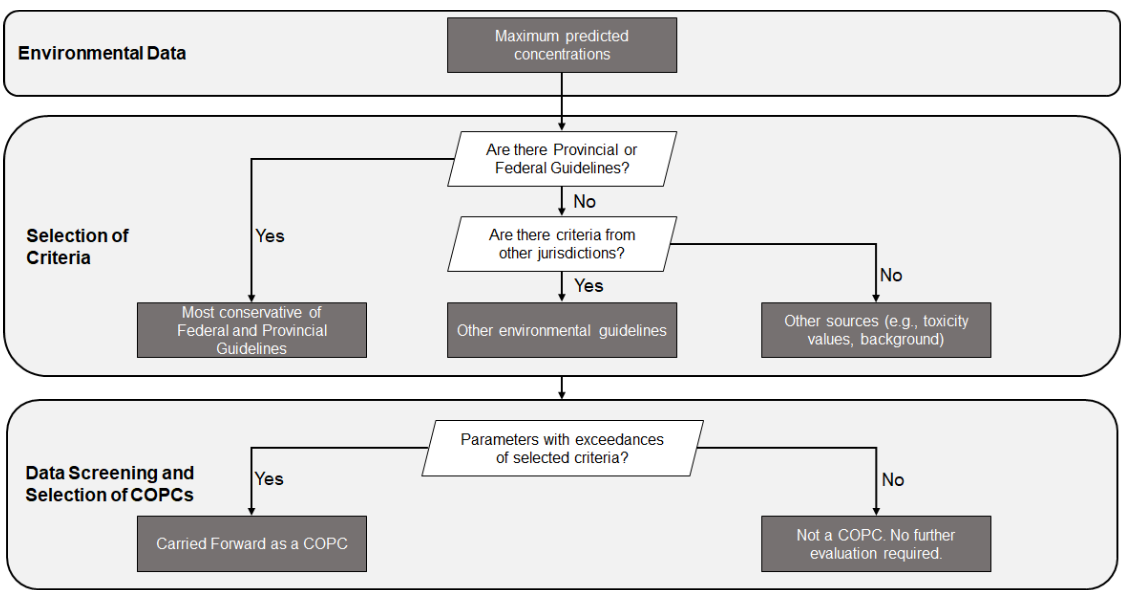


Figure 3-1: Selection of Surface Water Screening Values for the ERA

3.1.1.2 Constituents of Potential Concern in Surface Water

The screening involved a conservative process of comparing the reasonable upper bound treated effluent quality against the selected water quality guidelines protective of human and ecological health (Table 3-1). The reasonable upper bound treated effluent was derived using a combination of information available from lab tests conducted by Denison as well as derived effluent quality based on not exceeding water and sediment quality guidelines in the middle part of Whitefish Lake. Effluent treatment feed solution was prepared by leaching drill core material from the Phoenix deposit, and further processing that solution through two steps (process precipitate removal and yellowcake precipitation) prior to effluent treatment testing. Effluent treatment tests incorporated three stages: low pH, high pH, and neutralization. A combination of reagents (iron sulphate, barium chloride, lime, and sulphuric acid) was used to facilitate precipitation of constituents. After each stage, solid-liquid separation was conducted by mixing flocculant with solution to settle solids to the bottom of the test vessel. The supernatant liquid was used for the following stage. The solids were washed, filtered, and dried to determine solids mass generation for mass balance purposes. For each stage, the liquids and solids were assayed for various COPCs. The reasonable upper bound effluent was usually an expected effluent quality from Denison multiplied by a safety factor of three. The derived effluent quality was used for a handful of constituents including cadmium, chromium, and selenium.

Phosphorus was not considered a COPC for the ERA. Phosphorus is present in the aquatic environment as phosphate, where it acts as a nutrient rather than a toxicant. The water quality guideline selected for screening is the interim Ontario Provincial Water Quality Objective, which was set to avoid nuisance concentrations of algae in lakes and is not relevant to ecological health. Therefore, phosphorus was not considered a COPC for further quantitative assessment.

While the ERA focuses on chronic effects, it is acknowledged that Denison will not be allowed to release effluent above acute guidelines.

No formal screening was conducted for radionuclides. However, since radiation dose to human and ecological receptors is of great public and regulatory interest, the radionuclides in the U-238 decay series (U-238, U-234, thorium-230 [Th-230], radium-226 [Ra-226], Pb-210, polonium-210 [Po-210]) were considered COPCs for further modelling.

Radon-222 was not considered a COPC in surface water. Radon is expected to volatilize rapidly to air. Health Canada considers that the health risk from ingesting radon-contaminated drinking water is negligible (Health Canada, 2020). Radon is expected to escape at the faucet or water outlet, leaving only minimal amounts in the water itself. This assumption is consistent with Clause 5.1.8 of CSA N288.1-20, *Guidelines for calculating derived release limits for radioactive material in airborne or liquid effluents for normal operation of nuclear facilities*, which indicates that noble gases, including radon-222, are not considered relevant for release to water because they do not enter environmental compartments other than air (CSA, 2020).

Based on the screening (see Table 3-1), the following COPCs were included in the surface water modelling for the ERA.

- General Chemistry: chloride, sulphate, and total dissolved solids
- Metals and metalloids: arsenic, cadmium, chromium, cobalt, copper, molybdenum, selenium, uranium, zinc
- Radionuclides: uranium-238, uranium-234, thorium-230, radium-226, lead-210, polonium-210.

Table 3-1: Screening of Effluent Quality against Surface Water Quality Guidelines for the Wheeler River ERA

Constituent	Unit	Reasonable Upper Bound Effluent Quality	CCME Protection of Aquatic Life		Federal Environmental Quality Guideline		Saskatchewan Environmental Quality Guidelines (SEQG Online) (1)		Other		Drinking Water Guidelines			Selected Screening Value	Source	Is Effluent Quality Greater than Screening Value?
			Long Term	Note	Long Term	Note	Long Term	Note	Long Term	Note	Health Canada (15)	Other Source	Note			
Total suspended solids	mg/L	6.00E+00	background + 5 mg/L													N/A
Aluminum	mg/L	5.10E-02	1.00E-01	(6)			1.00E-01				1.00E-01			1.00E-01	SEQG/CCME	No
Arsenic	**mg/L**	**6.00E-03**	**5.00E-03**				**5.00E-03**				**1.00E-02**			**5.00E-03**	**SEQG/CCME**	**Yes**
Cadmium	**mg/L**	**1.80E-03**	**4.00E-05**				**4.00E-05**				**7.00E-03**			**4.00E-05**	**SEQG/CCME**	**Yes**
Chromium	**mg/L**	**2.50E-02**	**1.00E-03**				**1.00E-03**				**5.00E-02**			**1.00E-03**	**SEQG/CCME**	**Yes**
Cobalt	**mg/L**	**2.70E-03**			**7.80E-04**	**(11)**						**1.00E-03**	**(16)**	**7.80E-04**	**FEQG**	**Yes**
Copper	**mg/L**	**2.22E-02**	**2.00E-03**	**(8)**	**2.00E-04**	**(12)**					**2.00E+00**			**2.00E-04**	**FEQG**	**Yes**
Iron	mg/L	3.90E-03	3.00E-01								3.00E-01			3.00E-01	CCME	No
Lead	mg/L	3.00E-04	1.00E-03	(9)			1.00E-03	(2)			5.00E-03			1.00E-03	SEQG/CCME	No
Manganese	mg/L	3.00E-02	2.10E-01	(3)							1.20E-01			1.20E-01	Health Canada	No
Mercury	mg/L	1.00E-05	2.60E-05				2.60E-05				1.00E-03			2.60E-05	SEQG/CCME	No
Molybdenum	**mg/L**	**2.50E+00**	**7.30E-02**	-	-	-	**3.10E+01**	-	**7.60E+00**	-	-	**7.00E-02**	**(17)**	**7.00E-02** **7.60E+00**	**WHO (drinking water)** **BC MOE (eco)**	**Yes (human health)** **No (eco health)**
Nickel	mg/L	1.38E-02	2.50E-02	(9)	-	-	2.50E-02	(2)	-	-	-	7.00E-02	(17)	2.50E-02	SEQG/CCME	No
Phosphorous	mg/L	1.00E-02	-	-	-	-	-	-	0.004-0.01	(18)	-	1.00E-02	(16)	0.004-0.01	Ontario PWQO	No
Selenium	**mg/L**	**4.19E-02**	**1.00E-03**				**1.00E-03**				**5.00E-02**			**1.00E-03**	**SEQG/CCME**	**Yes**
Thallium	mg/L	6.00E-04	0.0008	-	-	-	-	-	-	-	-	-	-	0.0008	CCME	No
Uranium	**mg/L**	**5.70E-02**	**1.50E-02**	-	-	-	**1.50E-02**	-	-	-	**2.00E-02**	-	-	**1.50E-02**	**SEQG/CCME**	**Yes**
Vanadium	mg/L	5.90E-02	-	-	1.20E-01	(14)	-	-	-	-	-	-	-	1.20E-01	FEQG	No
Zinc	**mg/L**	**4.20E-02**	**1.30E-02**	**(10)**	-	-	**3.00E-02**	-	-	-	**5.00E+00**	-	-	**1.30E-02**	**CCME**	**Yes**
Total Ammonia as nitrogen	mg/L	3.90E+00	5.74E+00	(4)	-	-	5.74E+00	(4)	-	-	none required	-	-	5.74E+00	SEQG/CCME	No
Un-ionized ammonia as nitrogen (5)	mg/L	1.06E-02	1.56E-02	-	-	-	1.56E-02	-	-	-	none required	-	-	1.56E-02	SEQG/CCME	No
Chloride	**mg/L**	**6.00E+02**	**1.20E+02**	**(7)**	-	-	**1.20E+02**	-	-	-	**none required**	-	-	**1.20E+02**	**SEQG/CCME**	**Yes**
Total dissolved solids	**mg/L**	**6.42E+03**	-	-	-	-	**5.00E+02**	-	-	-	**5.00E+02**	-	-	**5.00E+02**	**SEQG**	**Yes (addressed in Section 10.2 of EIS)**

Constituent	Unit	Reasonable Upper Bound Effluent Quality	CCME Protection of Aquatic Life		Federal Environmental Quality Guideline		Saskatchewan Environmental Quality Guidelines (SEQG Online) (1)		Other		Drinking Water Guidelines			Selected Screening Value	Source	Is Effluent Quality Greater than Screening Value?
			Long Term	Note	Long Term	Note	Long Term	Note	Long Term	Note	Health Canada (15)	Other Source	Note			
Sulphate	**mg/L**	**3.92E+03**	**-**	**-**	**-**	**-**	**-**	**-**	**1.28E+02**	**(13)**	**5.00E+02**	**-**	**-**	**1.28E+02**	**BC MOE**	**Yes**
Radium-226	**Bq/L**	**1.50E-01**	**-**	**-**	**-**	**-**	**0.11**	**-**	**-**	**-**	**-**	**-**	**-**	**0.11**	**SEQG**	**Yes**
Thorium-230	Bq/L	9.00E-01	-	-	-	-	-	-	-	-	-	-	-	N/A	-	N/A
Lead-210	Bq/L	4.19E-01	-	-	-	-	-	-	-	-	-	-	-	N/A	-	N/A
Polonium-210	Bq/L	1.50E-01	-	-	-	-	-	-	-	-	-	-	-	N/A	-	N/A
Uranium-238	Bq/L	7.04E-01	-	-	-	-	-	-	-	-	-	-	-	N/A	-	N/A
Uranium-234	Bq/L	7.04E-01	-	-	-	-	-	-	-	-	-	-	-	N/A	-	N/A

Notes:

(1) Saskatchewan Water Quality Objectives, SEQG on-line (https://envrbrportal.crmp.saskatchewan.ca/seqg-search/), SEQG for the protection of aquatic life were selected, based on total concentrations, a temperature of 15°C and a pH of 7.0.

(2) Hardness dependent WQOs are for very soft water (hardness <25 mg $CaCO_3$/L). Site-specific hardness is 5.26 mg/L (95th percentile of LA-5 and LA-6).

(3) Scientific Criteria Document for the Development of the Canadian Water Quality Guidelines for the Protection of Aquatic Life - Manganese, Appendix B - Canadian Water Quality Guidelines Calculator (pH = 6.6, hardness = 5.6 mg/L). Guideline is based on dissolved manganese.

(4) Total ammonia-N calculated from the total ammonia guideline for a temperature of 15°C and a pH of 7.0.

(5) A pH of 7 and a temperature of 15°C were assumed to convert total ammonia to un-ionized ammonia in accordance with CCME (2002)

(6) Based on a pH of >6.5.

(7) Based on water hardness >0 to <17 mg/L.

(8) Based on water hardness >0 to <82 mg/L.

(9) Based on water hardness >0 to ≤60 mg/L.

(10) Guideline is based on dissolved zinc. Long term guideline is based on CWQG = exp(0.947[ln(hardness mg·L-1)] - 0.815[pH] + 0.398[ln(DOC mg·L-1)] + 4.625). (Site-specific background hardness is 5.26 mg/L, DOC is 2.24 mg/L, pH is 6.61 (95th percentile of LA-5 and LA-6). Note – extrapolated for value outside the hardness range.

(11) Environment Canada 2017. Federal Environmental Quality Guidelines, Cobalt, May. Based on equation and lowest hardness for equation of 52 mg/L.

(12) The Biotic Ligand Model was used. The calculated HC_5 is below 0.2 µg/L, however, 0.2 µg/L is considered to be the lowest concentration routinely measured and therefore replaces the calculated HC_5 value for this water chemistry.

(13) BC MECCS 2021. British Columbia Approved Water Quality Guidelines: Aquatic Life, Wildlife & Agriculture. https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/water-quality-guidelines/approved-wqgs/wqg_summary_aquaticlife_wildlife_agri.pdf

(14) Environment Canada 2016. Federal Environmental Quality Guidelines, Vanadium. May.

(15) Health Canada 2020. Guidelines for Canadian Drinking Water Quality Summary Table. September. https://www.canada.ca/content/dam/hc-sc/migration/hc-sc/ewh-semt/alt_formats/pdf/pubs/water-eau/sum_guide-res_recom/summary-table-EN-2020-02-11.pdf

(16) BC MECCS 2020. Source Drinking Water Quality Guidelines, Guideline Summary Ministry of Environment & Climate Change Strategy Water Protection & Sustainability Branch.

(17) WHO 2017. Guidelines for Drinking Water Quality. Fourth Edition Incorporating The First Addendum.

(18) Ontario Ministry of Environment and Energy: Water management: policies, guidelines, provincial water quality objectives (1994).

(19) BC MOE (B.C. Ministry of Environment and Climate Change Strategy). 2021. Molybdenum Water Quality Guidelines for the Protection of Freshwater Aquatic Life, Livestock, Wildlife and Irrigation. Water Quality Guideline Series, WQG-07. Prov. B.C., Victoria B.C.

3.1.2 Surface Water Quality Modelling

3.1.2.1 Project Phases

Surface water quality modeling was completed using IMPACT version 5.6.0. IMPACT is consistent with the COPC transport equations outlined in CSA N288.1-20. The modeling is discussed in detail in the IMPACT Model Report for the Project (Appendix A). Waterbodies from Whitefish Lake to the Russell Lake inlet were modelled in IMPACT to assess the effects of the Project on the downstream environment – this included the following distinct water polygons: Whitefish Lake Middle, Whitefish Lake South, McGowan Lake, and Russell Lake. Kratchkowsky Lake and Whitefish Lake North were modelled as reference locations.

Treated effluent will be released to Whitefish Lake Middle at an expected discharge rate of 36.5 m^3/h during the operation and decommissioning phases of the Project. The reasonable upper bound effluent quality during the phases where effluent will be released is summarized in Table 3-2 – effluent quality is assumed to be constant over that time period. Receiving water flow varies seasonally, resulting in seasonal fluctuations in receiving water quality. No effluent is expected to be released during construction or post-decommissioning.

Surface water quality modelling included predicting water and sediment concentrations in Whitefish Lake, the lake to which treated effluent will be released, as well as locations farther downstream. The geometric mean of measured water concentrations from baseline studies performed between 2011 and 2019 (Ecometrix, 2020) was selected as the water baseline concentration for constituents that had measured data over the detection limit. Sediment baseline concentrations were predicted from surface water concentrations using the partitioning coefficients (Kd) which consist of regional published values that have been calibrated on similar sites in northern Saskatchewan and have been checked against Wheeler River measurement data. In the case of constituents for which most or all measured concentrations in water were under the detection limit, but sediment concentration measurements were over the detection limit, the baseline water concentration was calculated from the geometric mean of the sediment measurements using the Kds (Section 3.3.2 in Appendix A).

When the treated effluent is released to Whitefish Lake (LA-5), water and sediment concentrations were predicted using IMPACT according to the equations outlined in the IMPACT model (Section 2.2.2 in Appendix A). The predicted maximum concentrations of COPCs in water and sediment are shown in Table 3-3. There are no predicted exceedances of water quality guidelines for any of the COPCs, except for copper where baseline concentrations exceed the federal environmental quality guideline (FEQG). A detailed comparison of sediment concentrations against sediment quality guidelines is discussed in Section 3.1.2.3.

Figure 3-2 and Figure 3-3 show the predicted concentrations of selected COPCs in water and sediment over time at the exposed locations (Whitefish Lake Middle, Whitefish Lake South, McGowan Lake, and Russell Lake) and reference locations (Kratchkowsky Lake and Whitefish Lake North) during project phases. The modelled maximum COPC concentrations in water during decommissioning phase were the same as those during operations (Table 3-3). The peak concentrations of arsenic and polonium-210 appear annually in June, and the peak concentrations of all other COPCs appear annually in March due to the variation of the monthly local inflow during the effluent discharge period (Figure 3-2). It is noted that the maximum predicted concentrations of COPCs in water occurred over short periods of effluent discharge and subsequently decrease relatively quickly during periods when there is no effluent discharge. This is related to the short retention time of the modelled lakes. As shown in Table 3-1 in Appendix A, the modelled lakes (excluding the reference lake) are small, with lake area ranging from 0.10 to 1.49 km^2 and with average depths ranging from 1.0 to 5.5 m. Based on the area, depth and outflow, the calculated retention times ranged from 0.88 to 51.61 days. As noted, the short retention times result in rapid increases and decreases of concentrations of COPCs in response to effluent discharge and then its cessation. Since COPCs accumulate in sediment, the peak concentrations of all COPCs in sediment appear at the end of each individual Project phase, which are year 20 for the operations and year 25 for the decommissioning phase, as shown in Figure 3-3.

Based on the screening methodology in Table 3-1, the effluent quality for TDS is expected to exceed its water quality guideline of 500 mg/L. The water quality guideline for TDS is an aesthetic drinking water objective from Health Canada (1991). No health effects associated with ingestion of TDS have been identified (Health Canada, 1991). Modelling of TDS was not included in the IMPACT model; however, TDS concentrations were predicted in the near-field water quality model in Section 10.2 (see Table 10.2-10) of the EIS, Surface Water Quality. Predicted TDS concentrations are expected to range from approximately 74 mg/L to 131 mg/L under various flow conditions and are well below the drinking water quality objective. Since TDS is not considered a health risk, and concentrations in LA-5 are predicted to be below the aesthetic objective, TDS is not considered further in the ERA.

Table 3-2: Summary of Effluent Quality for the Wheeler River Project

Constituent of Potential Concern	Unit	Effluent Quality
General Chemistry		
Chloride	mg/L	600
Sulphate	mg/L	3915
Total Dissolved Solids	mg/L	6420
Metals and Metalloids		
Arsenic	mg/L	0.006
Cadmium	mg/L	0.0018
Chromium	mg/L	0.025
Cobalt	mg/L	0.003
Copper	mg/L	0.022
Molybdenum	mg/L	2.5
Selenium	mg/L	0.042
Uranium	mg/L	0.057
Vanadium	mg/L	0.059
Zinc	mg/L	0.042
Radionuclides		

Constituent of Potential Concern	Unit	Effluent Quality
Uranium-238	Bq/L	0.7[(a)]
Uranium-234	Bq/L	0.7[(a)]
Thorium-230	Bq/L	0.9
Radium-226	Bq/L	0.15
Lead-210	Bq/L	0.419
Polonium-210	Bq/L	0.15

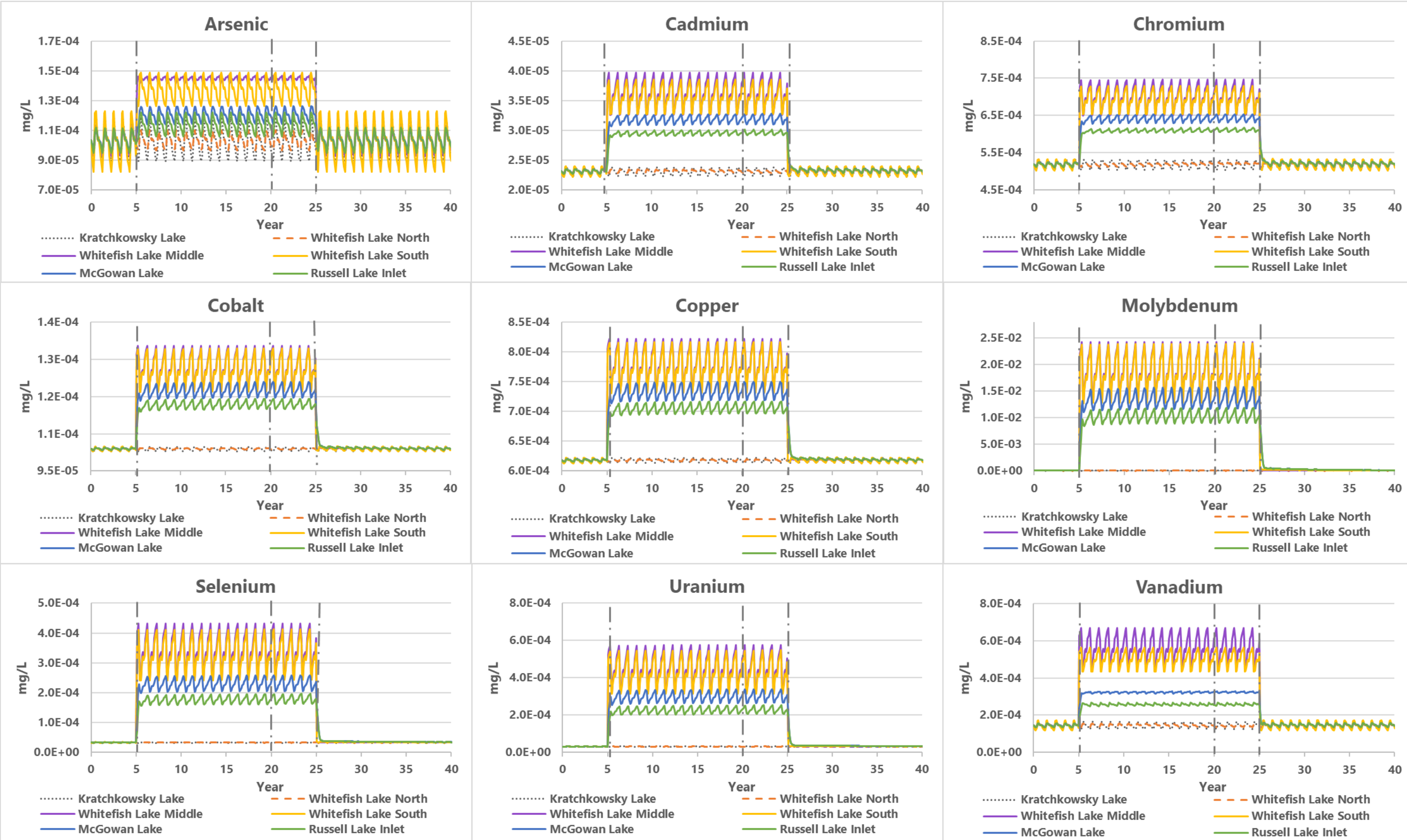
Note:
(a) Estimated from uranium using the specific activity of 12,356 Bq/g and assuming secular equilibrium between uranium-238 and uranium-234 (**https://www.wise-uranium.org/rup.html**)

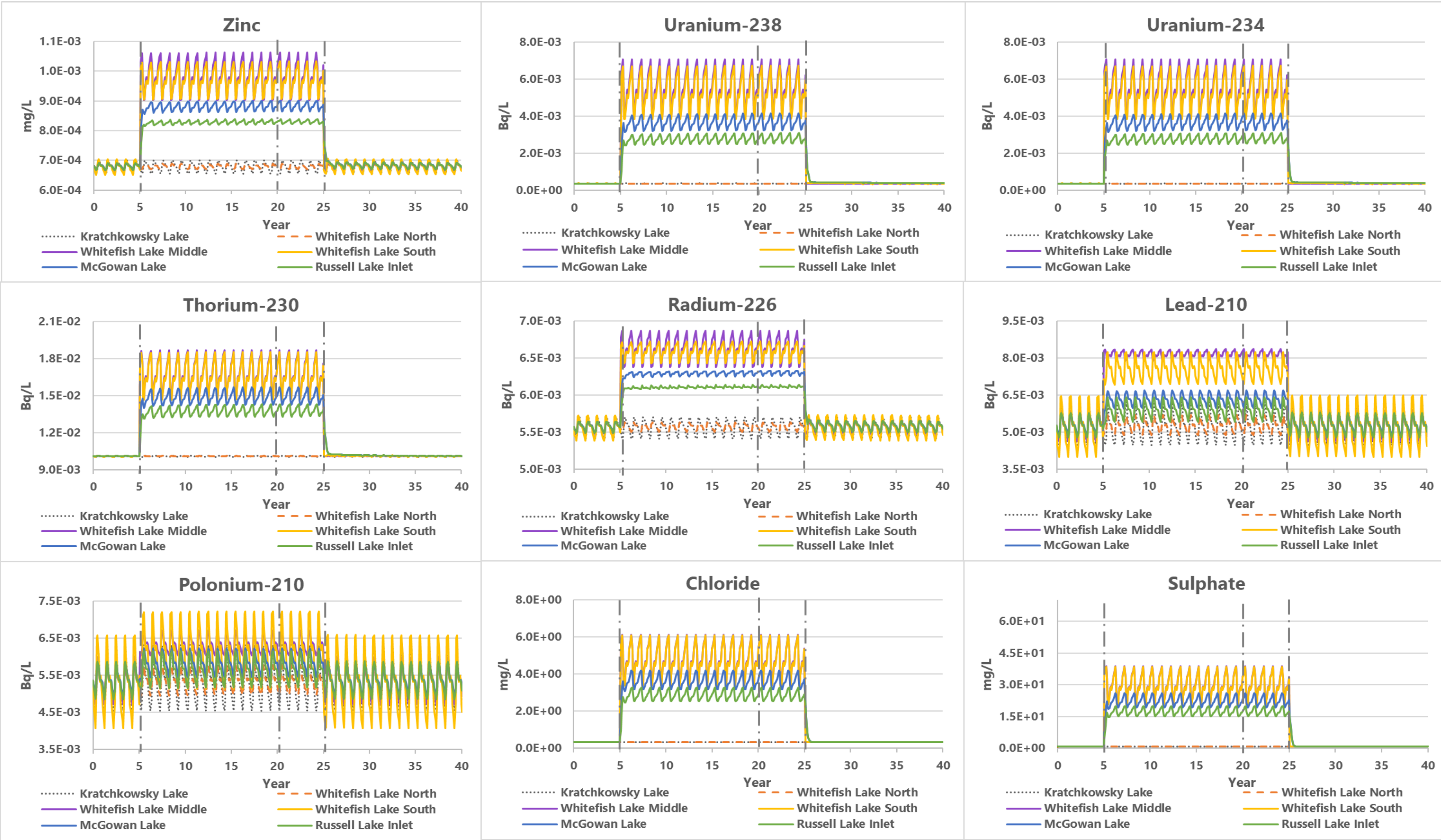
Table 3-3: Maximum Concentration of COPCs in Water and Sediment during Project Phases

Environmental Media	Location	Maximum Concentration of Non-radionuclides during Project Phases											
		Arsenic	Cadmium	Chloride	Cobalt	Chromium	Copper	Molybdenum	Sulphate	Selenium	Uranium	Vanadium	Zinc
Water (mg/L)	Quality Guideline	5.00E-03	4.00E-05	1.20E+02	2.95E-04	1.00E-03	2.00E-04	7.6E+00	1.28E+02	1.00E-03	1.50E-02	1.20E-01	1.30E-02
	Kratchkowsky Lake	1.19E-04	2.38E-05	3.22E-01	1.01E-04	5.30E-04	6.22E-04	1.07E-04	6.87E-01	3.35E-05	3.12E-05	1.67E-04	7.00E-04
	Whitefish Lake North	1.10E-04	2.34E-05	3.22E-01	1.01E-04	5.24E-04	6.20E-04	1.07E-04	6.87E-01	3.28E-05	3.05E-05	1.55E-04	6.89E-04
	Whitefish Lake Middle	1.46E-04	3.97E-05	6.14E+00	1.29E-04	7.46E-04	8.22E-04	2.43E-02	3.87E+01	4.33E-04	5.74E-04	6.70E-04	1.06E-03
	Whitefish Lake South	1.49E-04	3.86E-05	6.11E+00	1.28E-04	7.30E-04	8.17E-04	2.40E-02	3.85E+01	4.12E-04	5.47E-04	5.64E-04	1.03E-03
	McGowan Lake	1.26E-04	3.28E-05	4.20E+00	1.19E-04	6.54E-04	7.50E-04	1.58E-02	2.60E+01	2.59E-04	3.38E-04	3.28E-04	9.01E-04
	Icelander River	1.26E-04	3.26E-05	4.16E+00	1.19E-04	6.52E-04	7.49E-04	1.56E-02	2.57E+01	2.56E-04	3.34E-04	3.26E-04	8.99E-04
	Russell Lake Inlet	1.22E-04	3.01E-05	3.26E+00	1.14E-04	6.17E-04	7.17E-04	1.18E-02	1.99E+01	1.95E-04	2.52E-04	2.69E-04	8.40E-04
Sediment (mg/kg dw)	Quality Guideline	2.10E+01	6.00E-01	n/a	n/a	3.15E+01	9.10E+01	2.30E+01	n/a	3.60E+00	9.70E+01	3.51E+01	1.23E+02
	Kratchkowsky Lake	8.35E+00	3.38E-01	n/a	2.52E-01	5.86E+00	1.85E+00	3.37E-01	n/a	6.22E-01	5.78E-01	1.12E+01	9.93E+00
	Whitefish Lake North	8.35E+00	3.38E-01	n/a	2.52E-01	5.86E+00	1.85E+00	3.37E-01	n/a	6.22E-01	5.78E-01	1.12E+01	9.93E+00
	Whitefish Lake Middle	1.10E+01	4.97E-01	n/a	3.05E-01	7.59E+00	2.31E+00	5.72E+01	n/a	5.48E+00	7.18E+00	3.72E+01	1.36E+01
	Whitefish Lake South	1.05E+01	4.90E-01	n/a	3.04E-01	7.53E+00	2.30E+00	5.62E+01	n/a	5.26E+00	6.87E+00	3.33E+01	1.35E+01
	McGowan Lake	9.47E+00	4.43E-01	n/a	2.90E-01	7.03E+00	2.18E+00	4.11E+01	n/a	3.71E+00	4.78E+00	2.22E+01	1.24E+01
	Russell Lake Inlet	9.04E+00	4.15E-01	n/a	2.81E-01	6.73E+00	2.10E+00	3.13E+01	n/a	2.88E+00	3.64E+00	1.82E+01	1.17E+01

Environmental Media	Location	Maximum Concentration of Radionuclides during Project Phases					
		Uranium-238	Uranium-234	Thorium-230	Radium-226	Lead-210	Polonium-210
Water (Bq/L)	Quality Guideline	n/a	n/a	n/a	1.10E-01	n/a	n/a
	Kratchkowsky Lake	3.85E-04	3.85E-04	1.01E-02	5.70E-03	6.22E-03	6.33E-03
	Whitefish Lake North	3.77E-04	3.77E-04	1.01E-02	5.63E-03	5.68E-03	5.78E-03
	Whitefish Lake Middle	7.05E-03	7.05E-03	1.87E-02	6.87E-03	8.36E-03	6.71E-03
	Whitefish Lake South	6.72E-03	6.72E-03	1.85E-02	6.73E-03	8.25E-03	7.22E-03
	McGowan Lake	4.15E-03	4.15E-03	1.57E-02	6.33E-03	6.68E-03	6.23E-03
	Icelander River	4.11E-03	4.11E-03	1.56E-02	6.32E-03	6.66E-03	6.20E-03
	Russell Lake Inlet	3.09E-03	3.09E-03	1.43E-02	6.14E-03	6.41E-03	6.16E-03
Sediment (Bq/kg dw)	Quality Guideline	n/a	n/a	n/a	6.00E+02	9.00E+02	8.00E+02
	Kratchkowsky Lake	7.14E+00	7.14E+00	2.32E+01	6.51E+01	3.74E+02	3.80E+02
	Whitefish Lake North	7.14E+00	7.14E+00	2.32E+01	6.51E+01	3.74E+02	3.80E+02
	Whitefish Lake Middle	8.82E+01	8.82E+01	3.83E+01	7.57E+01	5.57E+02	5.58E+02
	Whitefish Lake South	8.44E+01	8.44E+01	3.80E+01	7.52E+01	5.19E+02	5.22E+02
	McGowan Lake	5.87E+01	5.87E+01	3.41E+01	7.23E+01	4.42E+02	4.47E+02
	Russell Lake Inlet	4.48E+01	4.48E+01	3.15E+01	7.04E+01	4.14E+02	4.20E+02

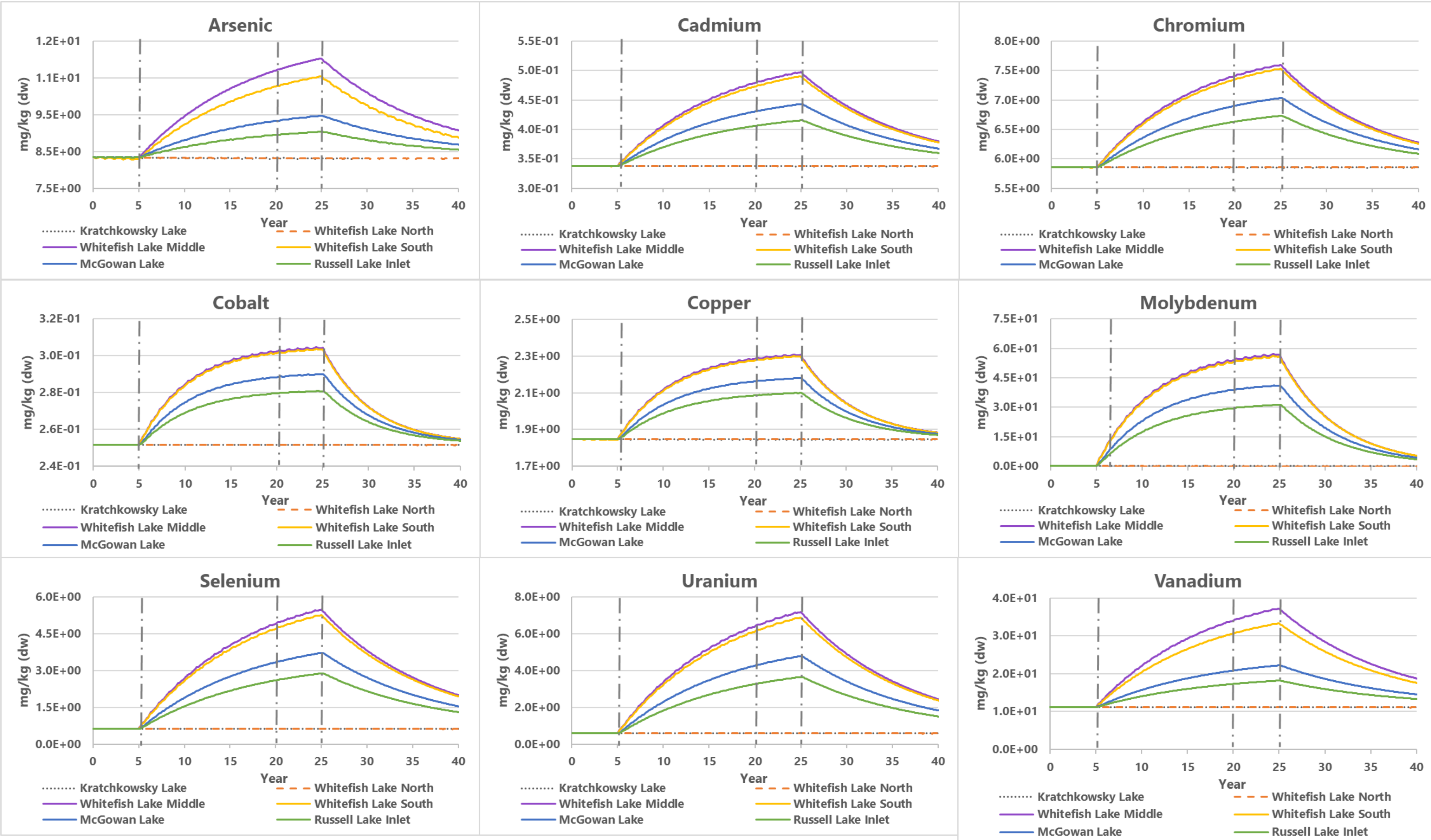
n/a = not applicable
Water quality guidelines are as shown in Table 3-1 and sediment quality guidelines are as shown in Table 3-6.

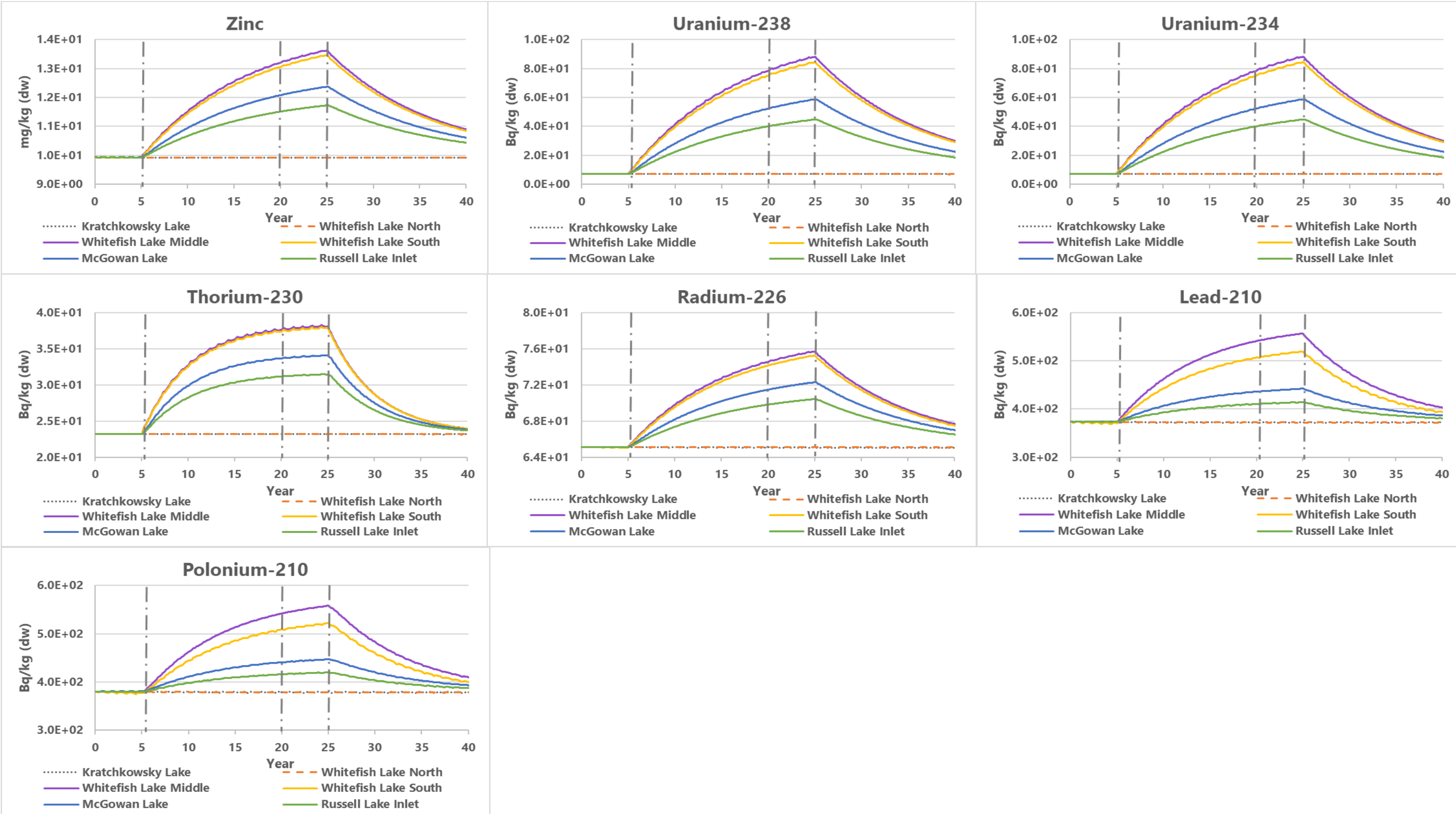

Arsenic
1.7E-04
1.5E-04
1.3E-04
1.1E-04
9.0E-05
7.0E-05
mg/L
0 5 10 15 20 25 30 35 40
Year
Cadmium
4.5E-05
4.0E-05
3.5E-05
3.0E-05
2.5E-05
2.0E-05
mg/L
0 5 10 15 20 25 30 35 40
Year
Chromium
8.5E-04
7.5E-04
6.5E-04
5.5E-04
4.5E-04
mg/L
0 5 10 15 20 25 30 35 40
Year
Cobalt
1.4E-04
1.3E-04
1.2E-04
1.1E-04
9.5E-05
mg/L
0 5 10 15 20 25 30 35 40
Year
Copper
8.5E-04
8.0E-04
7.5E-04
7.0E-04
6.5E-04
6.0E-04
mg/L
0 5 10 15 20 25 30 35 40
Year
Molybdenum
2.5E-02
2.0E-02
1.5E-02
1.0E-02
5.0E-03
0.0E+00
mg/L
0 5 10 15 20 25 30 35 40
Year
Selenium
5.0E-04
4.0E-04
3.0E-04
2.0E-04
1.0E-04
0.0E+00
mg/L
0 5 10 15 20 25 30 35 40
Year
Uranium
8.0E-04
6.0E-04
4.0E-04
2.0E-04
0.0E+00
mg/L
0 5 10 15 20 25 30 35 40
Year
Vanadium
8.0E-04
6.0E-04
4.0E-04
2.0E-04
0.0E+00
mg/L
0 5 10 15 20 25 30 35 40
Year
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet



Long dash dot lines separate the time periods of project phases: 3 years baseline; 2 years construction; 15 years operation; 5 years decommissioning; first 15 years post-decommissioning

Figure 3-2: Modelled Concentrations of COPCs in Water during Project Phases


Arsenic
1.2E+01
1.1E+01
9.5E+00
8.5E+00
7.5E+00
mg/kg (dw)
0 5 10 15 20 25 30 35 40
Year
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Cadmium
5.5E-01
5.0E-01
4.5E-01
4.0E-01
3.5E-01
3.0E-01
mg/kg (dw)
0 5 10 15 20 25 30 35 40
Year
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Chromium
8.0E+00
7.5E+00
7.0E+00
6.5E+00
6.0E+00
5.5E+00
mg/kg (dw)
0 5 10 15 20 25 30 35 40
Year
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Cobalt
3.2E-01
3.0E-01
2.8E-01
2.6E-01
2.4E-01
mg/kg (dw)
0 5 10 15 20 25 30 35 40
Year
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Copper
2.5E+00
2.3E+00
2.1E+00
1.9E+00
1.7E+00
mg/kg (dw)
0 5 10 15 20 25 30 35 40
Year
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Molybdenum
7.5E+01
6.0E+01
4.5E+01
3.0E+01
1.5E+01
0.0E+00
mg/kg (dw)
0 5 10 15 20 25 30 35 40
Year
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Selenium
6.0E+00
4.5E+00
3.0E+00
1.5E+00
0.0E+00
mg/kg (dw)
0 5 10 15 20 25 30 35 40
Year
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Uranium
8.0E+00
6.0E+00
4.0E+00
2.0E+00
0.0E+00
mg/kg (dw)
0 5 10 15 20 25 30 35 40
Year
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Vanadium
4.0E+01
3.0E+01
2.0E+01
1.0E+01
0.0E+00
mg/kg (dw)
0 5 10 15 20 25 30 35 40
Year
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet



Long dash dot lines separate the time periods of project phases: 3 years baseline; 2 years construction; 15 years operation; 5 years decommissioning; first 15 years post-decommissioning

Figure 3-3: Modelled Concentrations of COPCs in Sediment during Project Phases

3.1.2.2 Future Centuries

The potential migration of constituents from groundwater into Whitefish Lake (LA-5) which could influence the surface water quality is modelled in a "future centuries" scenario.

During decommissioning, groundwater quality within the ISR mining zone will be remediated to meet decommissioning objectives. In post-decommissioning, the freeze wall will be allowed to thaw and natural groundwater flow conditions will be re-established, as discussed in Section 9 of the EIS, Geology and Hydrogeology. During the "future centuries", groundwater plumes may develop from residual mass (i.e., remediated groundwater) remaining post mining (this is based on bench-scale lab tests of core flushing, and subsequent numerical modelling of reactive fate and transport).

Groundwater flow and reactive transport of dissolved constituents were modelled using three-dimensional modelling whereby the reactions were computed using PHREEQC and the transport was computed using FEFLOW (Ecometrix, 2022). Groundwater flow observed, and simulated in the calibrated groundwater model, travels eastward from the mining zone within the Lower Sandstone Aquifer before moving upward through the Desilicified Zone in the Athabasca Sandstone and overlying overburden deposits toward Whitefish Lake. Modelled transport of dissolved constituents along the groundwater flow path allowed for interactions of the dissolved constituents with the geologic media through which they are flowing. Due to the relatively low groundwater velocities between the mining zone and Whitefish Lake and chemical reactions along the groundwater flow pathway, the "future centuries" scenario spans 100s to 1000s of years.

The results of the numerical model (as provided in Section 7 of the EIS) indicate that dissolved constituent concentrations emanating over hundreds to thousands of years in the future from the deep Ore Zone to Whitefish Lake remain below fresh water environmental quality criteria in Whitefish Lake.

For the COPCs identified in the effluent, the predicted mass flux from groundwater into Whitefish Lake Middle starting 200 years after the Project phases, during the future centuries, was input to the IMPACT model to predict the water and sediment concentrations over time at the exposed locations. The COPCs in groundwater will be released to Whitefish Lake Middle at a predicted mass flux as shown in Table 3-4 (Ecometrix, 2022). The same modelling approach as described in Section 3.1.2 was applied in the "future centuries" scenario except that the annual average flow of the receiving water and a 2-year monitoring time step were used due to the long modelling time period of 1000 years.

The predicted maximum concentrations of COPCs in water and sediment during future centuries are shown in Table 3-5. There are no predicted exceedances of water and sediment quality guidelines for any of the COPCs, except for copper in water where baseline concentrations exceed the FEQG. Figure 3-4 and Figure 3-5 show the predicted concentrations of COPCs in water and sediment over time at the exposed locations (Whitefish Lake Middle, Whitefish Lake South, McGowan Lake, and Russell Lake) and reference locations (Kratchkowsky Lake and Whitefish Lake North) during future centuries.

Table 3-4: Summary of Predicted Mass Flux of COPCs in Groundwater for Future Centuries

Mass Flux (mg/s or Bq/s)									
Year after Project Phases	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1000**
General Chemistry									
Chloride	1.26E+02	1.28E+02	1.29E+02	1.29E+02	1.29E+02	1.29E+02	1.29E+02	1.28E+02	1.28E+02
Sulphate	4.08E+01	4.47E+01	4.69E+01	4.62E+01	4.44E+01	4.28E+01	4.16E+01	4.07E+01	3.99E+01
Metals and Metalloids									
Arsenic	5.73E-03	5.73E-03	5.73E-03	5.73E-03	5.73E-03	5.73E-03	5.73E-03	5.73E-03	5.74E-03
Cadmium	1.89E-04	1.89E-04	1.89E-04	1.89E-04	1.89E-04	1.89E-04	1.89E-04	1.88E-04	1.88E-04
Chromium	9.45E-03	9.45E-03	9.44E-03	9.43E-03	9.42E-03	9.42E-03	9.41E-03	9.40E-03	9.40E-03
Cobalt	7.51E-03	7.50E-03	7.49E-03	7.47E-03	7.46E-03	7.44E-03	7.43E-03	7.41E-03	7.40E-03
Copper	1.15E-02	1.15E-02	1.14E-02	1.14E-02	1.14E-02	1.14E-02	1.14E-02	1.14E-02	1.14E-02
Molybdenum	1.34E-02	1.34E-02	1.35E-02	1.35E-02	1.35E-02	1.35E-02	1.35E-02	1.35E-02	1.35E-02
Selenium	1.52E-02	1.52E-02	1.51E-02	1.51E-02	1.51E-02	1.51E-02	1.51E-02	1.51E-02	1.51E-02
Uranium	9.47E-03	9.47E-03	9.47E-03	9.46E-03	9.46E-03	9.45E-03	9.45E-03	9.45E-03	9.45E-03
Vanadium	1.89E-03	1.89E-03	1.90E-03	1.90E-03	1.91E-03	1.91E-03	1.91E-03	1.91E-03	1.92E-03
Zinc	8.30E-02	8.30E-02	8.30E-02	8.29E-02	8.29E-02	8.28E-02	8.28E-02	8.28E-02	8.28E-02
Radionuclides									
Uranium-238	1.17E-01	1.17E-01	1.17E-01	1.17E-01	1.17E-01	1.17E-01	1.17E-01	1.17E-01	1.17E-01
Uranium-234	1.17E-01	1.17E-01	1.17E-01	1.17E-01	1.17E-01	1.17E-01	1.17E-01	1.17E-01	1.17E-01
Thorium-230	3.69E-01	3.70E-01	3.71E-01	3.71E-01	3.72E-01	3.72E-01	3.72E-01	3.73E-01	3.73E-01
Radium-226	1.14E+00	1.14E+00	1.15E+00	1.15E+00	1.15E+00	1.15E+00	1.15E+00	1.15E+00	1.15E+00
Lead-210	1.14E+00	1.14E+00	1.15E+00	1.15E+00	1.15E+00	1.15E+00	1.15E+00	1.15E+00	1.15E+00
Polonium-210	1.16E+00	1.16E+00	1.17E+00	1.17E+00	1.17E+00	1.17E+00	1.17E+00	1.17E+00	1.17E+00

Note:

a) Estimated from uranium using the specific activity of 12356 Bq/g and assuming secular equilibrium between uranium-238 and uranium-234.

b) Unit conversion from mg/s to Bq/s using the specific activity of 7.47E+08 Bq/g which was calculated from its half-life of 77000 y.

c) Unit conversion from mg/s to Bq/s using the specific activity of 3.66E+10 Bq/g which was calculated from its half-life of 1600 y.

d) Assuming equilibrium between radium-226 and lead-210 due to the long half-life of radium-226.

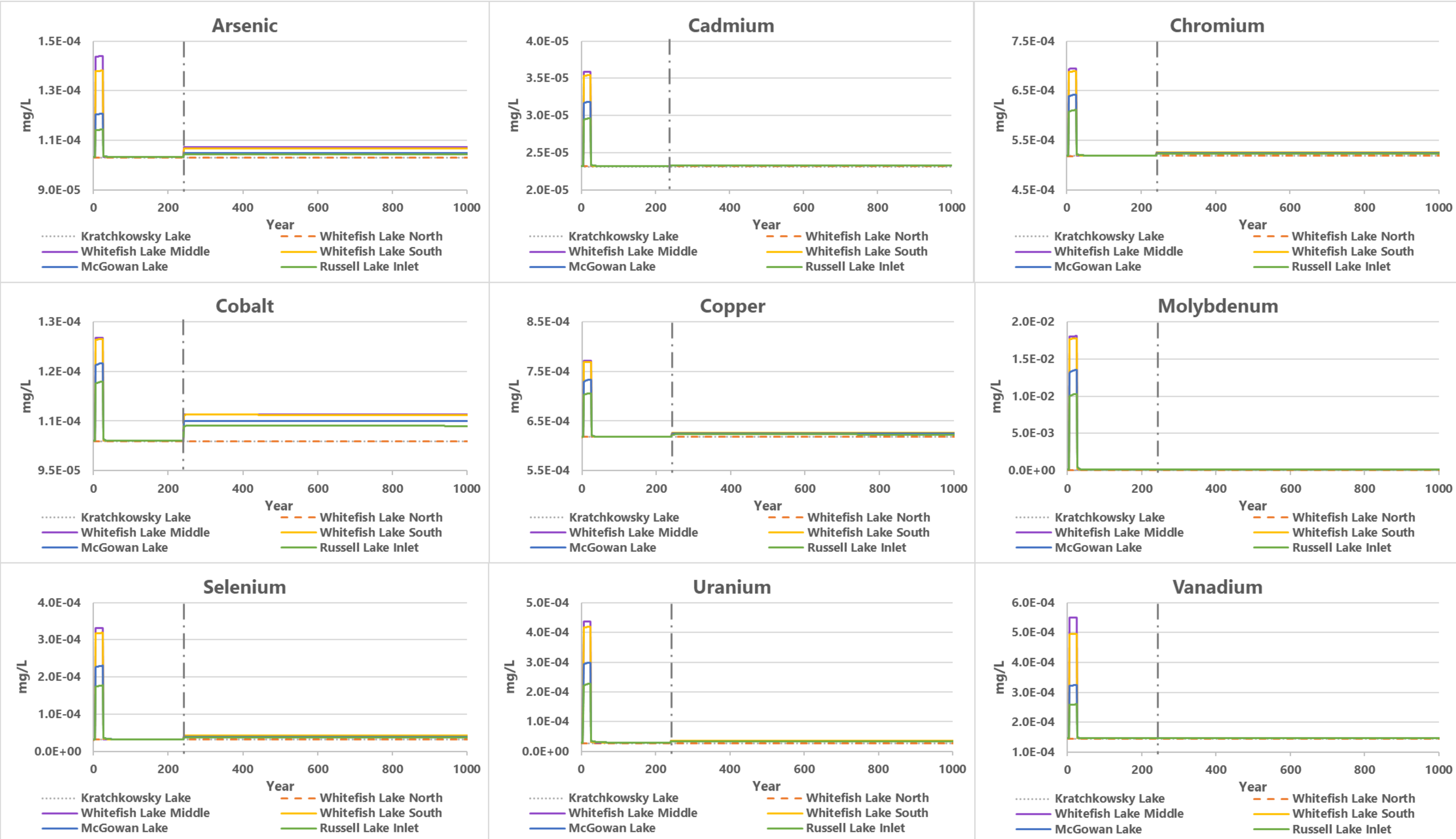
e) Calculated from lead-210 assuming transient equilibrium between lead-210 and polonium-210.

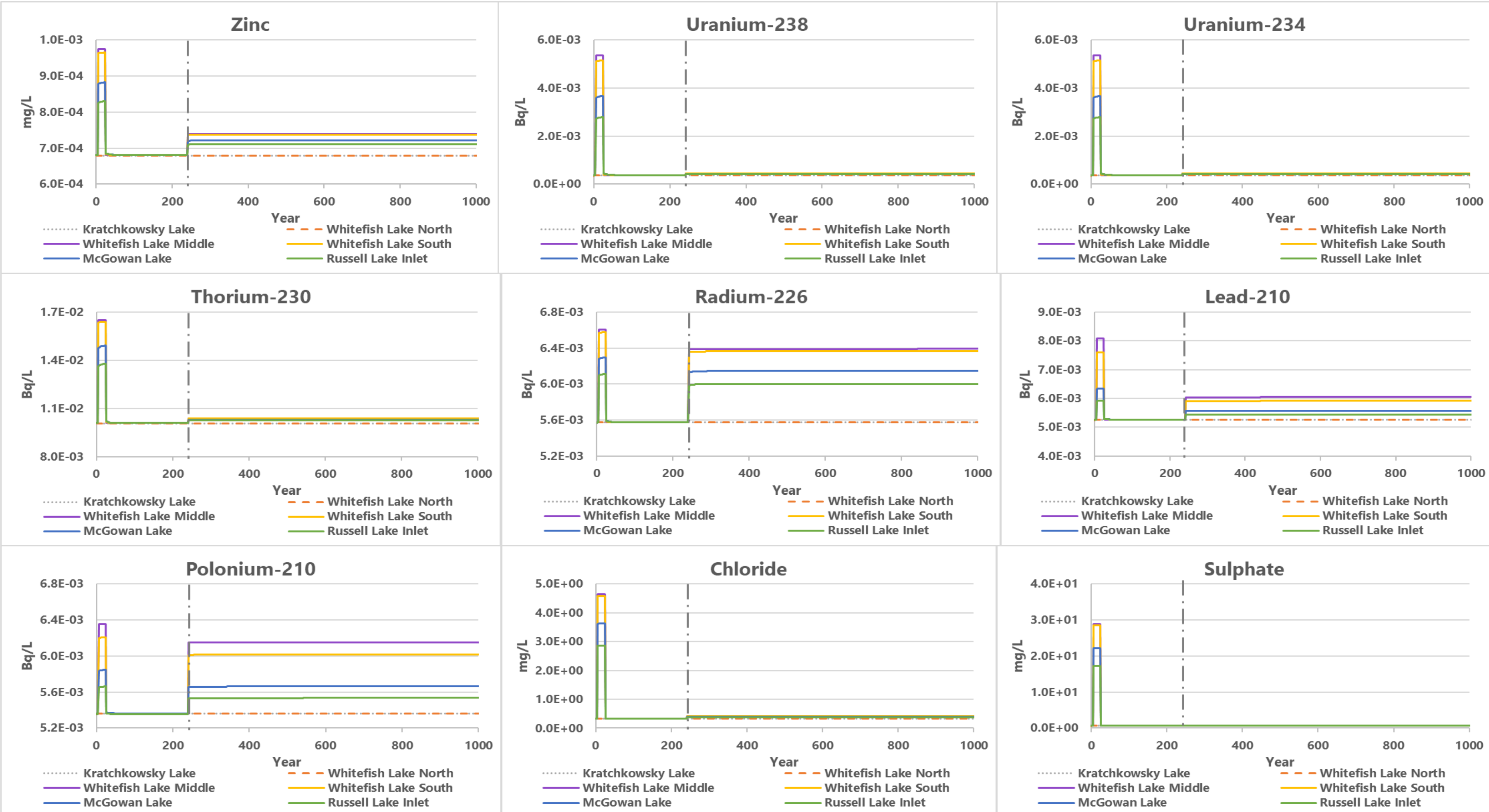
Table 3-5: Maximum Concentration of COPCs in Water and Sediment during Future Centuries

Environmental Media	Location	Maximum Concentration of Non-radionuclides during Project Phases											
		Arsenic	Cadmium	Chloride	Cobalt	Chromium	Copper	Molybdenum	Sulphate	Selenium	Uranium	Vanadium	Zinc
Water (mg/L)	Quality Guideline	5.00E-03	4.00E-05	1.20E+02	2.95E-04	1.00E-03	2.00E-04	7.60E+00	1.28E+02	1.00E-03	1.50E-02	1.20E-01	1.30E-02
	Kratchkowsky Lake	1.03E-04	2.32E-05	3.22E-01	1.01E-04	5.19E-04	6.18E-04	1.07E-04	6.87E-01	3.23E-05	3.01E-05	1.46E-04	6.81E-04
	Whitefish Lake North	1.03E-04	2.32E-05	3.22E-01	1.01E-04	5.19E-04	6.18E-04	1.07E-04	6.87E-01	3.23E-05	3.01E-05	1.46E-04	6.81E-04
	Whitefish Lake Middle	1.07E-04	2.33E-05	4.15E-01	1.06E-04	5.26E-04	6.26E-04	1.16E-04	7.21E-01	4.30E-05	3.68E-05	1.47E-04	7.40E-04
	Whitefish Lake South	1.07E-04	2.33E-05	4.14E-01	1.06E-04	5.26E-04	6.26E-04	1.16E-04	7.20E-01	4.26E-05	3.65E-05	1.47E-04	7.37E-04
	McGowan Lake	1.05E-04	2.33E-05	3.93E-01	1.05E-04	5.24E-04	6.24E-04	1.14E-04	7.13E-01	3.94E-05	3.45E-05	1.46E-04	7.21E-04
	Icelander River	1.05E-04	2.33E-05	3.92E-01	1.05E-04	5.24E-04	6.24E-04	1.14E-04	7.13E-01	3.94E-05	3.45E-05	1.46E-04	7.21E-04
	Russell Lake Inlet	1.04E-04	2.32E-05	3.76E-01	1.04E-04	5.23E-04	6.23E-04	1.12E-04	7.07E-01	3.76E-05	3.33E-05	1.46E-04	7.11E-04
Sediment (mg/kg dw)	Quality Guideline	2.10E+01	6.00E-01	n/a	n/a	3.15E+01	2.20E+01	2.30E+01	n/a	3.60E+00	9.70E+01	3.51E+01	1.23E+02
	Kratchkowsky Lake	8.35E+00	3.38E-01	n/a	2.52E-01	5.86E+00	1.85E+00	3.37E-01	n/a	6.22E-01	5.78E-01	1.12E+01	9.93E+00
	Whitefish Lake North	8.35E+00	3.38E-01	n/a	2.52E-01	5.86E+00	1.85E+00	3.37E-01	n/a	6.22E-01	5.78E-01	1.12E+01	9.93E+00
	Whitefish Lake Middle	8.66E+00	3.40E-01	n/a	2.65E-01	5.94E+00	1.87E+00	3.68E-01	n/a	8.28E-01	7.07E-01	1.13E+01	1.08E+01
	Whitefish Lake South	8.62E+00	3.40E-01	n/a	2.65E-01	5.93E+00	1.87E+00	3.67E-01	n/a	8.19E-01	7.02E-01	1.13E+01	1.08E+01
	McGowan Lake	8.48E+00	3.39E-01	n/a	2.62E-01	5.91E+00	1.87E+00	3.60E-01	n/a	7.59E-01	6.64E-01	1.13E+01	1.05E+01
	Russell Lake Inlet	8.43E+00	3.39E-01	n/a	2.59E-01	5.90E+00	1.86E+00	3.55E-01	n/a	7.22E-01	6.41E-01	1.12E+01	1.04E+01

Environmental Media	Location	Maximum Concentration of Radionuclides during Project Phases					
		Uranium-238	Uranium-234	Thorium-230	Radium-226	Lead-210	Polonium-210
Water (Bq/L)	Quality Guideline	n/a	n/a	n/a	1.10E-01	n/a	n/a
	Kratchkowsky Lake	3.71E-04	3.71E-04	1.01E-02	5.57E-03	5.27E-03	5.36E-03
	Whitefish Lake North	3.71E-04	3.71E-04	1.01E-02	5.57E-03	5.27E-03	5.36E-03
	Whitefish Lake Middle	4.54E-04	4.54E-04	1.04E-02	6.39E-03	6.05E-03	6.15E-03
	Whitefish Lake South	4.51E-04	4.51E-04	1.04E-02	6.37E-03	5.92E-03	6.02E-03
	McGowan Lake	4.26E-04	4.26E-04	1.03E-02	6.15E-03	5.57E-03	5.66E-03
	Icelander River	4.26E-04	4.26E-04	1.03E-02	6.14E-03	5.56E-03	5.64E-03
	Russell Lake Inlet	4.12E-04	4.12E-04	1.03E-02	6.00E-03	5.45E-03	5.53E-03
Sediment (Bq/kg dw)	Quality Guideline	n/a	n/a	n/a	6.00E+02	9.00E+02	8.00E+02
	Kratchkowsky Lake	7.14E+00	7.14E+00	2.32E+01	6.51E+01	3.74E+02	3.80E+02
	Whitefish Lake North	7.14E+00	7.14E+00	2.32E+01	6.51E+01	3.74E+02	3.80E+02
	Whitefish Lake Middle	8.74E+00	8.74E+00	2.38E+01	7.47E+01	4.29E+02	4.36E+02
	Whitefish Lake South	8.67E+00	8.67E+00	2.38E+01	7.44E+01	4.19E+02	4.27E+02
	McGowan Lake	8.20E+00	8.20E+00	2.36E+01	7.18E+01	3.95E+02	4.01E+02
	Russell Lake Inlet	7.92E+00	7.92E+00	2.35E+01	7.01E+01	3.86E+02	3.93E+02

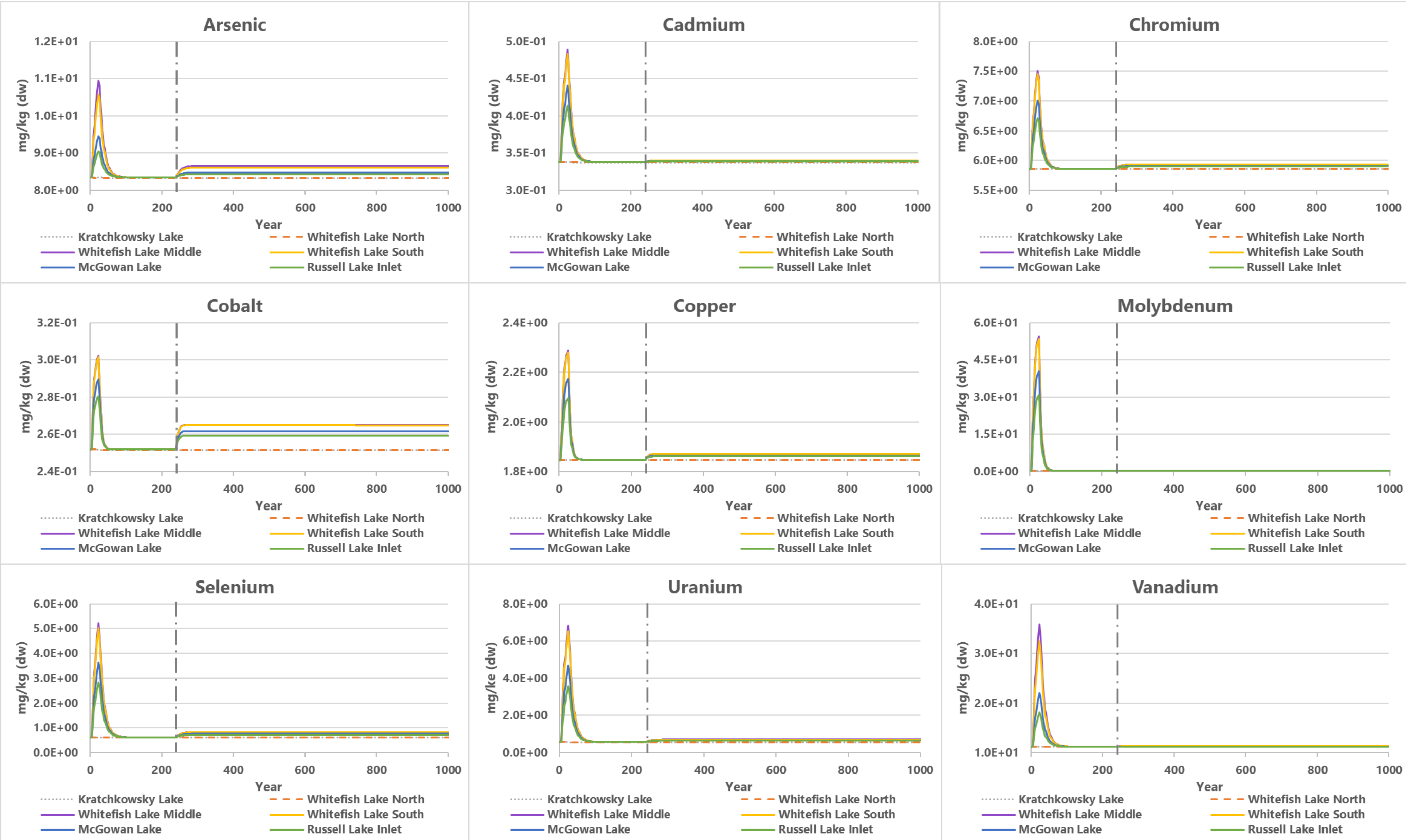
n/a = not applicable
Water quality guidelines are as shown in Table 3-1 and sediment quality guidelines are as shown in Table 3-6.

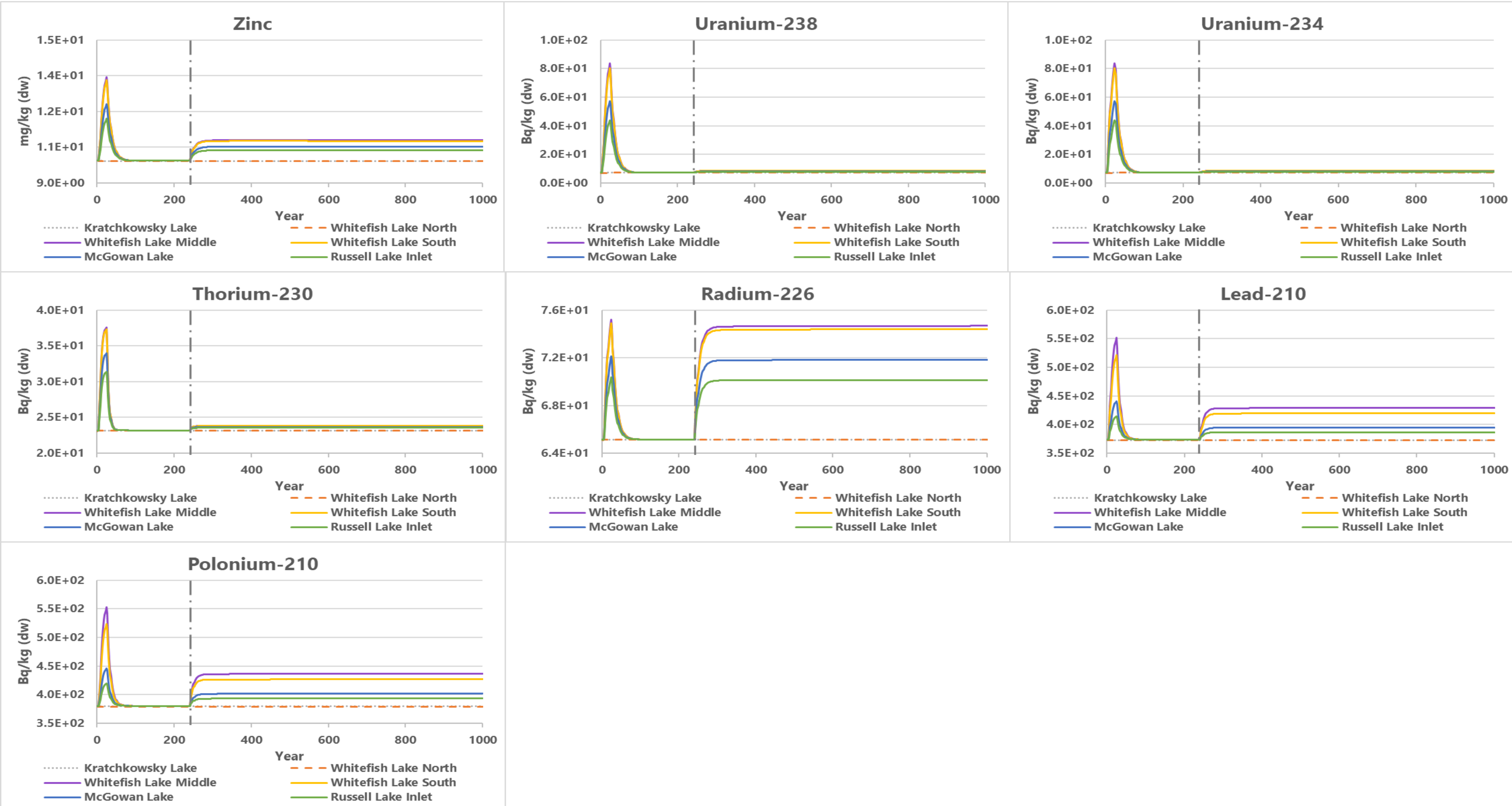

Arsenic
mg/L
1.5E-04
1.3E-04
1.1E-04
9.0E-05
0
200
400
600
800
1000
Year
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Cadmium
mg/L
4.0E-05
3.5E-05
3.0E-05
2.5E-05
2.0E-05
Year
Chromium
mg/L
7.5E-04
6.5E-04
5.5E-04
4.5E-04
Year
Cobalt
mg/L
1.3E-04
1.2E-04
1.1E-04
9.5E-05
Year
Copper
mg/L
8.5E-04
7.5E-04
6.5E-04
5.5E-04
Year
Molybdenum
mg/L
2.0E-02
1.5E-02
1.0E-02
5.0E-03
0.0E+00
Year
Selenium
mg/L
4.0E-04
3.0E-04
2.0E-04
1.0E-04
0.0E+00
Year
Uranium
mg/L
5.0E-04
4.0E-04
3.0E-04
2.0E-04
1.0E-04
0.0E+00
Year
Vanadium
mg/L
6.0E-04
5.0E-04
4.0E-04
3.0E-04
2.0E-04
1.0E-04
Year



Long dash dot lines represent the beginning of the future centuries period when the groundwater solutes reach Whitefish Lake.

Figure 3-4: Modelled Concentrations of COPCs in Water during Future Centuries


Arsenic
1.2E+01
1.1E+01
1.0E+01
9.0E+00
8.0E+00
mg/kg (dw)
0
200
400
600
800
1000
Year
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Cadmium
5.0E-01
4.5E-01
4.0E-01
3.5E-01
3.0E-01
mg/kg (dw)
Year
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Chromium
8.0E+00
7.5E+00
7.0E+00
6.5E+00
6.0E+00
5.5E+00
mg/kg (dw)
Year
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Cobalt
3.2E-01
3.0E-01
2.8E-01
2.6E-01
2.4E-01
mg/kg (dw)
Year
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Copper
2.4E+00
2.2E+00
2.0E+00
1.8E+00
mg/kg (dw)
Year
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Molybdenum
6.0E+01
4.5E+01
3.0E+01
1.5E+01
0.0E+00
mg/kg (dw)
Year
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Selenium
6.0E+00
5.0E+00
4.0E+00
3.0E+00
2.0E+00
1.0E+00
0.0E+00
mg/kg (dw)
Year
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Uranium
8.0E+00
6.0E+00
4.0E+00
2.0E+00
0.0E+00
mg/ke (dw)
Year
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Vanadium
4.0E+01
3.0E+01
2.0E+01
1.0E+01
mg/kg (dw)
Year
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet



Long dash dot lines represent the beginning of the future centuries period when the groundwater solutes reach Whitefish Lake.

Figure 3-5: Modelled Concentrations of COPCs in Sediment during Future Centuries

3.1.2.3 Constituents of Potential Concern in Sediment

A sediment screening was performed as a secondary check to determine if there are any constituents not identified as COPCs in the surface water screening that would be identified as COPCs based on exceedances of sediment quality guidelines. Predicted maximum concentrations of constituents of interest in sediment were compared against sediment quality guidelines for the protection of aquatic life and other relevant screening values. Sediment concentrations were predicted from surface water concentrations using IMPACT according to the equations outlined in the IMPACT model (Appendix A).

Sediment quality screening values were selected based on the following of sources:

- reference (REF) and no-effect (NE2) sediment quality values from Burnett-Seidel and Liber (Burnett-Seidel and Liber, 2013);
- lowest effect levels (LELs) and severe effect levels (SELs) from Thompson et al. (Thompson et al., 2005); and
- Canadian interim sediment quality guidelines (ISQGs) and probable effect levels (PELs) from the CCME (CCME, 1999a).

Burnett-Seidel and Liber (2013) was selected as the preferred source, as the reported NE2 and REF values are specifically applicable to Saskatchewan waterbodies. The REF values refer to locations upstream of mining or milling activities or located within separate but nearby drainages. Exceedances of REF values indicate that sediments downstream of predicted discharges contain elevated metal concentrations compared to natural background conditions. The NE2 values refer to exposed (lightly contaminated) areas with elevated concentrations but no significant effect on benthic invertebrate abundance, richness, and evenness. Concentrations below the NE2 values indicate that benthic invertebrate community metrics (abundance, richness, and evenness) downstream of discharges are not expected to differ significantly (less than 20% difference) from those observed at natural background conditions.

Two tiers of sediment quality guidelines are defined by Thompson et al. (2005): LELs and SELs. The CCME also provides two tiers of guidelines in sediments: ISQGs and PELs. If a predicted COPC concentration in sediment is less than the LEL or ISQG, adverse effects on benthic invertebrate communities are not anticipated for that constituent. Predicted concentrations in sediments that exceed the LEL or ISQG would not necessarily indicate that adverse effects are occurring but suggest that further investigation is warranted. These levels were, therefore, used for screening levels where there were no available REF levels.

An exceedance of a PEL or SEL is more likely to be associated with ecological effects. The SEL has been interpreted by some practitioners to be the specific COPC concentration in sediment that the majority of benthic organisms are not expected to tolerate (Persaud et al., 1993). The PEL is defined as the concentration of a COPC above which adverse effects are expected to occur frequently (more than approximately 50% of adverse effects occur above the PEL; (CCME, 1995)).

The sediment screening (Table 3-6) focused on COPCs identified in the surface water screening as exceeding screening values, and on other constituents of interest from other uranium mining and milling operations. Based on comparison of maximum predicted sediment quality in Whitefish Lake (LA-5) against the REF values from Burnett-Seidel and Liber (2013), molybdenum and selenium would exceed the REF values; however, they are not predicted to exceed the NE2 values. Molybdenum and selenium were already identified as COPCs based on the surface water screening, and are assessed further in the quantitative ERA, considering both water and sediment concentrations. The maximum vanadium concentration in sediment is 37.2 mg/kg dw in Whitefish Lake (LA-5), which exceeds its sediment quality guideline of 35.1 mg/kg dw (REF value from Burnett-Seidel and Liber, 2013). Therefore, vanadium was identified as a COPC in sediment. Note that, as indicated above, exceedances of REF values do not necessarily indicate effects, but indicate that sediments downstream of predicted discharges contain elevated metal concentrations compared to natural background conditions.

There is no sediment screening value for cobalt; however, cobalt has already been identified as a COPC in surface water. As such, it will be subject to further quantitative assessment in the ERA, considering both water and sediment concentrations.

Predicted concentrations of all other COPCs do not exceed sediment quality guidelines. The COPCs that were already considered COPCs based on the results of the surface water screening, as well as vanadium based on the results of the sediment screening, were evaluated further in the ERA, considering both water and sediment concentrations.

Table 3-6: Sediment Quality Screening for the Wheeler River Project

Constituent	Units	Maximum – Whitefish Lake (LA-5)	Sediment Quality Guidelines						Selected Sediment Screening Value	Is Concentration Greater than Selected Screening Value? (Y/N)
			Burnett-Seidel and Liber[b]		Thompson et al.[c]		CCME[d]			
			REF	NE2	LEL	SEL	ISQG	PEL		
Metals and Metalloids										
Arsenic	mg/kg dw	11.03	21	522	9.8	346	5.9	17	21	No
Cadmium	mg/kg dw	0.50	n/d	n/d	n/d	n/d	0.6	3.5	0.6	No
Chromium	mg/kg dw	7.59	31.5	26.2	47.6	115.4	37.3	90	31.5	No
Cobalt	mg/kg dw	0.30	n/d	n/d	n/d	n/d	n/d	n/d	n/d	n/a
Copper	mg/kg dw	2.31	9.1	11.3	22	268.8	35.7	197	9.1	No
Lead	mg/kg dw	10.24	16.3	19.7	37	412	35	91.3	16.3	No
Molybdenum	**mg/kg dw**	**57.20**	**23**	**245**	**14**	**1,239**	**n/d**	**n/d**	**23**	**Yes**
Nickel	mg/kg dw	4.08	21	326	23	484	n/d	n/d	21	No
Selenium	**mg/kg dw**	**5.48**	**3.6**	**30**	**1.9**	**16**	**n/d**	**n/d**	**3.6**	**Yes**
Uranium	mg/kg dw	7.18	97	2,296	104	5,874	n/d	n/d	97	No
Vanadium	**mg/kg dw**	**37.20**	**35.1**	**31.8**	**35.2**	**160**	**n/d**	**n/d**	**35.1**	**Yes**
Zinc	mg/kg dw	13.63	n/d	n/d	n/d	n/d	123	315	123	No
Radionuclides										
Uranium-234	Bq/kg dw	88.20	n/d	n/d	n/d	n/d	n/d	n/d	n/d	n/a
Uranium-238	Bq/kg dw	88.20	n/d	n/d	n/d	n/d	n/d	n/d	n/d	n/a
Thorium-230	Bq/kg dw	38.27	n/d	n/d	n/d	n/d	n/d	n/d	n/d	n/a
Radium-226	Bq/kg dw	75.71	n/d	n/d	600	14,400	n/d	n/d	600	No
Lead-210	Bq/kg dw	556.58	n/d	n/d	900	20,800	n/d	n/d	900	No
Polonium-210	Bq/kg dw	558.00	n/d	n/d	800	12,100	n/d	n/d	800	No

Bold and Grey shading indicates sediment concentration exceeds the REF or LEL value.
a) Sediment concentrations predicted based on release of aqueous source-terms to LA-5 and interaction with sediment. Modelling performed in IMPACT according to the equations outlined in Appendix A.

b) Burnett-Seidel and Liber (2013) – Sediment quality values derived for application at Saskatchewan uranium operations; reference (REF) values based on reference sites unaffected by mining and milling (representing background), and no-effect level (NE2) values based on sites with no significant difference in benthic invertebrate community effects criteria of abundance, richness and evenness between reference and exposure locations.
c) Thompson et al. (2005) – Sediment quality guidelines derived for application to uranium ore bearing regions of northern Saskatchewan and Ontario; lowest effect levels (LELs) and severe effect levels (SELs) from the "weighted method".
d) CCME – Canadian Sediment Quality Guidelines for the Protection of Freshwater Aquatic Life (CCME, 1999a); updated September 2007; accessed July 2021: **http://ceqg-rcqe.ccme.ca/**).

3.2 Atmospheric Sources

The Project has the potential to change air quality through the emission of gases and particulates as well as deposition of particulates generated by Project activities. For emission to the atmosphere, the ERA focused on the Construction, Operation and Decommissioning phases when effects on air quality are expected to be the greatest due to the intensity and number of Project-related activities.

The Project-related atmospheric releases considered in the ERA were consistent with the air emissions inventory detailed in the Air Quality Impact Assessment (EIS Section 6). The emissions will vary over time based on the schedule of Project activities. The major air emission sources considered for the ERA include the following:

- fossil fuel combustion emissions from mobile equipment and stationary equipment (e.g., generators, heaters, vehicle and equipment movements);
- fugitive dust emissions from drilling and blasting, material handling, crushing, vehicle-generated road dust, and wind erosion from waste piles;
- air emissions released from processing (e.g., the ISR calciner, dryer and hygiene scrubber stacks); and
- removal of site infrastructure and reclamation of waste piles and other storage areas/ponds during the decommissioning phase.

Project-related atmospheric releases would include criteria air contaminants (CACs; nitrogen oxides [assessed as nitrogen dioxide], sulphur dioxide, hydrogen sulphide, ozone, carbon monoxide, total suspended particulates [TSP], and fine particulate matter [PM_{10} and $PM_{2.5}$]), metals including uranium in dust, and radon.

Criteria air contaminants have either federal or provincial ambient air quality criteria or both. Nitrogen oxides, sulphur dioxide, carbon monoxide, and particulates (TSP, PM_{10}, and $PM_{2.5}$) would be CACs directly emitted by the Project from stationary and mobile sources. Sources of hydrogen sulphide and ozone are expected to be negligible and therefore were not retained for further assessment of impacts to air quality.

Particulates would be associated with such activities as road dust from unpaved roads; wind erosion; materials handling; dozing at the wellfield and waste pads; the ISR calciner, dryer and hygiene scrubber stacks (dusts emitted in the form of yellowcake); and construction activities. Particulates would be measured in terms of TSP, PM_{10}, and $PM_{2.5}$.

Metals would be emitted as a portion of dust. Dust emissions were assumed to contain metals from emissions from wellfield drilling in mineralized waste, wind erosion from the mineralized waste pad, material handling at the wellfield and mineralized waste pad, and stack emissions from the ISR Plant (the dryer, calciner, and hygiene scrubber stacks).

Long-lived radioactive dust is of primary concern at the back end of the ISR process, since the process is wet until the yellowcake product (uranium oxides) is precipitated out of solution and dried. The long-lived species of concern at that point are uraniuim-238 and uranium-234. The uranium mass is almost entirely uraniuim-238; on an activity basis, uranium-238 and uranium-234 contribute equal activity. It was assumed that other radionuclides in the uranium-238 decay chain would not be present at the point of release but decay and ingrowth is accounted for over time at the point of exposure.

Radon emissions from a number of sources were included in the air quality assessment: wellfield drilling, groundwater exposure to the atmosphere, mining solution venting from wellheads and leaking transport piping, radon surge tank venting, recovered solution pond, ISR plant ventilation, and the mineralized waste and Fe-Ra precipitates storage pads.

3.2.1 Screening for Constituents of Potential Concern

Constituents of potential concern for air, as defined by Health Canada (Health Canada, 2016a), are chemicals whose concentration(s) may become elevated in ambient air as a result of project-related activities, and which have the potential for adverse human or ecological health effects based on documented scientific evidence or suspected causal relationships. The purpose of this section is to identify those Project-related constituents in air that may be of concern for human and/or ecological health and require further assessment.

The screening of air quality constituents was based on maximum predicted concentrations of CACs, metals including uranium, radon, and maximum dust deposition, at air quality model locations that correspond with receptor locations (Table 3-7 below, see Figure 2 in Air Quality Impact Assessment, Section 6 of the EIS), as described in Section 4.2.1, Exposure Locations, Duration, and Frequency, for the human health risk assessment, and Section 5.2.1, Exposure Locations, for the ecological risk assessment.

Maximum predicted concentrations are total concentrations, including background, except for radon which is an incremental concentration.

Table 3-7: Concordance between Air Quality Model and Receptor Locations

Air Quality Model Location	Human and Ecological Receptor Location	Air Quality Model Coordinates	
		X (m)	Y (m)
Risk1	Ecological Location – On-site	477708	6374351
Risk2	Human Location – Recreational Fisher/Trapper (Seasonal resident at McGowan Lake [LA-1])	478245	6372039
Risk3	Human Location – Camp Worker	476896	6373487
Risk4	Human location – Seasonal Resident (Russell Lake)	478415	6368289
Risk5	Human location – Reference Receptor (LA-7)	473146	6375099

Human and ecological receptors at receptor locations were assumed to be in contact with air emissions for prolonged periods of time, at intervals that may be long-term (i.e., annual average) or repeated and short-term (i.e., 24 hours or less) over a lifetime. For this reason, long-term and short-term screening values at the receptor locations were used for the screening of constituents in air at receptor locations.

In addition to the specific receptor locations shown in Table 3-7 above, the screening also considered a fenceline receptor (a receptor at the Project boundary) for short-term exposures (i.e., 24 hours or less). Although the Wheeler River site is remote and access to the site fenceline by a receptor, other than at the locations of trails or roads is unlikely, receptors were assessed along the fenceline boundary. For each air constituent, concentrations were predicted all along the project fenceline boundary and the highest predicted concentration was retained as the maximum for screening purposes. This means that the “fenceline” receptor could occur in different discrete locations for different constituents.

Screening of constituents in air for the receptor locations was based on maximum predicted concentrations for all receptor locations for the relevant time period, as follows:

1. If the model results from the Air Quality Impact Assessment (EIS Section 6) for a constituent were below its relevant air quality screening values for all averaging times at all receptor locations, the constituent was assumed to be below levels associated with potential human health and ecological risks and was not considered further in the ERA for direct atmospheric exposures.

2. If the model result for an air quality constituent was greater than any one of its relevant air quality screening values at any receptor location, the constituent was evaluated further in secondary screening to determine if it should be carried forward as a COPC for quantitative risk assessment.

3.2.1.1 Screening Value Selection

Ambient air quality criteria are available for different exposure averaging periods (e.g., 1-hour, 24-hour, annual). Ambient air quality criteria for the relevant averaging periods were selected based on the following hierarchy:

- Saskatchewan Ambient Air Quality Standards (SAAQS) are maximum concentrations in ambient air from all sources as stipulated in *The Clean Air Regulations* (Government of Saskatchewan, 2015).

- Alberta Ambient Air Quality Objectives (AAAQO) are based on an evaluation of scientific, social, technical, and economic factors (Alberta, 2021).

- Ontario Ambient Air Quality Criteria (OAAQC) are concentrations of a constituent in air that are protective against adverse effects on health and/or the environment (MECP, 2020).

- Texas effects screening levels (ESLs) are air concentrations at or below which adverse health effect in the general public, including sensitive subgroups such as children, the elderly, pregnant women, and people with pre-existing health conditions, are not likely to occur (TCEQ, 2016).

Canadian Ambient Air Quality Standards (CAAQS) established under the national Air Quality Management System were considered as screening criteria, as appropriate.

Screening values for radionuclide concentrations in ambient air were not available. All relevant radionuclides were assessed in the ERA in terms of their contribution to the total radiological dose to human and ecological receptors.

As noted in the Air Quality assessment, the Ontario criteria for uranium in PM_{10} were conservatively selected given that the literature suggests that the particle size distribution for yellowcake is 80% less than PM_{10} (US EPA, 1980). The predictions for all other metals were compared to criteria based on TSP.

The selected ambient air quality screening values for different averaging periods, their source, and their rationale in terms of potential effects are summarized in Table 3-8. Where multiple sources recommended the same criterion value, each of the relevant sources is identified. The rationale provided in Table 3-8 for each of the selected screening values describes the sensitive effect that is the basis for the value cited by the relevant source.

Table 3-8: Screening Values for the Selection of Air Quality Constituents of Potential Concern for the Environmental Risk Assessment

Constituent	Averaging Period	Selected Screening Value	Source	Rationale
CACs				
Nitrogen dioxide (NO_2)	1 hour	300 (79)	SAAQS/AAAQO (CAAQS 2025)	Respiratory effects
	24-hour	200	SAAQS/OAAQC	Human health
	Annual	45 (23)	SAAQS/AAAQO (CAAQS 2025)	Vegetation
Sulphur dioxide (SO_2)	1 hour	450 (170)	SAAQS/AAAQO (CAAQS 2025)	Pulmonary function
	24-hour	125	SAAQS/AAAQO	Human health
	Annual	20 (11)	SAAQS/AAAQO (CAAQS 2025)	Ecosystem health
Carbon monoxide (CO)	1 hour	15000	SAAQS/AAAQO	Oxygen carrying capacity of blood
	8-hour	6000	SAAQS/AAAQO	Oxygen carrying capacity of blood
Total suspended particulates (TSP)	24-hour	100	SAAQS/AAAQO	Human health. Pulmonary effects
	Annual	60	SAAQS/OAAQC	Visibility
Particulate matter (PM_{10})	24-hour	50	SAAQS/OAAQC	Human health
Particulate matter ($PM_{2.5}$)	24-hour	27	OAAQC/CAAQS	Human health
	Annual	8.8	OAAQC/CAAQS	Human health
Dustfall				
TSP deposition	Annual	4.6	OAAQC	Dustfall criterion. Aesthetics (g/m^2/yr)
	30-day	2	SAAQS	Aesthetics (mg/cm^2/30 days)
Radionuclides				
	24-hour	n/v	n/a	Addressed in terms of radiation dose in the ERA

Constituent	Averaging Period	Selected Screening Value	Source	Rationale
Thorium-230, Radium-226, Lead-210, Polonium-210	Annual	n/v	n/a	Addressed in terms of radiation dose in the ERA
Radon				
Radon	Annual	n/v	n/a	Addressed in terms of radiation dose in the ERA
Metals				
Arsenic (As)	24-hour	0.3	OAAQC	Human health. Applies to arsenic and arsenic compounds.
	Annual	0.01	AAAQO	Human health. Carcinogenic effects.
Cadmium (Cd)	24-hour	0.025	OAAQC	Human health. Applies to cadmium and cadmium compounds. Converted from the annual AAQC to allow assessment of 24-hour air quality data.
	Annual	0.005	OAAQC	Human health. Applies to cadmium and cadmium compounds.
Cobalt (Co)	24-hour	0.1	OAAQC	Human health
	Annual	n/v	n/a	n/a
Chromium (Cr)	24-hour	0.5	OAAQC	Human health. Applies to either chromium metallic, divalent, and trivalent, or to the percentage of chromium metallic, divalent, and trivalent relative to total chromium.
	Annual	n/v	n/a	n/a
Copper (Cu)	24-hour	50	OAAQC	Human health
	Annual	n/v	n/a	n/a
Molybdenum (Mo)	24-hour	120	OAAQC	Particulate – visibility; molybdenum is more likely emitted as TSP, and therefore the AAQC for TSP is applied.
	Annual	n/v	n/a	n/a

Constituent	Averaging Period	Selected Screening Value	Source	Rationale
Nickel (Ni)	24-hour	0.2	OAAQC	In TSP. Human health. Applies to nickel and nickel compounds. Converted from the annual criterion to allow assessment of the 24-hour data (TSP). Intended to protect from development of chronic effects.
	Annual	0.04	OAAQC	In TSP. Human health. Applies to nickel and nickel compounds.
	24-hour	0.1	OAAQC	In PM_{10}. Human health. Applies to nickel and nickel compounds. Converted from the annual criterion to allow assessment of the 24-hour data (PM_{10}). Intended to protect from development of chronic effects
	Annual	0.02	OAAQC	In PM_{10}. Human health. Applies to nickel and nickel compounds.
Lead (Pb)	24-hour	0.5	OAAQC	Human health. Applies to lead and lead compounds. Converted from the 30-day AAQC to allow assessment of 24-hour air quality data
	Monthly	0.2	OAAQC	Human health. Applies to lead and lead compounds. As arithmetic mean of a 30-day period.
	Annual	n/v	n/a	n/a
Selenium (Se)	24-hour	10	OAAQC	Human health
	Annual	n/v	n/a	n/a
Uranium (U)	24-hour	0.3	OAAQC	In TSP. Human health. Applies to uranium and uranium compounds. Converted from the annual AAQC to allow assessment of 24-hour air quality data.
	Annual	0.06	OAAQC	In TSP. Human health. Applies to uranium and uranium compounds.
	24-hour	0.15	OAAQC	In PM_{10}. Human health. Applies to uranium and uranium compounds. Converted from the annual AAQC to allow assessment of 24-hour air quality data.
	Annual	0.03	OAAQC	In PM_{10}. Human health. Applies to uranium and uranium compounds.
Vanadium (V)	24-hour	2	OAAQC	Human health
	Annual	n/v	n/a	n/a

Constituent	Averaging Period	Selected Screening Value	Source	Rationale
Zinc (Zn)	24-hour	120	OAAQC	Particulates
	Annual	n/v	n/a	n/a
Other				
Acrolein	1-hour	4.5	OAAQC	Human health
	24-hour	0.4	OAAQC	Human health
	Annual	0.02	US EPA IRIS	Human Health. Chronic Reference Concentration

Notes:

Units are µg/m^3 unless otherwise specified.

3.2.1.2 Screening of Air Quality Constituents

The screening of air quality constituents involved the following two types of screenings:

- Primary Screening - Comparing the predicted maximum (short or long-term) air concentrations from the air quality model at all human and ecological receptor locations against the corresponding (short or long-term) air quality criteria (Table 3-9). For the fenceline receptor, comparison of the predicted maximum (short-term) air concentrations from the air quality model against the corresponding short-term air quality criteria (Table 3-10).

- Secondary Screening - For constituents exceeding air quality criteria, screening based on consideration of the locations, receptors present, the type of criterion exceeded (short or long-term) and the frequency of exceedance.

The primary screening of air quality constituents at the human and ecological receptor locations for short- and long-term averaging periods at receptor locations is provided in Table 3-9. Both human and ecological receptors were assumed to be present for extended periods of time at these locations and therefore susceptible to both short- and long-term exposures to airborne constituents. Constituents were not considered further if the maximum predicted concentrations for both short and long-term averaging periods was less than the applicable screening value, as shown in Table 3-9.

Air quality constituents with maximum concentrations that exceeded either their short- or long-term screening value at receptor locations were nitrogen dioxide, particulate matter (TSP, PM_{10}), and uranium. Air quality constituents with maximum concentrations that exceeded their short-term screening value at the fenceline were nitrogen dioxide and particulate matter (TSP, PM_{10}). These constituents were subjected to secondary screening in Section 3.2.1.3, to identify COPCs that require further evaluation in terms of human health and/or ecological risk.

Baseline concentrations were compared to the Project air quality criteria in EIS Appendix 6-A, Table 5.

Table 3-9: Air Quality Screening for Short-term and Long-term Exposures to Constituents in Air at Human and Ecological Receptor Locations

Constituent	Maximum Concentration at Receptor Locations			Screening Value	Averaging Period	Source	Is Concentration Greater than Selected Screening Value? (Yes/No)	Considered Further in Secondary Screening? (Yes/No)
	Construction	Operation	Decommissioning					
CACs								
Nitrogen dioxide (NO_2)	17.1	11.3	16.4	23	Annual	CAAQS	**Yes (1-hour)**	**Yes. No exceedances of annual or 24-hour screening values, but there is a 1-hour exceedance at the camp worker location during all phases of the project.**
	70.6	100	120	200	24-hour	SAAQS/OAAQC		
	181	**275**	**355**	79	1-hour	CAAQS		
Sulphur dioxide (SO_2)	0.0165	0.0111	0.0174	11	Annual	CAAQS	No	No
	0.0814	0.123	0.154	125	24-hour	SAAQS/AAAQO		
	0.216	0.371	0.471	450	1-hour	SAAQS/AAAQO		
Carbon monoxide (CO)	614	639	661	6000	8-hour	SAAQS/AAAQO	No	No. Toxicity of CO is only relevant for short-term (i.e., 8 hours or less) timeframes.
	646	691	741	15000	1-hour	SAAQS/AAAQO		
TSP	48.0	20.6	22.1	60	Annual	SAAQS/OAAQC	**Yes (24-hour)**	**Yes. No exceedances of its annual screening value, but there are exceedances of the 24-hour screening value during all phases of the project.**
	286	**124**	**135**	100	24-hour	SAAQS/AAAQO		
PM_{10}	**136**	**57.0**	**61.1**	50	24-hour	SAAQS/OAAQC	**Yes (24-hour)**	**Yes. No annual screening value but considered further because it exceeds its 24-hour screening value during all phases of the project.**
$PM_{2.5}$	5.4	3.66	3.99	8.8	Annual	OAAQC/CAAQS	No	No
	21	11.0	14.5	27	24-hour	OAAQC/CAAQS		

Constituent	Maximum Concentration at Receptor Locations			Screening Value	Averaging Period	Source	Is Concentration Greater than Selected Screening Value? (Yes/No)	Considered Further in Secondary Screening? (Yes/No)
	Construction	Operation	Decommissioning					
Dustfall								
TSP deposition	0.701	0.0802	0.811	7	Annual	OAAQC Dustfall Criteria ($g/m^2/yr$)	No	No
	1.05	0.181	0.197	2	Monthly	SAAQS ($mg/cm^2/30$ days)		
Radon (Bq/m^3)								
Radon (incremental)	2.15	33.3	15.7	<7.4 to 25	Annual	EIS *Appendix 6-A*	Yes	**Yes. Assessed in terms of radiation dose in the ERA**
Metals								
Arsenic (As)	7.05E-04	7.12E-04	7.01E-04	0.01	Annual	AAAQO	No	No
	3.03E-03	3.13E-03	3.01E-03	0.3	24-hour	OAAQC		
Cadmium (Cd)	7.50E-05	7.75E-05	7.45E-05	0.005	Annual	OAAQC	No	No
	2.81E-04	3.01E-04	2.79E-04	0.025	24-hour	OAAQC		
Cobalt (Co)	2.65E-03	2.75E-03	2.64E-03	0.1	24-hour	OAAQC	No	No. No annual screening value but not considered further because it does not exceed its 24-hour screening value
Chromium (Cr)	5.82E-04	8.96E-04	5.74E-04	0.5	24-hour	OAAQC	No	No. No annual screening value but not considered further because it does not exceed its 24-hour screening value
Copper (Cu)	3.30E-01	3.35E-01	3.29E-01	50	24-hour	OAAQC	No	No. No annual screening value but not considered further because it does not exceed its 24-hour screening value

Constituent	Maximum Concentration at Receptor Locations			Screening Value	Averaging Period	Source	Is Concentration Greater than Selected Screening Value? (Yes/No)	Considered Further in Secondary Screening? (Yes/No)
	Construction	Operation	Decommissioning					
Molybdenum (Mo)	2.71E-03	2.83E-03	2.70E-03	120	24-hour	OAAQC	No	No. No annual screening value but not considered further because it does not exceed its 24-hour screening value
Nickel (Ni) in TSP	4.08E-04	4.41E-04	4.02E-04	0.04	Annual	OAAQC	No	No
	2.05E-03	2.32E-03	2.02E-03	0.2	24-hour	OAAQC	No	No
Nickel (Ni) in PM_{10}	4.08E-04	4.41E-04	4.02E-04	0.02	Annual	OAAQC	No	No
	2.05E-03	2.32E-03	2.02E-03	0.1	24-hour	OAAQC	No	No
Lead (Pb)	6.43E-03	7.48E-03	6.31E-03	0.2	Monthly	OAAQC	No	No. No annual screening value but not considered further because it does not exceed its monthly or 24-hour screening values
	1.71E-02	2.32E-02	1.66E-02	0.5	24-hour	OAAQC		
Selenium (Se)	8.11E-04	8.58E-04	8.07E-04	10	24-hour	OAAQC	No	No. No annual screening value but not considered further because it does not exceed its 24-hour screening value
Uranium (U) in PM_{10}	4.12E-03	**3.45E-02**	1.47E-03	0.03	Annual	OAAQC	**Yes (24-hour and annual)**	**Yes. Exceedances of the 24-hour screening value during the Operation phase at the on-site ecological receptor location and the camp worker location, and of the annual screening value at the on-site ecological location only.**
	2.49E-02	**2.60E-01**	1.25E-02	0.15	24-hour	OAAQC		
Vanadium (V)	5.40E-03	5.93E-03	5.35E-03	2	24-hour	OAAQC	No	No. No annual screening value but not considered further because it

Constituent	Maximum Concentration at Receptor Locations			Screening Value	Averaging Period	Source	Is Concentration Greater than Selected Screening Value? (Yes/No)	Considered Further in Secondary Screening? (Yes/No)
	Construction	Operation	Decommissioning					
								does not exceed its 24-hour screening value
Zinc (Zn)	1.13E+00	1.13E+00	1.13E+00	120	24-hour	OAAQC	No	No. No annual screening value but not considered further because it does not exceed its 24-hour screening value
<u>Other</u>								
Acrolein	4.84E-02	3.91E-02	8.29E-02	4.5	1-hour	OAAQC	No	No
	1.75E-02	1.35E-02	2.66E-02	0.4	24-hour	OAAQC	No	No
	3.19E-03	6.02E-03	2.44E-03	0.02	Annual	US EPA IRIS	No	No

Notes:
Air Concentrations are maximum predicted values (including background) from the Air Quality model for human health and ecological receptor locations Risk1 to Risk5, inclusively, for the period indicated.
Maximum Concentration values are rounded to 3 significant figures.
Units are μg/m^3 unless otherwise specified.
Bold represents air quality parameters predicted to exceed screening values at receptor locations, or parameters that did not exceed the screening level but are discussed further in the ERA.
n/c = not calculated; n/v = no value; n/a = not applicable; ERA = environmental risk assessment; SAAQS = Saskatchewan Ambient Air Quality Standards (Government of Saskatchewan 2015); AAAQO = Alberta Ambient Air Quality Objectives (Alberta 2021); OAAQC = Ontario Ambient Air Quality Criteria (MECP 2020); CAAQS = Canadian Ambient Air Quality Standards (CCME 2021b); < = less than; Bq/m^3 = becquerels per cubic metre; TSP = total suspended particulates; PM_{10} = particulate matter with a diameter of 10 microns or less; $PM_{2.5}$ = particulate matter with a diameter of 2.5 microns or less; CAC = criteria air contaminant.

Table 3-10: Air Quality Screening for Short-term Exposures to Constituents in Air at the Fenceline

Constituent	Maximum Concentration at Fenceline			Screening Value	Averaging Period	Source	Is Concentration Greater than Selected Screening Value? (Yes/No)	Considered Further in Secondary Screening? (Yes/No)
	Construction	Operation	Decommissioning					
CACs								
Nitrogen dioxide (NO_2)	42.9	46.8	42.7	200	24-hour	SAAQS/OAAQC	**Yes (1-hour)**	**Yes. There are exceedances of the 1-hour screening value during all phases of the project.**
	176	**178**	**178**	79	1-hour	SAAQS/AAAQO		
Sulphur dioxide (SO_2)	0.0329	0.0403	0.0342	125	24-hour	SAAQS/AAAQO	No	No
	0.171	0.172	0.166	170	1-hour	CAAQS		
Carbon monoxide (CO)	596	596	596	6000	8-hour	SAAQS/AAAQO	No	No. Toxicity of CO is only relevant for short-term (i.e., 8 hours or less) timeframes.
	615	614	615	15000	1-hour	SAAQS/AAAQO		
TSP	**313**	**281**	**115**	100	24-hour	SAAQS/AAAQO	**Yes (24-hour)**	**Yes. There are exceedances of the 24-hour screening value during all phases of the project.**
PM_{10}	**116**	**104**	47.4	50	24-hour	SAAQS/OAAQC	**Yes (24-hour)**	**Yes. There are exceedances of the 24-hour screening value during Construction and Operation.**
$PM_{2.5}$	16.3	15.0	10.0	27	24-hour	OAAQC/CAAQS	No	No
Radon (Bq/m³)								
Radon (incremental)	1.12	12.5	7.04	<7.4 to 25	Annual	EIS *Appendix 6-A*	No	**Yes. Assessed in terms of radiation dose in the ERA**
Metals								
Arsenic (As)	3.01E-03	3.07E-03	3.01E-03	0.3	24-hour	OAAQC	No	No

Constituent	Maximum Concentration at Fenceline			Screening Value	Averaging Period	Source	Is Concentration Greater than Selected Screening Value? (Yes/No)	Considered Further in Secondary Screening? (Yes/No)
	Construction	Operation	Decommissioning					
Cadmium (Cd)	2.78E-04	2.94E-04	2.78E-04	0.025	24-hour	OAAQC	No	No
Cobalt (Co)	2.64E-03	2.72E-03	2.64E-03	0.1	24-hour	OAAQC	No	No
Chromium (Cr)	5.62E-04	7.98E-04	5.63E-04	0.5	24-hour	OAAQC	No	No
Copper (Cu)	3.29E-01	3.33E-01	3.29E-01	50	24-hour	OAAQC	No	No
Molybdenum (Mo)	2.69E-03	2.76E-03	2.69E-03	120	24-hour	OAAQC	No	No
Nickel (Ni) in TSP	2.01E-03	2.22E-03	2.01E-03	0.2	24-hour	OAAQC	No	No
Nickel (Ni) in PM_{10}	2.01E-03	2.22E-03	2.01E-03	0.1	24-hour	OAAQC	No	No
Lead (Pb)	1.64E-02	2.05E-02	1.64E-02	0.5	24-hour	OAAQC	No	No
Selenium (Se)	8.05E-04	8.42E-04	8.05E-04	10	24-hour	OAAQC	No	No
Uranium (U) in PM_{10}	8.75E-03	**2.23E-01**	7.41E-03	0.15	24-hour	OAAQC	**Yes**	**Yes. Exceedances of the 24-hour screening value during the Operation phase at the fenceline.**
Vanadium (V)	5.34E-03	5.75E-03	5.33E-03	2	24-hour	OAAQC	No	No
Zinc (Zn)	1.13E+00	1.13E+00	1.13E+00	120	24-hour	OAAQC	No	No
Other								
Acrolein	4.71E-02	2.47E-02	4.01E-02	4.5	1-hour	OAAQC	No	No
	9.56E-03	5.55E-03	8.02E-03	0.4	24-hour	OAAQC	No	No

Notes:
Air Concentrations are maximum predicted values (including background) from the Air Quality model for locations along the project fenceline, for the period indicated.
Maximum Concentration values are rounded to 3 significant figures.
Units are µg/m³ unless otherwise specified.
Bold represents air quality parameters predicted to exceed screening values at receptor locations, or parameters that did not exceed the screening level but are discussed further in the ERA.

n/c = not calculated; n/v = no value; n/a = not applicable; ERA = environmental risk assessment; SAAQS = Saskatchewan Ambient Air Quality Standards (Government of Saskatchewan 2015); AAAQO = Alberta Ambient Air Quality Objectives (Alberta 2021); OAAQC = Ontario Ambient Air Quality Criteria (MECP 2020); CAAQS = Canadian Ambient Air Quality Standards (CCME 2021b); < = less than; Bq/m^3 = becquerels per cubic metre; TSP = total suspended particulates; PM_{10} = particulate matter with a diameter of 10 microns or less; $PM_{2.5}$ = particulate matter with a diameter of 2.5 microns or less; CAC = criteria air contaminant.

3.2.1.3 Secondary Screening of Air Quality Constituents

Air quality constituents that exceeded a screening value were nitrogen dioxide, particulate matter (TSP, PM_{10}), and uranium (Table 3-11). These constituents were further evaluated to determine if they require additional quantitative assessment in the ERA.

Table 3-11: Summary of Air Quality Constituents that Exceed a Screening Value

Constituent	Screening Criteria Exceeded		Predicted Exceedances at Human/Ecological Locations	Hours/Days Exceeding at Human/Ecological Locations	Frequency of Exceedance at Human/Ecological Locations
	Short-Term	Long-Term			
Nitrogen dioxide	1-hour	none exceeded	Construction: exceedance of 1-hour screening value at the camp worker location and fenceline; no 24-hour or annual exceedances Operation: exceedance of 1-hour screening value at the camp worker location and fenceline; no 24-hour or annual exceedances Decommissioning: exceedance of 1-hour screening value at the camp worker location and fenceline; no 24-hour or annual exceedances	Construction: 1-hr: 296 hours (Camp) 28 hours (fenceline) Operation: 1-hr: 402 hours (Camp) 28 hours (fenceline) Decommissioning: 1-hr: 494 hours (Camp) 25 hours (fenceline)	Construction: 1-hr: 3.4% (Camp) 0.3% (fenceline) Operation: 1-hr: 4.6% (Camp) 0.3% (fenceline) Decommissioning: 1-hr: 5.6% (Camp) 0.2% (fenceline)
Particulate Matter: TSP	24-hour	none exceeded	Construction: exceedance of 24-hour screening value at camp worker location and fenceline; no annual exceedances Operation: exceedance of 24-hour screening value at camp worker location and fenceline; no annual exceedances Decommissioning: exceedance of 24-hour screening value at camp worker location and fenceline; no annual exceedances	Construction: 24-hr: 108 days (Camp), 104 days (fenceline) Operation: 24-hr: 8 days (Camp), 80 days (fenceline) Decommissioning: 24-hr: 6 days (Camp), 2 days (fenceline)	Construction: 24-hr: 30% (Camp), 29% (fenceline) Operation: 24-hr: 2.2% (Camp), 22% (fenceline) Decommissioning: 24-hr: 1.6% (Camp), 0.5% (fenceline)
Particulate Matter: PM_{10}	24-hour	n/a	Construction: exceedance of 24-hour screening value at camp worker location and fenceline	Construction: 24-hr: 78 days (Camp), 61 days (fenceline) Operation: 24-hr: 4 days (Camp), 42 days (fenceline)	Construction: 24-hr: 21% (Camp), 17% (fenceline) Operation: 24-hr: 1.1% (Camp), 12% (fenceline)

Constituent	Screening Criteria Exceeded		Predicted Exceedances at Human/Ecological Locations	Hours/Days Exceeding at Human/Ecological Locations	Frequency of Exceedance at Human/Ecological Locations
	Short-Term	Long-Term			
			Operation: exceedance of 24-hour screening value at camp worker location and fenceline Decommissioning: exceedance of 24-hour screening value at camp worker location	Decommissioning: 24-hr: 6 days	Decommissioning: 24-hr: 1.6%
Uranium	24-hour	Annual	Construction: no exceedances Operation: exceedance of 24-hour screening value at the on-site ecological receptor location and camp worker location, also fenceline; annual exceedance at the on-site ecological location Decommissioning: no exceedances	Construction: n/a Operation: 24-hr: 8 days (Camp), 3 days (fenceline) Decommissioning: 24-hr: 5%	Construction: n/a Operation: 24-hr: 5% (Camp), 0.8% (fenceline) Decommissioning: n/a

3.2.1.3.1 Nitrogen Dioxide

Screening values were available for 1-hour, 24-hour, and annual averaging periods for nitrogen dioxide. The exceedances are summarized below, followed by a discussion of the critical effects upon which the screening values were based and an overall conclusion related to whether nitrogen dioxide was ultimately retained for further evaluation in the ERA.

Summary of Exceedances at Human/Ecological Locations

- 1-hour: Exceedances during all project phases; however, the maximum 1-hour NO_2 concentration is during the decommissioning phase. The camp worker location (Risk3) had a predicted max 1-hour NO_2 concentration during decommissioning of 355 µg/m^3, which exceeds its screening value from the CAAQS of 79 µg/m^3. Exceedances at the camp worker location were noted for a maximum of 5.6% of the year (decommissioning), which corresponds to 494 hours out of 8760 hours in a year. Exceedances were also noted for 1-hour NO_2 at the fenceline for 0.3% of the year (for approximately 28 hours per year during construction and operation), although concentrations at the fenceline were lower than at the camp worker location.

- There were no exceedances of the 24-hour or annual screening values at any human or ecological locations for any Project phase.

Health/Environmental Effect(s) for Short-term and Long-term Exposures

- Long-term (annual): As noted, there are no predicted exceedances of annual screening values at any receptor location during all Project phases; therefore, no long-term effects are expected.
- Short-term (1-hour, 24-hour): There are no predicted exceedances of 24-hr screening values at any receptor location during all Project phases; however, there are infrequent predicted exceedances of 1-hr NO_2 at the camp worker location and the fenceline. There are no exceedances at other receptor locations.

To put the exceedances of NO_2 into context, hazard quotients (HQ) for all receptors have been calculated using the 1-hr and annual CAAQSs as the toxicity reference values (see Table 3-12). HQs above 1 require further discussion. As shown in Table 3-12, HQs are below 1 for long-term NO_2 exposure at all receptor locations, and HQs exceed 1 for short-term 1-hr NO_2 exposure only for the on-site receptors (camp worker, on-site ecological location), and the fenceline receptor.

Potential adverse health effects that are attributed to short-term exposures to ambient nitrogen dioxide include asthma exacerbations and possibly increased risk of cardiopulmonary effects, and to a lesser extent cardiovascular and respiratory mortality (Health Canada, 2016b). Individuals with certain pre-existing diseases such as asthma appear to be sensitive to exposure to ambient NO_2. Although it has been suggested that there may not be a threshold for the health effects of NO_2 even considering short-term (1-hour) exposures (CCME, 2020), at least some reviews (e.g. (Hesterberg TW et al., 2009) do not support this assertion and rather support a 1-hour threshold. Hesterberg et al. (2009) completed a critical review of over 50 human clinical studies in which human volunteers (including sensitive sub-populations: the elderly, children, and asthmatics) were exposed to NO_2 at concentrations ranging from 0.1 to 3.5 ppm (equivalent to 188 to 6,580 µg/m^3 [1 ppm = 1880 µg/m^3) for periods of 30 minutes to 6 hours, often combined with exercise and co-pollutants. Their findings indicated that there is evidence of no-effect at low concentrations, and that a threshold of approximately 0.2 ppm (or 376 µg/m^3) is supported. The maximum predicted concentration of 1-hour NO_2 was 355 µg/m^3, which is less than the concentration protective for short-term exposures in asthmatics per Hesterberg et al. (2009). If sensitive individuals are present at the camp worker location or the fenceline during periods when ambient NO_2 concentrations exceed the screening value, it is possible that they could experience minor irritation of the respiratory system. These effects would be reversible and would subside after exposure.

Additionally, as reported in Health Canada (2016b), both the WHO and US EPA concluded that healthy individuals do not experience any adverse effects at concentrations up to 1 ppm (or 1880 µg/m^3), and as such would not be affected by short-term exposures to NO_2 at the concentrations predicted for the Project.

Conclusion

Overall, the predicted exceedance of the 1-hour short-term screening value for nitrogen dioxide at the camp worker location (Risk3) and the fenceline would be limited to a small percentage of the time, and any health effects would be reversible and would subside after exposure. The elevated predicted NO_2 concentrations are based on the conservative assumption that backup diesel generators will be used continuously to supply power to support site activities; however, it is anticipated that power will be obtained from the provincial grid during the Project phases. The backup diesel generators make up more than 85% of the NO_2 emission sources, with the remaining coming from vehicle/equipment combustion, propane heaters, and the ISR Plant stacks.

Other strategies to reduce NO_2 emissions will include planning vehicle and equipment routes, to minimize travel distances and limit idling, and employing standard operating procedures for equipment and machinery use, completing regular inspections of equipment machinery to make sure it is in good working order.

Denison has committed to NO_2 monitoring during all Project phases. Monitoring will include monthly collection using passive samplers, and will follow an adaptive management process to identify if (and when) more frequent monitoring would be needed.

Considering the above discussion, NO_2 was not considered for further assessment in the ERA.

Table 3-12: Predicated 1-hr and Annual NO_2 Concentrations at Receptor Locations during all Project Phases and Associated Hazard Quotients

		NO_2 1 hr Air Concentration (µg/m^3)			NO_2 annual Air Concentration (µg/m^3)		
Location	**Name**	**Construction**	**Operation**	**Decommissioning**	**Construction**	**Operation**	**Decommissioning**
On-Site Ecological Location	Risk1	**124.3**	**116.3**	**120.9**	8.3	4.4	7.1
Recreational Fisher/Trapper (LA1) - McGowan Lake	Risk2	43.0	40.2	41.6	4.7	4.0	4.6
Camp Worker	Risk3	**181.0**	**274.8**	**355.1**	17.1	11.3	16.4
Seasonal Resident (Russell Lake)	Risk4	22.9	24.0	22.7	4.0	3.8	4.0
Reference Receptor (LA-7)	Risk5	40.2	43.2	39.0	4.2	3.9	4.2
Fenceline	-	**176.5**	**177.7**	**177.7**	6.8	4.4	6.6
	CAAQS	**79.0**	**79.0**	**79.0**	**23.0**	**23.0**	**23.0**
		NO_2 1 hr Hazard Quotient			**NO_2 annual Hazard Quotient**		
Location	**Name**	**Construction**	**Operation**	**Decommissioning**	**Construction**	**Operation**	**Decommissioning**
On-Site Ecological Location	Risk1	**1.6**	**1.5**	**1.5**	0.4	0.2	0.3
Recreational Fisher/Trapper (LA1) - McGowan Lake	Risk2	0.5	0.5	0.5	0.2	0.2	0.2
Camp Worker	Risk3	**2.3**	**3.5**	**4.5**	0.7	0.5	0.7
Seasonal Resident (Russell Lake)	Risk4	0.3	0.3	0.3	0.2	0.2	0.2
Reference Receptor (LA-7)	Risk5	0.5	0.5	0.5	0.2	0.2	0.2
Fenceline	-	**2.2**	**2.2**	**2.2**	0.3	0.2	0.3

Notes:
Bold and shaded values indicate exceedance of the CAAQS. Hazard quotients greater than 1 are bold and shaded.
Air concentrations are obtained from EIS Section 6, Appendix 6-A.

3.2.1.3.2 Particulate Matter

Particulate matter is defined as liquid or solid particles, or a mixture of both, less than 100 µm in diameter. Particulate matter includes TSP, particulate matter less that 10 µm (PM_{10}), and particulate matter less than 2.5 µm ($PM_{2.5}$). Particulate matter in the form of TSP, PM_{10}, $PM_{2.5}$, and TSP deposition were screened. Screening values were based on 24-hour and annual averaging periods for TSP, and a 24-hour averaging period for PM_{10}. No exceedances of $PM_{2.5}$ are predicted.

3.2.1.3.2.1 Total Suspended Particulates

Screening values were available for 24-hour and annual averaging periods for TSP. The exceedances are summarized below, followed by a discussion of the critical effects upon which the screening values were based and an overall conclusion related to whether TSP was ultimately retained for further evaluation in the ERA.

Summary of Exceedances at Human/Ecological Locations

- 24-hour: During the Construction, Operation and Decommissioning phases of the project, the camp worker location (Risk3) had predicted 24-hour TSP concentrations that exceeded the screening value. Compared to the 24-hour TSP screening value of 100 µg/m^3, concentrations ranged up to 286 µg/m^3 during Construction, 124 µg/m^3 during Operation, and 135 µg/m^3 during Decommissioning. The frequency of exceedance ranged from 30% during Construction, to 2.2% and 1.6% for Operation and Decommissioning, respectively.

- There were no exceedances of the annual screening value at any human or ecological locations for any phase of the project.

Summary of Exceedances at the Fenceline

- 24-hour: During the Construction, Operation and Decommissioning phases of the project, 24-hour TSP concentrations were predicted to exceed the screening value at the fenceline. Compared to the 24-hour TSP screening value of 100 µg/m^3, concentrations ranged up to 313 µg/m^3 during Construction, 281 µg/m^3 during Operation, and 115 µg/m^3 during Decommissioning. The frequency of exceedance ranged from 29% during Construction and 22% during Operation, to 0.5% for Decommissioning.

Health/Environmental Effect(s) for Short-term and Long-term Exposures

- The 24-hour screening value of 100 µg/m^3 for TSP is an ambient air quality standard cited by both Saskatchewan and Alberta. The 24-hour ambient air quality objective is based on potential adverse pulmonary effects (Alberta, 2021). A higher 24-hour effects-based screening value of 120 µg/m^3 for TSP in ambient air is available from Ontario. The Ontario 24-hour and annual ambient air quality criteria (OAAQC) are meant to be protective of chronic effects. Ontario identifies visibility as the sensitive endpoint for the TSP OAAQC rather than human or ecological health. Elevated TSP concentrations are generally not considered to pose significant health risks because these particles are too large to be inhaled deep into the lungs; therefore, TSP was not considered for further assessment in the ERA.

Discussion and Conclusion

As described above, TSP particles are too large to be inhaled deep into the lungs and the air quality objectives for TSP are generally based on an aesthetic endpoint (visibility) rather than a health endpoint. As such, TSP was not considered further in the ERA.

3.2.1.3.2.2 Fine Particulate Matter (PM_{10})

Screening values were available for the 24-hour averaging period for PM_{10}.

<u>Summary of Exceedances at Human/Ecological Locations</u>

- 24-hour: During the Construction, Operation and Decommissioning phases of the project, the camp worker location (Risk3) had predicted 24-hour PM_{10} concentrations that exceeded the screening value. Compared to the 24-hour PM_{10} screening value of 50 µg/m^3, concentrations ranged up to 136 µg/m^3 during Construction, 57.0 µg/m^3 during Operation, and 61.1 µg/m^3 during Decommissioning. The frequency of exceedance ranged from 21% during Construction, to 1.1% and 1.6% for Operation and Decommissioning, respectively.

<u>Summary of Exceedances at the Fenceline</u>

- 24-hour: During the Construction and Operation phases of the project, 24-hour PM_{10} concentrations had predicted concentrations exceeding the screening value at the fenceline. Compared to the 24-hour TSP screening value of 50 µg/m^3, concentrations ranged up to 116 µg/m^3 during Construction and 104 µg/m^3 during Operation. The frequency of exceedance ranged from 17% during Construction to 12% for Operation.

<u>Health/Environmental Effect(s) for Short-term and Long-term Exposures</u>

- Human health has been shown to be the most sensitive receptor for exposure to PM_{10} in ambient air (Health Canada, 1998). Exposure to elevated concentrations of PM_{10} are associated with various respiratory and cardiovascular effects in humans. The finer particles that can be inhaled deeply into the lungs (i.e., $PM_{2.5}$) are associated with greater risk because they are more chemically active and have more complex characteristics than larger particles (Health Canada, 2016c). For example, WHO has derived its particulate matter guidelines on $PM_{2.5}$, and its guidelines for PM_{10}, assuming that 50% of PM_{10} is present as $PM_{2.5}$ (i.e., the criteria for $PM_{2.5}$ are multiplied by 2)(WHO, 2006). If individuals are present during short-term periods of elevated PM_{10} and/or $PM_{2.5}$, they may experience respiratory symptoms such as coughing or difficulty breathing, or asthma symptoms and chronic bronchitis. For most individuals, effects would be reversible and would subside after exposure.

<u>Discussion and Conclusion</u>

Overall, exceedances of the 24-hour short-term screening values for PM_{10} were identified at the camp worker location during Construction, Operation and Decommissioning, with infrequent exceedances occurring during Operation and Decommissioning. Exceedances of the 24-hour short-term screening values were also identified at the fenceline during Construction and Operation. There were no exceedances of $PM_{2.5}$ which is generally considered to be a more reliable indicator of potential health effects. However, health effects would be infrequent and reversible, subsiding after exposure; therefore, PM_{10} was not considered for further quantitative assessment in the ERA.

3.2.1.3.3 Uranium

<u>Summary of Exceedances at Human/Ecological Locations</u>

- 24-hour: During the Operation phase, the on-site ecological location (Risk1) and the camp worker location (risk3) both had predicted 24-hour uranium concentrations that exceeded the screening value. Compared to the 24-hour screening value of 0.15 µg/m^3, concentrations ranged up to 0.26 µg/m^3 at the on-site ecological location and 0.208 µg/m^3 at the camp worker location, with the frequency of exceedance at 4.7% and 2.2%, respectively. The published 24-hour criterion for uranium is converted from the annual criterion to allow for assessment of the 24-hour data.

- Annual: During the Operation phase, the on-site ecological location (Risk 1) had a predicted annual uranium concentration of 0.0345 µg/m^3 which slightly exceeds its screening value of 0.03 µg/m^3.

Summary of Exceedances at the Fenceline

- 24-hour: During the Operation phase, the fenceline had predicted 24-hour uranium concentrations that exceeded the screening value. Compared to the 24-hour screening value of 0.15 µg/m^3, concentrations ranged up to 0.223 µg/m^3 with a frequency of exceedance of 0.8%.

Health/Environmental Effect(s) for Short-term and Long-term Exposures

- Uranium can be toxic to humans due to its chemical and radiological properties. The ambient air quality criteria for uranium (Ontario MOE, 2011) are based on non-radiological effects; kidney toxicity was the most sensitive endpoint associated with chronic exposure to uranium in air.

Discussion and Conclusion

The health effects associated with uranium (kidney toxicity) are linked to chronic exposures. However, there were no exceedances of the annual screening value at any potential human receptor location. Exceedances of the short-term, 24-hour screening value were identified at the camp worker location (Risk3) and the fenceline. However, these exceedances were infrequent, and as such uranium was not retained for further consideration in the ERA.

Uranium concentrations exceeded both the 24-hour and annual screening values at the on-site ecological location (Risk1). Given its exceedance of an annual screening value and that uranium is a metal and persistent in the environment, there is the potential that long-term generation of uranium in dust may contribute to deposition onto soil and subsequent uptake into the food chain. This pathway was assessed in Section 3.2.1.5 related to the screening of COPCs in soil.

3.2.1.4 Constituents of Potential Concern in Air

There were no non-radiological COPCs identified for further quantitative assessment in the air pathway. The secondary screening of NO_2, PM_{10} and uranium indicated that although there are exceedances of air quality screening values, these constituents are unlikely to be associated with a human health or environmental risk and as such were not carried forward as COPCs in air.

The only COPCs identified for air include radionuclides and radon due to public interest and not due to exceeding a screening value.

3.2.1.5 Constituents of Potential Concern in Soil

No specific COPCs were retained from the screening of atmospheric constituents; however, as a secondary check, mine-related metals which could potentially partition from air to soil were further assessed in terms of concentration in soil (Table 3-13).

The soil type selected for modeling of deposition to soil is sandy soil, consistent with baseline studies that describe sandy and gravelly Podzols, Brunisols, and Luvisols occurring on till materials, while sand and sandy loam Brunisols have developed on glaciofluvial deposits (Omnia, 2020).

Predicted soil concentrations were estimated from atmospheric deposition, using the maximum air concentrations at the on-site ecological receptor location (Table 3-14), along with constituent-specific deposition rates, according to the equations defined in the IMPACT Model Report (Appendix A, Section 2.3.4, Terrestrial Pathways). The on-site ecological receptor location has the highest concentration of metals in air compared to other locations assessed, and represents a worst-case location for deposition modelling.

Predicted maximum concentrations of constituents in soil from atmospheric deposition were compared against soil quality guidelines. The selected soil quality guidelines were the federal CCME (CCME, 1999b) soil quality guidelines for protection of human health and environmental health. Agricultural soil quality values were used, because these guidelines account for soil to plant uptake and ingestion of plants by birds and mammals. As shown in Table 3-13, all predicted soil concentrations were below the CCME soil quality guidelines. As such, no additional COPCs were identified for further quantitative assessment in the ERA based on the soil pathway. However, considering the multi-media pathways analysis, all terrestrial pathways (other than air inhalation) were considered further for the COPCs identified in the aquatic environment.

A summary of the maximum modelled concentrations at human and ecological receptor locations of interest is shown in Table 3-14.

Table 3-13: Soil Quality Screening for the Wheeler River ERA

Parameter	Maximum Predicted Air Concentrations [(a)]	Maximum Predicted Soil Concentration from Atmospheric Deposition[(b)]	Soil Screening Guideline[(c)]				Is Concentration Greater than Selected Screening Value? (Y/N)
			Agricultural	Residential/ Parkland	Commercial	Industrial	
Non-radionuclides	**µg/m³**	**mg/kg dw**	**mg/kg dw**	**mg/kg dw**	**mg/kg dw**	**mg/kg dw**	
Arsenic	7.12E-04	0.62	**12**	12	12	12	N
Cadmium	7.75E-05	0.36	**1.4**	10	22	22	N
Chromium	1.93E-04	3.31	**64**	64	87	87	N
Cobalt	7.22E-04	0.27	**40**	50	300	300	N
Copper	6.38E-02	1.51	**63**	63	91	91	N
Lead	3.89E-03	2.98	**70**	140	260	600	N
Molybdenum	7.34E-04	0.12	**5**	10	40	40	N
Nickel	4.41E-04	1.00	**45**	45	89	89	N
Selenium	1.61E-04	0.11	**1**	1	2.9	2.9	N
Uranium	3.45E-02	2.89	**23**	23	33	300	N
Vanadium	1.51E-03	4.82	**130**	130	130	130	N
Zinc	2.16E-01	5.33	**250**	250	410	410	N

Bold indicates soil guideline value selected for this assessment.
a) Maximum annual average concentrations out of all human/ecological receptor locations from CALPUFF (EIS Section 6).
b) Maximum soil concentrations estimated from maximum annual air concentrations in Table 3-14 of the HHRA and constituent-specific deposition rates in IMPACT.
c) (CCME, 1999b)
N = no; Y = yes; dw = dry weight.

Table 3-14: Maximum Concentration of COPCs in Air and Soil – Project Phases

Environmental Media	Location	Maximum Concentration of Non-radionuclides during Project Phases										
		Arsenic	Cadmium	Chloride	Cobalt	Chromium	Copper	Molybdenum	Sulphate	Selenium	Uranium	Zinc
Air (mg/m³)	Reference Location	7.00E-07	7.44E-08	n/a	7.07E-07	1.49E-07	6.30E-05	7.19E-07	n/a	1.54E-07	6.00E-07	2.16E-04
	Camp Location	7.05E-07	7.58E-08	n/a	7.14E-07	1.68E-07	6.33E-05	7.25E-07	n/a	1.57E-07	1.77E-05	2.16E-04
	Ecological On-site	7.12E-07	7.75E-08	n/a	7.22E-07	1.93E-07	6.38E-05	7.34E-07	n/a	1.61E-07	3.45E-05	2.16E-04
	McGowan Lake	7.01E-07	7.49E-08	n/a	7.09E-07	1.56E-07	6.31E-05	7.20E-07	n/a	1.55E-07	6.65E-06	2.16E-04
	Russell Lake Inlet	7.00E-07	7.45E-08	n/a	7.07E-07	1.50E-07	6.30E-05	7.19E-07	n/a	1.54E-07	1.79E-06	2.16E-04
Soil (mg/kg dw)	Reference Location	6.16E-01	3.61E-01	n/a	2.65E-01	3.31E+00	1.46E+00	1.15E-01	n/a	1.07E-01	3.82E-01	5.31E+00
	Camp Location	6.16E-01	3.61E-01	n/a	2.66E-01	3.31E+00	1.48E+00	1.15E-01	n/a	1.07E-01	1.68E+00	5.32E+00
	Ecological On-site	6.16E-01	3.61E-01	n/a	2.67E-01	3.31E+00	1.51E+00	1.15E-01	n/a	1.08E-01	2.89E+00	5.33E+00
	McGowan Lake	6.16E-01	3.61E-01	n/a	2.65E-01	3.31E+00	1.46E+00	1.15E-01	n/a	1.07E-01	8.30E-01	5.31E+00
	Russell Lake Inlet	6.16E-01	3.61E-01	n/a	2.65E-01	3.31E+00	1.46E+00	1.15E-01	n/a	1.07E-01	4.70E-01	5.31E+00

Environmental Media	Location	Maximum Concentration of Radionuclides during Project Phases						
		Uranium-238	Uranium-234	Thorium-230	Radium-226	Radon-222	Lead-210	Polonium-210
Air (Bq/m³)	Reference Location	7.41E-06	7.41E-06	n/a	n/a	0.00E+00	n/a	n/a
	Camp Location	2.19E-04	2.19E-04	n/a	n/a	1.24E+01	n/a	n/a
	Ecological On-site	4.26E-04	4.26E-04	n/a	n/a	3.61E+01	n/a	n/a
	McGowan Lake	8.22E-05	8.22E-05	n/a	n/a	2.50E+00	n/a	n/a
	Russell Lake Inlet	2.21E-05	2.21E-05	n/a	n/a	5.92E-01	n/a	n/a
Soil (Bq/kg dw)	Reference Location	4.72E+00	4.72E+00	2.00E+01	1.52E+01	n/a	7.29E+01	6.55E+01
	Camp Location	2.08E+01	2.08E+01	2.00E+01	1.52E+01	n/a	7.29E+01	6.55E+01
	Ecological On-site	3.57E+01	3.57E+01	2.00E+01	1.52E+01	n/a	7.29E+01	6.55E+01
	McGowan Lake	1.03E+01	1.03E+01	2.00E+01	1.52E+01	n/a	7.29E+01	6.55E+01
	Russell Lake Inlet	5.81E+00	5.81E+00	2.00E+01	1.52E+01	n/a	7.29E+01	6.55E+01

n/a = not applicable

3.3 Final List of Constituents of Potential Concern

Based on evaluation of aqueous and atmospheric sources, including a conservative screening of maximum predicted concentrations in surface water, sediment, air and soil, the final list of COPCs to be evaluated further in the HHRA and EcoRA is presented in Table 3-15.

No specific COPCs were identified in air for further quantitative assessment in the ERA; however, to be sure exposures were not underestimated in the multi-media pathways analysis, evaluation of potential human and ecological health risk via indirect exposures such as air to soil deposition, soil contact and exposure through the food chain was included for all COPCs identified in water.

Table 3-15: Final List of Constituents of Potential Concern for Wheeler River Environmental Risk Assessment

Major Ions	Physical Media where Guideline Exceeded
Chloride	Water
Sulphate	Water
Metals and Metalloids	
Arsenic	Water
Cadmium	Water
Chromium	Water
Cobalt	Water
Copper	Water
Molybdenum	Water, Sediment
Selenium	Water, Sediment
Uranium	Water
Vanadium	Sediment
Zinc	Water
Radionuclides	
Uranium-238	All pathways (based on public concern)
Uranium-234	All pathways (based on public concern)
Thorium-230	All pathways (based on public concern)
Radium-226	All pathways (based on public concern)
Radon-222	Air only
Lead-210	All pathways (based on public concern)
Polonium-210	All pathways (based on public concern)

COPC = constituent of potential concern.

4.0 Human Health Risk Assessment

The components of a human health risk assessment (HHRA) include: Problem Formulation (Section 4.1); Exposure Assessment (Section 4.2); Toxicity Assessment (Section 4.3); and Risk Characterization (Section 4.4).

4.1 Problem Formulation

The intent of the problem formulation for an HHRA is to define the goals of the risk assessment, develop an understanding of site conditions, and develop working hypotheses as to how potential exposure of people to constituents may result in potential risks to human health. The assessment endpoint of interest for the HHRA is the health of individual humans.

The problem formulation for this HHRA:

- Identifies COPCs for human health risks;
- Identifies and characterizes non-nuclear energy workers and other members of the public who may frequent the site, and the human health receptor groups that represent them in the ERA; and
- Identifies the complete exposure pathways by which the COPCs may affect the human health receptors in a conceptual site model.

The conceptual site model for the HHRA summarizes the links between constituent sources, exposure pathways, and receptors of concern.

4.1.1 Indigenous and Local Knowledge

Indigenous and Local Knowledge was used to inform assumptions for human health receptors (i.e., people) who consume Traditional Foods in terms of their locations, residency times, components, and quantities of the Traditional Foods diet.

The following studies and reports were reviewed to inform assumptions:

- Kineepik Métis Local (KML) and Northern Village of Pinehouse Lake (NVP). 2022a. Kineepik Métis Local #9 Kineepik Valued Ecosystem Components. KML Pre-statement for Denison EIS (KML and NVP, 2022a).
- Kineepik Métis Local and Northern Village of Pinehouse Lake. 2022b. Response to the Environment Impact Assessment. For the Proposed Ministry of Highways 914 Extension Project. Submitted February 11, 2022 (KML and NVP, 2022b).
- English River First Nation (ERFN) and Shared Value Solutions (SVS). 2022a. Wheeler River Project – Summary of Health and Socio-Economy Study Results – English River First Nation. Shared Value Solutions. Prepared for English River First Nation. March 2022 (ERFN and SVS, 2022a).

- English River First Nation and Shared Value Solutions. 2022b. Wheeler River Project – Summary of Traditional Knowledge Study Results – English River First Nation. Shared Value Solutions. Prepared for English River First Nation. March 2022 (ERFN and SVS, 2022b).

- CanNorth. 2017. English River First Nation Country Foods Study – Final Report (Project No. 2147). Canada North Environmental Services Limited Partnership (CanNorth, 2017).

- English River First Nation. 2011. English River First Nation, Aboriginal Traditional Knowledge Summary Report. Compiled by Environment Canada, September 2011 (ERFN, 2011).

- Ya'thi Néné Lands and Resources Office (YNLRO). 2022. An Exploration of Recorded Athabasca Denesųłine Traditional Knowledge, Land Use, and Occupancy Study in the Vicinity of Denison Mines Wheeler River Project. March 2022 (YNLRO, 2022).

A number of these studies including YNLRO (2022), ERFN and SVS (2022a, 2022b), and CanNorth (2017) provided guidance for identifying locations where people may reside, areas where traditional foods are hunted, fished, and gathered, and mammal, bird, and plant species that are traditionally used by local Indigenous communities for food, medicine, and other traditional uses. Additionally, available land use maps and information about local cabin locations was used to inform receptor locations as well as receptor types, and specific engagement activities (e.g., formal and informal engagement meetings with one or more community members) were used to better incorporate LK into the assessment of human health. Other sources of engagement included:

- Key Person Interview Program (KPI Program). 2018. ERFN Patuanak Reserve workshop conducted by Denison Mines. May 3, 2018 (KPI Program, 2018).

- Key Person Interview Program (KPI Program). 2019. Interview with the English River First Nation trapper conducted by Denison Mines. October 29, 2019. Notes finalized January 2, 2020 (KPI Program, 2019).

- Key Person Interview Program (KPI Program). 2020. Cabin owner survey conducted by Denison Mines. February 14–24, 2020 (KPI Program, 2020).

Information regarding IK and LK was primarily available for two Indigenous communities:

- English River First Nation; and

- Kineepik Métis Local 9.

4.1.2 Human Receptor Selection and Characterization

The human receptors for the HHRA were selected and characterized to represent potential exposures from both radiological and non-radiological COPCs. Human receptors would potentially be exposed to low levels of airborne or waterborne constituents being released during Project activities.

Nuclear Energy Workers (NEWs) and other workers on-Site (ISR mine and processing plant) are not addressed for the radiological assessment because their radiation exposure is monitored and their doses are controlled through a Radiation Protection Program. They are protected from non-radiological exposures through the Health and Safety Program. However, workers at the Denison Mine Camp (non-NEWs) will be assessed for both radiological and non-radiological exposures. This approach is consistent with CSA N288.6-22 (CSA, 2022) .

Recreational land users (fishers, hunters, firewood gatherers) and seasonal residents (visitors and lodge operators) may be present in the LSA and RSA for part of the year. The presence of industrial leases in the LSA and RSA suggest that workers may be present within the study area. The non-NEW workers at the Denison Mine residing part of the year at Denison's camp would be subject to the highest levels of exposures to COPCs from the operation given their close proximity to the source.

No permanent communities or residences have been identified within the LSA and RSA. Although it is not expected that individuals are present who harvest traditional foods from the area for subsistence on a permanent basis, individuals who hunt and/or fish are known to use the area and depend on a higher proportion of country foods in their diet than the general regional population. Therefore, an adult fisher/trapper receptor has been included in the assessment during all Project phases. The residency and dietary assumptions for the fisher/trapper, and for the recreational fisher/hunter, have been developed through engagement with communities during the EA process.

For the purposes of the assessment, a future permanent resident has been included as a conservative assumption that would cover off other types of receptors for post-decommissioning.

Human receptors are assumed to be in the project area during all phases of the project, with the exception of the Camp Worker which will be replaced by a Permanent Resident during the future centuries after all Project phases.

In summary, human receptors for the Project include:

- camp worker during all Project phases;
- seasonal resident during all Project phases;
- recreational fisher/hunter during all Project phases;
- fisher/trapper during all Project phases; and,
- future permanent resident in the future centuries.

During Post-Decommissioning, the Project area could be accessed intermittently by members of the public for various land use purposes. Any risks to these members of the public would be less than those assessed for the camp worker and therefore additional on-site receptors were not assessed during Post-Decommissioning.

4.1.2.1 Camp Worker

The camp worker is a non-NEW worker such as a camp cook. A camp worker is an adult male or female. This receptor group is assumed to work and reside at the Denison camp for 50% of the year and away from the site for the other 50% of the year, based on a two-weeks in and two-weeks out schedule. The camp worker would be present during construction, operation, decommissioning and post-decommissioning phases.

It is assumed that a camp worker will occasionally consume traditional foods and will hunt, fish or gather berries/plants in the area during operation. Drinking water and water for bathing would be obtained from local groundwater and surface water sources. A camp worker could come in direct contact with surface water through swimming, and with sediments through activities such as wading. Finally, a camp worker would be exposed to project related COPCs through inhalation of air and dermal contact with and/or incidental ingestion of dust deposited to soil.

4.1.2.2 Seasonal Resident

Seasonal residents are adults and one-year-olds (male and female), who would visit and reside in the area for part of the year, every year, during all project phases. Their residence during that time would be at the nearest reasonable location to the site. As indicated in Section 2.3, potential recreational leases occur at Russell Lake, McGowan Lake and Whitefish Lake North, with the majority surrounding Russell Lake (Denison, 2019), and traditional land use within the LSA and RSA also includes camping near Russell Lake. Therefore, the nearest reasonable location to the site for seasonal residents could be Russell Lake. The seasonal residents may be assumed to reside at a lodge on Russell Lake for three months of the year during the tourist season, or approximately 30% of the year.

While at Russell Lake, seasonal residents may ingest local country foods fished, hunted and gathered in the vicinity of Russell Lake as part of their diet while residing in the area. While at the lodge, water for drinking, bathing and swimming would be obtained from Russell Lake. The seasonal resident could come in contact with the surface water of Russell Lake while swimming, and with sediments during the practice of activities such as wading. Finally, a seasonal resident may be exposed to project related COPCs through inhalation of air and dermal contact and/or incidental ingestion of dust deposited to soil.

4.1.2.3 Recreational Fisher/Hunter

Recreational fishers/hunters are adults, male and female, who would visit and reside in the area for part of the year, every year, during all project phases. Traditional land uses that have been identified from available Traditional Land Use studies include hunting (large game and game birds), fishing, and firewood gathering. The traditional land use activities closest to the Project site are reported to occur in the Russell Lake area. Land use activities have also been reported further west, outside the RSA, near the MacIntyre Lake and Holgar Lake areas, which are representative of background environmental conditions. These regions have also been identified as overnight tent sites (ERFN and SVS, 2022b; YNLRO, 2022). Additionally, a potential recreational lease has been identified at McGowan Lake. A survey conducted by Denison determined a number of cabins used by local residents for recreational and outfitting/guiding purposes (KPI Program, 2020).

Traditional land use studies of the region around the Project site identified two camps considered by local Indigenous groups to be important locations for the facilitation of traditional land-based activities and Indigenous Knowledge transfer. These camps include:

- The ERFN culture camp, located approximately 85 km southwest of Russell Lake. This camp is an area where recreational activities occur, in addition to youth education activities, traditional Indigenous games and activities, and contemporary gathering.

- The Kineepik Metis (Pinehouse) camp, located approximately 67 km north of the village of Pinehouse. This camp is situated in an area where hunting, fishing and harvesting of country foods is commonly reportedly.

The two camps are situated well beyond the boundaries of the RSA; therefore, it is expected that the recreational fisher/hunter receptor will represent a highly conservative assessment of potential risk for Indigenous peoples engaging in traditional land-based activities at these culturally-significant camp sites.

Recreational fishers/hunters may ingest local country foods fished, hunted and gathered at and near Russell Lake or McGowan Lake; therefore, two recreational fishers/hunters were identified – one at McGowan Lake and one at Russell Lake.

They may also conserve local country foods collected from the area for consumption with their family throughout the year; therefore, a one-year old is also assessed. While at the lodge, water for drinking, bathing and swimming would be obtained from Russell Lake or McGowan Lake. The recreational fisher/hunter may come in contact with surface waters of Russell Lake or McGowan Lake while swimming, and with sediments during the practice of activities such as wading. In comparison to a seasonal resident, a recreational fisher/hunter would spend approximately the same amount of time annually in the study area, but obtain a higher portion of local country foods in their overall annual diet from the study area. Finally, a recreational fisher/hunter may be exposed to project related COPCs through inhalation of air and dermal contact and/or incidental ingestion of dust deposited to soil. The recreational fishers/hunters are assumed to reside at the exposure locations for approximately 30% of the year, as indicated in Table 4-2 in Section 4.2.1.

The Wheeler River is considered both culturally and economically important to ERFN, and is an area where traditional land activities such as hunting, fishing and trapping occur year-round.

Members of ERFN have expressed the importance of protecting the area and managing impacts to the environment to protect the ability for Indigenous residents to continue to engage in traditional land activities (ERFN and SVS, 2022a). The recreational fisher/hunter receptor is expected to adequately represent the traditional land uses identified in the Traditional Land Use studies, and to capture any potential risk to local Indigenous and non-Indigenous hunters and fishers.

4.1.2.4 Fisher/Trapper

The adult fisher/trapper represents a member of the public who lives in the region year-round and regularly consumes local country foods and water. The fisher/trapper will be assessed for all project phases. Assumptions made about the fisher/trapper receptor were formed following consultation with local Indigenous community members. Denison recognizes that ERFN considers the fisher/trapper's use of the area as representative of current and future land users and expects that their relationship to the Project Area will be continued and strengthened through generations of future use.

The residency characteristics of the fisher/trapper have been developed from resource use information collected from a local trapper. The local fisher/trapper had:

- A primary cabin along the Wheeler River upstream of its confluence with Moon Creek at Bobby's Pond (represented by Reference conditions);
- A secondary cabin at Russell Lake (which is downstream of the Icelander Creek drainage and represents a far-field exposure location); and,
- Two other minor residences away from the Project area (represented by Reference conditions).

For assessment purposes, it is assumed that the fisher/trapper spends 6 months of the year at a primary residence (a reference location) and the other 6 months of the year at a secondary residence on Russell Lake. Subsistence hunting is assumed to occur while at both cabin locations. While at the Russell Lake cabin, the fisher/trapper is assumed to hunt mallard ducks as indicated by the resource use information. In contrast to the resource use information which suggests that subsistence fishing would occur at multiple locations including Russell Lake and reference lakes in the Project area, it was conservatively assumed that 100% of the fish in the fisher/trapper's diet would be from the far-field exposure location at Russell Lake and no fish would be from the Reference location.

In comparison to the other adult human receptor groups, the fisher/trapper consumes a greater proportion of country game and fish in his diet annually. The fisher/trapper is assumed to consume local country foods and store foods in equal proportions on an annual basis. Country game meats and fish sources are assumed to be equally distributed in the diet, each representing approximately 25% of the annual diet based on fresh weight.

Similar to the recreational fisher/hunter, the fisher/trapper receptor is expected to sufficiently represent the traditional land uses recognized in the Traditional Land Use studies, and to capture any potential risk to local Indigenous community members who live in the region year-round, regularly partake in land-based traditional activities, and frequently consume a higher proportion of traditional foods in their diet.

4.1.2.5 Future Permanent Resident

The future permanent resident is a hypothetical adult and one-year-old (male or female) who would reside full time at the Denison camp site after the post-decommissioning phase has been fully implemented, during the future centuries. Currently, there are no permanent residents or communities within 150 km of the Project Area.

Permanent residents would have a diet similar to that of the seasonal resident and the recreational fisher but would ingest a high proportion of local country foods fished, hunted and gathered in the area because of their full-time residency in the Project area. Local country foods would likely be sourced from drainages affected and not affected by the former operation. Drinking water and water for bathing would be obtained from a local surface water source, such as Whitefish Lake Middle and Whitefish Lake South. A permanent resident could come in direct contact with surface water through swimming, and with sediments through the practice of activities such as wading. It is anticipated that a permanent resident would not be exposed to project related COPCs through inhalation of air after decommissioning; however, they could be exposed by dermal contact and/or incidental ingestion of dust deposited to soil for some time after decommissioning. Assumptions for a permanent resident after decommissioning should be refined near the time of decommissioning with community input where possible.

4.1.3 Selection of Chemical, Radiological, and Other Stressors

The selection of COPCs retained for the HHRA is presented in Section 3.0 of this report. The selection of chemical stressors to be evaluated in the HHRA followed a tiered screening approach to reduce the risk of overlooking Project-related COPCs relevant to human health that would be emitted through water and air.

The screening involved a conservative process of comparing the expected treated effluent quality against the selected water quality guidelines protective of human health (refer to Table 3-1 in Section 3.0). While chloride and sulphate were identified as COPCs for further assessment in the ERA, they are not considered further in the HHRA. These COPCs are associated with water ingestion. Chloride does not have a drinking water standard and is not considered to present a risk to human health at concentrations found in drinking water or at concentrations predicted for Whitefish Lake (LA-5). Sulphate in drinking water is associated with adverse physiological effects such as diarrhoea or dehydration at concentrations above 500 mg/L. The predicted maximum concentration of sulphate in LA-5 is 58 mg/L (Table 3-3), which is below 500 mg/L; therefore, concentrations at exposure points farther downstream would be less than those associated with adverse physiological effects. For these reasons, chloride and sulphate were not assessed further in the HHRA.

No formal screening was conducted for radionuclides. However, since radiation dose to human receptors is of public and regulatory interest, the radionuclides in the uranium-238 decay series are carried forward as COPCs for further assessment.

No specific COPCs were identified in air for further quantitative assessment in the ERA; however, to be sure exposures were not underestimated in the multi-media pathways analysis, evaluation of potential human health risk via indirect exposures such as air to soil deposition, soil contact and exposure through the food chain was included for all COPCs identified in water. Exposure to constituents that may deposit from air to surface water was not considered, as that pathway is considered negligible according to CSA N288.1-20.

4.1.4 Selection of Exposure Pathways

The potential exposure pathways are expected to be the same for most human receptors. Exposure pathways for human receptors are summarized in Table 4-1.

Table 4-1: Summary of Human Health Exposure Pathways

Human Receptor Group	Environmental Exposure Pathway				
	Air	Soil	Water	Sediment	Traditional Foods
Camp Worker	Inhalation[(a)]	Direct contact Incidental ingestion	Direct contact Ingestion	Direct contact Incidental ingestion	Ingestion
Seasonal Resident	Inhalation[(a)]	Direct contact Incidental ingestion	Direct contact Ingestion	Direct contact Incidental ingestion	Ingestion
Recreational Fisher/ Hunter	Inhalation[(a)]	Direct contact Incidental ingestion	Direct contact Ingestion	Direct contact Incidental ingestion	Ingestion
Fisher / Trapper	Inhalation[(a)]	Direct contact Incidental ingestion	Direct contact Ingestion	Direct contact Incidental ingestion	Ingestion
Future Permanent Resident	Incomplete Pathway	Direct contact Incidental ingestion	Direct contact Ingestion	Direct contact Incidental ingestion	Ingestion

Note:
(a) Inhalation pathway was only evaluated for radionuclides, as inhalation was not identified as a pathway of concern for non-radionuclides based on the atmospheric screening in Section 3.2.

4.1.4.1 Summary of Complete Exposure Pathways

Radiological and non-radiological exposure pathways were assessed in the HHRA. The primary exposure routes for human health included:

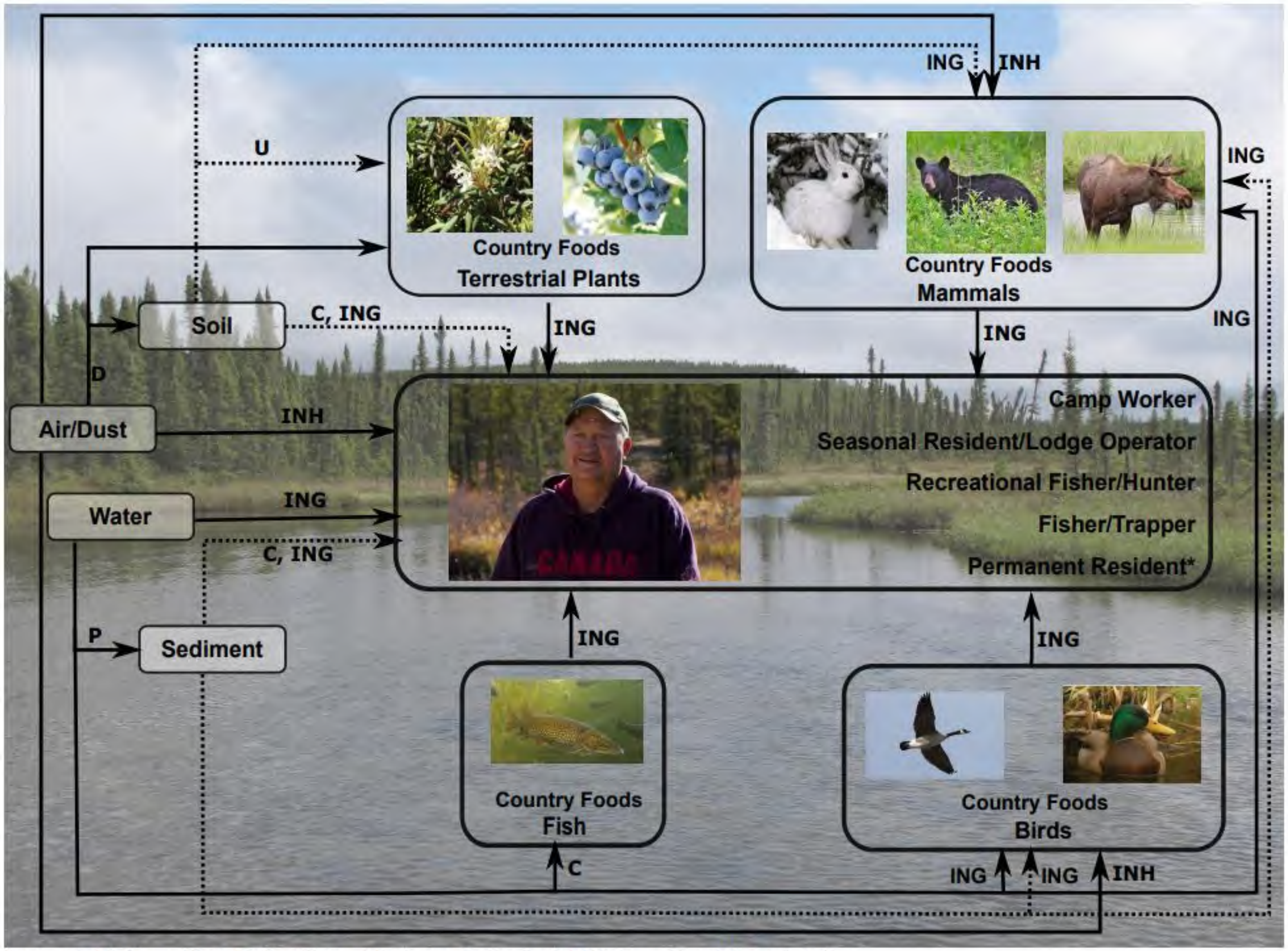
- Inhalation of airborne COPCs (outdoor air) for radionuclides only;

- Dermal contact with soil while gardening or harvesting;
- Ingestion of country foods (e.g., fish, vegetation, game), and ingestion of store-bought foods;
- Ingestion of surface water as drinking water and incidental ingestion during bathing and swimming;
- Incidental ingestion of soil (i.e., while harvesting) or sediment (i.e., while wading);
- Dermal contact with surface water and sediment while swimming or doing other recreational activities; and
- External exposure to radiation from air, water, soil, and sediment.

4.1.5 Human Health Conceptual Site Model

The human health conceptual model illustrates how receptors are exposed to COPCs. It represents the relationship between the source and receptors by identifying the source of constituents, the receptors, and the exposure pathways to be considered in the assessment for each receptor. Exposure pathways represent the various routes by which radionuclides and/or chemicals may enter the body of the receptor, or for radionuclides, how they may exert effects from outside the body.

The complete exposure pathways for the human receptors that are considered in the HHRA are illustrated in Figure 4-1 below.



Legend: D: Deposition; **P:** Partition; **U:** Uptake; **C:** Contact; **ING:** Ingestion; **INH:** Inhalation;
⟶ Exposure pathway from primary media; ┈┈➤ Exposure pathway from secondary media.

* Human Receptors are assumed to be present during all project stages, except the Permanent Resident who is assumed to be present during future centuries.

Figure 4-1: Human Health Conceptual Site Model (CSM) for the Wheeler River Project

Note: Denison would like to gratefully acknowledge the contributions of Bobby John (shown in the centre of this image) to this EIS and extend a thank you to his family for granting permission to use his image herein.

4.1.6 Uncertainty in the Problem Formulation

The assumptions used to characterize human health receptors and develop the conceptual site model followed best industry practices and CSA guidance. Where possible, region-specific information was used to develop initial assumptions for human health receptor groups, locations and frequency, and duration of exposures. Communities and regulators were engaged in the process, which resulted in adjustments to the initial assumptions to better represent affected communities and increase conservatism in areas (such as the Traditional Foods diet) where regional information was scarce.

The selection of Project-related COPCs was based on comparing maximum predicted water, sediment, air, and soil concentrations at the human health receptor locations to relevant environmental guideline concentrations (i.e., screening values). Numerous conservative measures were integrated into the models used to predict COPC concentrations used in the screening process (refer to Appendix A for a discussion of the modelling used to inform the ERA). The predicted concentrations were compared to screening values protective of both human health and ecological biota. There is, therefore, a high level of confidence that the HHRA captures all Project-related COPCs that would be emitted by Project activities to water and air.

4.2 Exposure Assessment

The exposure assessment included identification of exposure locations and exposure factors for each receptor, presentation of exposure concentrations and doses (radiological and non-radiological), and discussion of uncertainties. This section presents at a high-level, the information used in the IMPACT model; however, the details of the model are included in Appendix A.

4.2.1 Exposure Locations, Duration, and Frequency

The selection of exposure locations for human receptors groups was based on current understanding of how people use the LSA and RSA, including Indigenous and Local Knowledge from land use maps, as well as the potential for exposure to Project-related media concentrations during one or more Project phases. Exposure locations are shown in Figure 4-2.

The residency assumptions for human receptors used for the human health risk assessment are summarized in Table 4-2. This includes the fraction of time the receptor spends at a given location as well as the exposure frequency (which refers to the frequency at which the activity causing the exposure occurs). The exposure duration (which refers to the length of time the receptor engages in the activity causing the exposure) was either the duration of the Project phases (30 years) for non-carcinogens, or the lifetime of the receptor (80 years) for carcinogens, except for the camp worker, where only the adult life stage would be relevant for carcinogens.

With the exception of the future permanent resident, all of the human receptors were assumed to spend part of their time away from the LSA and RSA at a location represented in the model by the reference location.

Table 4-2: Summary of Residency Assumptions for Human Health Receptor Groups

Human Health Receptor Group	Age Group(s)	Residence within Study Area	Project Phases	Fraction of Time at Residence/ Reference Location	Exposure Frequency at Residence/Refence Location (months/year)
Camp Worker (such as a cook)	Adult	Whitefish Lake (LA-5)	Construction Operation Decommissioning Post-decommissioning	0.5/0.5	6/6
Recreational Fisher/Hunter	Adult and one-year-old	McGowan Lake (LA-1) Russell Lake	Construction Operation Decommissioning Post-decommissioning Future centuries	0.3/0.7	4/8
Seasonal Resident	Adult and one-year-old	Russell Lake			
Fisher/Trapper	Adult	Russell Lake		0.5/0.5	6/6
Future Permanent Resident	Adult and one-year-old	Whitefish Lake (LA-5)	Future centuries	1	12

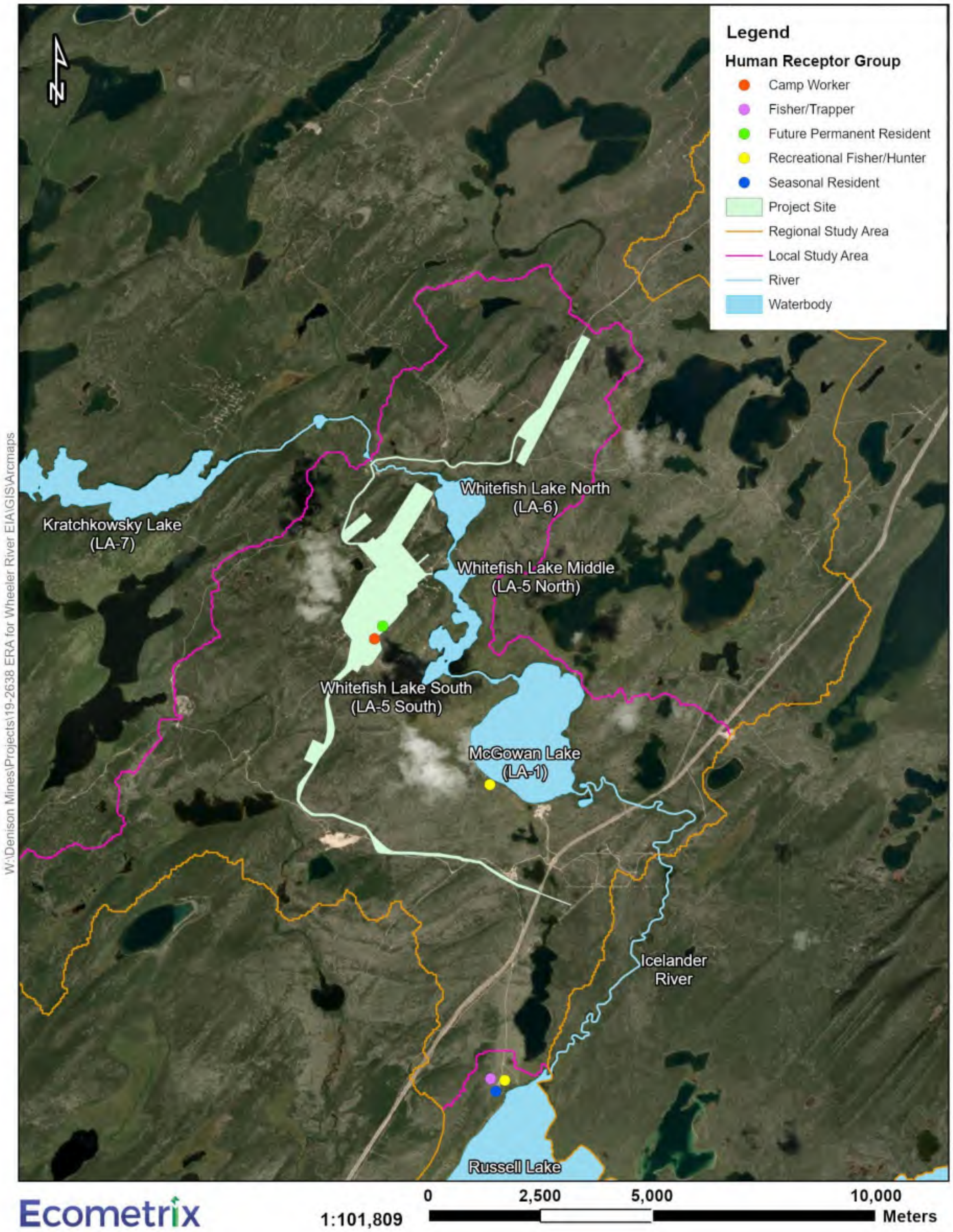


Figure 4-2: Human Receptor Locations for the Wheeler River HHRA

4.2.2 Exposure and Dose Calculations

Exposure and dose calculations for human receptors were completed using IMPACT version 5.6.0. IMPACT is consistent with the COPC transport equations and radiological dose calculations outlined in CSA N288.1-20. Equations used for non-radiological dose calculations are consistent with CSA N288.6-22, which have generally been obtained from Health Canada guidance.

The equations are outlined in the Wheeler River IMPACT Model Report, in Appendix A.

4.2.3 Exposure Factors

Exposure estimates rely on several COPC- and media-specific exposure factors for the dose calculations. These parameters include body characteristics and intake rates as well as exposure duration and frequency (Section 4.2.1, Exposure Locations, Durations, and Frequency) and dose coefficients.

Exposure factors are outlined in detail in the IMPACT Model Report for the Wheeler River Project, Appendix A. Exposure factors including inhalation rates, water, sediment and soil ingestion rates and total food ingestion rates were generally mean values from CSA N288.1-20 (CSA, 2020). Ingestion rates including the Traditional Foods diet are discussed in Section 4.2.4, Human Diet.

Dose coefficients (DCFs) for all internal and external exposure routes for humans are used to estimate radiological exposure. The DCFs for ingestion and inhalation by human receptors were taken from CSA N288.1-20 (CSA, 2020). The external DCFs used in the IMPACT model were derived based on the methods described in N288.1-20. Dose coefficients used in the IMPACT model are provided in Appendix A.

For non-radiological dose calculations relative absorption factors (RAF) were needed. The RAF for soil ingestion was assumed to be 1 for all non-radiological COPCs. The RAFs for soil dermal exposure were COPC specific and generally obtained from Health Canada (Health Canada, 2021b) or Ontario MECP (MECP, 2011).

4.2.3.1 Bioavailability

In general, the IMPACT model was used to calculate exposure doses for arsenic. However, the general assumption in IMPACT is that a COPC is 100% bioavailable from all media types, including food.

Arsenic may be present in the environment in different chemical forms such as arsenopyrite and arsenic trioxide. Some forms of arsenic can be absorbed in the gastrointestinal tract and taken up by plants, while other forms are poorly absorbed.

To account for that uncertainty, and provide a more realistic interpretation of results, the model outputs were amended to incorporate arsenic bioaccessibility into the outputs for moose meat and moose organs, using data collected as part of a study based out of British Columbia (Laird and Chan, 2013). Laird and Chan (2013) collected samples of various types of traditional foods including moose organs (kidney and liver) and moose meat. The mean percent in vitro bioaccessibility (a surrogate for bioavailability) ranged from 7% to 19% for moose organs, and was 59% for moose meat. These bioaccessibilities were incorporated into the exposure assessment by adjusting the model outputs from IMPACT by 0.19 for moose organs and 0.59 for moose meat. The bioaccessibility for moose meat of 0.59 was also applied to caribou meat.

ATSDR indicates that in seafood (i.e., fish), approximately 10% of arsenic is present in the inorganic form, while the remainder is in an organic form (arsenobetaine) that is generally not associated with toxicity (ATSDR, 2007). Therefore, the estimates of exposure generated by IMPACT overestimate arsenic exposure from the fish consumption pathway. As such, the model outputs from IMPACT were adjusted such that the exposure doses from fish were multiplied by a factor of 0.10.

These are reasonable estimates of bioaccessibility and are expected to reduce the uncertainty associated with the risk estimates for those food types. However, 100% bioaccessibility was assumed for the remaining food types (i.e., terrestrial plants, muskrat, mallard, and goose), and as such, exposure and risks for those other food types may be overestimated.

4.2.4 Human Diet

The total human diet is comprised of the portion of the diet obtained from Traditional Foods and the portion of the diet obtained from store bought foods. Traditional Foods are those animals and plants that are fished, hunted, or gathered from the land and consumed as food (Health Canada, 2018).

4.2.4.1 Total Diet

The initial assumptions for ingestion rates and components of the total foods diet for the HHRA were taken from CSA N288.1-20 Adult (Table G.9b – Central) total diet. The CSA N288.1-20 dietary composition was based on the 2004 Canadian nutrition survey results (Health Canada, 2004), processed for International Commission on Radiological Protection (ICRP) age groups and for two sexes in the adult age group. The dietary intakes for ICRP ages were adjusted to align with ICRP reference energy intakes for each age group (ICRP, 2003).

The N288.1-20 human diet was selected over the Health Canada human diet for the HHRA (Health Canada, 2010a). Health Canada references Richardson (Richardson, 1997), which used survey results from the late 1970s. The Richardson diet was also a combined adult male/female diet. The CSA N288.1-20 total adult diet is a smaller overall diet (706 kg/yr) than the Richardson diet (808 kg/yr; by about 100 kg/yr) and is based on more recent data.

Annual food consumption rates for the one-year-old diet were calculated using adult-to-one-year-old ratios from CSA N288.1-20 for each of the selected food categories. Annual ingestion rates for individual food categories were combined into relevant food categories, and the adult-to-one-year-old ratios were determined for each of these food categories.

4.2.4.2 Traditional Foods Diet

Human receptors were assumed to consume lower or higher proportions of Traditional Foods in their overall diets depending on their lifestyles. These are referred to as average Traditional Foods consumers and high Traditional Foods consumers, respectively. In both cases, the proportion of Traditional Foods in the overall diet of human health receptor groups in the HHRA was based on dietary studies from local and Indigenous communities.

The Project is a remote site, with no communities in close proximity. By distance, the closest communities are approximately 150 km away in the northern settlement of Wallaston Lake and Lac La Hache. The closest community by road is Pinehouse which is approximately 260 km away. The communities and associated Indigenous Communities of Interest that Denison has identified for engagement activities includes: the English River First Nation (ERFN), the Kineepik Métis Local 9, the Sipisishik Métis Local 37, the A La Baie Métis Local 21, and the Patuanak Métis Local 82.

Indigenous Knowledge was available from Indigenous Communities of Interest, including a dietary study for the ERFN (CanNorth, 2017). Local Knowledge was available from a local fisher/trapper whose primary residence has been in the LSA, that has extensive experience fishing, hunting, and trapping throughout the LSA and RSA.

The ERFN is comprised of seven reserve lands across Saskatchewan. Patuanak is located on the Churchill River and the north end of Lac-Île-à-la-Crosse, approximately 90 km north of Beauval and over 500 km from Saskatoon. Patuanak has 625 members on reserve and a hamlet with approximately 75 residents. La Plonge is located approximately 90 km south of Patuanak 8 km east of the town of Beauval near the Beaver River, and has approximately 148 people living on reserve. ERFN community members also travel to a seasonal culture camp along Highway 914 approximately 50 km south of the Key Lake Operation to hunt, fish, and gather berries (CanNorth, 2017).

A dietary study was performed for residents of Patuanak and La Plonge to understand which traditional foods were consumed by each community and the approximate amounts consumed. The results of the survey were summarized in CanNorth (2017) by average daily intake in grams (fresh weight) of country foods by species and season, for Patuanak, La Plonge, and an average. A summary of the ERFN traditional food ingestion rates by food type is shown in Table 4-3 and the proportions of food types are shown in Figure 4-3. Overall, fish, large mammals (meat and organs) and plants make up the majority of the traditional food diet, in similar proportions. Small mammals and birds make up a smaller proportion of the traditional food diet. Moose (*Alces americanus)* is the most commonly eaten large mammal. The most commonly eaten fish include walleye (*Sander vitreus*) and lake whitefish (*Coregonus clupeaformis*).

The results of the dietary study indicate that Patuanak has a higher traditional food ingestion rate than La Plonge, and has a similar distribution of country food types as the average diet. As a conservative approach for this assessment, the Patuanak diet was selected to represent the average traditional foods consumer in the HHRA. This includes the seasonal resident and the recreational fisher/hunter.

The traditional foods diet for past assessments for other uranium mining facilities in the area were based on the Hatchet Lake First Nation study (CanNorth, 2000). Overall, the quantities and types of traditional foods documented in the Hatchet Lake First Nation study were similar to the results from the ERFN dietary study, with the exception of the high ingestion rate of barren-ground caribou (*Rangifer tarandus groenlandicus*). Responses from the ERFN dietary study indicated that the Patuanak and La Plonge communities consume small quantities of caribou and preferred to eat moose.

Table 4-3: ERFN Ingestion Rates – Traditional Food

Country Food Type	La Plonge (g/d)	Patuanak (g/d)	All (g/d)
Birds	4.1	13.3	10.2
Edible Plants	62.8	54.3	57.2
Fish	16.4	73.0	53.7
Mammals (meat)	19.4	35.5	30.0
Mammals (organs)	6.2	16.2	12.8
Small mammal	3.3	6.7	5.5
Total	**112.2**	**199.0**	**169.4**

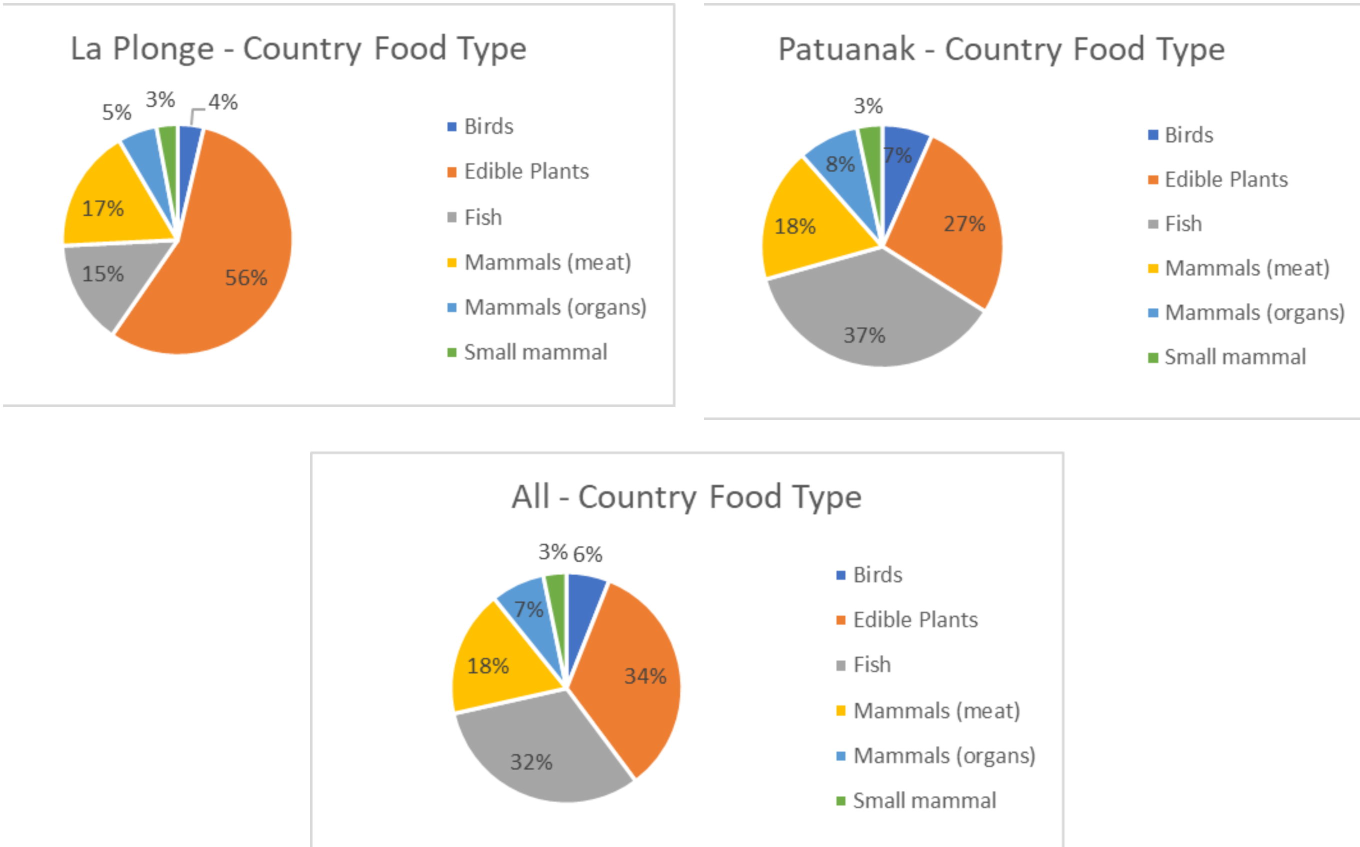


Figure 4-3: Proportion of Food Types in ERFN Traditional Food Diet

For the high traditional foods consumer, the dietary assumptions were from resource use information from a local fisher/trapper that has been used for past assessments in the area. The overall assumptions regarding types of food consumed and general proportions were re-confirmed with the local fisher/trapper during an interview with Denison on October 29, 2019 (KPI Program, 2019).

A detailed breakdown of diet by food type for each Traditional Foods consumer, as modelled in the HHRA, is shown in Table 4-4. Representative ecological receptors were selected from the IMPACT model to represent each Traditional Foods group. The Total Food Intake row is the total food intake from both traditional foods and store-bought foods. Since it is assumed that someone would obtain a portion of their overall diet from traditional foods and the rest from store bought foods, Table 4-4 shows the breakdown between the total food intake from traditional foods and the remaining food intake from store bought foods.

Table 4-4: Annual Food Intakes for Components of the Human Receptors' Diet

Food Components	Unit	Average Traditional Foods Consumer				High Traditional Foods Consumer			
		Adult [1]		One-year-old [2]		Adult [1]		One-year-old [2]	
Country Meat and Fish	kg/yr	52.82	-	9.34	-	366.88	-	63.50	-
Caribou	kg/yr	-	2.63	-	0.33	-	175.28	-	21.79
Moose	kg/yr	-	11.75	-	1.46	-	4.65	-	0.58
Moose (organs)	kg/yr	-	4.49	-	0.56	-	0	-	0
Small Mammals [4]	kg/yr	-	2.45	-	0.23	-	0.87	-	0.08
Mallard [5]	kg/yr	-	2.99	-	0.53	-	1.55	-	0.28
Canada Goose [6]	kg/yr	-	1.86	-	0.33	-	1.09	-	0.19
Fish [7]	kg/yr	-	26.65	-	5.89	-	183.44	-	40.58
Country Plants [8]	kg/yr	19.82	-	10.83	-	0	-	0	-
Blueberries	kg/yr	-	19.64	-	10.79	-	0	-	0
Labrador Tea	kg/yr	-	0.18	-	0.04	-	0	-	0
Store Foods	kg/yr	633.38		389.28		339.13		345.95	
Total Food Intake [3] (fresh weight)	kg/yr	706.01	-	409.45	-	706.01	-	409.45	-

Notes:

[1] Food intake for human receptors that are average Traditional Foods consumers were developed from the results of a dietary survey of the English River First Nation (CanNorth, 2017).

[2] CanNorth (2017) provides survey results for adults. Food intake for one-year-olds was proportioned from the adult receptor group using Central Adult - to Central 1-Year-Old derived from the N288.1-20 Human Diet (Table G.9b).

[3] The total food intake is from Table G.9b in CSA N288.1-20 (2020) which represents the central dietary intake based on reference energy intakes.

[4] While ERFN predominantly eat hare, modelling for small mammals is represented by muskrat to have a stronger link to the aquatic environment.

[5] Mallard was selected to represent all waterbirds in the country food diet.

[6] Canada goose was selected to represent upland birds in the country food diet.

[7] Assumed to include 50% predator fish (northern pike) and 50% forage fish (white sucker) based on ERFN dietary survey (CanNorth, 2017).

[8] Blueberries include edible fruits and berries. Labrador Tea includes edible plants other than fruits and berries.

4.2.5 Exposure Point Concentrations and Doses

Concentrations of COPCs in environmental media including water, sediment, soil, and Traditional Food items were predicted using the environmental pathways model IMPACT at defined human receptor locations. Air concentrations at human receptor locations were obtained from the air quality model (Section 8 of the EIS) and dictated into the IMPACT model. Concentrations of COPCs in environmental media were predicted over all Project phases. Water and sediment concentrations at exposure locations (Whitefish Lake Middle, Whitefish Lake South, McGowan Lake, and Russell Lake) and reference locations (Kratchkowsky Lake and Whitefish Lake North) are summarized in Figure 3-2 and Figure 3-3 showing the variation of concentrations over time. Maximum water and sediment concentrations are shown in Table 3-3. Maximum air and soil concentrations are shown in Table 3-14. The estimated non-radiological and radiological concentrations in environmental media and biota tissue concentrations relevant to human ingestion pathways are also summarized in Appendix B, Model Results in Support of the ERA.

Assessment of radiation exposures to members of the public is commonly based on estimation of the incremental effects of the project or site. Assessments consider the radiation dose received from external exposure to radiation as well as the dose received from inhalation and ingestion of radionuclides. The radionuclide dose to human receptors from all pathways is converted into a dose that is presented in millisieverts per year (mSv/yr).

Assessment of non-radiological exposures to members of the public is commonly based on estimation of the total effects of the project or site. Assessments consider the dose received from ingestion of constituents of concern as well as dermal absorption due to contact with soil. The inhalation dose was not included as no air COPCs were identified in the screening. This is presented as a dose in milligrams per kilogram per day (mg/kg/d) for each pathway.

The estimated non-radiological doses and radiological doses to human receptors due to releases from the Project during all phases are presented in the following subsections. Non-radiological doses are presented as baseline doses (based on existing exposures prior to the Project), Project doses (includes the Project dose in addition to the baseline dose), as well as incremental Project doses (includes the Project dose only with baseline component removed). For radiological doses, only the incremental doses are presented, as the dose limit is based on an incremental dose. Doses from ingestion of store-bought foods are considered as a portion of the baseline dose.

The results represent the expected EA case based on the source term presented in Section 3.0, Source Term Characterization for the COPCs identified. Sample calculations for radiological and non-radiological dose are presented in Appendix B.

4.2.5.1 Non-radiological Dose to Human Receptors

4.2.5.1.1 Non-carcinogen Dose

The estimated non-radiological doses to human receptors due to releases from the Project during all phases are presented in Table 4-5. The doses are presented for existing conditions (baseline) as well as for the Project, and represent the maximum dose predicted during the Project phases. This is a conservative representation as exposure varies over the different Project phases. The non-carcinogens evaluated include: cadmium, cobalt, chromium, copper, molybdenum, selenium, uranium, vanadium, and zinc. Doses are presented for the camp worker, recreational fisher/hunter, fisher/trapper, and seasonal resident for the Project phases (Table 4-5). Doses are presented for the future permanent resident, recreational fisher/hunter, fisher/trapper, and seasonal resident for the future centuries (Table 4-6).

Table 4-5: Estimated Non-radiological Doses to Human Receptors – Project Phases

Human Receptor	COPC	Non-radiological Dose by Pathway during Project Phases (mg/kg/d)									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
Camp Worker Adult (Whitefish Lake)		Average Baseline Dose									
	Cadmium	3.40E-07	7.55E-09	3.46E-08	2.35E-09	1.08E-08	0.00E+00	3.57E-08	3.51E-06	2.05E-04	**2.09E-04**
	Chromium	7.62E-06	6.93E-08	3.17E-06	4.08E-08	1.87E-06	0.00E+00	1.47E-05	5.58E-06	1.50E-05	**4.80E-05**
	Cobalt	1.48E-06	5.55E-09	2.54E-08	1.76E-09	8.04E-09	0.00E+00	6.25E-07	3.14E-05	1.64E-04	**1.97E-04**
	Copper	9.09E-06	3.05E-08	8.37E-07	1.29E-08	3.54E-07	0.00E+00	1.59E-04	2.19E-03	2.06E-02	**2.29E-02**
	Molybdenum	1.57E-06	2.40E-09	1.10E-08	2.35E-09	1.08E-08	0.00E+00	5.51E-09	2.59E-05	2.53E-03	**2.56E-03**
	Selenium	4.74E-07	2.24E-09	1.03E-08	4.33E-09	1.98E-08	0.00E+00	8.37E-05	2.19E-05	1.69E-03	**1.79E-03**
	Uranium	4.41E-07	8.00E-09	3.66E-07	4.03E-09	1.84E-07	0.00E+00	3.08E-07	1.36E-05	3.67E-05	**5.17E-05**
	Vanadium	2.13E-06	1.01E-07	4.61E-06	7.79E-08	3.57E-06	0.00E+00	7.12E-06	3.60E-06	3.62E-04	**3.83E-04**
	Zinc	9.99E-06	1.11E-07	5.09E-06	6.92E-08	3.17E-06	0.00E+00	6.99E-04	5.35E-03	1.21E-01	**1.27E-01**
		Project Total Dose - Project Phases									
	Cadmium	4.56E-07	7.55E-09	3.46E-08	2.91E-09	1.33E-08	0.00E+00	5.01E-08	3.51E-06	2.05E-04	**2.09E-04**
	Chromium	9.19E-06	6.93E-08	3.17E-06	4.69E-08	2.15E-06	0.00E+00	1.84E-05	5.58E-06	1.63E-05	**5.49E-05**
	Cobalt	1.68E-06	5.56E-09	2.54E-08	1.94E-09	8.88E-09	0.00E+00	7.34E-07	3.15E-05	1.64E-04	**1.98E-04**
	Copper	1.06E-05	3.07E-08	8.44E-07	1.45E-08	3.98E-07	0.00E+00	1.93E-04	2.20E-03	2.06E-02	**2.30E-02**
	Molybdenum	1.79E-04	2.41E-09	1.10E-08	2.01E-07	9.18E-07	0.00E+00	7.95E-07	2.59E-05	2.57E-03	**2.78E-03**
	Selenium	3.41E-06	2.25E-09	1.03E-08	2.13E-08	9.74E-08	0.00E+00	5.39E-04	2.19E-05	1.75E-03	**2.31E-03**
	Uranium	4.43E-06	2.16E-08	9.88E-07	2.70E-08	1.24E-06	0.00E+00	3.36E-06	3.03E-05	3.93E-05	**7.96E-05**
	Vanadium	5.86E-06	1.01E-07	4.61E-06	1.69E-07	7.72E-06	0.00E+00	1.59E-05	3.61E-06	3.70E-04	**4.08E-04**
	Zinc	1.26E-05	1.11E-07	5.09E-06	8.21E-08	3.76E-06	0.00E+00	9.20E-04	5.35E-03	1.21E-01	**1.27E-01**
		Project Incremental Dose - Project Phases									
	Cadmium	1.16E-07	1.13E-12	5.19E-12	5.56E-10	2.55E-09	0.00E+00	1.44E-08	1.66E-09	1.22E-07	**2.58E-07**
	Chromium	1.57E-06	6.66E-12	3.05E-10	6.07E-09	2.78E-07	0.00E+00	3.72E-06	6.63E-09	1.29E-06	**6.87E-06**
	Cobalt	1.99E-07	5.98E-12	2.74E-11	1.85E-10	8.46E-10	0.00E+00	1.09E-07	1.72E-08	3.71E-07	**6.98E-07**
	Copper	1.47E-06	2.72E-10	7.47E-09	1.61E-09	4.42E-08	0.00E+00	3.33E-05	8.27E-06	3.60E-05	**7.92E-05**
	Molybdenum	1.78E-04	1.85E-12	8.46E-12	1.98E-07	9.08E-07	0.00E+00	7.90E-07	9.28E-09	4.11E-05	**2.21E-04**
	Selenium	2.94E-06	2.38E-12	1.09E-11	1.70E-08	7.76E-08	0.00E+00	4.55E-04	1.38E-08	6.36E-05	**5.21E-04**
	Uranium	3.99E-06	1.36E-08	6.22E-07	2.30E-08	1.05E-06	0.00E+00	3.05E-06	1.66E-05	2.50E-06	**2.79E-05**
	Vanadium	3.73E-06	3.03E-11	1.39E-09	9.08E-08	4.16E-06	0.00E+00	8.77E-06	1.12E-08	7.65E-06	**2.44E-05**
	Zinc	2.65E-06	9.51E-11	4.36E-09	1.29E-08	5.92E-07	0.00E+00	2.21E-04	1.87E-06	1.01E-04	**3.27E-04**

Human Receptor	COPC	Non-radiological Dose by Pathway during Project Phases (mg/kg/d)									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
Rec F/H Adult (McGowan Lake)		**Average Baseline Dose**									
	Cadmium	3.40E-07	7.55E-09	3.46E-09	2.35E-09	1.08E-09	0.00E+00	7.14E-08	7.02E-06	1.99E-04	**2.06E-04**
	Chromium	7.62E-06	6.93E-08	3.17E-07	4.08E-08	1.87E-07	0.00E+00	2.94E-05	1.12E-05	3.03E-05	**7.90E-05**
	Cobalt	1.48E-06	5.55E-09	2.54E-09	1.76E-09	8.04E-10	0.00E+00	1.25E-06	6.29E-05	1.77E-04	**2.42E-04**
	Copper	9.09E-06	3.05E-08	8.37E-08	1.29E-08	3.54E-08	0.00E+00	3.19E-04	4.37E-03	2.55E-02	**3.02E-02**
	Molybdenum	1.57E-06	2.40E-09	1.10E-09	2.35E-09	1.08E-09	0.00E+00	1.10E-08	5.17E-05	2.41E-03	**2.47E-03**
	Selenium	4.74E-07	2.24E-09	1.03E-09	4.33E-09	1.98E-09	0.00E+00	1.68E-04	4.39E-05	1.65E-03	**1.86E-03**
	Uranium	4.41E-07	8.00E-09	3.66E-08	4.03E-09	1.84E-08	0.00E+00	6.16E-07	2.73E-05	3.52E-05	**6.36E-05**
	Vanadium	2.13E-06	1.01E-07	4.61E-07	7.79E-08	3.57E-07	0.00E+00	1.42E-05	7.20E-06	3.60E-04	**3.85E-04**
	Zinc	9.99E-06	1.11E-07	5.09E-07	6.92E-08	3.17E-07	0.00E+00	1.40E-03	1.07E-02	1.33E-01	**1.45E-01**
		Project Total Dose - Project Phases									
	Cadmium	3.82E-07	7.55E-09	3.46E-09	2.57E-09	1.18E-09	0.00E+00	1.00E-07	7.03E-06	1.99E-04	**2.06E-04**
	Chromium	8.25E-06	6.93E-08	3.17E-07	4.33E-08	1.98E-07	0.00E+00	3.68E-05	1.12E-05	3.29E-05	**8.97E-05**
	Cobalt	1.56E-06	5.55E-09	2.54E-09	1.84E-09	8.40E-10	0.00E+00	1.47E-06	6.29E-05	1.77E-04	**2.43E-04**
	Copper	9.63E-06	3.05E-08	8.38E-08	1.36E-08	3.73E-08	0.00E+00	3.86E-04	4.39E-03	2.55E-02	**3.03E-02**
	Molybdenum	7.07E-05	2.40E-09	1.10E-09	8.77E-08	4.02E-08	0.00E+00	1.59E-06	5.17E-05	2.50E-03	**2.62E-03**
	Selenium	1.46E-06	2.24E-09	1.03E-09	1.08E-08	4.94E-09	0.00E+00	1.08E-03	4.39E-05	1.78E-03	**2.90E-03**
	Uranium	1.79E-06	1.01E-08	4.61E-08	1.28E-08	5.87E-08	0.00E+00	6.71E-06	6.05E-05	4.02E-05	**1.09E-04**
	Vanadium	3.12E-06	1.01E-07	4.61E-07	1.01E-07	4.62E-07	0.00E+00	3.18E-05	7.22E-06	3.76E-04	**4.19E-04**
	Zinc	1.10E-05	1.11E-07	5.09E-07	7.43E-08	3.40E-07	0.00E+00	1.84E-03	1.07E-02	1.34E-01	**1.46E-01**
		Project Incremental Dose - Project Phases									
	Cadmium	4.22E-08	1.58E-13	7.19E-14	2.20E-10	1.01E-10	0.00E+00	2.88E-08	3.32E-09	2.47E-07	**3.21E-07**
	Chromium	6.24E-07	1.03E-12	4.72E-12	2.47E-09	1.13E-08	0.00E+00	7.44E-06	1.33E-08	2.59E-06	**1.07E-05**
	Cobalt	7.28E-08	8.30E-13	3.80E-13	8.01E-11	3.66E-11	0.00E+00	2.18E-07	3.44E-08	7.40E-07	**1.07E-06**
	Copper	5.35E-07	3.79E-11	1.04E-10	6.96E-10	1.91E-09	0.00E+00	6.67E-05	1.65E-05	7.20E-05	**1.56E-04**
	Molybdenum	6.91E-05	1.85E-13	8.48E-14	8.54E-08	3.91E-08	0.00E+00	1.58E-06	1.86E-08	8.21E-05	**1.53E-04**
	Selenium	9.85E-07	3.33E-13	1.52E-13	6.47E-09	2.96E-09	0.00E+00	9.10E-04	2.75E-08	1.28E-04	**1.04E-03**
	Uranium	1.34E-06	2.07E-09	9.47E-09	8.79E-09	4.02E-08	0.00E+00	6.10E-06	3.32E-05	5.02E-06	**4.58E-05**
	Vanadium	9.91E-07	4.21E-12	1.93E-11	2.31E-08	1.06E-07	0.00E+00	1.75E-05	2.24E-08	1.53E-05	**3.40E-05**
	Zinc	1.03E-06	1.33E-11	6.07E-11	5.13E-09	2.35E-08	0.00E+00	4.42E-04	3.74E-06	2.02E-04	**6.49E-04**
Rec F/H One-year-old		**Average Baseline Dose**									
	Cadmium	3.80E-07	4.93E-07	5.91E-09	1.54E-07	1.84E-09	0.00E+00	6.76E-08	1.57E-05	5.03E-04	**5.20E-04**

Human Receptor	COPC	Non-radiological Dose by Pathway during Project Phases (mg/kg/d)									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
(McGowan Lake)	Chromium	8.51E-06	4.53E-06	5.42E-07	2.67E-06	3.20E-07	0.00E+00	2.78E-05	2.58E-05	1.76E-05	**8.78E-05**
	Cobalt	1.66E-06	3.63E-07	4.35E-09	1.15E-07	1.37E-09	0.00E+00	1.18E-06	1.46E-04	3.78E-04	**5.27E-04**
	Copper	1.02E-05	1.99E-06	1.43E-07	8.42E-07	6.05E-08	0.00E+00	3.02E-04	1.01E-02	4.29E-02	**5.33E-02**
	Molybdenum	1.75E-06	1.57E-07	1.88E-09	1.54E-07	1.84E-09	0.00E+00	1.04E-08	1.20E-04	6.29E-03	**6.41E-03**
	Selenium	5.30E-07	1.47E-07	1.76E-09	2.83E-07	3.39E-09	0.00E+00	1.59E-04	1.03E-04	4.13E-03	**4.39E-03**
	Uranium	4.93E-07	5.22E-07	6.26E-08	2.63E-07	3.15E-08	0.00E+00	5.84E-07	6.25E-05	9.10E-05	**1.55E-04**
	Vanadium	2.38E-06	6.58E-06	7.89E-07	5.09E-06	6.10E-07	0.00E+00	1.35E-05	1.30E-05	8.78E-04	**9.20E-04**
	Zinc	1.12E-05	7.26E-06	8.70E-07	4.52E-06	5.42E-07	0.00E+00	1.32E-03	2.45E-02	2.76E-01	**3.02E-01**
		Project Total Dose - Project Phases									
	Cadmium	4.27E-07	4.93E-07	5.91E-09	1.68E-07	2.02E-09	0.00E+00	9.49E-08	1.58E-05	5.03E-04	**5.20E-04**
	Chromium	9.21E-06	4.53E-06	5.42E-07	2.83E-06	3.39E-07	0.00E+00	3.48E-05	2.58E-05	1.93E-05	**9.74E-05**
	Cobalt	1.74E-06	3.63E-07	4.35E-09	1.20E-07	1.44E-09	0.00E+00	1.39E-06	1.46E-04	3.78E-04	**5.28E-04**
	Copper	1.07E-05	1.99E-06	1.43E-07	8.87E-07	6.38E-08	0.00E+00	3.65E-04	1.01E-02	4.29E-02	**5.35E-02**
	Molybdenum	7.89E-05	1.57E-07	1.88E-09	5.73E-06	6.87E-08	0.00E+00	1.51E-06	1.20E-04	6.33E-03	**6.54E-03**
	Selenium	1.63E-06	1.47E-07	1.76E-09	7.06E-07	8.46E-09	0.00E+00	1.02E-03	1.03E-04	4.21E-03	**5.34E-03**
	Uranium	1.99E-06	6.58E-07	7.88E-08	8.37E-07	1.00E-07	0.00E+00	6.36E-06	1.29E-04	9.42E-05	**2.33E-04**
	Vanadium	3.49E-06	6.58E-06	7.89E-07	6.60E-06	7.91E-07	0.00E+00	3.01E-05	1.31E-05	8.86E-04	**9.48E-04**
	Zinc	1.23E-05	7.26E-06	8.70E-07	4.86E-06	5.82E-07	0.00E+00	1.74E-03	2.46E-02	2.76E-01	**3.02E-01**
		Project Incremental Dose - Project Phases									
	Cadmium	4.71E-08	1.03E-11	1.23E-13	1.44E-08	1.73E-10	0.00E+00	2.73E-08	6.84E-09	1.71E-07	**2.66E-07**
	Chromium	6.97E-07	6.73E-11	8.07E-12	1.61E-07	1.93E-08	0.00E+00	7.05E-06	1.73E-08	1.71E-06	**9.65E-06**
	Cobalt	8.13E-08	5.42E-11	6.50E-13	5.23E-09	6.27E-11	0.00E+00	2.07E-07	7.64E-08	4.22E-07	**7.92E-07**
	Copper	5.97E-07	2.48E-09	1.78E-10	4.54E-08	3.27E-09	0.00E+00	6.32E-05	3.87E-05	4.19E-05	**1.44E-04**
	Molybdenum	7.71E-05	1.21E-11	1.45E-13	5.58E-06	6.69E-08	0.00E+00	1.50E-06	4.15E-08	4.67E-05	**1.31E-04**
	Selenium	1.10E-06	2.18E-11	2.61E-13	4.23E-07	5.07E-09	0.00E+00	8.62E-04	6.26E-08	8.15E-05	**9.45E-04**
	Uranium	1.50E-06	1.35E-07	1.62E-08	5.74E-07	6.88E-08	0.00E+00	5.77E-06	6.60E-05	3.17E-06	**7.73E-05**
	Vanadium	1.11E-06	2.76E-10	3.30E-11	1.51E-06	1.81E-07	0.00E+00	1.66E-05	2.88E-08	8.46E-06	**2.79E-05**
	Zinc	1.15E-06	8.65E-10	1.04E-10	3.35E-07	4.02E-08	0.00E+00	4.19E-04	8.72E-06	1.02E-04	**5.30E-04**
		Average Baseline Dose									
Rec F/H Adult (Russell Lake)	Cadmium	3.40E-07	7.55E-09	3.46E-09	2.35E-09	1.08E-09	0.00E+00	7.14E-08	7.02E-06	1.99E-04	**2.06E-04**
	Chromium	7.62E-06	6.93E-08	3.17E-07	4.08E-08	1.87E-07	0.00E+00	2.94E-05	1.12E-05	3.03E-05	**7.90E-05**
	Cobalt	1.48E-06	5.55E-09	2.54E-09	1.76E-09	8.04E-10	0.00E+00	1.25E-06	6.29E-05	1.77E-04	**2.42E-04**

Human Receptor	COPC	Non-radiological Dose by Pathway during Project Phases (mg/kg/d)									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Copper	9.09E-06	3.05E-08	8.37E-08	1.29E-08	3.54E-08	0.00E+00	3.19E-04	4.37E-03	2.55E-02	**3.02E-02**
	Molybdenum	1.57E-06	2.40E-09	1.10E-09	2.35E-09	1.08E-09	0.00E+00	1.10E-08	5.17E-05	2.41E-03	**2.47E-03**
	Selenium	4.74E-07	2.24E-09	1.03E-09	4.33E-09	1.98E-09	0.00E+00	1.68E-04	4.39E-05	1.65E-03	**1.86E-03**
	Uranium	4.41E-07	8.00E-09	3.66E-08	4.03E-09	1.84E-08	0.00E+00	6.16E-07	2.73E-05	3.52E-05	**6.36E-05**
	Vanadium	2.13E-06	1.01E-07	4.61E-07	7.79E-08	3.57E-07	0.00E+00	1.42E-05	7.20E-06	3.60E-04	**3.85E-04**
	Zinc	9.99E-06	1.11E-07	5.09E-07	6.92E-08	3.17E-07	0.00E+00	1.40E-03	1.07E-02	1.33E-01	**1.45E-01**
		Project Total Dose - Project Phases									
	Cadmium	3.74E-07	7.55E-09	3.46E-09	2.52E-09	1.15E-09	0.00E+00	9.23E-08	7.03E-06	1.99E-04	**2.06E-04**
	Chromium	8.14E-06	6.93E-08	3.17E-07	4.27E-08	1.95E-07	0.00E+00	3.48E-05	1.12E-05	3.22E-05	**8.70E-05**
	Cobalt	1.54E-06	5.55E-09	2.54E-09	1.82E-09	8.31E-10	0.00E+00	1.41E-06	6.29E-05	1.77E-04	**2.43E-04**
	Copper	9.49E-06	3.05E-08	8.37E-08	1.34E-08	3.68E-08	0.00E+00	3.69E-04	4.38E-03	2.55E-02	**3.03E-02**
	Molybdenum	5.34E-05	2.40E-09	1.10E-09	6.71E-08	3.07E-08	0.00E+00	1.20E-06	5.17E-05	2.48E-03	**2.58E-03**
	Selenium	1.18E-06	2.24E-09	1.03E-09	9.06E-09	4.15E-09	0.00E+00	8.36E-04	4.39E-05	1.74E-03	**2.62E-03**
	Uranium	1.41E-06	8.55E-09	3.91E-08	1.04E-08	4.78E-08	0.00E+00	5.01E-06	3.62E-05	3.81E-05	**8.08E-05**
	Vanadium	2.89E-06	1.01E-07	4.61E-07	9.26E-08	4.24E-07	0.00E+00	2.60E-05	7.20E-06	3.71E-04	**4.08E-04**
	Zinc	1.08E-05	1.11E-07	5.09E-07	7.30E-08	3.34E-07	0.00E+00	1.72E-03	1.07E-02	1.33E-01	**1.46E-01**
		Project Incremental Dose - Project Phases									
	Cadmium	3.42E-08	4.09E-14	1.82E-14	1.63E-10	7.44E-11	0.00E+00	2.09E-08	8.54E-10	1.83E-07	**2.39E-07**
	Chromium	5.12E-07	2.70E-13	1.22E-12	1.83E-09	8.40E-09	0.00E+00	5.45E-06	3.45E-09	1.95E-06	**7.93E-06**
	Cobalt	5.45E-08	2.13E-13	9.75E-14	6.09E-11	2.79E-11	0.00E+00	1.64E-07	8.85E-09	5.35E-07	**7.63E-07**
	Copper	4.00E-07	9.75E-12	2.68E-11	5.28E-10	1.45E-09	0.00E+00	5.01E-05	4.26E-06	3.94E-05	**9.41E-05**
	Molybdenum	5.18E-05	3.73E-14	1.70E-14	6.48E-08	2.97E-08	0.00E+00	1.19E-06	3.71E-09	6.22E-05	**1.15E-04**
	Selenium	7.07E-07	8.57E-14	3.92E-14	4.73E-09	2.16E-09	0.00E+00	6.68E-04	7.08E-09	9.41E-05	**7.63E-04**
	Uranium	9.66E-07	5.52E-10	2.53E-09	6.42E-09	2.94E-08	0.00E+00	4.40E-06	8.88E-06	2.95E-06	**1.72E-05**
	Vanadium	7.62E-07	1.08E-12	4.95E-12	1.47E-08	6.71E-08	0.00E+00	1.18E-05	5.77E-09	1.03E-05	**2.30E-05**
	Zinc	8.49E-07	3.40E-12	1.56E-11	3.78E-09	1.73E-08	0.00E+00	3.21E-04	9.64E-07	1.48E-04	**4.71E-04**
		Average Baseline Dose									
	Cadmium	3.80E-07	4.93E-07	5.91E-09	1.54E-07	1.84E-09	0.00E+00	6.76E-08	1.57E-05	5.03E-04	**5.20E-04**
Rec F/H One-year-old (Russell Lake)	Chromium	8.51E-06	4.53E-06	5.42E-07	2.67E-06	3.20E-07	0.00E+00	2.78E-05	2.58E-05	1.76E-05	**8.78E-05**
	Cobalt	1.66E-06	3.63E-07	4.35E-09	1.15E-07	1.37E-09	0.00E+00	1.18E-06	1.46E-04	3.78E-04	**5.27E-04**
	Copper	1.02E-05	1.99E-06	1.43E-07	8.42E-07	6.05E-08	0.00E+00	3.02E-04	1.01E-02	4.29E-02	**5.33E-02**
	Molybdenum	1.75E-06	1.57E-07	1.88E-09	1.54E-07	1.84E-09	0.00E+00	1.04E-08	1.20E-04	6.29E-03	**6.41E-03**

Human Receptor	COPC	Non-radiological Dose by Pathway during Project Phases (mg/kg/d)									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Selenium	5.30E-07	1.47E-07	1.76E-09	2.83E-07	3.39E-09	0.00E+00	1.59E-04	1.03E-04	4.13E-03	**4.39E-03**
	Uranium	4.93E-07	5.22E-07	6.26E-08	2.63E-07	3.15E-08	0.00E+00	5.84E-07	6.25E-05	9.10E-05	**1.55E-04**
	Vanadium	2.38E-06	6.58E-06	7.89E-07	5.09E-06	6.10E-07	0.00E+00	1.35E-05	1.30E-05	8.78E-04	**9.20E-04**
	Zinc	1.12E-05	7.26E-06	8.70E-07	4.52E-06	5.42E-07	0.00E+00	1.32E-03	2.45E-02	2.76E-01	**3.02E-01**
		Project Total Dose - Project Phases									
	Cadmium	4.18E-07	4.93E-07	5.91E-09	1.64E-07	1.97E-09	0.00E+00	8.74E-08	1.57E-05	5.03E-04	**5.20E-04**
	Chromium	9.08E-06	4.53E-06	5.42E-07	2.79E-06	3.34E-07	0.00E+00	3.30E-05	2.58E-05	1.89E-05	**9.49E-05**
	Cobalt	1.72E-06	3.63E-07	4.35E-09	1.19E-07	1.42E-09	0.00E+00	1.34E-06	1.46E-04	3.78E-04	**5.27E-04**
	Copper	1.06E-05	1.99E-06	1.43E-07	8.76E-07	6.30E-08	0.00E+00	3.49E-04	1.01E-02	4.29E-02	**5.34E-02**
	Molybdenum	5.96E-05	1.57E-07	1.88E-09	4.39E-06	5.26E-08	0.00E+00	1.13E-06	1.20E-04	6.32E-03	**6.51E-03**
	Selenium	1.32E-06	1.47E-07	1.76E-09	5.92E-07	7.09E-09	0.00E+00	7.91E-04	1.03E-04	4.19E-03	**5.09E-03**
	Uranium	1.57E-06	5.59E-07	6.69E-08	6.82E-07	8.18E-08	0.00E+00	4.75E-06	8.01E-05	9.29E-05	**1.81E-04**
	Vanadium	3.23E-06	6.58E-06	7.89E-07	6.05E-06	7.25E-07	0.00E+00	2.47E-05	1.30E-05	8.84E-04	**9.39E-04**
	Zinc	1.21E-05	7.26E-06	8.70E-07	4.77E-06	5.71E-07	0.00E+00	1.63E-03	2.45E-02	2.76E-01	**3.02E-01**
		Project Incremental Dose - Project Phases									
	Cadmium	3.82E-08	2.67E-12	3.15E-14	1.06E-08	1.27E-10	0.00E+00	1.98E-08	1.76E-09	1.26E-07	**1.97E-07**
	Chromium	5.72E-07	1.77E-11	2.10E-12	1.20E-07	1.44E-08	0.00E+00	5.17E-06	4.50E-09	1.29E-06	**7.16E-06**
	Cobalt	6.08E-08	1.40E-11	1.67E-13	3.98E-09	4.77E-11	0.00E+00	1.55E-07	1.96E-08	3.06E-07	**5.46E-07**
	Copper	4.47E-07	6.37E-10	4.58E-11	3.45E-08	2.48E-09	0.00E+00	4.74E-05	9.94E-06	2.38E-05	**8.16E-05**
	Molybdenum	5.79E-05	2.43E-12	2.89E-14	4.23E-06	5.07E-08	0.00E+00	1.12E-06	8.30E-09	3.54E-05	**9.87E-05**
	Selenium	7.90E-07	5.60E-12	6.72E-14	3.09E-07	3.70E-09	0.00E+00	6.33E-04	1.61E-08	6.00E-05	**6.94E-04**
	Uranium	1.08E-06	3.61E-08	4.32E-09	4.19E-07	5.03E-08	0.00E+00	4.16E-06	1.76E-05	1.86E-06	**2.52E-05**
	Vanadium	8.51E-07	7.09E-11	8.47E-12	9.58E-07	1.15E-07	0.00E+00	1.12E-05	7.42E-09	5.67E-06	**1.88E-05**
	Zinc	9.48E-07	2.22E-10	2.67E-11	2.47E-07	2.96E-08	0.00E+00	3.04E-04	2.24E-06	7.44E-05	**3.82E-04**
		Average Baseline Dose									
Seasonal Resident Adult (Russell Lake)	Cadmium	3.40E-07	7.55E-09	3.46E-09	2.35E-09	1.08E-09	0.00E+00	7.14E-08	7.02E-06	1.99E-04	**2.06E-04**
	Chromium	7.62E-06	6.93E-08	3.17E-07	4.08E-08	1.87E-07	0.00E+00	2.94E-05	1.12E-05	3.03E-05	**7.90E-05**
	Cobalt	1.48E-06	5.55E-09	2.54E-09	1.76E-09	8.04E-10	0.00E+00	1.25E-06	6.29E-05	1.77E-04	**2.42E-04**
	Copper	9.09E-06	3.05E-08	8.37E-08	1.29E-08	3.54E-08	0.00E+00	3.19E-04	4.37E-03	2.55E-02	**3.02E-02**
	Molybdenum	1.57E-06	2.40E-09	1.10E-09	2.35E-09	1.08E-09	0.00E+00	1.10E-08	5.17E-05	2.41E-03	**2.47E-03**
	Selenium	4.74E-07	2.24E-09	1.03E-09	4.33E-09	1.98E-09	0.00E+00	1.68E-04	4.39E-05	1.65E-03	**1.86E-03**
	Uranium	4.41E-07	8.00E-09	3.66E-08	4.03E-09	1.84E-08	0.00E+00	6.16E-07	2.73E-05	3.52E-05	**6.36E-05**

Human Receptor	COPC	Non-radiological Dose by Pathway during Project Phases (mg/kg/d)									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Vanadium	2.13E-06	1.01E-07	4.61E-07	7.79E-08	3.57E-07	0.00E+00	1.42E-05	7.20E-06	3.60E-04	**3.85E-04**
	Zinc	9.99E-06	1.11E-07	5.09E-07	6.92E-08	3.17E-07	0.00E+00	1.40E-03	1.07E-02	1.33E-01	**1.45E-01**
		Project Total Dose - Project Phases									
	Cadmium	3.74E-07	7.55E-09	3.46E-09	2.52E-09	1.15E-09	0.00E+00	7.83E-08	7.03E-06	1.99E-04	**2.06E-04**
	Chromium	8.14E-06	6.93E-08	3.17E-07	4.27E-08	1.95E-07	0.00E+00	3.12E-05	1.12E-05	3.09E-05	**8.21E-05**
	Cobalt	1.54E-06	5.55E-09	2.54E-09	1.82E-09	8.31E-10	0.00E+00	1.30E-06	6.29E-05	1.77E-04	**2.42E-04**
	Copper	9.49E-06	3.05E-08	8.37E-08	1.34E-08	3.68E-08	0.00E+00	3.33E-04	4.38E-03	2.55E-02	**3.02E-02**
	Molybdenum	5.34E-05	2.40E-09	1.10E-09	6.71E-08	3.07E-08	0.00E+00	3.67E-07	5.17E-05	2.43E-03	**2.54E-03**
	Selenium	1.18E-06	2.24E-09	1.03E-09	9.06E-09	4.15E-09	0.00E+00	3.64E-04	4.39E-05	1.68E-03	**2.09E-03**
	Uranium	1.41E-06	8.55E-09	3.91E-08	1.04E-08	4.78E-08	0.00E+00	1.92E-06	3.00E-05	3.65E-05	**6.99E-05**
	Vanadium	2.89E-06	1.01E-07	4.61E-07	9.26E-08	4.24E-07	0.00E+00	1.91E-05	7.20E-06	3.64E-04	**3.94E-04**
	Zinc	1.08E-05	1.11E-07	5.09E-07	7.30E-08	3.34E-07	0.00E+00	1.51E-03	1.07E-02	1.33E-01	**1.46E-01**
		Project Incremental Dose - Project Phases									
	Cadmium	3.42E-08	4.09E-14	1.82E-14	1.63E-10	7.44E-11	0.00E+00	6.90E-09	2.56E-10	5.90E-08	**1.01E-07**
	Chromium	5.12E-07	2.70E-13	1.22E-12	1.83E-09	8.40E-09	0.00E+00	1.89E-06	1.05E-09	6.36E-07	**3.05E-06**
	Cobalt	5.45E-08	2.13E-13	9.75E-14	6.09E-11	2.79E-11	0.00E+00	4.55E-08	2.66E-09	1.49E-07	**2.51E-07**
	Copper	4.00E-07	9.75E-12	2.68E-11	5.28E-10	1.45E-09	0.00E+00	1.39E-05	1.28E-06	1.16E-05	**2.72E-05**
	Molybdenum	5.18E-05	3.73E-14	1.70E-14	6.48E-08	2.97E-08	0.00E+00	3.56E-07	1.12E-09	1.86E-05	**7.09E-05**
	Selenium	7.07E-07	8.57E-14	3.92E-14	4.73E-09	2.16E-09	0.00E+00	1.97E-04	2.12E-09	2.99E-05	**2.27E-04**
	Uranium	9.66E-07	5.52E-10	2.53E-09	6.42E-09	2.94E-08	0.00E+00	1.30E-06	2.67E-06	1.33E-06	**6.32E-06**
	Vanadium	7.62E-07	1.08E-12	4.95E-12	1.47E-08	6.71E-08	0.00E+00	4.82E-06	1.75E-09	3.98E-06	**9.65E-06**
	Zinc	8.49E-07	3.40E-12	1.56E-11	3.78E-09	1.73E-08	0.00E+00	1.14E-04	2.89E-07	5.70E-05	**1.72E-04**
		Average Baseline Dose									
	Cadmium	3.80E-07	4.93E-07	5.91E-09	1.54E-07	1.84E-09	0.00E+00	6.76E-08	1.57E-05	5.03E-04	**5.20E-04**
	Chromium	8.51E-06	4.53E-06	5.42E-07	2.67E-06	3.20E-07	0.00E+00	2.78E-05	2.58E-05	1.76E-05	**8.78E-05**
Seasonal Resident One-year-old (Russell Lake)	Cobalt	1.66E-06	3.63E-07	4.35E-09	1.15E-07	1.37E-09	0.00E+00	1.18E-06	1.46E-04	3.78E-04	**5.27E-04**
	Copper	1.02E-05	1.99E-06	1.43E-07	8.42E-07	6.05E-08	0.00E+00	3.02E-04	1.01E-02	4.29E-02	**5.33E-02**
	Molybdenum	1.75E-06	1.57E-07	1.88E-09	1.54E-07	1.84E-09	0.00E+00	1.04E-08	1.20E-04	6.29E-03	**6.41E-03**
	Selenium	5.30E-07	1.47E-07	1.76E-09	2.83E-07	3.39E-09	0.00E+00	1.59E-04	1.03E-04	4.13E-03	**4.39E-03**
	Uranium	4.93E-07	5.22E-07	6.26E-08	2.63E-07	3.15E-08	0.00E+00	5.84E-07	6.25E-05	9.10E-05	**1.55E-04**
	Vanadium	2.38E-06	6.58E-06	7.89E-07	5.09E-06	6.10E-07	0.00E+00	1.35E-05	1.30E-05	8.78E-04	**9.20E-04**
	Zinc	1.12E-05	7.26E-06	8.70E-07	4.52E-06	5.42E-07	0.00E+00	1.32E-03	2.45E-02	2.76E-01	**3.02E-01**

Human Receptor	COPC	Non-radiological Dose by Pathway during Project Phases (mg/kg/d)									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
		Project Total Dose - Project Phases									
Fisher/Trapper Adult (Russell Lake)	Cadmium	4.18E-07	4.93E-07	5.91E-09	1.64E-07	1.97E-09	0.00E+00	7.41E-08	1.57E-05	5.03E-04	**5.20E-04**
	Chromium	9.08E-06	4.53E-06	5.42E-07	2.79E-06	3.34E-07	0.00E+00	2.96E-05	2.58E-05	1.80E-05	**9.07E-05**
	Cobalt	1.72E-06	3.63E-07	4.35E-09	1.19E-07	1.42E-09	0.00E+00	1.23E-06	1.46E-04	3.78E-04	**5.27E-04**
	Copper	1.06E-05	1.99E-06	1.43E-07	8.76E-07	6.30E-08	0.00E+00	3.15E-04	1.01E-02	4.29E-02	**5.34E-02**
	Molybdenum	5.96E-05	1.57E-07	1.88E-09	4.39E-06	5.26E-08	0.00E+00	3.47E-07	1.20E-04	6.30E-03	**6.48E-03**
	Selenium	1.32E-06	1.47E-07	1.76E-09	5.92E-07	7.09E-09	0.00E+00	3.45E-04	1.03E-04	4.15E-03	**4.60E-03**
	Uranium	1.57E-06	5.59E-07	6.69E-08	6.82E-07	8.18E-08	0.00E+00	1.82E-06	6.78E-05	9.18E-05	**1.64E-04**
	Vanadium	3.23E-06	6.58E-06	7.89E-07	6.05E-06	7.25E-07	0.00E+00	1.81E-05	1.30E-05	8.80E-04	**9.29E-04**
	Zinc	1.21E-05	7.26E-06	8.70E-07	4.77E-06	5.71E-07	0.00E+00	1.43E-03	2.45E-02	2.76E-01	**3.02E-01**
		Project Incremental Dose - Project Phases									
	Cadmium	3.82E-08	2.67E-12	3.15E-14	1.06E-08	1.27E-10	0.00E+00	6.53E-09	5.28E-10	3.87E-08	**9.47E-08**
	Chromium	5.72E-07	1.77E-11	2.10E-12	1.20E-07	1.44E-08	0.00E+00	1.79E-06	1.34E-09	4.03E-07	**2.90E-06**
	Cobalt	6.08E-08	1.40E-11	1.67E-13	3.98E-09	4.77E-11	0.00E+00	4.31E-08	5.88E-09	8.25E-08	**1.96E-07**
	Copper	4.47E-07	6.37E-10	4.58E-11	3.45E-08	2.48E-09	0.00E+00	1.32E-05	2.98E-06	6.81E-06	**2.34E-05**
	Molybdenum	5.79E-05	2.43E-12	2.89E-14	4.23E-06	5.07E-08	0.00E+00	3.37E-07	2.49E-09	1.03E-05	**7.27E-05**
	Selenium	7.90E-07	5.60E-12	6.72E-14	3.09E-07	3.70E-09	0.00E+00	1.86E-04	4.83E-09	1.85E-05	**2.06E-04**
	Uranium	1.08E-06	3.61E-08	4.32E-09	4.19E-07	5.03E-08	0.00E+00	1.24E-06	5.28E-06	8.05E-07	**8.91E-06**
	Vanadium	8.51E-07	7.09E-11	8.47E-12	9.58E-07	1.15E-07	0.00E+00	4.57E-06	2.21E-09	2.19E-06	**8.69E-06**
	Zinc	9.48E-07	2.22E-10	2.67E-11	2.47E-07	2.96E-08	0.00E+00	1.07E-04	6.76E-07	2.94E-05	**1.39E-04**
		Average Baseline Dose									
	Cadmium	3.40E-07	7.55E-09	3.46E-09	2.35E-09	1.08E-09	0.00E+00	4.91E-07	0.00E+00	1.61E-04	**1.62E-04**
	Chromium	7.62E-06	6.93E-08	3.17E-07	4.08E-08	1.87E-07	0.00E+00	2.02E-04	0.00E+00	8.27E-04	**1.04E-03**
	Cobalt	1.48E-06	5.55E-09	2.54E-09	1.76E-09	8.04E-10	0.00E+00	8.60E-06	0.00E+00	7.79E-05	**8.80E-05**
	Copper	9.09E-06	3.05E-08	8.37E-08	1.29E-08	3.54E-08	0.00E+00	2.19E-03	0.00E+00	1.19E-02	**1.41E-02**
	Molybdenum	1.57E-06	2.40E-09	1.10E-09	2.35E-09	1.08E-09	0.00E+00	7.58E-08	0.00E+00	1.28E-03	**1.28E-03**
	Selenium	4.74E-07	2.24E-09	1.03E-09	4.33E-09	1.98E-09	0.00E+00	1.15E-03	0.00E+00	1.58E-03	**2.73E-03**
	Uranium	4.41E-07	8.00E-09	3.66E-08	4.03E-09	1.84E-08	0.00E+00	4.24E-06	0.00E+00	2.19E-05	**2.66E-05**
	Vanadium	2.13E-06	1.01E-07	4.61E-07	7.79E-08	3.57E-07	0.00E+00	9.80E-05	0.00E+00	7.72E-04	**8.73E-04**
	Zinc	9.99E-06	1.11E-07	5.09E-07	6.92E-08	3.17E-07	0.00E+00	9.62E-03	0.00E+00	3.08E-01	**3.18E-01**
		Project Total Dose - Project Phases									
	Cadmium	3.90E-07	7.55E-09	3.46E-09	2.63E-09	1.20E-09	0.00E+00	6.35E-07	0.00E+00	1.62E-04	**1.63E-04**

Human Receptor	COPC	Non-radiological Dose by Pathway during Project Phases (mg/kg/d)									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Chromium	8.36E-06	6.93E-08	3.17E-07	4.39E-08	2.01E-07	0.00E+00	2.40E-04	0.00E+00	8.37E-04	**1.09E-03**
	Cobalt	1.58E-06	5.55E-09	2.54E-09	1.86E-09	8.50E-10	0.00E+00	9.73E-06	0.00E+00	7.80E-05	**8.94E-05**
	Copper	9.79E-06	3.05E-08	8.37E-08	1.38E-08	3.78E-08	0.00E+00	2.54E-03	0.00E+00	1.20E-02	**1.46E-02**
	Molybdenum	8.79E-05	2.40E-09	1.10E-09	1.10E-07	5.05E-08	0.00E+00	8.24E-06	0.00E+00	1.32E-03	**1.41E-03**
	Selenium	1.66E-06	2.24E-09	1.03E-09	1.22E-08	5.59E-09	0.00E+00	5.75E-03	0.00E+00	1.91E-03	**7.67E-03**
	Uranium	2.06E-06	8.92E-09	4.08E-08	1.47E-08	6.74E-08	0.00E+00	3.45E-05	0.00E+00	9.70E-05	**1.34E-04**
	Vanadium	3.18E-06	1.01E-07	4.61E-07	1.02E-07	4.68E-07	0.00E+00	1.79E-04	0.00E+00	8.55E-04	**1.04E-03**
	Zinc	1.12E-05	1.11E-07	5.09E-07	7.55E-08	3.46E-07	0.00E+00	1.18E-02	0.00E+00	3.09E-01	**3.21E-01**
		Project Incremental Dose - Project Phases									
	Cadmium	5.04E-08	6.75E-14	3.09E-14	2.71E-10	1.24E-10	0.00E+00	1.44E-07	0.00E+00	5.73E-07	**7.68E-07**
	Chromium	7.37E-07	4.48E-13	2.02E-12	3.05E-09	1.40E-08	0.00E+00	3.75E-05	0.00E+00	1.01E-05	**4.84E-05**
	Cobalt	9.49E-08	3.56E-13	1.63E-13	1.01E-10	4.64E-11	0.00E+00	1.13E-06	0.00E+00	1.37E-07	**1.36E-06**
	Copper	6.96E-07	1.63E-11	4.46E-11	8.80E-10	2.42E-09	0.00E+00	3.45E-04	0.00E+00	6.32E-05	**4.08E-04**
	Molybdenum	8.64E-05	6.22E-14	2.82E-14	1.08E-07	4.94E-08	0.00E+00	8.17E-06	0.00E+00	3.40E-05	**1.29E-04**
	Selenium	1.19E-06	1.43E-13	6.54E-14	7.88E-09	3.61E-09	0.00E+00	4.60E-03	0.00E+00	3.35E-04	**4.93E-03**
	Uranium	1.62E-06	9.20E-10	4.21E-09	1.07E-08	4.90E-08	0.00E+00	3.03E-05	0.00E+00	7.52E-05	**1.07E-04**
	Vanadium	1.05E-06	1.80E-12	8.27E-12	2.44E-08	1.12E-07	0.00E+00	8.12E-05	0.00E+00	8.30E-05	**1.65E-04**
	Zinc	1.22E-06	5.68E-12	2.60E-11	6.30E-09	2.88E-08	0.00E+00	2.21E-03	0.00E+00	1.07E-03	**3.28E-03**

COPC = constituent of potential concern.

Table 4-6: Estimated Non-radiological Doses to Human Receptors – Future Centuries

Human Receptor	COPC	Maximum Dose by Pathway during Future Centuries (mg/kg/d)									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
Permanent Resident (Whitefish Lake)		**Baseline Dose**									
	Cadmium	3.41E-07	7.55E-09	3.46E-09	2.36E-09	1.08E-09	0.00E+00	7.15E-08	7.02E-06	1.99E-04	**2.06E-04**
	Chromium	7.63E-06	6.93E-08	3.17E-07	4.09E-08	1.87E-07	0.00E+00	2.94E-05	1.12E-05	3.03E-05	**7.91E-05**
	Cobalt	1.49E-06	5.55E-09	2.54E-09	1.76E-09	8.04E-10	0.00E+00	1.25E-06	6.29E-05	1.77E-04	**2.42E-04**
	Copper	9.09E-06	3.05E-08	8.37E-08	1.29E-08	3.54E-08	0.00E+00	3.19E-04	4.37E-03	2.55E-02	**3.02E-02**
	Molybdenum	1.57E-06	2.40E-09	1.10E-09	2.35E-09	1.08E-09	0.00E+00	1.10E-08	5.17E-05	2.41E-03	**2.47E-03**
	Selenium	4.75E-07	2.24E-09	1.03E-09	4.34E-09	1.98E-09	0.00E+00	1.68E-04	4.39E-05	1.65E-03	**1.86E-03**
	Uranium	4.42E-07	8.00E-09	3.66E-08	4.03E-09	1.85E-08	0.00E+00	6.18E-07	2.73E-05	3.52E-05	**6.36E-05**
	Vanadium	2.14E-06	1.01E-07	4.61E-07	7.82E-08	3.58E-07	0.00E+00	1.43E-05	7.20E-06	3.60E-04	**3.85E-04**
	Zinc	1.00E-05	1.11E-07	5.09E-07	6.93E-08	3.17E-07	0.00E+00	1.40E-03	1.07E-02	1.33E-01	**1.45E-01**
		Project Total Dose - Future Centuries									
	Cadmium	3.43E-07	7.55E-09	3.46E-09	2.37E-09	1.09E-09	0.00E+00	7.19E-08	7.03E-06	1.99E-04	**2.06E-04**
	Chromium	7.73E-06	6.93E-08	3.17E-07	4.14E-08	1.90E-07	0.00E+00	2.98E-05	1.12E-05	3.05E-05	**7.97E-05**
	Cobalt	1.56E-06	5.56E-09	2.54E-09	1.85E-09	8.47E-10	0.00E+00	1.32E-06	6.30E-05	1.77E-04	**2.43E-04**
	Copper	9.22E-06	3.05E-08	8.37E-08	1.31E-08	3.59E-08	0.00E+00	3.23E-04	4.38E-03	2.55E-02	**3.02E-02**
	Molybdenum	1.71E-06	2.40E-09	1.10E-09	2.56E-09	1.17E-09	0.00E+00	1.20E-08	5.17E-05	2.41E-03	**2.47E-03**
	Selenium	6.33E-07	2.24E-09	1.03E-09	5.77E-09	2.64E-09	0.00E+00	2.17E-04	4.39E-05	1.66E-03	**1.92E-03**
	Uranium	5.41E-07	9.53E-09	4.36E-08	4.93E-09	2.26E-08	0.00E+00	7.56E-07	3.69E-05	3.53E-05	**7.36E-05**
	Vanadium	2.16E-06	1.01E-07	4.61E-07	7.89E-08	3.61E-07	0.00E+00	1.44E-05	7.20E-06	3.60E-04	**3.85E-04**
	Zinc	1.09E-05	1.11E-07	5.09E-07	7.53E-08	3.45E-07	0.00E+00	1.52E-03	1.07E-02	1.33E-01	**1.46E-01**
		Project Incremental Dose - Future Centuries									
	Cadmium	1.97E-09	1.26E-13	5.75E-14	1.37E-11	6.25E-12	0.00E+00	4.14E-10	2.29E-10	4.19E-09	**6.83E-09**
	Chromium	9.89E-08	0.00E+00	0.00E+00	5.29E-10	2.42E-09	0.00E+00	3.81E-07	0.00E+00	1.58E-07	**6.41E-07**
	Cobalt	7.89E-08	5.50E-12	2.52E-12	9.33E-11	4.27E-11	0.00E+00	6.64E-08	1.29E-07	1.80E-07	**4.55E-07**
	Copper	1.21E-07	1.72E-11	4.71E-11	1.71E-10	4.70E-10	0.00E+00	4.24E-06	4.64E-06	3.31E-06	**1.23E-05**
	Molybdenum	1.42E-07	0.00E+00	0.00E+00	2.13E-10	9.73E-11	0.00E+00	9.97E-10	0.00E+00	4.63E-08	**1.90E-07**
	Selenium	1.58E-07	2.35E-14	1.08E-14	1.44E-09	6.59E-10	0.00E+00	4.96E-05	9.64E-10	7.47E-06	**5.73E-05**

Human Receptor	COPC	Maximum Dose by Pathway during Future Centuries (mg/kg/d)									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Uranium	9.87E-08	1.53E-09	7.02E-09	9.00E-10	4.12E-09	0.00E+00	1.38E-07	9.63E-06	1.03E-07	**9.98E-06**
	Vanadium	1.93E-08	8.39E-12	3.85E-11	7.04E-10	3.22E-09	0.00E+00	1.29E-07	6.47E-10	1.24E-07	**2.77E-07**
	Zinc	8.67E-07	1.06E-11	4.86E-11	6.00E-09	2.74E-08	0.00E+00	1.21E-04	1.82E-06	5.55E-05	**1.79E-04**
Permanent Resident One-year-old (Whitefish Lake)		**Baseline Dose**									
	Cadmium	3.80E-07	4.93E-07	5.91E-09	1.54E-07	1.85E-09	0.00E+00	6.77E-08	1.57E-05	5.03E-04	**5.20E-04**
	Chromium	8.52E-06	4.53E-06	5.42E-07	2.67E-06	3.20E-07	0.00E+00	2.78E-05	2.58E-05	1.76E-05	**8.78E-05**
	Cobalt	1.66E-06	3.63E-07	4.35E-09	1.15E-07	1.38E-09	0.00E+00	1.18E-06	1.46E-04	3.78E-04	**5.27E-04**
	Copper	1.02E-05	1.99E-06	1.43E-07	8.42E-07	6.05E-08	0.00E+00	3.02E-04	1.01E-02	4.29E-02	**5.33E-02**
	Molybdenum	1.75E-06	1.57E-07	1.88E-09	1.54E-07	1.84E-09	0.00E+00	1.04E-08	1.20E-04	6.29E-03	**6.41E-03**
	Selenium	5.31E-07	1.47E-07	1.76E-09	2.83E-07	3.39E-09	0.00E+00	1.59E-04	1.03E-04	4.13E-03	**4.39E-03**
	Uranium	4.94E-07	5.22E-07	6.26E-08	2.63E-07	3.16E-08	0.00E+00	5.85E-07	6.25E-05	9.10E-05	**1.55E-04**
	Vanadium	2.39E-06	6.58E-06	7.89E-07	5.11E-06	6.12E-07	0.00E+00	1.35E-05	1.30E-05	8.78E-04	**9.20E-04**
	Zinc	1.12E-05	7.26E-06	8.70E-07	4.53E-06	5.42E-07	0.00E+00	1.33E-03	2.45E-02	2.76E-01	**3.02E-01**
		Project Total Dose - Future Centuries									
	Cadmium	3.83E-07	4.93E-07	5.91E-09	1.55E-07	1.86E-09	0.00E+00	6.81E-08	1.57E-05	5.03E-04	**5.20E-04**
	Chromium	8.63E-06	4.53E-06	5.42E-07	2.71E-06	3.24E-07	0.00E+00	2.82E-05	2.58E-05	1.77E-05	**8.84E-05**
	Cobalt	1.75E-06	3.63E-07	4.35E-09	1.21E-07	1.45E-09	0.00E+00	1.25E-06	1.46E-04	3.78E-04	**5.27E-04**
	Copper	1.03E-05	1.99E-06	1.43E-07	8.53E-07	6.13E-08	0.00E+00	3.06E-04	1.01E-02	4.29E-02	**5.33E-02**
	Molybdenum	1.91E-06	1.57E-07	1.88E-09	1.68E-07	2.01E-09	0.00E+00	1.14E-08	1.20E-04	6.29E-03	**6.41E-03**
	Selenium	7.07E-07	1.47E-07	1.76E-09	3.77E-07	4.52E-09	0.00E+00	2.06E-04	1.03E-04	4.13E-03	**4.44E-03**
	Uranium	6.04E-07	6.23E-07	7.46E-08	3.22E-07	3.86E-08	0.00E+00	7.16E-07	8.51E-05	9.11E-05	**1.79E-04**
	Vanadium	2.41E-06	6.58E-06	7.89E-07	5.16E-06	6.18E-07	0.00E+00	1.37E-05	1.30E-05	8.78E-04	**9.20E-04**
	Zinc	1.21E-05	7.26E-06	8.70E-07	4.92E-06	5.89E-07	0.00E+00	1.44E-03	2.45E-02	2.76E-01	**3.02E-01**
		Project Incremental Dose - Future Centuries									
	Cadmium	2.20E-09	8.24E-12	9.81E-14	8.92E-10	1.07E-11	0.00E+00	3.92E-10	5.17E-10	2.91E-09	**6.93E-09**
	Chromium	1.10E-07	0.00E+00	0.00E+00	3.46E-08	4.14E-09	0.00E+00	3.60E-07	0.00E+00	1.05E-07	**6.14E-07**
	Cobalt	8.81E-08	3.59E-10	4.30E-12	6.10E-09	7.31E-11	0.00E+00	6.29E-08	3.03E-07	1.06E-07	**5.67E-07**
	Copper	1.35E-07	1.12E-09	8.06E-11	1.12E-08	8.04E-10	0.00E+00	4.01E-06	1.09E-05	2.04E-06	**1.71E-05**

Human Receptor	COPC	Maximum Dose by Pathway during Future Centuries (mg/kg/d)									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Molybdenum	1.59E-07	0.00E+00	0.00E+00	1.39E-08	1.67E-10	0.00E+00	9.44E-10	0.00E+00	2.70E-08	**2.01E-07**
	Selenium	1.76E-07	1.53E-12	1.84E-14	9.41E-08	1.13E-09	0.00E+00	4.70E-05	2.26E-09	4.90E-06	**5.22E-05**
	Uranium	1.10E-07	1.00E-07	1.20E-08	5.88E-08	7.05E-09	0.00E+00	1.31E-07	2.26E-05	7.20E-08	**2.31E-05**
	Vanadium	2.15E-08	5.49E-10	6.58E-11	4.60E-08	5.51E-09	0.00E+00	1.22E-07	1.52E-09	6.90E-08	**2.66E-07**
	Zinc	9.68E-07	6.93E-10	8.31E-11	3.92E-07	4.70E-08	0.00E+00	1.15E-04	4.27E-06	2.81E-05	**1.49E-04**
Rec F/H (McGowan Lake)		Baseline Dose									
	Cadmium	3.41E-07	7.55E-09	3.46E-09	2.36E-09	1.08E-09	0.00E+00	7.15E-08	7.02E-06	1.99E-04	**2.06E-04**
	Chromium	7.63E-06	6.93E-08	3.17E-07	4.09E-08	1.87E-07	0.00E+00	2.94E-05	1.12E-05	3.03E-05	**7.91E-05**
	Cobalt	1.49E-06	5.55E-09	2.54E-09	1.76E-09	8.04E-10	0.00E+00	1.25E-06	6.29E-05	1.77E-04	**2.42E-04**
	Copper	9.09E-06	3.05E-08	8.37E-08	1.29E-08	3.54E-08	0.00E+00	3.19E-04	4.37E-03	2.55E-02	**3.02E-02**
	Molybdenum	1.57E-06	2.40E-09	1.10E-09	2.35E-09	1.08E-09	0.00E+00	1.10E-08	5.17E-05	2.41E-03	**2.47E-03**
	Selenium	4.75E-07	2.24E-09	1.03E-09	4.34E-09	1.98E-09	0.00E+00	1.68E-04	4.39E-05	1.65E-03	**1.86E-03**
	Uranium	4.42E-07	8.00E-09	3.66E-08	4.03E-09	1.85E-08	0.00E+00	6.18E-07	2.73E-05	3.52E-05	**6.36E-05**
	Vanadium	2.14E-06	1.01E-07	4.61E-07	7.82E-08	3.58E-07	0.00E+00	1.43E-05	7.20E-06	3.60E-04	**3.85E-04**
	Zinc	1.00E-05	1.11E-07	5.09E-07	6.93E-08	3.17E-07	0.00E+00	1.40E-03	1.07E-02	1.33E-01	**1.45E-01**
		Project Total Dose - Future Centuries									
	Cadmium	3.41E-07	7.55E-09	3.46E-09	2.36E-09	1.08E-09	0.00E+00	7.18E-08	7.02E-06	1.99E-04	**2.06E-04**
	Chromium	7.66E-06	6.93E-08	3.17E-07	4.10E-08	1.88E-07	0.00E+00	2.97E-05	1.12E-05	3.04E-05	**7.95E-05**
	Cobalt	1.50E-06	5.55E-09	2.54E-09	1.78E-09	8.13E-10	0.00E+00	1.30E-06	6.29E-05	1.77E-04	**2.42E-04**
	Copper	9.12E-06	3.05E-08	8.37E-08	1.29E-08	3.55E-08	0.00E+00	3.22E-04	4.38E-03	2.55E-02	**3.02E-02**
	Molybdenum	1.60E-06	2.40E-09	1.10E-09	2.40E-09	1.10E-09	0.00E+00	1.18E-08	5.17E-05	2.41E-03	**2.47E-03**
	Selenium	5.07E-07	2.24E-09	1.03E-09	4.62E-09	2.12E-09	0.00E+00	2.01E-04	4.39E-05	1.65E-03	**1.90E-03**
	Uranium	4.62E-07	8.11E-09	3.71E-08	4.21E-09	1.93E-08	0.00E+00	7.09E-07	2.86E-05	3.52E-05	**6.50E-05**
	Vanadium	2.14E-06	1.01E-07	4.61E-07	7.83E-08	3.58E-07	0.00E+00	1.44E-05	7.20E-06	3.60E-04	**3.85E-04**
	Zinc	1.02E-05	1.11E-07	5.09E-07	7.05E-08	3.23E-07	0.00E+00	1.48E-03	1.07E-02	1.33E-01	**1.46E-01**
		Project Incremental Dose - Future Centuries									
	Cadmium	4.06E-10	8.88E-15	3.77E-15	2.81E-12	1.29E-12	0.00E+00	2.84E-10	2.50E-11	3.04E-09	**3.76E-09**
	Chromium	2.09E-08	0.00E+00	0.00E+00	1.12E-10	5.11E-10	0.00E+00	2.68E-07	0.00E+00	1.16E-07	**4.05E-07**

Human Receptor	COPC	Maximum Dose by Pathway during Future Centuries (mg/kg/d)									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Cobalt	1.77E-08	3.81E-13	1.75E-13	2.10E-11	9.61E-12	0.00E+00	4.98E-08	1.40E-08	1.68E-07	**2.49E-07**
	Copper	2.71E-08	1.20E-12	3.29E-12	3.83E-11	1.05E-10	0.00E+00	3.16E-06	5.02E-07	2.65E-06	**6.34E-06**
	Molybdenum	3.18E-08	0.00E+00	0.00E+00	4.76E-11	2.18E-11	0.00E+00	7.43E-10	0.00E+00	4.33E-08	**7.59E-08**
	Selenium	3.15E-08	1.55E-15	6.66E-16	2.87E-10	1.31E-10	0.00E+00	3.31E-05	1.06E-10	5.14E-06	**3.83E-05**
	Uranium	1.97E-08	1.17E-10	5.34E-10	1.79E-10	8.21E-10	0.00E+00	9.16E-08	1.25E-06	4.54E-08	**1.41E-06**
	Vanadium	2.54E-09	5.76E-13	2.67E-12	9.29E-11	4.25E-10	0.00E+00	5.66E-08	7.05E-11	5.72E-08	**1.17E-07**
	Zinc	1.79E-07	7.46E-13	3.41E-12	1.24E-09	5.66E-09	0.00E+00	8.33E-05	1.97E-07	3.81E-05	**1.22E-04**
Rec F/H One-year-old (McGowan Lake)		Baseline Dose									
	Cadmium	3.80E-07	4.93E-07	5.91E-09	1.54E-07	1.85E-09	0.00E+00	6.77E-08	1.57E-05	5.03E-04	**5.20E-04**
	Chromium	8.52E-06	4.53E-06	5.42E-07	2.67E-06	3.20E-07	0.00E+00	2.78E-05	2.58E-05	1.76E-05	**8.78E-05**
	Cobalt	1.66E-06	3.63E-07	4.35E-09	1.15E-07	1.38E-09	0.00E+00	1.18E-06	1.46E-04	3.78E-04	**5.27E-04**
	Copper	1.02E-05	1.99E-06	1.43E-07	8.42E-07	6.05E-08	0.00E+00	3.02E-04	1.01E-02	4.29E-02	**5.33E-02**
	Molybdenum	1.75E-06	1.57E-07	1.88E-09	1.54E-07	1.84E-09	0.00E+00	1.04E-08	1.20E-04	6.29E-03	**6.41E-03**
	Selenium	5.31E-07	1.47E-07	1.76E-09	2.83E-07	3.39E-09	0.00E+00	1.59E-04	1.03E-04	4.13E-03	**4.39E-03**
	Uranium	4.94E-07	5.22E-07	6.26E-08	2.63E-07	3.16E-08	0.00E+00	5.85E-07	6.25E-05	9.10E-05	**1.55E-04**
	Vanadium	2.39E-06	6.58E-06	7.89E-07	5.11E-06	6.12E-07	0.00E+00	1.35E-05	1.30E-05	8.78E-04	**9.20E-04**
	Zinc	1.12E-05	7.26E-06	8.70E-07	4.53E-06	5.42E-07	0.00E+00	1.33E-03	2.45E-02	2.76E-01	**3.02E-01**
		Project Total Dose - Future Centuries									
	Cadmium	3.81E-07	4.93E-07	5.91E-09	1.54E-07	1.85E-09	0.00E+00	6.80E-08	1.57E-05	5.03E-04	**5.20E-04**
	Chromium	8.55E-06	4.53E-06	5.42E-07	2.68E-06	3.21E-07	0.00E+00	2.81E-05	2.58E-05	1.77E-05	**8.82E-05**
	Cobalt	1.68E-06	3.63E-07	4.35E-09	1.16E-07	1.39E-09	0.00E+00	1.23E-06	1.46E-04	3.78E-04	**5.27E-04**
	Copper	1.02E-05	1.99E-06	1.43E-07	8.44E-07	6.07E-08	0.00E+00	3.05E-04	1.01E-02	4.29E-02	**5.33E-02**
	Molybdenum	1.79E-06	1.57E-07	1.88E-09	1.57E-07	1.88E-09	0.00E+00	1.11E-08	1.20E-04	6.29E-03	**6.41E-03**
	Selenium	5.66E-07	1.47E-07	1.76E-09	3.02E-07	3.62E-09	0.00E+00	1.90E-04	1.03E-04	4.13E-03	**4.43E-03**
	Uranium	5.16E-07	5.30E-07	6.35E-08	2.75E-07	3.30E-08	0.00E+00	6.72E-07	6.55E-05	9.11E-05	**1.59E-04**
	Vanadium	2.39E-06	6.58E-06	7.89E-07	5.12E-06	6.13E-07	0.00E+00	1.36E-05	1.30E-05	8.78E-04	**9.20E-04**
	Zinc	1.14E-05	7.26E-06	8.70E-07	4.61E-06	5.52E-07	0.00E+00	1.41E-03	2.45E-02	2.76E-01	**3.02E-01**
		Project Incremental Dose - Future Centuries									

Human Receptor	COPC	Maximum Dose by Pathway during Future Centuries (mg/kg/d)									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Cadmium	4.54E-10	5.68E-13	6.66E-15	1.84E-10	2.20E-12	0.00E+00	2.69E-10	5.64E-11	2.10E-09	**3.06E-09**
	Chromium	2.33E-08	0.00E+00	0.00E+00	7.30E-09	8.75E-10	0.00E+00	2.54E-07	0.00E+00	7.68E-08	**3.62E-07**
	Cobalt	1.98E-08	2.49E-11	2.98E-13	1.37E-09	1.64E-11	0.00E+00	4.72E-08	3.29E-08	9.69E-08	**1.98E-07**
	Copper	3.02E-08	7.82E-11	5.61E-12	2.50E-09	1.80E-10	0.00E+00	3.00E-06	1.18E-06	1.62E-06	**5.83E-06**
	Molybdenum	3.55E-08	0.00E+00	0.00E+00	3.11E-09	3.73E-11	0.00E+00	7.04E-10	0.00E+00	2.47E-08	**6.40E-08**
	Selenium	3.51E-08	9.95E-14	1.22E-15	1.88E-08	2.25E-10	0.00E+00	3.14E-05	2.47E-10	3.35E-06	**3.48E-05**
	Uranium	2.20E-08	7.63E-09	9.14E-10	1.17E-08	1.40E-09	0.00E+00	8.68E-08	2.95E-06	3.30E-08	**3.11E-06**
	Vanadium	2.84E-09	3.87E-11	4.55E-12	6.07E-09	7.27E-10	0.00E+00	5.36E-08	1.65E-10	3.18E-08	**9.53E-08**
	Zinc	1.99E-07	4.77E-11	5.80E-12	8.07E-08	9.68E-09	0.00E+00	7.89E-05	4.62E-07	1.93E-05	**9.89E-05**
Rec F/H (Russell Lake)		**Baseline Dose**									
	Cadmium	3.41E-07	7.55E-09	3.46E-09	2.36E-09	1.08E-09	0.00E+00	7.15E-08	7.02E-06	1.99E-04	**2.06E-04**
	Chromium	7.63E-06	6.93E-08	3.17E-07	4.09E-08	1.87E-07	0.00E+00	2.94E-05	1.12E-05	3.03E-05	**7.91E-05**
	Cobalt	1.49E-06	5.55E-09	2.54E-09	1.76E-09	8.04E-10	0.00E+00	1.25E-06	6.29E-05	1.77E-04	**2.42E-04**
	Copper	9.09E-06	3.05E-08	8.37E-08	1.29E-08	3.54E-08	0.00E+00	3.19E-04	4.37E-03	2.55E-02	**3.02E-02**
	Molybdenum	1.57E-06	2.40E-09	1.10E-09	2.35E-09	1.08E-09	0.00E+00	1.10E-08	5.17E-05	2.41E-03	**2.47E-03**
	Selenium	4.75E-07	2.24E-09	1.03E-09	4.34E-09	1.98E-09	0.00E+00	1.68E-04	4.39E-05	1.65E-03	**1.86E-03**
	Uranium	4.42E-07	8.00E-09	3.66E-08	4.03E-09	1.85E-08	0.00E+00	6.18E-07	2.73E-05	3.52E-05	**6.36E-05**
	Vanadium	2.14E-06	1.01E-07	4.61E-07	7.82E-08	3.58E-07	0.00E+00	1.43E-05	7.20E-06	3.60E-04	**3.85E-04**
	Zinc	1.00E-05	1.11E-07	5.09E-07	6.93E-08	3.17E-07	0.00E+00	1.40E-03	1.07E-02	1.33E-01	**1.45E-01**
		Project Total Dose - Future Centuries									
	Cadmium	3.41E-07	7.55E-09	3.46E-09	2.36E-09	1.08E-09	0.00E+00	7.17E-08	7.02E-06	1.99E-04	**2.06E-04**
	Chromium	7.65E-06	6.93E-08	3.17E-07	4.10E-08	1.87E-07	0.00E+00	2.96E-05	1.12E-05	3.04E-05	**7.94E-05**
	Cobalt	1.50E-06	5.55E-09	2.54E-09	1.77E-09	8.11E-10	0.00E+00	1.29E-06	6.29E-05	1.77E-04	**2.42E-04**
	Copper	9.12E-06	3.05E-08	8.37E-08	1.29E-08	3.55E-08	0.00E+00	3.21E-04	4.37E-03	2.55E-02	**3.02E-02**
	Molybdenum	1.60E-06	2.40E-09	1.10E-09	2.39E-09	1.09E-09	0.00E+00	1.16E-08	5.17E-05	2.41E-03	**2.47E-03**
	Selenium	4.98E-07	2.24E-09	1.03E-09	4.55E-09	2.08E-09	0.00E+00	1.92E-04	4.39E-05	1.65E-03	**1.89E-03**
	Uranium	4.57E-07	8.03E-09	3.67E-08	4.16E-09	1.91E-08	0.00E+00	6.85E-07	2.76E-05	3.52E-05	**6.41E-05**
	Vanadium	2.14E-06	1.01E-07	4.61E-07	7.82E-08	3.58E-07	0.00E+00	1.43E-05	7.20E-06	3.60E-04	**3.85E-04**

Human Receptor	COPC	Maximum Dose by Pathway during Future Centuries (mg/kg/d)									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Zinc	1.01E-05	1.11E-07	5.09E-07	7.02E-08	3.21E-07	0.00E+00	1.46E-03	1.07E-02	1.33E-01	**1.46E-01**
		Project Incremental Dose - Future Centuries									
	Cadmium	3.02E-10	2.66E-15	1.11E-15	2.09E-12	9.55E-13	0.00E+00	2.11E-10	6.37E-12	2.27E-09	**2.79E-09**
	Chromium	1.56E-08	0.00E+00	0.00E+00	8.35E-11	3.82E-10	0.00E+00	2.00E-07	0.00E+00	8.78E-08	**3.04E-07**
	Cobalt	1.35E-08	9.81E-14	4.46E-14	1.60E-11	7.32E-12	0.00E+00	3.80E-08	3.59E-09	1.25E-07	**1.81E-07**
	Copper	2.06E-08	3.09E-13	8.53E-13	2.92E-11	8.02E-11	0.00E+00	2.41E-06	1.29E-07	1.74E-06	**4.30E-06**
	Molybdenum	2.42E-08	0.00E+00	0.00E+00	3.62E-11	1.66E-11	0.00E+00	5.66E-10	0.00E+00	3.28E-08	**5.77E-08**
	Selenium	2.31E-08	2.22E-16	1.11E-16	2.11E-10	9.65E-11	0.00E+00	2.44E-05	2.55E-11	3.82E-06	**2.82E-05**
	Uranium	1.44E-08	3.11E-11	1.42E-10	1.32E-10	6.03E-10	0.00E+00	6.73E-08	3.35E-07	3.04E-08	**4.48E-07**
	Vanadium	1.63E-09	1.42E-13	7.11E-13	5.94E-11	2.72E-10	0.00E+00	3.62E-08	1.77E-11	3.82E-08	**7.64E-08**
	Zinc	1.33E-07	1.92E-13	8.53E-13	9.17E-10	4.20E-09	0.00E+00	6.18E-05	5.03E-08	2.89E-05	**9.09E-05**
Rec F/H One-year-old (Russell Lake)		**Baseline Dose**									
	Cadmium	3.80E-07	4.93E-07	5.91E-09	1.54E-07	1.85E-09	0.00E+00	6.77E-08	1.57E-05	5.03E-04	**5.20E-04**
	Chromium	8.52E-06	4.53E-06	5.42E-07	2.67E-06	3.20E-07	0.00E+00	2.78E-05	2.58E-05	1.76E-05	**8.78E-05**
	Cobalt	1.66E-06	3.63E-07	4.35E-09	1.15E-07	1.38E-09	0.00E+00	1.18E-06	1.46E-04	3.78E-04	**5.27E-04**
	Copper	1.02E-05	1.99E-06	1.43E-07	8.42E-07	6.05E-08	0.00E+00	3.02E-04	1.01E-02	4.29E-02	**5.33E-02**
	Molybdenum	1.75E-06	1.57E-07	1.88E-09	1.54E-07	1.84E-09	0.00E+00	1.04E-08	1.20E-04	6.29E-03	**6.41E-03**
	Selenium	5.31E-07	1.47E-07	1.76E-09	2.83E-07	3.39E-09	0.00E+00	1.59E-04	1.03E-04	4.13E-03	**4.39E-03**
	Uranium	4.94E-07	5.22E-07	6.26E-08	2.63E-07	3.16E-08	0.00E+00	5.85E-07	6.25E-05	9.10E-05	**1.55E-04**
	Vanadium	2.39E-06	6.58E-06	7.89E-07	5.11E-06	6.12E-07	0.00E+00	1.35E-05	1.30E-05	8.78E-04	**9.20E-04**
	Zinc	1.12E-05	7.26E-06	8.70E-07	4.53E-06	5.42E-07	0.00E+00	1.33E-03	2.45E-02	2.76E-01	**3.02E-01**
		Project Total Dose - Future Centuries									
	Cadmium	3.81E-07	4.93E-07	5.91E-09	1.54E-07	1.85E-09	0.00E+00	6.79E-08	1.57E-05	5.03E-04	**5.20E-04**
	Chromium	8.54E-06	4.53E-06	5.42E-07	2.68E-06	3.21E-07	0.00E+00	2.80E-05	2.58E-05	1.77E-05	**8.81E-05**
	Cobalt	1.67E-06	3.63E-07	4.35E-09	1.16E-07	1.39E-09	0.00E+00	1.22E-06	1.46E-04	3.78E-04	**5.27E-04**
	Copper	1.02E-05	1.99E-06	1.43E-07	8.44E-07	6.07E-08	0.00E+00	3.04E-04	1.01E-02	4.29E-02	**5.33E-02**
	Molybdenum	1.78E-06	1.57E-07	1.88E-09	1.56E-07	1.87E-09	0.00E+00	1.10E-08	1.20E-04	6.29E-03	**6.41E-03**
	Selenium	5.57E-07	1.47E-07	1.76E-09	2.97E-07	3.56E-09	0.00E+00	1.82E-04	1.03E-04	4.13E-03	**4.42E-03**

Human Receptor	COPC	Maximum Dose by Pathway during Future Centuries (mg/kg/d)									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Uranium	5.10E-07	5.25E-07	6.29E-08	2.72E-07	3.26E-08	0.00E+00	6.49E-07	6.33E-05	9.10E-05	**1.56E-04**
	Vanadium	2.39E-06	6.58E-06	7.89E-07	5.11E-06	6.13E-07	0.00E+00	1.36E-05	1.30E-05	8.78E-04	**9.20E-04**
	Zinc	1.13E-05	7.26E-06	8.70E-07	4.59E-06	5.50E-07	0.00E+00	1.38E-03	2.45E-02	2.76E-01	**3.02E-01**
		Project Incremental Dose - Future Centuries									
	Cadmium	3.37E-10	1.71E-13	1.78E-15	1.36E-10	1.63E-12	0.00E+00	2.00E-10	1.46E-11	1.57E-09	**2.26E-09**
	Chromium	1.74E-08	0.00E+00	0.00E+00	5.46E-09	6.54E-10	0.00E+00	1.90E-07	0.00E+00	5.81E-08	**2.71E-07**
	Cobalt	1.51E-08	6.39E-12	7.64E-14	1.05E-09	1.25E-11	0.00E+00	3.60E-08	8.44E-09	7.26E-08	**1.33E-07**
	Copper	2.30E-08	2.00E-11	1.45E-12	1.91E-09	1.37E-10	0.00E+00	2.28E-06	3.04E-07	1.09E-06	**3.70E-06**
	Molybdenum	2.70E-08	0.00E+00	0.00E+00	2.37E-09	2.84E-11	0.00E+00	5.36E-10	0.00E+00	1.91E-08	**4.91E-08**
	Selenium	2.58E-08	1.42E-14	2.22E-16	1.38E-08	1.65E-10	0.00E+00	2.31E-05	6.55E-11	2.49E-06	**2.56E-05**
	Uranium	1.61E-08	2.03E-09	2.44E-10	8.61E-09	1.03E-09	0.00E+00	6.37E-08	7.87E-07	2.25E-08	**9.01E-07**
	Vanadium	1.82E-09	1.00E-11	1.19E-12	3.88E-09	4.65E-10	0.00E+00	3.43E-08	4.18E-11	2.11E-08	**6.16E-08**
	Zinc	1.48E-07	1.23E-11	1.53E-12	5.99E-08	7.18E-09	0.00E+00	5.85E-05	1.21E-07	1.46E-05	**7.35E-05**
Seasonal Resident (Russell Lake)		**Baseline Dose**									
	Cadmium	3.41E-07	7.55E-09	3.46E-09	2.36E-09	1.08E-09	0.00E+00	7.15E-08	7.02E-06	1.99E-04	**2.06E-04**
	Chromium	7.63E-06	6.93E-08	3.17E-07	4.09E-08	1.87E-07	0.00E+00	2.94E-05	1.12E-05	3.03E-05	**7.91E-05**
	Cobalt	1.49E-06	5.55E-09	2.54E-09	1.76E-09	8.04E-10	0.00E+00	1.25E-06	6.29E-05	1.77E-04	**2.42E-04**
	Copper	9.09E-06	3.05E-08	8.37E-08	1.29E-08	3.54E-08	0.00E+00	3.19E-04	4.37E-03	2.55E-02	**3.02E-02**
	Molybdenum	1.57E-06	2.40E-09	1.10E-09	2.35E-09	1.08E-09	0.00E+00	1.10E-08	5.17E-05	2.41E-03	**2.47E-03**
	Sulphate	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
	Selenium	4.75E-07	2.24E-09	1.03E-09	4.34E-09	1.98E-09	0.00E+00	1.68E-04	4.39E-05	1.65E-03	**1.86E-03**
	Uranium	4.42E-07	8.00E-09	3.66E-08	4.03E-09	1.85E-08	0.00E+00	6.18E-07	2.73E-05	3.52E-05	**6.36E-05**
	Vanadium	2.14E-06	1.01E-07	4.61E-07	7.82E-08	3.58E-07	0.00E+00	1.43E-05	7.20E-06	3.60E-04	**3.85E-04**
	Zinc	1.00E-05	1.11E-07	5.09E-07	6.93E-08	3.17E-07	0.00E+00	1.40E-03	1.07E-02	1.33E-01	**1.45E-01**
		Project Total Dose - Future Centuries									
	Cadmium	3.41E-07	7.55E-09	3.46E-09	2.36E-09	1.08E-09	0.00E+00	7.16E-08	7.02E-06	1.99E-04	**2.06E-04**
	Chromium	7.65E-06	6.93E-08	3.17E-07	4.10E-08	1.87E-07	0.00E+00	2.95E-05	1.12E-05	3.03E-05	**7.92E-05**
	Cobalt	1.50E-06	5.55E-09	2.54E-09	1.77E-09	8.11E-10	0.00E+00	1.26E-06	6.29E-05	1.77E-04	**2.42E-04**

Human Receptor	COPC	Maximum Dose by Pathway during Future Centuries (mg/kg/d)									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Copper	9.12E-06	3.05E-08	8.37E-08	1.29E-08	3.55E-08	0.00E+00	3.20E-04	4.37E-03	2.55E-02	**3.02E-02**
	Molybdenum	1.60E-06	2.40E-09	1.10E-09	2.39E-09	1.09E-09	0.00E+00	1.12E-08	5.17E-05	2.41E-03	**2.47E-03**
	Selenium	4.98E-07	2.24E-09	1.03E-09	4.55E-09	2.08E-09	0.00E+00	1.75E-04	4.39E-05	1.65E-03	**1.87E-03**
	Uranium	4.57E-07	8.03E-09	3.67E-08	4.16E-09	1.91E-08	0.00E+00	6.38E-07	2.74E-05	3.52E-05	**6.38E-05**
	Vanadium	2.14E-06	1.01E-07	4.61E-07	7.82E-08	3.58E-07	0.00E+00	1.43E-05	7.20E-06	3.60E-04	**3.85E-04**
	Zinc	1.01E-05	1.11E-07	5.09E-07	7.02E-08	3.21E-07	0.00E+00	1.42E-03	1.07E-02	1.33E-01	**1.45E-01**
		Project Incremental Dose - Future Centuries									
	Cadmium	3.02E-10	2.66E-15	1.11E-15	2.09E-12	9.55E-13	0.00E+00	6.33E-11	1.82E-12	7.13E-10	**1.08E-09**
	Chromium	1.56E-08	0.00E+00	0.00E+00	8.35E-11	3.82E-10	0.00E+00	6.01E-08	0.00E+00	2.85E-08	**1.05E-07**
	Cobalt	1.35E-08	9.81E-14	4.46E-14	1.60E-11	7.32E-12	0.00E+00	1.14E-08	1.08E-09	3.73E-08	**6.33E-08**
	Copper	2.06E-08	3.09E-13	8.53E-13	2.92E-11	8.02E-11	0.00E+00	7.23E-07	3.86E-08	5.22E-07	**1.30E-06**
	Molybdenum	2.42E-08	0.00E+00	0.00E+00	3.62E-11	1.66E-11	0.00E+00	1.70E-10	0.00E+00	9.78E-09	**3.42E-08**
	Selenium	2.31E-08	2.22E-16	1.11E-16	2.11E-10	9.65E-11	0.00E+00	7.31E-06	7.28E-12	1.22E-06	**8.56E-06**
	Uranium	1.44E-08	3.11E-11	1.42E-10	1.32E-10	6.03E-10	0.00E+00	2.02E-08	1.00E-07	9.43E-09	**1.45E-07**
	Vanadium	1.63E-09	1.42E-13	7.11E-13	5.94E-11	2.72E-10	0.00E+00	1.09E-08	5.00E-12	1.33E-08	**2.61E-08**
	Zinc	1.33E-07	1.92E-13	8.53E-13	9.17E-10	4.20E-09	0.00E+00	1.85E-05	1.49E-08	9.63E-06	**2.83E-05**
Seasonal Resident One-year-old (Russell Lake)		**Baseline Dose**									
	Cadmium	3.80E-07	4.93E-07	5.91E-09	1.54E-07	1.85E-09	0.00E+00	6.77E-08	1.57E-05	5.03E-04	**5.20E-04**
	Chromium	8.52E-06	4.53E-06	5.42E-07	2.67E-06	3.20E-07	0.00E+00	2.78E-05	2.58E-05	1.76E-05	**8.78E-05**
	Cobalt	1.66E-06	3.63E-07	4.35E-09	1.15E-07	1.38E-09	0.00E+00	1.18E-06	1.46E-04	3.78E-04	**5.27E-04**
	Copper	1.02E-05	1.99E-06	1.43E-07	8.42E-07	6.05E-08	0.00E+00	3.02E-04	1.01E-02	4.29E-02	**5.33E-02**
	Molybdenum	1.75E-06	1.57E-07	1.88E-09	1.54E-07	1.84E-09	0.00E+00	1.04E-08	1.20E-04	6.29E-03	**6.41E-03**
	Selenium	5.31E-07	1.47E-07	1.76E-09	2.83E-07	3.39E-09	0.00E+00	1.59E-04	1.03E-04	4.13E-03	**4.39E-03**
	Uranium	4.94E-07	5.22E-07	6.26E-08	2.63E-07	3.16E-08	0.00E+00	5.85E-07	6.25E-05	9.10E-05	**1.55E-04**
	Vanadium	2.39E-06	6.58E-06	7.89E-07	5.11E-06	6.12E-07	0.00E+00	1.35E-05	1.30E-05	8.78E-04	**9.20E-04**
	Zinc	1.12E-05	7.26E-06	8.70E-07	4.53E-06	5.42E-07	0.00E+00	1.33E-03	2.45E-02	2.76E-01	**3.02E-01**
		Project Total Dose - Future Centuries									
	Cadmium	3.81E-07	4.93E-07	5.91E-09	1.54E-07	1.85E-09	0.00E+00	6.78E-08	1.57E-05	5.03E-04	**5.20E-04**

Human Receptor	COPC	Maximum Dose by Pathway during Future Centuries (mg/kg/d)									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Chromium	8.54E-06	4.53E-06	5.42E-07	2.68E-06	3.21E-07	0.00E+00	2.79E-05	2.58E-05	1.76E-05	**8.79E-05**
	Cobalt	1.67E-06	3.63E-07	4.35E-09	1.16E-07	1.39E-09	0.00E+00	1.19E-06	1.46E-04	3.78E-04	**5.27E-04**
	Copper	1.02E-05	1.99E-06	1.43E-07	8.44E-07	6.07E-08	0.00E+00	3.03E-04	1.01E-02	4.29E-02	**5.33E-02**
	Molybdenum	1.78E-06	1.57E-07	1.88E-09	1.56E-07	1.87E-09	0.00E+00	1.06E-08	1.20E-04	6.29E-03	**6.41E-03**
	Selenium	5.57E-07	1.47E-07	1.76E-09	2.97E-07	3.56E-09	0.00E+00	1.66E-04	1.03E-04	4.13E-03	**4.40E-03**
	Uranium	5.10E-07	5.25E-07	6.29E-08	2.72E-07	3.26E-08	0.00E+00	6.04E-07	6.27E-05	9.10E-05	**1.56E-04**
	Vanadium	2.39E-06	6.58E-06	7.89E-07	5.11E-06	6.13E-07	0.00E+00	1.36E-05	1.30E-05	8.78E-04	**9.20E-04**
	Zinc	1.13E-05	7.26E-06	8.70E-07	4.59E-06	5.50E-07	0.00E+00	1.34E-03	2.45E-02	2.76E-01	**3.02E-01**
		Project Incremental Dose - Future Centuries									
	Cadmium	3.37E-10	1.71E-13	1.78E-15	1.36E-10	1.63E-12	0.00E+00	5.99E-11	3.64E-12	4.66E-10	**1.00E-09**
	Chromium	1.74E-08	0.00E+00	0.00E+00	5.46E-09	6.54E-10	0.00E+00	5.69E-08	0.00E+00	1.82E-08	**9.86E-08**
	Cobalt	1.51E-08	6.39E-12	7.64E-14	1.05E-09	1.25E-11	0.00E+00	1.08E-08	2.52E-09	2.08E-08	**5.03E-08**
	Copper	2.30E-08	2.00E-11	1.45E-12	1.91E-09	1.37E-10	0.00E+00	6.84E-07	9.22E-08	3.13E-07	**1.11E-06**
	Molybdenum	2.70E-08	0.00E+00	0.00E+00	2.37E-09	2.84E-11	0.00E+00	1.61E-10	0.00E+00	5.59E-09	**3.52E-08**
	Selenium	2.58E-08	1.42E-14	2.22E-16	1.38E-08	1.65E-10	0.00E+00	6.93E-06	2.18E-11	7.66E-07	**7.73E-06**
	Uranium	1.61E-08	2.03E-09	2.44E-10	8.61E-09	1.03E-09	0.00E+00	1.91E-08	2.36E-07	6.59E-09	**2.90E-07**
	Vanadium	1.82E-09	1.00E-11	1.19E-12	3.88E-09	4.65E-10	0.00E+00	1.03E-08	1.18E-11	7.39E-09	**2.39E-08**
	Zinc	1.48E-07	1.23E-11	1.53E-12	5.99E-08	7.18E-09	0.00E+00	1.76E-05	3.54E-08	5.07E-06	**2.29E-05**
Fisher/Trapper (Russell Lake)		Baseline Dose									
	Cadmium	3.41E-07	7.55E-09	3.46E-09	2.36E-09	1.08E-09	0.00E+00	4.92E-07	0.00E+00	1.61E-04	**1.62E-04**
	Chromium	7.63E-06	6.93E-08	3.17E-07	4.09E-08	1.87E-07	0.00E+00	2.02E-04	0.00E+00	8.27E-04	**1.04E-03**
	Cobalt	1.49E-06	5.55E-09	2.54E-09	1.76E-09	8.04E-10	0.00E+00	8.61E-06	0.00E+00	7.79E-05	**8.80E-05**
	Copper	9.09E-06	3.05E-08	8.37E-08	1.29E-08	3.54E-08	0.00E+00	2.20E-03	0.00E+00	1.19E-02	**1.41E-02**
	Molybdenum	1.57E-06	2.40E-09	1.10E-09	2.35E-09	1.08E-09	0.00E+00	7.59E-08	0.00E+00	1.28E-03	**1.28E-03**
	Selenium	4.75E-07	2.24E-09	1.03E-09	4.34E-09	1.98E-09	0.00E+00	1.16E-03	0.00E+00	1.58E-03	**2.74E-03**
	Uranium	4.42E-07	8.00E-09	3.66E-08	4.03E-09	1.85E-08	0.00E+00	4.25E-06	0.00E+00	2.19E-05	**2.66E-05**
	Vanadium	2.14E-06	1.01E-07	4.61E-07	7.82E-08	3.58E-07	0.00E+00	9.85E-05	0.00E+00	7.72E-04	**8.74E-04**
	Zinc	1.00E-05	1.11E-07	5.09E-07	6.93E-08	3.17E-07	0.00E+00	9.64E-03	0.00E+00	3.08E-01	**3.18E-01**

Human Receptor	COPC	Maximum Dose by Pathway during Future Centuries (mg/kg/d)									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
		Project Total Dose - Future Centuries									
	Cadmium	3.41E-07	7.55E-09	3.46E-09	2.36E-09	1.08E-09	0.00E+00	4.94E-07	0.00E+00	1.61E-04	**1.62E-04**
	Chromium	7.66E-06	6.93E-08	3.17E-07	4.10E-08	1.88E-07	0.00E+00	2.04E-04	0.00E+00	8.27E-04	**1.04E-03**
	Cobalt	1.51E-06	5.55E-09	2.54E-09	1.78E-09	8.16E-10	0.00E+00	8.87E-06	0.00E+00	7.79E-05	**8.83E-05**
	Copper	9.13E-06	3.05E-08	8.37E-08	1.29E-08	3.55E-08	0.00E+00	2.21E-03	0.00E+00	1.19E-02	**1.42E-02**
	Molybdenum	1.61E-06	2.40E-09	1.10E-09	2.41E-09	1.10E-09	0.00E+00	7.98E-08	0.00E+00	1.28E-03	**1.28E-03**
	Selenium	5.14E-07	2.24E-09	1.03E-09	4.69E-09	2.15E-09	0.00E+00	1.32E-03	0.00E+00	1.59E-03	**2.92E-03**
	Uranium	4.66E-07	8.05E-09	3.68E-08	4.25E-09	1.95E-08	0.00E+00	4.72E-06	0.00E+00	2.19E-05	**2.72E-05**
	Vanadium	2.14E-06	1.01E-07	4.61E-07	7.83E-08	3.58E-07	0.00E+00	9.87E-05	0.00E+00	7.73E-04	**8.74E-04**
	Zinc	1.02E-05	1.11E-07	5.09E-07	7.08E-08	3.24E-07	0.00E+00	1.01E-02	0.00E+00	3.08E-01	**3.18E-01**
		Project Incremental Dose - Future Centuries									
	Cadmium	5.03E-10	3.55E-15	1.55E-15	3.48E-12	1.59E-12	0.00E+00	1.45E-09	0.00E+00	6.43E-09	**8.39E-09**
	Chromium	2.60E-08	0.00E+00	0.00E+00	1.39E-10	6.37E-10	0.00E+00	1.38E-06	0.00E+00	3.77E-07	**1.78E-06**
	Cobalt	2.26E-08	1.63E-13	7.46E-14	2.67E-11	1.22E-11	0.00E+00	2.61E-07	0.00E+00	2.61E-08	**3.10E-07**
	Copper	3.43E-08	5.15E-13	1.41E-12	4.87E-11	1.34E-10	0.00E+00	1.66E-05	0.00E+00	1.07E-06	**1.77E-05**
	Molybdenum	4.03E-08	0.00E+00	0.00E+00	6.04E-11	2.76E-11	0.00E+00	3.90E-09	0.00E+00	1.84E-08	**6.27E-08**
	Selenium	3.85E-08	6.66E-16	3.33E-16	3.51E-10	1.61E-10	0.00E+00	1.68E-04	0.00E+00	1.31E-05	**1.81E-04**
	Uranium	2.41E-08	5.19E-11	2.37E-10	2.20E-10	1.00E-09	0.00E+00	4.63E-07	0.00E+00	5.65E-08	**5.45E-07**
	Vanadium	2.71E-09	2.49E-13	1.14E-12	9.89E-11	4.53E-10	0.00E+00	2.49E-07	0.00E+00	3.16E-07	**5.68E-07**
	Zinc	2.21E-07	3.13E-13	1.42E-12	1.53E-09	7.00E-09	0.00E+00	4.25E-04	0.00E+00	1.78E-04	**6.04E-04**

COPC = constituent of potential concern.

4.2.5.1.2 Carcinogen Dose

Arsenic was evaluated in the HHRA as a non-threshold carcinogen (i.e., a linear dose-response relationship); therefore, predicted exposure was averaged over the receptor's lifetime to estimate a lifetime average daily dose representing a combination of all life stages (Health Canada, 2021a). For this assessment, the lifetime average daily dose was estimated for various age groups (toddler, child, teen, adult) to permit estimation of the lifetime risk to a composite receptor for each of the recreational fisher/hunter, and seasonal resident (Table 4-7) for the Project phases. Therefore, a composite receptor was calculated assuming 4.5 years as a toddler, 7 years as a child, 8 years as a teen and 60 years as an adult. For the camp worker, an adult receptor was considered appropriate. The composite receptor represents a person exposed to the constituent throughout all stages of a lifetime. The lifetime average daily dose was estimated during the future centuries for a permanent resident, recreational fisher/hunter, seasonal resident, and fisher/trapper (Table 4-8).

Cadmium is considered a carcinogen due to inhalation exposure; however, since cadmium has not been identified as an air COPC, cadmium is not evaluated separately as a carcinogen.

Table 4-7: Estimated Carcinogen Doses for Arsenic to Human Receptors – Project Phases

	Lifetime Average Daily Dose (mg/kg/d)				
Age Group	Camp Worker	Recreational Fisher/Hunter (LA-1)	Recreational Fisher/Hunter (Russell Lake)	Seasonal Resident (Russell Lake)	Fisher/Trapper (Russell Lake)
1-year-old	n/a	8.81E-08	5.21E-08	1.56E-08	n/a
Child	n/a	2.04E-07	1.21E-07	3.63E-08	n/a
Teen	n/a	1.71E-07	1.03E-07	3.09E-08	n/a
Adult	5.54E-07	1.94E-06	1.17E-06	3.51E-07	6.55E-06

n/a = not applicable, life stage was not assessed for the receptor.

Table 4-8: Estimated Carcinogen Doses for Arsenic to Human Receptors – Future Centuries

	Lifetime Average Daily Dose (mg/kg/d)				
Age Group	Permanent Resident (LA-5)	Recreational Fisher/Hunter (LA-1)	Recreational Fisher/Hunter (Russell Lake)	Seasonal Resident (Russell Lake)	Fisher/Trapper (Russell Lake)
1-year-old	2.65E-08	1.26E-08	8.12E-09	2.43E-09	n/a
Child	6.13E-08	2.92E-08	1.89E-08	5.66E-09	n/a
Teen	5.03E-08	2.42E-08	1.57E-08	4.70E-09	n/a
Adult	5.65E-07	2.72E-07	1.76E-07	5.29E-08	9.67E-07

n/a = not applicable, life stage was not assessed for the receptor.

4.2.5.2 Radiological Dose

The estimated radiological doses to human receptors due to releases from the Project during all phases is presented in Table 4-9, and in the future centuries in Table 4-10. The doses shown represent the maximum annual dose over the assessment period. The tables present the dose breakdown by radionuclide and exposure pathway, as well as the total dose. The radiation dose is presented as an incremental dose (i.e., only considering Project effects) because the dose limit is an incremental value.

During the Project phases, the maximum predicted incremental dose is 0.06 mSv/yr for the fisher/trapper (adult) who fishes in the embayment at the inlet to Russell Lake and hunts in the area around Russell Lake. The main contribution to total dose is from polonium-210 from eating local fish (white sucker and northern pike). During the future centuries, the maximum predicted incremental dose is 0.04 mSv/yr for the permanent resident (one-year old) who lives on the former Project site and fishes and hunts around Whitefish Lake. The main contribution to total dose is from polonium-210 from consuming terrestrial animals hunted in the area.

Table 4-9: Estimated Radiological Doses to Human Receptor – Project Phases

Human Receptor	COPC	Maximum Incremental Dose by Pathway during Project Phases (mSv/yr)												
		Air (internal)	Air (external)	Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by Radionuclide
Camp Worker Adult (Whitefish Lake)	Uranium-238	1.83E-03	5.02E-12	5.69E-05	4.32E-10	1.95E-07	2.16E-03	3.28E-07	3.50E-06	0.00E+00	4.35E-05	2.38E-04	3.59E-05	**4.37E-03**
	Uranium-234	2.21E-03	1.23E-11	6.20E-05	7.53E-11	2.12E-07	1.09E-05	3.58E-07	1.27E-08	0.00E+00	4.73E-05	2.60E-04	3.90E-05	**2.63E-03**
	Thorium-230	0.00E+00	0.00E+00	3.40E-04	2.30E-10	1.99E-10	3.06E-09	2.85E-07	7.05E-09	0.00E+00	9.20E-05	2.97E-08	4.31E-04	**8.63E-04**
	Radium-226	0.00E+00	0.00E+00	6.14E-05	2.74E-08	1.82E-12	4.10E-08	2.68E-07	3.21E-05	0.00E+00	3.31E-05	4.66E-09	1.08E-05	**1.38E-04**
	Lead-210	0.00E+00	0.00E+00	4.82E-04	4.24E-10	0.00E+00	0.00E+00	1.15E-05	6.48E-07	0.00E+00	7.32E-04	0.00E+00	1.30E-03	**2.52E-03**
	Polonium-210	0.00E+00	0.00E+00	5.39E-04	1.62E-12	0.00E+00	0.00E+00	1.94E-05	2.66E-09	0.00E+00	2.04E-03	0.00E+00	1.21E-02	**1.47E-02**
	Total by Pathway	**4.03E-03**	**1.73E-11**	**1.54E-03**	**2.86E-08**	**4.07E-07**	**2.17E-03**	**3.21E-05**	**3.63E-05**	**0.00E+00**	**2.98E-03**	**4.98E-04**	**1.39E-02**	**2.52E-02**
Rec F/H Adult (McGowan Lake)	Uranium-238	2.84E-04	7.80E-13	1.92E-05	1.46E-10	2.97E-08	3.29E-04	1.25E-07	1.34E-06	0.00E+00	8.69E-05	4.77E-04	7.19E-05	**1.27E-03**
	Uranium-234	3.43E-04	1.91E-12	2.09E-05	2.54E-11	3.23E-08	1.66E-06	1.36E-07	4.85E-09	0.00E+00	9.47E-05	5.19E-04	7.82E-05	**1.06E-03**
	Thorium-230	0.00E+00	0.00E+00	1.31E-04	8.84E-11	3.00E-11	4.62E-10	1.24E-07	3.06E-09	0.00E+00	1.84E-04	5.94E-08	8.57E-04	**1.17E-03**
	Radium-226	0.00E+00	0.00E+00	3.21E-05	1.43E-08	2.27E-13	7.45E-09	1.09E-07	1.31E-05	0.00E+00	6.62E-05	9.31E-09	2.15E-05	**1.33E-04**
	Lead-210	0.00E+00	0.00E+00	2.92E-04	2.58E-10	0.00E+00	0.00E+00	2.63E-06	1.49E-07	0.00E+00	1.47E-03	0.00E+00	2.58E-03	**4.34E-03**
	Polonium-210	0.00E+00	0.00E+00	4.39E-04	1.32E-12	0.00E+00	0.00E+00	4.49E-06	6.16E-10	0.00E+00	4.07E-03	0.00E+00	2.45E-02	**2.90E-02**
	Total by Pathway	**6.28E-04**	**2.69E-12**	**9.34E-04**	**1.49E-08**	**6.20E-08**	**3.31E-04**	**7.61E-06**	**1.46E-05**	**0.00E+00**	**5.97E-03**	**9.96E-04**	**2.81E-02**	**3.70E-02**
Rec F/H One-year-old (McGowan Lake)	Uranium-238	2.84E-04	1.01E-12	1.33E-05	3.60E-11	1.21E-06	4.40E-04	5.10E-06	1.74E-06	0.00E+00	5.12E-05	5.90E-04	2.82E-05	**1.41E-03**
	Uranium-234	3.32E-04	2.48E-12	1.44E-05	6.28E-12	1.31E-06	2.22E-06	5.52E-06	6.30E-09	0.00E+00	5.55E-05	6.39E-04	3.06E-05	**1.08E-03**
	Thorium-230	0.00E+00	0.00E+00	6.64E-05	2.19E-11	9.02E-10	5.24E-10	3.68E-06	3.97E-09	0.00E+00	7.94E-05	6.37E-08	2.06E-04	**3.55E-04**
	Radium-226	0.00E+00	0.00E+00	2.87E-05	3.55E-09	1.46E-11	7.45E-09	5.70E-06	1.71E-05	0.00E+00	5.01E-05	2.24E-08	8.82E-06	**1.10E-04**
	Lead-210	0.00E+00	0.00E+00	3.97E-04	5.22E-11	0.00E+00	0.00E+00	2.09E-04	1.93E-07	0.00E+00	1.69E-03	0.00E+00	1.66E-03	**3.96E-03**
	Polonium-210	0.00E+00	0.00E+00	8.39E-04	3.27E-13	0.00E+00	0.00E+00	5.02E-04	8.00E-10	0.00E+00	6.60E-03	0.00E+00	3.21E-02	**4.00E-02**

Human Receptor	COPC	Maximum Incremental Dose by Pathway during Project Phases (mSv/yr)												
		Air (internal)	Air (external)	Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by Radionuclide
	Total by Pathway	**6.15E-04**	**3.50E-12**	**1.36E-03**	**3.67E-09**	**2.51E-06**	**4.43E-04**	**7.31E-04**	**1.90E-05**	**0.00E+00**	**8.53E-03**	**1.23E-03**	**3.40E-02**	**4.69E-02**
Rec F/H Adult (Russell Lake)														
	Uranium-238	7.60E-05	2.08E-13	1.38E-05	1.05E-10	7.92E-09	8.79E-05	9.15E-08	9.76E-07	0.00E+00	6.27E-05	1.27E-04	4.23E-05	**4.11E-04**
	Uranium-234	9.17E-05	5.10E-13	1.50E-05	1.82E-11	8.63E-09	4.43E-07	9.97E-08	3.54E-09	0.00E+00	6.83E-05	1.39E-04	4.60E-05	**3.60E-04**
	Thorium-230	0.00E+00	0.00E+00	9.75E-05	6.61E-11	7.73E-12	1.20E-10	9.40E-08	2.32E-09	0.00E+00	1.39E-04	1.59E-08	6.45E-04	**8.81E-04**
	Radium-226	0.00E+00	0.00E+00	2.75E-05	1.23E-08	0.00E+00	0.00E+00	8.11E-08	9.72E-06	0.00E+00	4.99E-05	1.86E-09	1.66E-05	**1.04E-04**
	Lead-210	0.00E+00	0.00E+00	2.71E-04	2.39E-10	0.00E+00	0.00E+00	1.60E-06	9.03E-08	0.00E+00	1.17E-03	0.00E+00	2.03E-03	**3.47E-03**
	Polonium-210	0.00E+00	0.00E+00	4.30E-04	1.29E-12	0.00E+00	0.00E+00	2.72E-06	3.74E-10	0.00E+00	3.66E-03	0.00E+00	1.48E-02	**1.89E-02**
	Total by Pathway	**1.68E-04**	**7.18E-13**	**8.55E-04**	**1.27E-08**	**1.66E-08**	**8.83E-05**	**4.69E-06**	**1.08E-05**	**0.00E+00**	**5.15E-03**	**2.66E-04**	**1.76E-02**	**2.42E-02**
Rec F/H One-year-old (Russell Lake)														
	Uranium-238	7.57E-05	2.71E-13	9.58E-06	2.58E-11	3.22E-07	1.18E-04	3.72E-06	1.27E-06	0.00E+00	3.69E-05	1.57E-04	1.65E-05	**4.19E-04**
	Uranium-234	8.86E-05	6.63E-13	1.04E-05	4.51E-12	3.49E-07	5.93E-07	4.03E-06	4.60E-09	0.00E+00	4.00E-05	1.71E-04	1.79E-05	**3.32E-04**
	Thorium-230	0.00E+00	0.00E+00	4.96E-05	1.64E-11	2.40E-10	1.42E-10	2.80E-06	3.02E-09	0.00E+00	5.98E-05	1.70E-08	1.55E-04	**2.67E-04**
	Radium-226	0.00E+00	0.00E+00	2.46E-05	3.04E-09	0.00E+00	0.00E+00	4.24E-06	1.27E-05	0.00E+00	3.78E-05	3.73E-09	6.80E-06	**8.61E-05**
	Lead-210	0.00E+00	0.00E+00	3.68E-04	4.84E-11	0.00E+00	0.00E+00	1.27E-04	1.17E-07	0.00E+00	1.35E-03	0.00E+00	1.30E-03	**3.15E-03**
	Polonium-210	0.00E+00	0.00E+00	8.22E-04	3.20E-13	0.00E+00	0.00E+00	3.05E-04	4.86E-10	0.00E+00	5.94E-03	0.00E+00	1.94E-02	**2.64E-02**
	Total by Pathway	**1.64E-04**	**9.34E-13**	**1.28E-03**	**3.14E-09**	**6.71E-07**	**1.18E-04**	**4.46E-04**	**1.41E-05**	**0.00E+00**	**7.46E-03**	**3.28E-04**	**2.09E-02**	**3.07E-02**
Seasonal Resident Adult (Russell Lake)														
	Uranium-238	7.60E-05	2.08E-13	1.38E-05	1.05E-10	7.92E-09	8.79E-05	9.15E-08	9.76E-07	0.00E+00	1.86E-05	3.83E-05	1.91E-05	**2.55E-04**
	Uranium-234	9.17E-05	5.10E-13	1.50E-05	1.82E-11	8.63E-09	4.43E-07	9.97E-08	3.54E-09	0.00E+00	2.03E-05	4.18E-05	2.08E-05	**1.90E-04**
	Thorium-230	0.00E+00	0.00E+00	9.75E-05	6.61E-11	7.73E-12	1.20E-10	9.40E-08	2.32E-09	0.00E+00	4.05E-05	4.77E-09	1.85E-04	**3.23E-04**
	Radium-226	0.00E+00	0.00E+00	2.75E-05	1.23E-08	0.00E+00	0.00E+00	8.11E-08	9.72E-06	0.00E+00	2.17E-05	0.00E+00	7.15E-06	**6.62E-05**
	Lead-210	0.00E+00	0.00E+00	2.71E-04	2.39E-10	0.00E+00	0.00E+00	1.60E-06	9.03E-08	0.00E+00	1.01E-03	0.00E+00	1.67E-03	**2.96E-03**
	Polonium-210	0.00E+00	0.00E+00	4.30E-04	1.29E-12	0.00E+00	0.00E+00	2.72E-06	3.74E-10	0.00E+00	4.02E-03	0.00E+00	4.82E-03	**9.28E-03**

Human Receptor	COPC	Maximum Incremental Dose by Pathway during Project Phases (mSv/yr)												
		Air (internal)	Air (external)	Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by Radionuclide
	Total by Pathway	**1.68E-04**	**7.18E-13**	**8.55E-04**	**1.27E-08**	**1.66E-08**	**8.83E-05**	**4.69E-06**	**1.08E-05**	**0.00E+00**	**5.13E-03**	**8.01E-05**	**6.73E-03**	**1.31E-02**
Seasonal Resident One-year-old (Russell Lake)														
	Uranium-238	7.57E-05	2.71E-13	9.58E-06	2.58E-11	3.22E-07	1.18E-04	3.72E-06	1.27E-06	0.00E+00	1.10E-05	4.71E-05	7.17E-06	**2.73E-04**
	Uranium-234	8.86E-05	6.63E-13	1.04E-05	4.51E-12	3.49E-07	5.93E-07	4.03E-06	4.60E-09	0.00E+00	1.19E-05	5.11E-05	7.77E-06	**1.75E-04**
	Thorium-230	0.00E+00	0.00E+00	4.96E-05	1.64E-11	2.40E-10	1.42E-10	2.80E-06	3.02E-09	0.00E+00	1.75E-05	5.12E-09	4.30E-05	**1.13E-04**
	Radium-226	0.00E+00	0.00E+00	2.46E-05	3.04E-09	0.00E+00	0.00E+00	4.24E-06	1.27E-05	0.00E+00	1.65E-05	3.73E-09	2.97E-06	**6.10E-05**
	Lead-210	0.00E+00	0.00E+00	3.68E-04	4.84E-11	0.00E+00	0.00E+00	1.27E-04	1.17E-07	0.00E+00	1.17E-03	0.00E+00	1.07E-03	**2.73E-03**
	Polonium-210	0.00E+00	0.00E+00	8.22E-04	3.20E-13	0.00E+00	0.00E+00	3.05E-04	4.86E-10	0.00E+00	6.52E-03	0.00E+00	5.86E-03	**1.35E-02**
	Total by Pathway	**1.64E-04**	**9.34E-13**	**1.28E-03**	**3.14E-09**	**6.71E-07**	**1.18E-04**	**4.46E-04**	**1.41E-05**	**0.00E+00**	**7.74E-03**	**9.82E-05**	**6.99E-03**	**1.69E-02**
Fisher/ Trapper Adult (Russell Lake)														
	Uranium-238	1.27E-04	3.47E-13	2.31E-05	1.76E-10	1.32E-08	1.46E-04	1.53E-07	1.63E-06	0.00E+00	4.32E-04	0.00E+00	1.08E-03	**1.81E-03**
	Uranium-234	1.53E-04	8.50E-13	2.52E-05	3.06E-11	1.44E-08	7.38E-07	1.66E-07	5.90E-09	0.00E+00	4.70E-04	0.00E+00	1.17E-03	**1.82E-03**
	Thorium-230	0.00E+00	0.00E+00	1.65E-04	1.12E-10	1.32E-11	2.04E-10	1.57E-07	3.88E-09	0.00E+00	9.53E-04	0.00E+00	6.56E-05	**1.18E-03**
	Radium-226	0.00E+00	0.00E+00	3.65E-05	1.63E-08	0.00E+00	0.00E+00	1.35E-07	1.62E-05	0.00E+00	3.43E-04	0.00E+00	1.04E-04	**5.00E-04**
	Lead-210	0.00E+00	0.00E+00	2.81E-04	2.47E-10	0.00E+00	0.00E+00	2.63E-06	1.49E-07	0.00E+00	8.06E-03	0.00E+00	2.25E-03	**1.06E-02**
	Polonium-210	0.00E+00	0.00E+00	4.15E-04	1.25E-12	0.00E+00	0.00E+00	4.48E-06	6.15E-10	0.00E+00	2.52E-02	0.00E+00	1.56E-02	**4.12E-02**
	Total by Pathway	**2.79E-04**	**1.20E-12**	**9.45E-04**	**1.68E-08**	**2.76E-08**	**1.47E-04**	**7.72E-06**	**1.80E-05**	**0.00E+00**	**3.55E-02**	**0.00E+00**	**2.02E-02**	**5.71E-02**

Table 4-10: Estimated Radiological Doses to Human Receptor – Future Centuries

Human Receptor	COPC	Maximum Incremental Dose by Pathway during Future Centuries (mSv/yr)										
		Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by Radionuclide
Permanent Resident Adult (Whitefish Lake)	Uranium-238	1.42E-06	1.07E-11	2.20E-08	2.44E-04	1.29E-08	1.38E-07	0.00E+00	1.98E-06	1.38E-04	1.48E-06	**3.87E-04**
	Uranium-234	1.54E-06	1.87E-12	2.40E-08	1.23E-06	1.41E-08	4.99E-10	0.00E+00	2.15E-06	1.50E-04	1.62E-06	**1.57E-04**
	Thorium-230	2.12E-05	1.44E-11	7.69E-10	1.18E-08	2.31E-08	5.71E-10	0.00E+00	8.93E-06	8.84E-07	3.11E-05	**6.22E-05**
	Radium-226	8.68E-05	3.87E-08	9.39E-11	2.43E-06	4.80E-07	5.75E-05	0.00E+00	7.28E-05	2.07E-06	2.40E-05	**2.46E-04**
	Lead-210	2.03E-04	1.79E-10	0.00E+00	0.00E+00	6.83E-06	3.86E-07	0.00E+00	8.12E-04	0.00E+00	7.09E-04	**1.73E-03**
	Polonium-210	3.59E-04	1.08E-12	0.00E+00	0.00E+00	1.21E-05	1.66E-09	0.00E+00	3.59E-03	0.00E+00	2.02E-02	**2.42E-02**
	Total by Pathway	**6.73E-04**	**3.89E-08**	**4.68E-08**	**2.48E-04**	**1.94E-05**	**5.81E-05**	**0.00E+00**	**4.49E-03**	**2.91E-04**	**2.10E-02**	**2.67E-02**
Permanent Resident One-year-old (Whitefish Lake)	Uranium-238	9.84E-07	2.66E-12	8.95E-07	3.27E-04	5.25E-07	1.79E-07	0.00E+00	1.17E-06	2.02E-04	6.43E-07	**5.33E-04**
	Uranium-234	1.07E-06	4.64E-13	9.70E-07	1.65E-06	5.69E-07	6.49E-10	0.00E+00	1.26E-06	2.19E-04	6.97E-07	**2.25E-04**
	Thorium-230	1.08E-05	3.56E-12	2.29E-08	1.34E-08	6.88E-07	7.42E-10	0.00E+00	3.85E-06	9.46E-07	7.46E-06	**2.38E-05**
	Radium-226	7.75E-05	9.59E-09	4.90E-09	3.26E-06	2.51E-05	7.51E-05	0.00E+00	5.52E-05	3.90E-06	9.87E-06	**2.50E-04**
	Lead-210	2.76E-04	3.63E-11	0.00E+00	0.00E+00	5.43E-04	5.02E-07	0.00E+00	9.36E-04	0.00E+00	4.63E-04	**2.22E-03**
	Polonium-210	6.87E-04	2.68E-13	0.00E+00	0.00E+00	1.35E-03	2.15E-09	0.00E+00	5.82E-03	0.00E+00	2.65E-02	**3.43E-02**
	Total by Pathway	**1.05E-03**	**9.63E-09**	**1.89E-06**	**3.32E-04**	**1.92E-03**	**7.58E-05**	**0.00E+00**	**6.82E-03**	**4.26E-04**	**2.69E-02**	**3.76E-02**
Rec F/H Adult (McGowan Lake)	Uranium-238	2.82E-07	2.14E-12	1.67E-09	1.86E-05	2.57E-09	2.75E-08	0.00E+00	1.31E-06	1.80E-05	6.51E-07	**3.89E-05**
	Uranium-234	3.07E-07	3.73E-13	1.82E-09	9.36E-08	2.80E-09	9.95E-11	0.00E+00	1.43E-06	1.96E-05	7.09E-07	**2.22E-05**
	Thorium-230	4.78E-06	3.24E-12	5.84E-11	8.91E-10	5.20E-09	1.29E-10	0.00E+00	6.70E-06	1.15E-07	3.09E-05	**4.25E-05**
	Radium-226	1.82E-05	8.15E-09	7.05E-12	1.83E-07	1.01E-07	1.21E-05	0.00E+00	5.11E-05	2.68E-07	1.76E-05	**9.96E-05**
	Lead-210	2.31E-05	2.03E-11	0.00E+00	0.00E+00	7.76E-07	4.39E-08	0.00E+00	3.07E-04	0.00E+00	5.62E-04	**8.93E-04**
	Polonium-210	4.08E-05	1.23E-13	0.00E+00	0.00E+00	1.37E-06	1.88E-10	0.00E+00	1.36E-03	0.00E+00	7.67E-03	**9.07E-03**
	Total by Pathway	**8.75E-05**	**8.17E-09**	**3.56E-09**	**1.88E-05**	**2.26E-06**	**1.22E-05**	**0.00E+00**	**1.73E-03**	**3.80E-05**	**8.28E-03**	**1.02E-02**

Human Receptor	COPC	Maximum Incremental Dose by Pathway during Future Centuries (mSv/yr)										
		Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by Radionuclide
Rec F/H One-year-old (McGowan Lake)	Uranium-238	1.96E-07	5.30E-13	6.81E-08	2.48E-05	1.05E-07	3.57E-08	0.00E+00	7.75E-07	2.63E-05	2.95E-07	**5.27E-05**
	Uranium-234	2.13E-07	9.24E-14	7.38E-08	1.25E-07	1.13E-07	1.29E-10	0.00E+00	8.39E-07	2.85E-05	3.19E-07	**3.02E-05**
	Thorium-230	2.43E-06	8.02E-13	1.75E-09	1.02E-09	1.55E-07	1.67E-10	0.00E+00	2.89E-06	1.23E-07	7.40E-06	**1.30E-05**
	Radium-226	1.63E-05	2.02E-09	3.78E-10	2.46E-07	5.28E-06	1.58E-05	0.00E+00	3.87E-05	5.07E-07	7.27E-06	**8.41E-05**
	Lead-210	3.14E-05	4.13E-12	0.00E+00	0.00E+00	6.17E-05	5.71E-08	0.00E+00	3.55E-04	0.00E+00	3.63E-04	**8.10E-04**
	Polonium-210	7.80E-05	3.04E-14	0.00E+00	0.00E+00	1.54E-04	2.45E-10	0.00E+00	2.20E-03	0.00E+00	1.00E-02	**1.25E-02**
	Total by Pathway	**1.29E-04**	**2.02E-09**	**1.44E-07**	**2.52E-05**	**2.21E-04**	**1.59E-05**	**0.00E+00**	**2.60E-03**	**5.55E-05**	**1.04E-02**	**1.35E-02**
Rec F/H Adult (Russell Lake)	Uranium-238	2.07E-07	1.57E-12	4.47E-10	4.95E-06	1.89E-09	2.02E-08	0.00E+00	9.65E-07	4.80E-06	4.36E-07	**1.14E-05**
	Uranium-234	2.26E-07	2.74E-13	4.86E-10	2.50E-08	2.06E-09	7.31E-11	0.00E+00	1.05E-06	5.23E-06	4.74E-07	**7.01E-06**
	Thorium-230	3.64E-06	2.47E-12	1.55E-11	2.40E-10	3.97E-09	9.81E-11	0.00E+00	5.11E-06	3.07E-08	2.35E-05	**3.23E-05**
	Radium-226	1.36E-05	6.08E-09	1.82E-12	4.84E-08	7.54E-08	9.04E-06	0.00E+00	3.81E-05	7.26E-08	1.35E-05	**7.45E-05**
	Lead-210	1.40E-05	1.23E-11	0.00E+00	0.00E+00	4.69E-07	2.65E-08	0.00E+00	1.86E-04	0.00E+00	3.42E-04	**5.42E-04**
	Polonium-210	2.33E-05	7.01E-14	0.00E+00	0.00E+00	8.27E-07	1.14E-10	0.00E+00	7.80E-04	0.00E+00	4.63E-03	**5.44E-03**
	Total by Pathway	**5.50E-05**	**6.10E-09**	**9.50E-10**	**5.03E-06**	**1.38E-06**	**9.09E-06**	**0.00E+00**	**1.01E-03**	**1.01E-05**	**5.01E-03**	**6.10E-03**
Rec F/H One-year-old (Russell Lake)	Uranium-238	1.44E-07	3.89E-13	1.82E-08	6.63E-06	7.69E-08	2.62E-08	0.00E+00	5.69E-07	7.02E-06	2.01E-07	**1.47E-05**
	Uranium-234	1.56E-07	6.79E-14	1.97E-08	3.34E-08	8.33E-08	9.50E-11	0.00E+00	6.16E-07	7.61E-06	2.17E-07	**8.74E-06**
	Thorium-230	1.85E-06	6.11E-13	4.66E-10	2.73E-10	1.18E-07	1.27E-10	0.00E+00	2.21E-06	3.28E-08	5.65E-06	**9.86E-06**
	Radium-226	1.22E-05	1.51E-09	9.46E-11	6.71E-08	3.94E-06	1.18E-05	0.00E+00	2.89E-05	1.38E-07	5.56E-06	**6.26E-05**
	Lead-210	1.90E-05	2.49E-12	0.00E+00	0.00E+00	3.73E-05	3.45E-08	0.00E+00	2.14E-04	0.00E+00	2.21E-04	**4.92E-04**
	Polonium-210	4.46E-05	1.74E-14	0.00E+00	0.00E+00	9.25E-05	1.48E-10	0.00E+00	1.26E-03	0.00E+00	6.06E-03	**7.46E-03**
	Total by Pathway	**7.79E-05**	**1.51E-09**	**3.84E-08**	**6.73E-06**	**1.34E-04**	**1.19E-05**	**0.00E+00**	**1.51E-03**	**1.48E-05**	**6.29E-03**	**8.04E-03**

Human Receptor	COPC	Maximum Incremental Dose by Pathway during Future Centuries (mSv/yr)										
		Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by Radionuclide
Seasonal Resident Adult (Russell Lake)	Uranium-238	2.07E-07	1.57E-12	4.47E-10	4.95E-06	1.89E-09	2.02E-08	0.00E+00	2.90E-07	1.44E-06	1.35E-07	**7.05E-06**
	Uranium-234	2.26E-07	2.74E-13	4.86E-10	2.50E-08	2.06E-09	7.31E-11	0.00E+00	3.15E-07	1.57E-06	1.47E-07	**2.28E-06**
	Thorium-230	3.64E-06	2.47E-12	1.55E-11	2.40E-10	3.97E-09	9.81E-11	0.00E+00	1.53E-06	9.31E-09	6.94E-06	**1.21E-05**
	Radium-226	1.36E-05	6.08E-09	1.82E-12	4.84E-08	7.54E-08	9.04E-06	0.00E+00	1.14E-05	2.05E-08	4.51E-06	**3.88E-05**
	Lead-210	1.40E-05	1.23E-11	0.00E+00	0.00E+00	4.69E-07	2.65E-08	0.00E+00	5.58E-05	0.00E+00	1.03E-04	**1.73E-04**
	Polonium-210	2.33E-05	7.01E-14	0.00E+00	0.00E+00	8.27E-07	1.14E-10	0.00E+00	2.34E-04	0.00E+00	1.42E-03	**1.68E-03**
	Total by Pathway	**5.50E-05**	**6.10E-09**	**9.50E-10**	**5.03E-06**	**1.38E-06**	**9.09E-06**	**0.00E+00**	**3.03E-04**	**3.04E-06**	**1.54E-03**	**1.91E-03**
Seasonal Resident One-year-old (Russell Lake)	Uranium-238	1.44E-07	3.89E-13	1.82E-08	6.63E-06	7.69E-08	2.62E-08	0.00E+00	1.71E-07	2.11E-06	5.89E-08	**9.23E-06**
	Uranium-234	1.56E-07	6.79E-14	1.97E-08	3.34E-08	8.33E-08	9.50E-11	0.00E+00	1.85E-07	2.28E-06	6.39E-08	**2.82E-06**
	Thorium-230	1.85E-06	6.11E-13	4.66E-10	2.73E-10	1.18E-07	1.27E-10	0.00E+00	6.62E-07	9.90E-09	1.62E-06	**4.26E-06**
	Radium-226	1.22E-05	1.51E-09	9.46E-11	6.71E-08	3.94E-06	1.18E-05	0.00E+00	8.67E-06	4.10E-08	1.91E-06	**3.86E-05**
	Lead-210	1.90E-05	2.49E-12	0.00E+00	0.00E+00	3.73E-05	3.45E-08	0.00E+00	6.43E-05	0.00E+00	6.53E-05	**1.86E-04**
	Polonium-210	4.46E-05	1.74E-14	0.00E+00	0.00E+00	9.25E-05	1.48E-10	0.00E+00	3.79E-04	0.00E+00	1.75E-03	**2.26E-03**
	Total by Pathway	**7.79E-05**	**1.51E-09**	**3.84E-08**	**6.73E-06**	**1.34E-04**	**1.19E-05**	**0.00E+00**	**4.53E-04**	**4.44E-06**	**1.82E-03**	**2.50E-03**
Fisher/ Trapper Adult (Russell Lake)	Uranium-238	3.45E-07	2.62E-12	7.44E-10	8.26E-06	3.15E-09	3.36E-08	0.00E+00	6.65E-06	0.00E+00	8.10E-07	**1.61E-05**
	Uranium-234	3.76E-07	4.57E-13	8.11E-10	4.16E-08	3.43E-09	1.22E-10	0.00E+00	7.24E-06	0.00E+00	8.82E-07	**8.54E-06**
	Thorium-230	6.07E-06	4.11E-12	2.57E-11	4.00E-10	6.61E-09	1.63E-10	0.00E+00	3.52E-05	0.00E+00	2.40E-06	**4.37E-05**
	Radium-226	2.27E-05	1.01E-08	3.18E-12	8.20E-08	1.26E-07	1.51E-05	0.00E+00	2.63E-04	0.00E+00	8.59E-05	**3.86E-04**
	Lead-210	2.33E-05	2.05E-11	0.00E+00	0.00E+00	7.82E-07	4.42E-08	0.00E+00	1.28E-03	0.00E+00	3.90E-04	**1.69E-03**
	Polonium-210	3.89E-05	1.17E-13	0.00E+00	0.00E+00	1.38E-06	1.89E-10	0.00E+00	5.37E-03	0.00E+00	4.57E-03	**9.98E-03**
	Total by Pathway	**9.16E-05**	**1.02E-08**	**1.58E-09**	**8.38E-06**	**2.30E-06**	**1.51E-05**	**0.00E+00**	**6.96E-03**	**0.00E+00**	**5.05E-03**	**1.21E-02**

4.2.5.3 Radon Dose

Radon will be released to the environment during all Project phases. During construction, the main source of radon to air will be during wellfield drilling from radium-bearing ore cuttings. During operation, radon from the ore body will be removed by the mining solution as it travels through the wellfield. The main source of radon to air will be from venting of the process water in the radon surge tank. During decommissioning radon will be released during wellfield restoration, and the main source of radon to air will also be from venting of the radon surge tank.

The radon dose was calculated separately from the dose from other radionuclides and was estimated outside of IMPACT. The atmospheric model used for the Project to estimate radon concentrations at various locations based on radon source emissions was CALPUFF, an advanced three-dimensional dispersion model (EIS Section 8).

The camp worker would be exposed to radon through inhalation while at the camp site, located southwest of the wellfield. The camp worker represents an adult who resides at the camp for 6 months of the year and away from the site for the remaining 6 months of the year. For exposure to radon, it has been conservatively assumed that the camp worker spends 100% of their time indoors when on site. The predicted radon concentrations at the camp site, from CALPUFF, are 2.1 Bq/m^3 during construction, 12.4 Bq/m^3 during operation, and 8.6 Bq/m^3 during decommissioning. These radon concentrations are incremental concentrations (excluding any background radon).

The dose from radon in air considers ingrowth of radon decay progeny (polonium-218, lead-214, bismuth-214) during dispersion of radon gas from the source to receptor. Ingrowth was quantified in terms of the radon progeny equilibrium ratio, according to the methods outlined in Health Canada’s federal guidance on contaminated site radiological risk assessment in Canada, Part VI (Health Canada, 2010b). Radon dose is dependent on the radon equilibrium fraction as well as the exposure time for the receptor.

Consistent with recommendations in CSA N288.6-22 and Health Canada, the dose from radon in air was calculated according to the equation in Appendix A, Section 2.4.3, with input values shown in Table 4-11.

Indoor radon dose dominates over outdoor radon dose; and therefore, only indoor radon dose was quantified. However, the outdoor equilibrium fraction (F_{out}) was needed to estimate the indoor equilibrium fraction (F_{in}), which is needed to include short-lived progeny in the radon dose calculation.

The maximum predicted radon dose to the camp worker would be 0.13 mSv/yr during operation. A summary of the predicted radon dose to the camp worker during all Project phases is shown in Table 4-12.

Table 4-11: Summary of Input Parameters for Radon Dose Calculation

Parameter	Construction	Operation	Decommissioning	Source
Incremental C_{Rn} (at camp)	2.15 Bq/m^3	12.4 Bq/m^3	8.57 Bq/m^3	Atmospheric Model (EIS Section 7.2)
Distance from source to camp	403 m	981 m	981 m	From CALPUFF
Mean wind speed	204 m/min	204 m/min	204 m/min	From meteorological dataset
t (travel time to camp)	2.0 min	4.8 min	4.8 min	Calculated t = distance / wind speed
Exposure time	4,380 h/yr	4,380 h/yr	4,380 h/yr	Assumption based on camp worker residency of 0.5 of the year
F_{out}	0.04	0.10	0.10	Calculated
F_{in}	0.37	0.38	0.38	Calculated

Bq/m^3 = becquerels per cubic metre; F_{out} = outdoor equilibrium fraction; F_{in} = indoor equilibrium fraction; C_{Rn} = concentration of radon in air

Table 4-12: Predicted Radon Dose to Camp Worker during all Project Phases

Project Phase	Radon Dose at Camp (mSv/yr)
Construction	2.2E-02
Operation	1.3E-01
Decommissioning	9.2E-02

4.2.6 Uncertainty in Exposure Assessment

The exposure assessment followed CSA and Health Canada guidance. Key uncertainties in the human health exposure assumptions and how they are addressed in the HHRA are summarized in Table 4-13.

Concentrations of COPCs in environmental media including water, sediment, air, soil, and Traditional Food items were estimated based on the assumption that human and ecological receptors are exposed to the maximum exposure concentrations at their location for each model scenario and Project phase. The duration of this exposure was assumed to be sufficient for each receptor to be in equilibrium with their environment. This results in conservatively high predicted uptakes of COPCs by ecological receptors and exposures to human health receptors.

The assumptions to address uncertainties in the exposure assessment were anticipated to produce conservative exposure estimates for human health receptors. Therefore, the risk that the exposure assessment underestimated potential exposure of human health receptors to COPCs from the Project is low.

Table 4-13: Uncertainties in the Human Health Exposure Assessment

Area of Uncertainty	Description of Uncertainty	How Uncertainty has been Addressed
Receptor Selection	There are no permanent residents in the LSA or RSA, but the area is known to be used for harvesting including fishing, hunting, and gathering, and there are cabins in the LSA. There are uncertainties on how potential receptors would realistically use the LSA and RSA (i.e., locations and residency times).	• Based residency and location assumptions on current understanding of how people use the LSA and RSA. • Assumed reasonably conservative residency times for receptors that conservatively represent receptors with shorter residency times. • Located receptors in the LSA and RSA at locations known to have cabins and camps.
Traditional Foods Diet	Applied ERFN country foods study to the Traditional Diet for all average consumers of Traditional Foods. Applied Bobby John diet to the high consumer of Traditional Foods which includes a high proportion of fish and caribou in the diet	• Assumed all receptors consume Traditional Foods. Receptors included a high consumer and an average consumer of Traditional Foods. • Based the total food intake for male and female receptors on an adult male diet (N288.1-20 central tendency). • Used available information from Indigenous and Local Knowledge for the diet.
Selection of representative ecological receptors in the IMPACT model to represent Traditional Food components	Where possible, there is interest to simplify the environmental pathways model used to estimate potential human health risks without leading to an underestimate of potential risk.	• Selected representative foods from the Traditional Foods types known to be used by Indigenous and Local Communities. • Representative foods with linkages to the aquatic environment were preferred over terrestrial receptors from the same location because they have the potential to be more exposed to Project related COPCs through atmospheric and aquatic pathways.

4.3 Toxicity Assessment

4.3.1 Toxicity Reference Values

For assessment of non-radiological COPCs, a toxicity reference value (TRV) is used. A TRV is a toxicological index, associating specific health effects with a level of exposure to a chemical. TRVs may include slope factors and unit risks for carcinogens, and reference doses, tolerable daily intakes, or acceptable daily intakes for non-carcinogens.

No COPCs in air were identified for further evaluation of potential risks for human health; therefore, toxicity via inhalation was not included in the toxicity assessment. Separate toxicity benchmarks for direct contact effects from dermal exposure are not available. Although some of the COPCs present in soil may cause direct contact dermatitis, information is not available to suggest that such effects can occur at environmental levels (CSA, 2022). A summary of the TRVs used in the HHRA is shown in Table 4-14.

Chloride and sulphate were identified as COPCs; however, as discussed in Section 4.1.3, they were not evaluated further in the HHRA.

Arsenic, cadmium, chromium, cobalt, copper, molybdenum, selenium, uranium, and zinc were retained for further evaluation in the HHRA because effluent quality for these constituents were predicted to exceed water quality screening benchmarks (Section 3.1.1).

The relevant non-cancer TRVs are expressed as a quantity of a chemical per unit body weight per unit time (mg/kg/d) for oral exposure and have generally been derived for sensitive individuals in the public based on sensitive endpoints. Additionally, these factors typically involve the incorporation of uncertainty factors by regulatory agencies to account for uncertainties inherent in the underlying studies or their applicability for protection of members of the public. Carcinogenic effects TRVs are generally referred to as slope factors or unit risks and are used to estimate upper-bound lifetime probabilities of an individual developing cancer as a result of exposure to a particular level of a potential carcinogen. The carcinogen slope factor or unit risk is, therefore, the lifetime cancer risk per unit of dose or concentration. The slope factor is expressed as risk per mg/kg/d, or $(mg/kg/d)^{-1}$, for oral exposure. Arsenic was the only Project-related COPC evaluated as a carcinogen.

Preference was given to toxicological benchmarks derived by Health Canada, the USEPA Integrated Risk Information System database, the Agency for Toxic Substances and Disease Registry (ATSDR) and the WHO. The supporting documentation for each toxicity benchmark was reviewed and professional judgment was used to evaluate the appropriateness of the benchmark value.

The human health TRVs were generally obtained from Health Canada's TRV Guidance (Health Canada, 2021b). Since Health Canada does not have a published TRV for cobalt, the cobalt TRV was obtained from the ATSDR (ATSDR, 2004).

For molybdenum, selenium and zinc, Health Canada has developed tolerable upper intake levels (ULs) for all of their defined age groups: infant, toddler, child, adolescent, and adult (Health Canada, 2021b). Given that the infant and adult life stages were assessed in the HHRA, the infant and adult ULs are shown in the table below.

Table 4-14: Human Health Oral Exposure Toxicity Reference Values

Constituent of Potential Concern	Benchmark Value	Unit	Reference
Arsenic (cancer)	1.8	$(mg/kg/d)^{-1}$	(Health Canada, 2021b)
Cadmium	0.0008	mg/kg/d	(Health Canada, 2021b)
Chromium	1.5	mg/kg/d	(Health Canada, 2021b)
Cobalt	0.01	mg/kg/d	(ATSDR, 2004)
Copper	0.426	mg/kg/d	(Health Canada, 2021b)
Molybdenum	0.023 (infant) 0.028 (adult)	mg/kg/d	(Health Canada, 2021b)
Selenium	0.0055 (infant) 0.0057 (adult)	mg/kg/d	(Health Canada, 2021b)
Uranium	0.0006	mg/kg/d	(Health Canada, 2021b)
Vanadium	0.0021	mg/kg/d	(MECP, 2011)
Zinc	0.49 (infant) 0.57 (adult)	mg/kg/d	(Health Canada, 2021b)

4.3.1.1 Arsenic

Arsenic is classified as a Group I carcinogen to humans (EC and HC, 1993). Health Canada recommends 1.8 $(mg/kg/d)^{-1}$ as the oral slope factor for arsenic (Health Canada, 2021b). It was originally developed by Health Canada when the agency was deriving a Guideline for Canadian Drinking Water Quality (Health Canada, 2006). The TRV is based on the risk of bladder, lung, and liver cancer in people exposed to arsenic in their drinking water (Chen et al., 1985; Morales et al., 2000; Wu et al., 1989).

4.3.1.2 Cadmium

Cadmium is not classified as a human carcinogen via the oral route of exposure. Health Canada provides a provisional oral tolerable daily intake (TDI) of 0.0008 mg/kg/d based on a meta-analysis of human epidemiological studies where the primary exposure route was via food (Health Canada, 2021b). A no-observed adverse effect level (NOAEL) of 1.2 µg/kg/d (corresponding with 5.24 µg Cd/g creatinine in urine) was identified (WHO, 2011). The critical endpoint was nephrotoxicity (renal tubular dysfunction). Uncertainty factors for toxicodynamic and toxicokinetic variation were incorporated into the model that calculated a lower bound TDI of 0.8 µg/kg/d (or 0.0008 mg/kg/d).

4.3.1.3 Chromium

Chromium is not classified as a human carcinogen via the oral route of exposure. Health Canada provides an oral TDI of 1.5 mg/kg/d for trivalent chromium based on a chronic dietary study in male and female BD rats administered chromic oxide (Cr_2O_3) in the diet at concentrations of 0%, 1% (360 g/kg-bw), 2% (720 g/kg-bw), or 5% (1800 g/kg-bw) for 5 days per week for a total of 600 feedings ((US EPA, 1998); based on (Ivankovic and Preussmann, 1975)). No adverse effects were observed at any dose level. As such, the highest dose level of 1800 g/kg-bw was selected as the point of departure. Uncertainty factors of 10 for interspecies variability, 10 for intraspecies variability, and 10 for database deficiencies were applied to derive the TDI of 1.5 mg/kg/d.

4.3.1.4 Cobalt

Cobalt is a trace element that is essential to human health (Health Canada, 2021b). Cobalt is not classified as a human carcinogen. Health Canada does not provide a threshold oral TRV for cobalt (Health Canada, 2021b). The listed TRV of 0.01 mg/kg/d is recommended by ATSDR (2004). The ATSDR TRV is an intermediate Minimal Risk Level, and is based on a study by Davis and Fields (Davis and Fields, 1958), in which human males ingested a 2% cobalt chloride solution (in water or milk) for up to 22 days. The critical endpoint was hematological effects (increased levels of erythrocytes). The ATSDR took the lowest observed adverse effect level (LOAEL) of 1 mg/kg/d and applied a total uncertainty factor of 100 to arrive at their intermediate minimal risk level. The ATSDR did not derive a chronic minimal risk level for cobalt due to a lack of relevant animal and human studies.

4.3.1.5 Copper

Copper is a trace element that is essential for human health (Health Canada, 2021b). Copper is not classified as a human carcinogen. Health Canada recommends 0.426 mg/kg/d as the threshold oral TRV for copper for all age groups. The TRV was originally developed by Health Canada when the agency was deriving a Guideline for Canadian Drinking Water Quality (Health Canada, 2019a). The TRV is based on a critical health effect of gastrointestinal toxicity and liver function (hepatoxicity) in human infants exposed to copper in drinking water (Olivares et al., 1998). The TRV is based directly (no uncertainty factors applied) on the upper bound of the 95th confidence interval for a NOAEL of 2 mg/L copper in drinking water (0.318 mg/kg/d).

4.3.1.6 Molybdenum

Molybdenum is considered to be an essential trace element for human health (Health Canada, 2021b). However, Health Canada recommends that potential health risks to human receptors be characterized if molybdenum is identified as a COPC (Health Canada, 2021b). The TRVs for essential trace elements are tolerable upper intake levels (ULs), which are considered to be the highest average daily nutrient intake levels that are likely to pose no risk of adverse health effects to almost all individuals in the general population. Health Canada recommends age-specific ULs for molybdenum that are based on a NOAEL value derived for adults (Health

Canada, 2010c; IOM, 2001) from sub-chronic developmental and reproductive effects on rats consuming molybdate in drinking water. An uncertainty factor of 30 was applied (10 for interspecies variability and 3 for intraspecies variability) to the NOAEL value of 0.9 mg/kg-d. The adult UL was weight adjusted to derive age-based TRVs. As with other essential trace elements, Health Canada recommends that adjustments for relative bioavailability of molybdenum may be necessary when considering oral exposures from different pathways (Health Canada, 2010c).

4.3.1.7 Selenium

Similar to molybdenum, selenium is also considered to be an essential trace element for human health (Health Canada, 2021b). Where selenium is identified as a COPC, age-based ULs are recommended. The ULs for selenium are based on the data from two epidemiological studies. The first study considered dietary intake by adults ((IOM, 2000); based on Yang and Zhou 1994) and the second study considered intake from breast milk by infants ((IOM, 2000); based on Shearer and Hadjimarkos 1975).

- The dietary study in adults identified a NOAEL of 800 µg/day based on mean selenium intake in adults associated with signs and symptoms of selenosis (hair and nail brittleness and loss). An uncertainty factor of 2 was incorporated into the derivation of the UL to account for the increased sensitivity of some individuals; furthermore, it is also noted that HC adjusted the IOM's original adult ULs to account for HC's adult age group. A UL of 0.0057 mg/kg/d was derived for adults.

- The breast milk study in infants aged up to six months considered concentrations ranging from 7 to 60 µg/L in unsupplemented women. The NOAEL of 60 µg/L adjusted for the estimated average intake of 0.78 L/d was used to derive the UL. Given that no evidence of infant or maternal toxicity was identified in the study, an uncertainty factor of 1 was applied. Considering the Health Canada (2010) age groups, age-based ULs were derived for older infants (0.006 mg/kg/d), children (0.0063 mg/kg/d) and adolescents (0.0062 mg/kg/d) based on the infant UL of 0.0055 mg/kg/d (Health Canada, 2010c).

4.3.1.8 Uranium

Health Canada recommends 6.0 x 10^{-4} mg/kg/d as the threshold oral TRV for uranium for non-radiological effects for all age groups (Health Canada, 2021b). Uranium (non-radiological) is not classified as a human carcinogen. The TRV was originally developed by Health Canada when the agency was deriving a Guideline for Canadian Drinking Water Quality and it has since been re-affirmed (Health Canada, 2019b). The TRV is based on the critical health effect of kidney toxicity in rats exposed to uranium in drinking water (Gilman et al., 1998). The TRV is based on a NOAEL of 0.06 mg/kg/d and a total uncertainty factor of 100.

4.3.1.9 Vanadium

Vanadium is present naturally in the diet of humans; an upper limit of 1.8 mg/d has been derived for adults between the ages of 18 and 50 years. Health Canada (2021b) has not derived nor adopted a TRV for vanadium. The listed TRV of 0.0021 mg/kg/d from MECP (2011) was adopted. MECP (2011) adopted its TRV from the California Office of Environmental Health Hazard Assessment (Cal OEHHA), which relied on the TRV of 0.0021 mg/kg/d to derive its action level of 15 µg/L for vanadium in drinking water. The TRV is based upon a developmental and reproductive rat study ((Cal OEHHA, 2000); based on Domingo et al. 1986) wherein no maternal toxicity was identified, but pups born to mothers administered all dose levels (5, 10 and 20 mg/kg of sodium metavanadate by oral gavage) prior to mating showed signs of developmental effects (low body weight and reduced pup length). The lowest dose level of 5 mg/kg was used to derive the point of departure of 2.1 mg/kg/d as the LOAEL. An uncertainty factor of 1000 was applied (10 for intraspecies variability, 10 for interspecies variability, and 10 for extrapolation from a LOAEL to a NOAEL).

4.3.1.10 Zinc

As described from molybdenum and selenium, zinc is an essential trace element for human health (Health Canada, 2021b). Where zinc is identified as a COPC, age-based ULs are recommended. The ULs for zinc are based on the data from two prospective epidemiological studies. The first study considered dietary supplementation by adult women ((IOM, 2001); based on Yadrick et al. 1989) and the second study considered intake from fortified formula by infants ((IOM, 2001); based on Walravens and Hambridge 1976).

- The dietary supplementation in adults identified a LOAEL of 60 mg/day based on mean zinc intake from food of 10 mg/day and supplementation of 50 mg/day as zinc gluconate. The LOAEL was associated with indications of copper deficiency (decrease in red blood cell (or erythrocyte) superoxide dismutase (ESOD) activity). An uncertainty factor of 1.5 was incorporated into the derivation of the UL to account for the increased sensitivity of some individuals and extrapolation from a LOAEL to a NOAEL; furthermore, it is also noted that HC adjusted the IOM's original adult ULs to account for HC's adult age group. A UL of 0.49 mg/kg/d was derived for adults.

- The formula study in infants aged up to six months considered concentrations of formula with 1.8 mg Zn/L, one group was given formula alone, and the other group was given formula with a 4 mg Zn/L supplement. No signs of copper deficiency or other indicators of adverse effect were identified in any exposure group. The NOAEL of 5.8 mg/L adjusted for the estimated average intake of 0.78 L/d was used to derive the UL. Given that no evidence of toxicity was identified in the study, an uncertainty factor of 1 was applied. Considering the HC (Health Canada, 2010c) age groups, age-based ULs were derived for older infants (0.48 mg/kg/d), children (0.51 mg/kg/d) and adolescents (0.54 mg/kg/d) based on the infant UL of 0.49 mg/kg/d.

4.3.2 Radiation Dose Limits and Targets

Potential effects from radiation were compared to an effective dose limit. The effective dose is defined as the sum of all tissue equivalent doses multiplied by the appropriate tissue weighting factors associated with each respective tissue (Health Canada, 2010b). The limit is incremental and is exclusive of natural background, such as natural levels of radon, and medical exposures.

The public dose limit and dose limit for a non-NEW for radiation protection is 1 mSv/yr, as described in the *Radiation Protection Regulations* under the *Nuclear Safety and Control Act*, and as recommended in CSA N288.6-22. A higher incremental dose than the effective dose limit is considered unacceptable.

Incremental dose from the Project can also be compared to a dose constraint. A dose constraint is a conservative value for the annual increment dose applied to a single operation that is considered protective without further demonstration in situations where multiple sources may contribute to incremental dose (Health Canada, 2011). Application of a dose constraint is meant to ensure that the combined doses from multiple sources do not exceed the dose limit of 1 mSv/yr. A dose constraint of 0.3 mSv/yr is used in the ERA, as recommended by Health Canada (Health Canada, 2011). The dose constraint represents a dose, lower than the dose limit that ensures that the combined dose from multiple sources does not result in exceedance of the dose limit. Exceedance of the dose constraint does not indicate that adverse effects would occur, but instead indicates that the assumptions used in the calculation of exposure estimates for the operation should be examined in more detail.

4.3.3 Uncertainties in the Toxicity Assessment

In general, TRVs are usually based on limited toxicological data. For this reason, a margin of safety is built into TRV estimates, by use of uncertainty factors or conservative confidence levels, and actual risks are lower than those estimated. In this risk assessment, TRVs recommended by Health Canada were used when available to reduce uncertainty that potential health risks for human receptors would be underestimated in the risk evaluation.

The two major areas of uncertainty introduced in this toxicity assessment are animal to human extrapolation for Health Canada's recommend TRV for uranium, and use of an intermediate-duration TRV from a regulatory agency other than Health Canada for cobalt. In both cases, uncertainty factors were applied in the derivation of the TRVs. For uranium, the chronic TRV was based on a no observed adverse effects level for rats and a total uncertainty factor of 100. For cobalt, the intermediate (sub-chronic) TRV was based on a LOAEL for humans and a total uncertainty factor of 100. As a result, overestimation of the potential for adverse effects on humans is more likely than underestimation for similar exposure scenarios.

4.4 Risk Characterization

4.4.1 Risk Estimation

The potential for adverse effects on human receptors was determined in the risk assessment through the risk characterization step, where risk estimates were calculated to determine the potential for effects on the human receptors identified. The risk estimate was determined by comparing the predicted exposures, in terms of doses, with exposures that are known to be protective based on effects data (i.e., TRVs or radiation dose limits).

The methods of non-radiological risk estimation used for the HHRA were:

- HQs for non-carcinogens; and
- ILCR for carcinogens.

Hazard quotients (HQs) were calculated in IMPACT as the ratio of the exposure concentration or intake rate divided by the benchmark value, as shown below:

$$HQ = \frac{Exposure\ (Dose)\ Estimate}{TRV}$$

The HQs were compared to benchmark values. Non-carcinogenic constituents are not expected to cause any adverse health effects at exposures below the TRV. The HQs can be compared to a benchmark value of one (1) if all exposure pathways (exposures from all pathways including background and store-bought foods) are accounted for.

To account for uncertainty in pathways beyond Project activities (i.e., exposure to background sources unrelated to the Project), it was determined that to be protective a benchmark HQ value of 0.2 per medium (e.g., water, soil, food, air) would be considered acceptable for the assessment. This approach is consistent with the approach taken by Health Canada in its guidance on human health preliminary quantitative risk assessment (Health Canada, 2021a).

For carcinogens (e.g., arsenic), the incremental risk (i.e., total risk minus background risk) of developing cancer over a lifetime was estimated by multiplying the predicted dose above background by the cancer slope factor, as shown below:

$$ILCR = \sum LADD_i \times SF \times ADAF_i$$

where,

ILCR	=	incremental lifetime cancer risk (unitless)
$LADD_i$	=	dose received during lifestage i averaged over a lifetime (mg/kg/d)
SF	=	adult cancer slope factor (per mg/kg/d)
$ADAF_i$	=	age-dependent adjustment factors for lifestage i

Health Canada recommends that for carcinogens where the mode of action is unknown or the burden of proof for a threshold mode of action is not met, that the assessment should follow the non-threshold approach (i.e., a linear dose-response relationship) (Health Canada, 2013). The Canadian drinking water guideline technical document for arsenic indicates that there is limited data on the mode of action for arsenic and that the use of a non-linear relationship may overestimate cancer risks of internal organs (Health Canada, 2006). Therefore, for this assessment, a linear approach for arsenic was used. Additionally, since the mode of action is unknown, and arsenic-specific data are not available on quantitative differences between early lifestages and adults, Health Canada's default age-dependent adjustment factors for all life stages were not used (ADAF = 1 for all life stages).

Incremental lifetime cancer risks were compared to de minimis risk levels that are considered essentially negligible compared to background cancer risks. Cancer risks that are considered acceptable can range from 1 in 10,000 to 1 in 1,000,000 in different jurisdictions. Health Canada considers an increase in lifetime cancer risk of 1 in 100,000 (or 0.00001) to be essentially negligible compared to the background cancer risk level in North America of approximately 5 in 10 (or 0.5) (Health Canada, 2021a).

Total radiation doses due to radionuclides in the uranium-238 decay series were predicted. Incremental radiation doses were compared to the regulatory public dose limit and dose limit for a non-NEW of 1 mSv/yr and a dose constraint of 0.3 mSv/yr, as described in Section 4.3.2, Radiation Dose Limits and Targets. Radon dose was also considered; and was also compared to the dose limit of 1 mSv/yr.

4.4.1.1 Non-carcinogen Risk

The HQs in Table 4-15 are presented as baseline HQs (based on existing risk prior to the Project), Project Total HQs (includes the Project risk in addition to the baseline risk), as well as Project incremental HQs (includes the Project risk only with baseline component removed). The HQs represent the maximum HQ over the Project phase for the COPCs of interest, which is a conservative representation as exposure varies within each Project phase. HQs were evaluated for the adult and the one-year-old; however, for assessment of non-carcinogens, the one-year-old is typically considered the most sensitive receptor (Health Canada 2010a).

For the Project incremental HQs, there are no exceedances of the HQ benchmark (HQ<0.2) for human receptors for non-carcinogens (cadmium, copper, chromium, cobalt, molybdenum, uranium, and zinc) during all phases of the Project, with the exception of selenium for the fisher/trapper at Russell Lake. The incremental Project HQ for the fisher/trapper from fish ingestion (northern pike and white sucker) was predicted to be 0.81. The Project incremental HQ represents an incremental HQ with existing baseline risk removed.

Since baseline risk includes all exposures not associated with the Project (including store-bought foods), it is also appropriate to discuss the Project total HQ (baseline plus Project) and compare against a HQ benchmark of 1. There are no exceedances of the HQ benchmark of 1 for human receptors for non-carcinogens (cadmium, copper, chromium, cobalt, molybdenum, uranium, vanadium, and zinc) during all phases of the Project, with the exception of selenium for the fisher/trapper at Russell Lake (Project total HQ = 1.35). The Project total HQs for the fisher/trapper for selenium are predicted to be equal to or greater than 1; and as previously indicated above, the Project incremental HQs for the fish ingestion pathway for selenium are predicted to be above 0.2. This indicates that the Project is expected to contribute to selenium in the environment and the food chain; however, conservatism in the assessment is discussed further.

The traditional foods diet for the fisher/trapper is conservative and is based on engagement with a local fisher/trapper. The diet of the fisher/trapper is representative of one person, who consumes a unique composition and quantity of traditional foods. Most people fishing, hunting, and trapping in the Project Area would consume traditional foods more consistent with the average traditional foods consumer diet which was developed from the ERFN country foods study (CanNorth, 2017). However, it is recognized that the ERFN considers the fisher/trapper's use of the area as representative of current and future land users and expects that their relationship to the Project Area will be continued and strengthened through generations of future use.

The ingestion rate for caribou based on engagement with a local fisher/trapper was 175 kg/yr of caribou (equivalent to approximately 2 to 3 servings per day). This ingestion rate is conservative compared to an annual caribou ingestion rate of 2.6 kg/yr (1 to 2 servings per month) from the ERFN's Country Food Study (CanNorth, 2017) and 54.4 kg/yr for the total game diet for a high traditional foods consumer in the Boreal Shield in the First Nations Food, Nutrition and Environment Study for Saskatchewan (Chan et al., 2018). Thus, the local fisher/trapper is relatively extreme with respect to local game consumption.

Additionally, the traditional foods diet for the fisher/trapper is conservative for fish as it assumes that all fish consumed in the diet is obtained from Russell Lake, whereas it is likely that someone would fish from many different lakes including those outside of the RSA. The annual fish consumption based on engagement with a local fisher/trapper was assumed to be 183 kg/yr (approximately 1 to 2 servings per day), which is conservative compared to an annual fish consumption of 27 kg/yr (2 servings per week) from the ERFN's Country Food Study (CanNorth, 2017) and 88 kg/yr (approximately 1 serving per day) for the high consumer for the Boreal Shield in the First Nations Food, Nutrition and Environment Study for Saskatchewan (Chan et al., 2018). Thus, the local fisher/trapper is relatively extreme with respect to local fish consumption. The Project incremental HQs are below 0.2 for all other pathways including consumption of terrestrial and riparian animals harvested in the Project area. The overall risk to the fisher/trapper from selenium is low.

The presence and concentrations of COPCs in the receiving environment would be monitored and the associated dose and risk estimates would be periodically reassessed in accordance with the processes outlined in the Environmental Protection Program.

The HQs for the future centuries (beyond the Project timeline) are presented in Table 4-16. During the future centuries a permanent resident is included on the former mine site instead of a camp worker. For the Project incremental HQs, there are no predicted exceedances of the HQ benchmark (HQ<0.2) for any human receptors for any non-carcinogens evaluated during the future centuries.

Table 4-15: Estimated Non-radiological Risk to Human Receptors – Project Phases

Human Receptor	COPC	HQs during Project Phases									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
		Average Baseline HQ									
Camp Worker Adult (Whitefish Lake)	Cadmium	4.25E-04	9.44E-06	4.32E-05	2.94E-06	1.35E-05	0.00E+00	4.46E-05	4.39E-03	2.56E-01	2.61E-01
	Chromium	5.08E-06	4.62E-08	2.11E-06	2.72E-08	1.25E-06	0.00E+00	9.78E-06	3.72E-06	1.00E-05	3.20E-05
	Cobalt	1.48E-04	5.55E-07	2.54E-06	1.76E-07	8.04E-07	0.00E+00	6.25E-05	3.14E-03	1.64E-02	1.97E-02
	Copper	2.13E-05	7.15E-08	1.96E-06	3.02E-08	8.30E-07	0.00E+00	3.74E-04	5.13E-03	4.83E-02	5.38E-02
	Molybdenum	5.61E-05	8.58E-08	3.93E-07	8.40E-08	3.84E-07	0.00E+00	1.97E-07	9.24E-04	9.05E-02	9.15E-02
	Selenium	8.32E-05	3.93E-07	1.80E-06	7.59E-07	3.48E-06	0.00E+00	1.47E-02	3.85E-03	2.96E-01	3.14E-01
	Uranium	7.35E-04	1.33E-05	6.10E-04	6.71E-06	3.07E-04	0.00E+00	5.14E-04	2.27E-02	6.12E-02	8.62E-02
	Vanadium	1.01E-03	4.80E-05	2.20E-03	3.71E-05	1.70E-03	0.00E+00	3.39E-03	1.71E-03	1.72E-01	1.82E-01
	Zinc	1.75E-05	1.95E-07	8.92E-06	1.21E-07	5.56E-06	0.00E+00	1.23E-03	9.38E-03	2.12E-01	2.23E-01
		Project Total HQ - Project Phases									
	Cadmium	5.70E-04	9.44E-06	4.32E-05	3.64E-06	1.67E-05	0.00E+00	6.26E-05	4.39E-03	2.56E-01	2.61E-01
	Chromium	6.13E-06	4.62E-08	2.11E-06	3.13E-08	1.43E-06	0.00E+00	1.23E-05	3.72E-06	1.09E-05	3.66E-05
	Cobalt	1.68E-04	5.56E-07	2.54E-06	1.94E-07	8.88E-07	0.00E+00	7.34E-05	3.15E-03	1.64E-02	1.98E-02
	Copper	2.48E-05	7.22E-08	1.98E-06	3.40E-08	9.34E-07	0.00E+00	4.52E-04	5.15E-03	4.83E-02	5.40E-02
	Molybdenum	6.41E-03	8.59E-08	3.93E-07	7.17E-06	3.28E-05	0.00E+00	2.84E-05	9.24E-04	9.20E-02	9.94E-02
	Selenium	5.98E-04	3.94E-07	1.80E-06	3.73E-06	1.71E-05	0.00E+00	9.45E-02	3.85E-03	3.07E-01	4.06E-01
	Uranium	7.39E-03	3.60E-05	1.65E-03	4.51E-05	2.06E-03	0.00E+00	5.59E-03	5.04E-02	6.54E-02	1.33E-01
	Vanadium	2.79E-03	4.80E-05	2.20E-03	8.03E-05	3.68E-03	0.00E+00	7.57E-03	1.72E-03	1.76E-01	1.94E-01
	Zinc	2.22E-05	1.95E-07	8.93E-06	1.44E-07	6.59E-06	0.00E+00	1.61E-03	9.38E-03	2.13E-01	2.24E-01
		Project Incremental HQ - Project Phases									
	Cadmium	1.45E-04	1.42E-09	6.48E-09	6.95E-07	3.18E-06	0.00E+00	1.80E-05	2.07E-06	1.53E-04	3.22E-04
	Chromium	1.05E-06	4.44E-12	2.03E-10	4.05E-09	1.85E-07	0.00E+00	2.48E-06	4.42E-09	8.57E-07	4.58E-06
	Cobalt	1.99E-05	5.98E-10	2.74E-09	1.85E-08	8.46E-08	0.00E+00	1.09E-05	1.72E-06	3.71E-05	6.98E-05
	Copper	3.45E-06	6.38E-10	1.75E-08	3.78E-09	1.04E-07	0.00E+00	7.83E-05	1.94E-05	8.46E-05	1.86E-04
	Molybdenum	6.35E-03	6.60E-11	3.02E-10	7.08E-06	3.24E-05	0.00E+00	2.82E-05	3.31E-07	1.47E-03	7.89E-03
	Selenium	5.15E-04	4.18E-10	1.91E-09	2.98E-06	1.36E-05	0.00E+00	7.98E-02	2.42E-06	1.12E-02	9.15E-02
	Uranium	6.66E-03	2.26E-05	1.04E-03	3.84E-05	1.76E-03	0.00E+00	5.08E-03	2.77E-02	4.17E-03	4.65E-02

Human Receptor	COPC	HQs during Project Phases									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Vanadium	1.77E-03	1.45E-08	6.61E-07	4.32E-05	1.98E-03	0.00E+00	4.18E-03	5.34E-06	3.64E-03	1.16E-02
	Zinc	4.64E-06	1.67E-10	7.64E-09	2.27E-08	1.04E-06	0.00E+00	3.88E-04	3.28E-06	1.77E-04	5.74E-04
Rec F/H Adult (McGowan Lake)		Average Baseline HQ									
	Cadmium	4.25E-04	9.44E-06	4.32E-06	2.94E-06	1.35E-06	0.00E+00	8.92E-05	8.78E-03	2.48E-01	2.57E-01
	Chromium	5.08E-06	4.62E-08	2.11E-07	2.72E-08	1.25E-07	0.00E+00	1.96E-05	7.43E-06	2.02E-05	5.27E-05
	Cobalt	1.48E-04	5.55E-07	2.54E-07	1.76E-07	8.04E-08	0.00E+00	1.25E-04	6.29E-03	1.77E-02	2.42E-02
	Copper	2.13E-05	7.15E-08	1.96E-07	3.02E-08	8.30E-08	0.00E+00	7.48E-04	1.03E-02	5.98E-02	7.08E-02
	Molybdenum	5.61E-05	8.58E-08	3.93E-08	8.40E-08	3.84E-08	0.00E+00	3.94E-07	1.85E-03	8.62E-02	8.81E-02
	Selenium	8.32E-05	3.93E-07	1.80E-07	7.59E-07	3.48E-07	0.00E+00	2.94E-02	7.70E-03	2.89E-01	3.26E-01
	Uranium	7.35E-04	1.33E-05	6.10E-05	6.71E-06	3.07E-05	0.00E+00	1.03E-03	4.55E-02	5.86E-02	1.06E-01
	Vanadium	1.01E-03	4.80E-05	2.20E-04	3.71E-05	1.70E-04	0.00E+00	6.78E-03	3.43E-03	1.72E-01	1.83E-01
	Zinc	1.75E-05	1.95E-07	8.92E-07	1.21E-07	5.56E-07	0.00E+00	2.45E-03	1.88E-02	2.34E-01	2.55E-01
		Project Total HQ - Project Phases									
	Cadmium	4.78E-04	9.44E-06	4.32E-06	3.22E-06	1.47E-06	0.00E+00	1.25E-04	8.79E-03	2.48E-01	2.58E-01
	Chromium	5.50E-06	4.62E-08	2.11E-07	2.89E-08	1.32E-07	0.00E+00	2.45E-05	7.44E-06	2.19E-05	5.98E-05
	Cobalt	1.56E-04	5.55E-07	2.54E-07	1.84E-07	8.40E-08	0.00E+00	1.47E-04	6.29E-03	1.77E-02	2.43E-02
	Copper	2.26E-05	7.16E-08	1.97E-07	3.19E-08	8.75E-08	0.00E+00	9.05E-04	1.03E-02	6.00E-02	7.12E-02
	Molybdenum	2.52E-03	8.59E-08	3.93E-08	3.13E-06	1.43E-06	0.00E+00	5.68E-05	1.85E-03	8.91E-02	9.36E-02
	Selenium	2.56E-04	3.94E-07	1.80E-07	1.90E-06	8.67E-07	0.00E+00	1.89E-01	7.70E-03	3.12E-01	5.09E-01
	Uranium	2.98E-03	1.68E-05	7.68E-05	2.14E-05	9.78E-05	0.00E+00	1.12E-02	1.01E-01	6.70E-02	1.82E-01
	Vanadium	1.49E-03	4.80E-05	2.20E-04	4.81E-05	2.20E-04	0.00E+00	1.51E-02	3.44E-03	1.79E-01	1.99E-01
	Zinc	1.93E-05	1.95E-07	8.93E-07	1.30E-07	5.97E-07	0.00E+00	3.23E-03	1.88E-02	2.34E-01	2.56E-01
		Project Incremental HQ - Project Phases									
	Cadmium	5.28E-05	1.97E-10	9.00E-11	2.75E-07	1.26E-07	0.00E+00	3.60E-05	4.14E-06	3.08E-04	4.01E-04
	Chromium	4.16E-07	6.86E-13	3.14E-12	1.64E-09	7.53E-09	0.00E+00	4.96E-06	8.84E-09	1.72E-06	7.12E-06
	Cobalt	7.28E-06	8.29E-11	3.80E-11	8.01E-09	3.66E-09	0.00E+00	2.18E-05	3.44E-06	7.40E-05	1.07E-04
	Copper	1.25E-06	8.90E-11	2.44E-10	1.63E-09	4.48E-09	0.00E+00	1.57E-04	3.88E-05	1.69E-04	3.66E-04
	Molybdenum	2.47E-03	6.62E-12	3.03E-12	3.05E-06	1.40E-06	0.00E+00	5.64E-05	6.63E-07	2.93E-03	5.46E-03
	Selenium	1.73E-04	5.85E-11	2.68E-11	1.14E-06	5.20E-07	0.00E+00	1.60E-01	4.83E-06	2.24E-02	1.82E-01

Human Receptor	COPC	HQs during Project Phases									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Uranium	2.24E-03	3.45E-06	1.58E-05	1.46E-05	6.70E-05	0.00E+00	1.02E-02	5.54E-02	8.36E-03	7.63E-02
	Vanadium	4.72E-04	2.01E-09	9.18E-09	1.10E-05	5.03E-05	0.00E+00	8.36E-03	1.07E-05	7.29E-03	1.62E-02
	Zinc	1.81E-06	2.32E-11	1.06E-10	9.00E-09	4.12E-08	0.00E+00	7.76E-04	6.57E-06	3.54E-04	1.14E-03
Rec F/H One-year-old (McGowan Lake)		Average Baseline HQ									
	Cadmium	4.75E-04	6.17E-04	7.39E-06	1.92E-04	2.30E-06	0.00E+00	8.45E-05	1.97E-02	6.29E-01	6.50E-01
	Chromium	5.67E-06	3.02E-06	3.62E-07	1.78E-06	2.13E-07	0.00E+00	1.85E-05	1.72E-05	1.17E-05	5.85E-05
	Cobalt	1.66E-04	3.63E-05	4.35E-07	1.15E-05	1.37E-07	0.00E+00	1.18E-04	1.46E-02	3.78E-02	5.27E-02
	Copper	2.38E-05	4.67E-06	3.36E-07	1.98E-06	1.42E-07	0.00E+00	7.09E-04	2.37E-02	1.01E-01	1.25E-01
	Molybdenum	7.63E-05	6.83E-06	8.18E-08	6.68E-06	8.00E-08	0.00E+00	4.54E-07	5.20E-03	2.73E-01	2.79E-01
	Selenium	9.63E-05	2.66E-05	3.19E-07	5.14E-05	6.16E-07	0.00E+00	2.88E-02	1.87E-02	7.51E-01	7.98E-01
	Uranium	8.21E-04	8.71E-04	1.04E-04	4.38E-04	5.25E-05	0.00E+00	9.73E-04	1.04E-01	1.52E-01	2.59E-01
	Vanadium	1.13E-03	3.13E-03	3.76E-04	2.42E-03	2.91E-04	0.00E+00	6.42E-03	6.21E-03	4.18E-01	4.38E-01
	Zinc	2.28E-05	1.48E-05	1.78E-06	9.23E-06	1.11E-06	0.00E+00	2.70E-03	5.01E-02	5.63E-01	6.16E-01
		Project Total HQ - Project Phases									
	Cadmium	5.34E-04	6.17E-04	7.39E-06	2.10E-04	2.52E-06	0.00E+00	1.19E-04	1.97E-02	6.29E-01	6.50E-01
	Chromium	6.14E-06	3.02E-06	3.62E-07	1.89E-06	2.26E-07	0.00E+00	2.32E-05	1.72E-05	1.29E-05	6.49E-05
	Cobalt	1.74E-04	3.63E-05	4.35E-07	1.20E-05	1.44E-07	0.00E+00	1.39E-04	1.46E-02	3.78E-02	5.28E-02
	Copper	2.52E-05	4.68E-06	3.36E-07	2.08E-06	1.50E-07	0.00E+00	8.57E-04	2.38E-02	1.01E-01	1.26E-01
	Molybdenum	3.43E-03	6.83E-06	8.18E-08	2.49E-04	2.99E-06	0.00E+00	6.55E-05	5.20E-03	2.75E-01	2.84E-01
	Selenium	2.96E-04	2.66E-05	3.19E-07	1.28E-04	1.54E-06	0.00E+00	1.86E-01	1.87E-02	7.66E-01	9.70E-01
	Uranium	3.32E-03	1.10E-03	1.31E-04	1.40E-03	1.67E-04	0.00E+00	1.06E-02	2.14E-01	1.57E-01	3.88E-01
	Vanadium	1.66E-03	3.13E-03	3.76E-04	3.14E-03	3.77E-04	0.00E+00	1.43E-02	6.22E-03	4.22E-01	4.51E-01
	Zinc	2.51E-05	1.48E-05	1.78E-06	9.91E-06	1.19E-06	0.00E+00	3.56E-03	5.01E-02	5.64E-01	6.17E-01
		Project Incremental HQ - Project Phases									
	Cadmium	5.89E-05	1.29E-08	1.55E-10	1.80E-05	2.16E-07	0.00E+00	3.41E-05	8.55E-06	2.13E-04	3.33E-04
	Chromium	4.64E-07	4.50E-11	5.37E-12	1.07E-07	1.29E-08	0.00E+00	4.70E-06	1.15E-08	1.14E-06	6.44E-06
	Cobalt	8.13E-06	5.42E-09	6.50E-11	5.23E-07	6.27E-09	0.00E+00	2.07E-05	7.64E-06	4.22E-05	7.92E-05
	Copper	1.40E-06	5.81E-09	4.18E-10	1.07E-07	7.67E-09	0.00E+00	1.48E-04	9.07E-05	9.83E-05	3.39E-04
	Molybdenum	3.35E-03	5.27E-10	6.31E-12	2.43E-04	2.91E-06	0.00E+00	6.51E-05	1.80E-06	2.03E-03	5.70E-03

Human Receptor	COPC	HQs during Project Phases									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Selenium	2.00E-04	3.96E-09	4.74E-11	7.69E-05	9.22E-07	0.00E+00	1.57E-01	1.14E-05	1.48E-02	1.72E-01
	Uranium	2.50E-03	2.25E-04	2.70E-05	9.57E-04	1.15E-04	0.00E+00	9.62E-03	1.10E-01	5.28E-03	1.29E-01
	Vanadium	5.27E-04	1.31E-07	1.57E-08	7.18E-04	8.61E-05	0.00E+00	7.91E-03	1.37E-05	4.03E-03	1.33E-02
	Zinc	2.35E-06	1.77E-09	2.12E-10	6.84E-07	8.20E-08	0.00E+00	8.54E-04	1.78E-05	2.07E-04	1.08E-03
Rec F/H Adult (Russell Lake)		Average Baseline HQ									
	Cadmium	4.25E-04	9.44E-06	4.32E-06	2.94E-06	1.35E-06	0.00E+00	8.92E-05	8.78E-03	2.48E-01	2.57E-01
	Chromium	5.08E-06	4.62E-08	2.11E-07	2.72E-08	1.25E-07	0.00E+00	1.96E-05	7.43E-06	2.02E-05	5.27E-05
	Cobalt	1.48E-04	5.55E-07	2.54E-07	1.76E-07	8.04E-08	0.00E+00	1.25E-04	6.29E-03	1.77E-02	2.42E-02
	Copper	2.13E-05	7.15E-08	1.96E-07	3.02E-08	8.30E-08	0.00E+00	7.48E-04	1.03E-02	5.98E-02	7.08E-02
	Molybdenum	5.61E-05	8.58E-08	3.93E-08	8.40E-08	3.84E-08	0.00E+00	3.94E-07	1.85E-03	8.62E-02	8.81E-02
	Selenium	8.32E-05	3.93E-07	1.80E-07	7.59E-07	3.48E-07	0.00E+00	2.94E-02	7.70E-03	2.89E-01	3.26E-01
	Uranium	7.35E-04	1.33E-05	6.10E-05	6.71E-06	3.07E-05	0.00E+00	1.03E-03	4.55E-02	5.86E-02	1.06E-01
	Vanadium	1.01E-03	4.80E-05	2.20E-04	3.71E-05	1.70E-04	0.00E+00	6.78E-03	3.43E-03	1.72E-01	1.83E-01
	Zinc	1.75E-05	1.95E-07	8.92E-07	1.21E-07	5.56E-07	0.00E+00	2.45E-03	1.88E-02	2.34E-01	2.55E-01
		Project Total HQ - Project Phases									
	Cadmium	4.68E-04	9.44E-06	4.32E-06	3.15E-06	1.44E-06	0.00E+00	1.15E-04	8.78E-03	2.48E-01	2.58E-01
	Chromium	5.42E-06	4.62E-08	2.11E-07	2.84E-08	1.30E-07	0.00E+00	2.32E-05	7.44E-06	2.15E-05	5.80E-05
	Cobalt	1.54E-04	5.55E-07	2.54E-07	1.82E-07	8.31E-08	0.00E+00	1.41E-04	6.29E-03	1.77E-02	2.43E-02
	Copper	2.23E-05	7.16E-08	1.97E-07	3.15E-08	8.64E-08	0.00E+00	8.66E-04	1.03E-02	5.99E-02	7.11E-02
	Molybdenum	1.91E-03	8.58E-08	3.93E-08	2.40E-06	1.10E-06	0.00E+00	4.28E-05	1.85E-03	8.84E-02	9.22E-02
	Selenium	2.07E-04	3.93E-07	1.80E-07	1.59E-06	7.27E-07	0.00E+00	1.47E-01	7.70E-03	3.06E-01	4.60E-01
	Uranium	2.35E-03	1.42E-05	6.52E-05	1.74E-05	7.97E-05	0.00E+00	8.35E-03	6.03E-02	6.36E-02	1.35E-01
	Vanadium	1.38E-03	4.80E-05	2.20E-04	4.41E-05	2.02E-04	0.00E+00	1.24E-02	3.43E-03	1.76E-01	1.94E-01
	Zinc	1.90E-05	1.95E-07	8.92E-07	1.28E-07	5.86E-07	0.00E+00	3.02E-03	1.88E-02	2.34E-01	2.56E-01
		Project Incremental HQ - Project Phases									
	Cadmium	4.28E-05	5.09E-11	2.32E-11	2.03E-07	9.30E-08	0.00E+00	2.62E-05	1.07E-06	2.29E-04	2.99E-04
	Chromium	3.42E-07	1.78E-13	8.10E-13	1.22E-09	5.60E-09	0.00E+00	3.64E-06	2.30E-09	1.30E-06	5.29E-06
	Cobalt	5.45E-06	2.13E-11	9.75E-12	6.09E-09	2.79E-09	0.00E+00	1.64E-05	8.85E-07	5.35E-05	7.63E-05
	Copper	9.39E-07	2.29E-11	6.29E-11	1.24E-09	3.41E-09	0.00E+00	1.18E-04	9.99E-06	9.25E-05	2.21E-04
	Molybdenum	1.85E-03	1.32E-12	6.04E-13	2.31E-06	1.06E-06	0.00E+00	4.24E-05	1.33E-07	2.22E-03	4.12E-03

Human Receptor	COPC	HQs during Project Phases									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Selenium	1.24E-04	1.50E-11	6.88E-12	8.29E-07	3.80E-07	0.00E+00	1.17E-01	1.24E-06	1.65E-02	1.34E-01
	Uranium	1.61E-03	9.20E-07	4.21E-06	1.07E-05	4.90E-05	0.00E+00	7.33E-03	1.48E-02	4.92E-03	2.87E-02
	Vanadium	3.63E-04	5.17E-10	2.36E-09	6.98E-06	3.20E-05	0.00E+00	5.62E-03	2.75E-06	4.91E-03	1.09E-02
	Zinc	1.49E-06	5.97E-12	2.74E-11	6.64E-09	3.04E-08	0.00E+00	5.64E-04	1.69E-06	2.59E-04	8.26E-04
		Average Baseline HQ									
	Cadmium	4.75E-04	6.17E-04	7.39E-06	1.92E-04	2.30E-06	0.00E+00	8.45E-05	1.97E-02	6.29E-01	6.50E-01
	Chromium	5.67E-06	3.02E-06	3.62E-07	1.78E-06	2.13E-07	0.00E+00	1.85E-05	1.72E-05	1.17E-05	5.85E-05
	Cobalt	1.66E-04	3.63E-05	4.35E-07	1.15E-05	1.37E-07	0.00E+00	1.18E-04	1.46E-02	3.78E-02	5.27E-02
	Copper	2.38E-05	4.67E-06	3.36E-07	1.98E-06	1.42E-07	0.00E+00	7.09E-04	2.37E-02	1.01E-01	1.25E-01
	Molybdenum	7.63E-05	6.83E-06	8.18E-08	6.68E-06	8.00E-08	0.00E+00	4.54E-07	5.20E-03	2.73E-01	2.79E-01
	Selenium	9.63E-05	2.66E-05	3.19E-07	5.14E-05	6.16E-07	0.00E+00	2.88E-02	1.87E-02	7.51E-01	7.98E-01
	Uranium	8.21E-04	8.71E-04	1.04E-04	4.38E-04	5.25E-05	0.00E+00	9.73E-04	1.04E-01	1.52E-01	2.59E-01
	Vanadium	1.13E-03	3.13E-03	3.76E-04	2.42E-03	2.91E-04	0.00E+00	6.42E-03	6.21E-03	4.18E-01	4.38E-01
	Zinc	2.28E-05	1.48E-05	1.78E-06	9.23E-06	1.11E-06	0.00E+00	2.70E-03	5.01E-02	5.63E-01	6.16E-01
		Project Total HQ - Project Phases									
Rec F/H One-year-old (Russell Lake)	Cadmium	5.22E-04	6.17E-04	7.39E-06	2.06E-04	2.46E-06	0.00E+00	1.09E-04	1.97E-02	6.29E-01	6.50E-01
	Chromium	6.06E-06	3.02E-06	3.62E-07	1.86E-06	2.23E-07	0.00E+00	2.20E-05	1.72E-05	1.26E-05	6.33E-05
	Cobalt	1.72E-04	3.63E-05	4.35E-07	1.19E-05	1.42E-07	0.00E+00	1.34E-04	1.46E-02	3.78E-02	5.27E-02
	Copper	2.49E-05	4.68E-06	3.36E-07	2.06E-06	1.48E-07	0.00E+00	8.20E-04	2.38E-02	1.01E-01	1.25E-01
	Molybdenum	2.59E-03	6.83E-06	8.18E-08	1.91E-04	2.29E-06	0.00E+00	4.93E-05	5.20E-03	2.75E-01	2.83E-01
	Selenium	2.40E-04	2.66E-05	3.19E-07	1.08E-04	1.29E-06	0.00E+00	1.44E-01	1.87E-02	7.62E-01	9.25E-01
	Uranium	2.62E-03	9.31E-04	1.12E-04	1.14E-03	1.36E-04	0.00E+00	7.91E-03	1.34E-01	1.55E-01	3.01E-01
	Vanadium	1.54E-03	3.13E-03	3.76E-04	2.88E-03	3.45E-04	0.00E+00	1.17E-02	6.21E-03	4.21E-01	4.47E-01
	Zinc	2.47E-05	1.48E-05	1.78E-06	9.73E-06	1.17E-06	0.00E+00	3.32E-03	5.01E-02	5.64E-01	6.17E-01
		Project Incremental HQ - Project Phases									
	Cadmium	4.78E-05	3.32E-09	3.96E-11	1.33E-05	1.59E-07	0.00E+00	2.48E-05	2.20E-06	1.58E-04	2.46E-04
	Chromium	3.81E-07	1.18E-11	1.39E-12	7.99E-08	9.58E-09	0.00E+00	3.44E-06	3.00E-09	8.57E-07	4.77E-06
	Cobalt	6.08E-06	1.39E-09	1.67E-11	3.98E-07	4.77E-09	0.00E+00	1.55E-05	1.96E-06	3.06E-05	5.46E-05
	Copper	1.05E-06	1.50E-09	1.08E-10	8.10E-08	5.83E-09	0.00E+00	1.11E-04	2.33E-05	5.58E-05	1.92E-04
	Molybdenum	2.52E-03	1.06E-10	1.26E-12	1.84E-04	2.21E-06	0.00E+00	4.89E-05	3.61E-07	1.54E-03	4.29E-03

Human Receptor	COPC	HQs during Project Phases									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
Seasonal Resident (Russell Lake)	Selenium	1.44E-04	1.02E-09	1.22E-11	5.62E-05	6.73E-07	0.00E+00	1.15E-01	2.93E-06	1.09E-02	1.26E-01
	Uranium	1.80E-03	6.01E-05	7.21E-06	6.99E-04	8.38E-05	0.00E+00	6.94E-03	2.94E-02	3.10E-03	4.21E-02
	Vanadium	4.05E-04	3.38E-08	4.05E-09	4.56E-04	5.47E-05	0.00E+00	5.32E-03	3.54E-06	2.70E-03	8.94E-03
	Zinc	1.94E-06	4.55E-10	5.45E-11	5.05E-07	6.05E-08	0.00E+00	6.21E-04	4.58E-06	1.52E-04	7.80E-04
		Average Baseline HQ									
	Cadmium	4.25E-04	9.44E-06	4.32E-06	2.94E-06	1.35E-06	0.00E+00	8.92E-05	8.78E-03	<u>2.48E-01</u>	2.57E-01
	Chromium	5.08E-06	4.62E-08	2.11E-07	2.72E-08	1.25E-07	0.00E+00	1.96E-05	7.43E-06	2.02E-05	5.27E-05
	Cobalt	1.48E-04	5.55E-07	2.54E-07	1.76E-07	8.04E-08	0.00E+00	1.25E-04	6.29E-03	1.77E-02	2.42E-02
	Copper	2.13E-05	7.15E-08	1.96E-07	3.02E-08	8.30E-08	0.00E+00	7.48E-04	1.03E-02	5.98E-02	7.08E-02
	Molybdenum	5.61E-05	8.58E-08	3.93E-08	8.40E-08	3.84E-08	0.00E+00	3.94E-07	1.85E-03	8.62E-02	8.81E-02
	Selenium	8.32E-05	3.93E-07	1.80E-07	7.59E-07	3.48E-07	0.00E+00	2.94E-02	7.70E-03	<u>2.89E-01</u>	3.26E-01
	Uranium	7.35E-04	1.33E-05	6.10E-05	6.71E-06	3.07E-05	0.00E+00	1.03E-03	4.55E-02	5.86E-02	1.06E-01
	Vanadium	1.01E-03	4.80E-05	2.20E-04	3.71E-05	1.70E-04	0.00E+00	6.78E-03	3.43E-03	1.72E-01	1.83E-01
	Zinc	1.75E-05	1.95E-07	8.92E-07	1.21E-07	5.56E-07	0.00E+00	2.45E-03	1.88E-02	<u>2.34E-01</u>	2.55E-01
		Project Total HQ - Project Phases									
	Cadmium	4.68E-04	9.44E-06	4.32E-06	3.15E-06	1.44E-06	0.00E+00	9.78E-05	8.78E-03	<u>2.48E-01</u>	2.58E-01
	Chromium	5.42E-06	4.62E-08	2.11E-07	2.84E-08	1.30E-07	0.00E+00	2.08E-05	7.43E-06	2.06E-05	5.47E-05
	Cobalt	1.54E-04	5.55E-07	2.54E-07	1.82E-07	8.31E-08	0.00E+00	1.30E-04	6.29E-03	1.77E-02	2.42E-02
	Copper	2.23E-05	7.16E-08	1.97E-07	3.15E-08	8.64E-08	0.00E+00	7.81E-04	1.03E-02	5.98E-02	7.09E-02
	Molybdenum	1.91E-03	8.58E-08	3.93E-08	2.40E-06	1.10E-06	0.00E+00	1.31E-05	1.85E-03	8.69E-02	9.06E-02
	Selenium	2.07E-04	3.93E-07	1.80E-07	1.59E-06	7.27E-07	0.00E+00	6.39E-02	7.70E-03	<u>2.94E-01</u>	3.66E-01
	Uranium	2.35E-03	1.42E-05	6.52E-05	1.74E-05	7.97E-05	0.00E+00	3.20E-03	4.99E-02	6.09E-02	1.17E-01
	Vanadium	1.38E-03	4.80E-05	2.20E-04	4.41E-05	2.02E-04	0.00E+00	9.08E-03	3.43E-03	1.73E-01	1.88E-01
	Zinc	1.90E-05	1.95E-07	8.92E-07	1.28E-07	5.86E-07	0.00E+00	2.65E-03	1.88E-02	<u>2.34E-01</u>	2.55E-01
		Project Incremental HQ - Project Phases									
	Cadmium	4.28E-05	5.09E-11	2.32E-11	2.03E-07	9.30E-08	0.00E+00	8.62E-06	3.21E-07	7.37E-05	1.26E-04
	Chromium	3.42E-07	1.78E-13	8.10E-13	1.22E-09	5.60E-09	0.00E+00	1.26E-06	6.97E-10	4.24E-07	2.03E-06
	Cobalt	5.45E-06	2.13E-11	9.75E-12	6.09E-09	2.79E-09	0.00E+00	4.55E-06	2.66E-07	1.49E-05	2.51E-05
	Copper	9.39E-07	2.29E-11	6.29E-11	1.24E-09	3.41E-09	0.00E+00	3.26E-05	3.00E-06	2.73E-05	6.39E-05

Human Receptor	COPC	HQs during Project Phases									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Molybdenum	1.85E-03	1.32E-12	6.04E-13	2.31E-06	1.06E-06	0.00E+00	1.27E-05	3.99E-08	6.64E-04	2.53E-03
	Selenium	1.24E-04	1.50E-11	6.88E-12	8.29E-07	3.80E-07	0.00E+00	3.45E-02	3.73E-07	5.25E-03	3.99E-02
	Uranium	1.61E-03	9.20E-07	4.21E-06	1.07E-05	4.90E-05	0.00E+00	2.17E-03	4.45E-03	2.22E-03	1.05E-02
	Vanadium	3.63E-04	5.17E-10	2.36E-09	6.98E-06	3.20E-05	0.00E+00	2.30E-03	8.33E-07	1.89E-03	4.59E-03
	Zinc	1.49E-06	5.97E-12	2.74E-11	6.64E-09	3.04E-08	0.00E+00	1.99E-04	5.07E-07	1.00E-04	3.01E-04
Seasonal Resident One-year-old (Russell Lake)		**Average Baseline HQ**									
	Cadmium	4.75E-04	6.17E-04	7.39E-06	1.92E-04	2.30E-06	0.00E+00	8.45E-05	1.97E-02	6.29E-01	6.50E-01
	Chromium	5.67E-06	3.02E-06	3.62E-07	1.78E-06	2.13E-07	0.00E+00	1.85E-05	1.72E-05	1.17E-05	5.85E-05
	Cobalt	1.66E-04	3.63E-05	4.35E-07	1.15E-05	1.37E-07	0.00E+00	1.18E-04	1.46E-02	3.78E-02	5.27E-02
	Copper	2.38E-05	4.67E-06	3.36E-07	1.98E-06	1.42E-07	0.00E+00	7.09E-04	2.37E-02	1.01E-01	1.25E-01
	Molybdenum	7.63E-05	6.83E-06	8.18E-08	6.68E-06	8.00E-08	0.00E+00	4.54E-07	5.20E-03	2.73E-01	2.79E-01
	Selenium	9.63E-05	2.66E-05	3.19E-07	5.14E-05	6.16E-07	0.00E+00	2.88E-02	1.87E-02	7.51E-01	7.98E-01
	Uranium	8.21E-04	8.71E-04	1.04E-04	4.38E-04	5.25E-05	0.00E+00	9.73E-04	1.04E-01	1.52E-01	2.59E-01
	Vanadium	1.13E-03	3.13E-03	3.76E-04	2.42E-03	2.91E-04	0.00E+00	6.42E-03	6.21E-03	4.18E-01	4.38E-01
	Zinc	2.28E-05	1.48E-05	1.78E-06	9.23E-06	1.11E-06	0.00E+00	2.70E-03	5.01E-02	5.63E-01	6.16E-01
		Project Total HQ - Project Phases									
	Cadmium	5.22E-04	6.17E-04	7.39E-06	2.06E-04	2.46E-06	0.00E+00	9.26E-05	1.97E-02	6.29E-01	6.50E-01
	Chromium	6.06E-06	3.02E-06	3.62E-07	1.86E-06	2.23E-07	0.00E+00	1.97E-05	1.72E-05	1.20E-05	6.04E-05
	Cobalt	1.72E-04	3.63E-05	4.35E-07	1.19E-05	1.42E-07	0.00E+00	1.23E-04	1.46E-02	3.78E-02	5.27E-02
	Copper	2.49E-05	4.68E-06	3.36E-07	2.06E-06	1.48E-07	0.00E+00	7.40E-04	2.37E-02	1.01E-01	1.25E-01
	Molybdenum	2.59E-03	6.83E-06	8.18E-08	1.91E-04	2.29E-06	0.00E+00	1.51E-05	5.20E-03	2.74E-01	2.82E-01
	Selenium	2.40E-04	2.66E-05	3.19E-07	1.08E-04	1.29E-06	0.00E+00	6.27E-02	1.87E-02	7.54E-01	8.36E-01
	Uranium	2.62E-03	9.31E-04	1.12E-04	1.14E-03	1.36E-04	0.00E+00	3.03E-03	1.13E-01	1.53E-01	2.74E-01
	Vanadium	1.54E-03	3.13E-03	3.76E-04	2.88E-03	3.45E-04	0.00E+00	8.60E-03	6.21E-03	4.19E-01	4.42E-01
	Zinc	2.47E-05	1.48E-05	1.78E-06	9.73E-06	1.17E-06	0.00E+00	2.92E-03	5.01E-02	5.63E-01	6.17E-01
		Project Incremental HQ - Project Phases									
	Cadmium	4.78E-05	3.32E-09	3.96E-11	1.33E-05	1.59E-07	0.00E+00	8.17E-06	6.59E-07	4.84E-05	1.18E-04
	Chromium	3.81E-07	1.18E-11	1.39E-12	7.99E-08	9.58E-09	0.00E+00	1.19E-06	8.93E-10	2.69E-07	1.93E-06
	Cobalt	6.08E-06	1.39E-09	1.67E-11	3.98E-07	4.77E-09	0.00E+00	4.31E-06	5.89E-07	8.26E-06	1.96E-05

Human Receptor	COPC	HQs during Project Phases									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Copper	1.05E-06	1.50E-09	1.08E-10	8.10E-08	5.83E-09	0.00E+00	3.09E-05	7.00E-06	1.60E-05	5.50E-05
	Molybdenum	2.52E-03	1.06E-10	1.26E-12	1.84E-04	2.21E-06	0.00E+00	1.47E-05	1.08E-07	4.46E-04	3.16E-03
	Selenium	1.44E-04	1.02E-09	1.22E-11	5.62E-05	6.73E-07	0.00E+00	3.39E-02	8.77E-07	3.36E-03	3.75E-02
	Uranium	1.80E-03	6.01E-05	7.21E-06	6.99E-04	8.38E-05	0.00E+00	2.06E-03	8.80E-03	1.34E-03	1.48E-02
	Vanadium	4.05E-04	3.38E-08	4.05E-09	4.56E-04	5.47E-05	0.00E+00	2.18E-03	1.05E-06	1.04E-03	4.14E-03
	Zinc	1.94E-06	4.55E-10	5.45E-11	5.05E-07	6.05E-08	0.00E+00	2.19E-04	1.37E-06	6.00E-05	2.83E-04
Fisher/Trapper (Russell Lake)		Average Baseline HQ									
	Cadmium	4.25E-04	9.44E-06	4.32E-06	2.94E-06	1.35E-06	0.00E+00	6.14E-04	0.00E+00	2.01E-01	2.02E-01
	Chromium	5.08E-06	4.62E-08	2.11E-07	2.72E-08	1.25E-07	0.00E+00	1.35E-04	0.00E+00	5.51E-04	6.91E-04
	Cobalt	1.48E-04	5.55E-07	2.54E-07	1.76E-07	8.04E-08	0.00E+00	8.60E-04	0.00E+00	7.79E-03	8.80E-03
	Copper	2.13E-05	7.15E-08	1.96E-07	3.02E-08	8.30E-08	0.00E+00	5.15E-03	0.00E+00	2.80E-02	3.32E-02
	Molybdenum	5.61E-05	8.58E-08	3.93E-08	8.40E-08	3.84E-08	0.00E+00	2.71E-06	0.00E+00	4.58E-02	4.59E-02
	Selenium	8.32E-05	3.93E-07	1.80E-07	7.59E-07	3.48E-07	0.00E+00	2.02E-01	0.00E+00	2.77E-01	4.79E-01
	Uranium	7.35E-04	1.33E-05	6.10E-05	6.71E-06	3.07E-05	0.00E+00	7.07E-03	0.00E+00	3.64E-02	4.44E-02
	Vanadium	1.01E-03	4.80E-05	2.20E-04	3.71E-05	1.70E-04	0.00E+00	4.67E-02	0.00E+00	3.67E-01	4.16E-01
	Zinc	1.75E-05	1.95E-07	8.92E-07	1.21E-07	5.56E-07	0.00E+00	1.69E-02	0.00E+00	5.40E-01	5.57E-01
		Project Total HQ - Project Phases									
	Cadmium	4.88E-04	9.44E-06	4.32E-06	3.28E-06	1.50E-06	0.00E+00	7.94E-04	0.00E+00	2.02E-01	2.03E-01
	Chromium	5.57E-06	4.62E-08	2.11E-07	2.93E-08	1.34E-07	0.00E+00	1.60E-04	0.00E+00	5.58E-04	7.24E-04
	Cobalt	1.58E-04	5.55E-07	2.54E-07	1.86E-07	8.50E-08	0.00E+00	9.73E-04	0.00E+00	7.80E-03	8.94E-03
	Copper	2.30E-05	7.16E-08	1.97E-07	3.23E-08	8.87E-08	0.00E+00	5.96E-03	0.00E+00	2.82E-02	3.42E-02
	Molybdenum	3.14E-03	8.59E-08	3.93E-08	3.94E-06	1.80E-06	0.00E+00	2.94E-04	0.00E+00	4.70E-02	5.05E-02
	Selenium	2.92E-04	3.93E-07	1.80E-07	2.14E-06	9.80E-07	0.00E+00	1.01E+00	0.00E+00	3.36E-01	**1.35E+00**
	Uranium	3.44E-03	1.49E-05	6.80E-05	2.45E-05	1.12E-04	0.00E+00	5.75E-02	0.00E+00	1.62E-01	2.23E-01
	Vanadium	1.52E-03	4.80E-05	2.20E-04	4.87E-05	2.23E-04	0.00E+00	8.53E-02	0.00E+00	4.07E-01	4.94E-01
	Zinc	1.97E-05	1.95E-07	8.93E-07	1.32E-07	6.06E-07	0.00E+00	2.08E-02	0.00E+00	5.42E-01	5.63E-01
		Project Incremental HQ - Project Phases									
	Cadmium	6.30E-05	8.46E-11	3.87E-11	3.39E-07	1.55E-07	0.00E+00	1.80E-04	0.00E+00	7.17E-04	9.60E-04
	Chromium	4.92E-07	2.98E-13	1.35E-12	2.04E-09	9.33E-09	0.00E+00	2.50E-05	0.00E+00	6.74E-06	3.23E-05

Human Receptor	COPC	HQs during Project Phases									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Cobalt	9.49E-06	3.55E-11	1.63E-11	1.01E-08	4.64E-09	0.00E+00	1.13E-04	0.00E+00	1.37E-05	1.36E-04
	Copper	1.63E-06	3.81E-11	1.05E-10	2.06E-09	5.67E-09	0.00E+00	8.09E-04	0.00E+00	1.48E-04	9.59E-04
	Molybdenum	3.08E-03	2.20E-12	1.01E-12	3.86E-06	1.76E-06	0.00E+00	2.92E-04	0.00E+00	1.21E-03	4.59E-03
	Selenium	2.09E-04	2.51E-11	1.15E-11	1.38E-06	6.33E-07	0.00E+00	<u>8.07E-01</u>	0.00E+00	5.87E-02	8.66E-01
	Uranium	2.70E-03	1.53E-06	7.02E-06	1.78E-05	8.16E-05	0.00E+00	5.04E-02	0.00E+00	1.25E-01	1.79E-01
	Vanadium	5.01E-04	8.62E-10	3.94E-09	1.16E-05	5.32E-05	0.00E+00	3.87E-02	0.00E+00	3.95E-02	7.88E-02
	Zinc	2.13E-06	9.96E-12	4.56E-11	1.11E-08	5.06E-08	0.00E+00	3.88E-03	0.00E+00	1.87E-03	5.75E-03

<u>Underlined values</u> indicate exceedance of the HQ of 0.2 for a given exposure pathway; **Bolded** values indicate exceedance of the HQ of 1 for all exposure pathways.
HQ = hazard quotient; COPC = constituent of potential concern.

Table 4-16: Estimated Non-radiological Risk to Human Receptors – Future Centuries

Human Receptor	COPC	HQ during Future Centuries									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
Permanent Resident Adult (Whitefish Lake)		Baseline HQ									
	Cadmium	4.26E-04	9.44E-06	4.32E-06	2.95E-06	1.35E-06	0.00E+00	8.94E-05	8.78E-03	2.48E-01	2.57E-01
	Chromium	5.09E-06	4.62E-08	2.11E-07	2.73E-08	1.25E-07	0.00E+00	1.96E-05	7.43E-06	2.02E-05	5.27E-05
	Cobalt	1.49E-04	5.55E-07	2.54E-07	1.76E-07	8.04E-08	0.00E+00	1.25E-04	6.29E-03	1.77E-02	2.42E-02
	Copper	2.13E-05	7.15E-08	1.96E-07	3.02E-08	8.31E-08	0.00E+00	7.49E-04	1.03E-02	5.98E-02	7.08E-02
	Molybdenum	5.61E-05	8.58E-08	3.93E-08	8.40E-08	3.85E-08	0.00E+00	3.94E-07	1.85E-03	8.62E-02	8.81E-02
	Selenium	8.34E-05	3.93E-07	1.80E-07	7.61E-07	3.48E-07	0.00E+00	2.94E-02	7.70E-03	2.89E-01	3.26E-01
	Uranium	7.37E-04	1.33E-05	6.10E-05	6.72E-06	3.08E-05	0.00E+00	1.03E-03	4.55E-02	5.86E-02	1.06E-01
	Vanadium	1.02E-03	4.80E-05	2.20E-04	3.72E-05	1.70E-04	0.00E+00	6.81E-03	3.43E-03	1.72E-01	1.83E-01
	Zinc	1.76E-05	1.95E-07	8.92E-07	1.22E-07	5.56E-07	0.00E+00	2.46E-03	1.88E-02	2.34E-01	2.55E-01
		Project Total HQ - Future Centuries									
	Cadmium	4.28E-04	9.44E-06	4.32E-06	2.96E-06	1.36E-06	0.00E+00	8.99E-05	8.78E-03	2.48E-01	2.57E-01
	Chromium	5.16E-06	4.62E-08	2.11E-07	2.76E-08	1.26E-07	0.00E+00	1.98E-05	7.43E-06	2.03E-05	5.32E-05
	Cobalt	1.56E-04	5.56E-07	2.54E-07	1.85E-07	8.47E-08	0.00E+00	1.32E-04	6.30E-03	1.77E-02	2.43E-02
	Copper	2.16E-05	7.16E-08	1.97E-07	3.06E-08	8.42E-08	0.00E+00	7.59E-04	1.03E-02	5.98E-02	7.09E-02
	Molybdenum	6.12E-05	8.58E-08	3.93E-08	9.16E-08	4.19E-08	0.00E+00	4.29E-07	1.85E-03	8.62E-02	8.81E-02
	Selenium	1.11E-04	3.93E-07	1.80E-07	1.01E-06	4.64E-07	0.00E+00	3.82E-02	7.70E-03	2.91E-01	3.37E-01
	Uranium	9.01E-04	1.59E-05	7.27E-05	8.22E-06	3.76E-05	0.00E+00	1.26E-03	6.15E-02	5.88E-02	1.23E-01
	Vanadium	1.03E-03	4.80E-05	2.20E-04	3.76E-05	1.72E-04	0.00E+00	6.87E-03	3.43E-03	1.72E-01	1.83E-01
	Zinc	1.91E-05	1.95E-07	8.93E-07	1.32E-07	6.04E-07	0.00E+00	2.67E-03	1.88E-02	2.34E-01	2.55E-01
		Project Incremental HQ - Future Centuries									
	Cadmium	2.47E-06	1.57E-10	7.19E-11	1.71E-08	7.81E-09	0.00E+00	5.17E-07	2.86E-07	5.25E-06	8.54E-06
	Chromium	6.59E-08	0.00E+00	0.00E+00	3.53E-10	1.62E-09	0.00E+00	2.54E-07	0.00E+00	1.05E-07	4.27E-07
	Cobalt	7.89E-06	5.50E-10	2.52E-10	9.33E-09	4.27E-09	0.00E+00	6.64E-06	1.29E-05	1.80E-05	4.55E-05
	Copper	2.84E-07	4.03E-11	1.11E-10	4.02E-10	1.10E-09	0.00E+00	9.94E-06	1.09E-05	7.76E-06	2.89E-05
	Molybdenum	5.07E-06	0.00E+00	0.00E+00	7.59E-09	3.48E-09	0.00E+00	3.56E-08	0.00E+00	1.66E-06	6.78E-06

Human Receptor	COPC	HQ during Future Centuries									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Selenium	2.77E-05	4.12E-12	1.89E-12	2.53E-07	1.16E-07	0.00E+00	8.71E-03	1.69E-07	1.31E-03	1.00E-02
	Uranium	1.64E-04	2.56E-06	1.17E-05	1.50E-06	6.87E-06	0.00E+00	2.30E-04	1.60E-02	1.72E-04	1.66E-02
	Vanadium	9.19E-06	4.00E-09	1.83E-08	3.35E-07	1.54E-06	0.00E+00	6.14E-05	3.08E-07	5.90E-05	1.32E-04
	Zinc	1.52E-06	1.86E-11	8.53E-11	1.05E-08	4.82E-08	0.00E+00	2.13E-04	3.19E-06	9.73E-05	3.15E-04
Permanent Resident One-year-old (Whitefish Lake)		Baseline HQ									
	Cadmium	4.76E-04	6.17E-04	7.39E-06	1.93E-04	2.31E-06	0.00E+00	8.46E-05	1.97E-02	6.29E-01	6.50E-01
	Chromium	5.68E-06	3.02E-06	3.62E-07	1.78E-06	2.13E-07	0.00E+00	1.86E-05	1.72E-05	1.17E-05	5.85E-05
	Cobalt	1.66E-04	3.63E-05	4.35E-07	1.15E-05	1.38E-07	0.00E+00	1.18E-04	1.46E-02	3.78E-02	5.27E-02
	Copper	2.38E-05	4.67E-06	3.36E-07	1.98E-06	1.42E-07	0.00E+00	7.09E-04	2.37E-02	1.01E-01	1.25E-01
	Molybdenum	7.63E-05	6.83E-06	8.18E-08	6.68E-06	8.01E-08	0.00E+00	4.54E-07	5.20E-03	2.73E-01	2.79E-01
	Selenium	9.65E-05	2.66E-05	3.19E-07	5.15E-05	6.17E-07	0.00E+00	2.89E-02	1.87E-02	7.51E-01	7.99E-01
	Uranium	8.23E-04	8.71E-04	1.04E-04	4.39E-04	5.26E-05	0.00E+00	9.75E-04	1.04E-01	1.52E-01	2.59E-01
	Vanadium	1.14E-03	3.13E-03	3.76E-04	2.43E-03	2.92E-04	0.00E+00	6.45E-03	6.21E-03	4.18E-01	4.38E-01
	Zinc	2.28E-05	1.48E-05	1.78E-06	9.24E-06	1.11E-06	0.00E+00	2.71E-03	5.01E-02	5.63E-01	6.16E-01
		Project Total HQ - Future Centuries									
	Cadmium	4.78E-04	6.17E-04	7.39E-06	1.94E-04	2.32E-06	0.00E+00	8.51E-05	1.97E-02	6.29E-01	6.50E-01
	Chromium	5.76E-06	3.02E-06	3.62E-07	1.80E-06	2.16E-07	0.00E+00	1.88E-05	1.72E-05	1.18E-05	5.90E-05
	Cobalt	1.75E-04	3.63E-05	4.35E-07	1.21E-05	1.45E-07	0.00E+00	1.25E-04	1.46E-02	3.78E-02	5.27E-02
	Copper	2.42E-05	4.68E-06	3.36E-07	2.00E-06	1.44E-07	0.00E+00	7.18E-04	2.38E-02	1.01E-01	1.25E-01
	Molybdenum	8.32E-05	6.83E-06	8.18E-08	7.29E-06	8.73E-08	0.00E+00	4.95E-07	5.20E-03	2.73E-01	2.79E-01
	Selenium	1.29E-04	2.66E-05	3.19E-07	6.86E-05	8.22E-07	0.00E+00	3.74E-02	1.87E-02	7.52E-01	8.08E-01
	Uranium	1.01E-03	1.04E-03	1.24E-04	5.37E-04	6.44E-05	0.00E+00	1.19E-03	1.42E-01	1.52E-01	2.98E-01
	Vanadium	1.15E-03	3.13E-03	3.76E-04	2.45E-03	2.94E-04	0.00E+00	6.51E-03	6.21E-03	4.18E-01	4.38E-01
	Zinc	2.48E-05	1.48E-05	1.78E-06	1.00E-05	1.20E-06	0.00E+00	2.94E-03	5.01E-02	5.63E-01	6.17E-01
		Project Incremental HQ - Future Centuries									
	Cadmium	2.75E-06	1.03E-08	1.23E-10	1.12E-06	1.34E-08	0.00E+00	4.90E-07	6.48E-07	3.64E-06	8.67E-06
	Chromium	7.36E-08	0.00E+00	0.00E+00	2.31E-08	2.76E-09	0.00E+00	2.40E-07	0.00E+00	6.99E-08	4.10E-07
	Cobalt	8.81E-06	3.59E-08	4.30E-10	6.10E-07	7.31E-09	0.00E+00	6.29E-06	3.03E-05	1.06E-05	5.67E-05

Human Receptor	COPC	HQ during Future Centuries									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Copper	3.17E-07	2.63E-09	1.89E-10	2.62E-08	1.89E-09	0.00E+00	9.42E-06	2.56E-05	4.80E-06	4.02E-05
	Molybdenum	6.90E-06	0.00E+00	0.00E+00	6.04E-07	7.24E-09	0.00E+00	4.10E-08	0.00E+00	1.16E-06	8.71E-06
	Selenium	3.21E-05	2.78E-10	3.33E-12	1.71E-05	2.05E-07	0.00E+00	8.55E-03	4.10E-07	8.92E-04	9.49E-03
	Uranium	1.84E-04	1.67E-04	2.00E-05	9.80E-05	1.17E-05	0.00E+00	2.18E-04	3.77E-02	1.20E-04	3.85E-02
	Vanadium	1.03E-05	2.61E-07	3.13E-08	2.19E-05	2.63E-06	0.00E+00	5.81E-05	7.25E-07	3.29E-05	1.27E-04
	Zinc	1.97E-06	1.42E-09	1.70E-10	8.00E-07	9.58E-08	0.00E+00	2.34E-04	8.70E-06	5.74E-05	3.03E-04
Rec F/H Adult (McGowan Lake)		Baseline HQ									
	Cadmium	4.26E-04	9.44E-06	4.32E-06	2.95E-06	1.35E-06	0.00E+00	8.94E-05	8.78E-03	2.48E-01	2.57E-01
	Chromium	5.09E-06	4.62E-08	2.11E-07	2.73E-08	1.25E-07	0.00E+00	1.96E-05	7.43E-06	2.02E-05	5.27E-05
	Cobalt	1.49E-04	5.55E-07	2.54E-07	1.76E-07	8.04E-08	0.00E+00	1.25E-04	6.29E-03	1.77E-02	2.42E-02
	Copper	2.13E-05	7.15E-08	1.96E-07	3.02E-08	8.31E-08	0.00E+00	7.49E-04	1.03E-02	5.98E-02	7.08E-02
	Molybdenum	5.61E-05	8.58E-08	3.93E-08	8.40E-08	3.85E-08	0.00E+00	3.94E-07	1.85E-03	8.62E-02	8.81E-02
	Selenium	8.34E-05	3.93E-07	1.80E-07	7.61E-07	3.48E-07	0.00E+00	2.94E-02	7.70E-03	2.89E-01	3.26E-01
	Uranium	7.37E-04	1.33E-05	6.10E-05	6.72E-06	3.08E-05	0.00E+00	1.03E-03	4.55E-02	5.86E-02	1.06E-01
	Vanadium	1.02E-03	4.80E-05	2.20E-04	3.72E-05	1.70E-04	0.00E+00	6.81E-03	3.43E-03	1.72E-01	1.83E-01
	Zinc	1.76E-05	1.95E-07	8.92E-07	1.22E-07	5.56E-07	0.00E+00	2.46E-03	1.88E-02	2.34E-01	2.55E-01
		Project Total HQ - Future Centuries									
	Cadmium	4.26E-04	9.44E-06	4.32E-06	2.95E-06	1.35E-06	0.00E+00	8.97E-05	8.78E-03	2.48E-01	2.57E-01
	Chromium	5.10E-06	4.62E-08	2.11E-07	2.73E-08	1.25E-07	0.00E+00	1.98E-05	7.43E-06	2.03E-05	5.30E-05
	Cobalt	1.50E-04	5.55E-07	2.54E-07	1.78E-07	8.13E-08	0.00E+00	1.30E-04	6.29E-03	1.77E-02	2.42E-02
	Copper	2.14E-05	7.15E-08	1.96E-07	3.03E-08	8.33E-08	0.00E+00	7.56E-04	1.03E-02	5.98E-02	7.09E-02
	Molybdenum	5.73E-05	8.58E-08	3.93E-08	8.57E-08	3.92E-08	0.00E+00	4.20E-07	1.85E-03	8.62E-02	8.81E-02
	Selenium	8.89E-05	3.93E-07	1.80E-07	8.11E-07	3.71E-07	0.00E+00	3.53E-02	7.70E-03	2.90E-01	3.33E-01
	Uranium	7.70E-04	1.35E-05	6.19E-05	7.02E-06	3.21E-05	0.00E+00	1.18E-03	4.76E-02	5.87E-02	1.08E-01
	Vanadium	1.02E-03	4.80E-05	2.20E-04	3.73E-05	1.71E-04	0.00E+00	6.84E-03	3.43E-03	1.72E-01	1.83E-01
	Zinc	1.79E-05	1.95E-07	8.92E-07	1.24E-07	5.66E-07	0.00E+00	2.60E-03	1.88E-02	2.34E-01	2.55E-01
		Project Incremental HQ - Future Centuries									
	Cadmium	5.08E-07	1.09E-11	5.00E-12	3.52E-09	1.61E-09	0.00E+00	3.55E-07	3.17E-08	3.80E-06	4.70E-06

Human Receptor	COPC	HQ during Future Centuries									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Chromium	1.39E-08	0.00E+00	0.00E+00	7.45E-11	3.41E-10	0.00E+00	1.78E-07	0.00E+00	7.72E-08	2.70E-07
	Cobalt	1.77E-06	3.81E-11	1.75E-11	2.10E-09	9.61E-10	0.00E+00	4.98E-06	1.40E-06	1.68E-05	2.49E-05
	Copper	6.35E-08	2.81E-12	7.72E-12	9.00E-11	2.47E-10	0.00E+00	7.43E-06	1.18E-06	6.22E-06	1.49E-05
	Molybdenum	1.14E-06	0.00E+00	0.00E+00	1.70E-09	7.78E-10	0.00E+00	2.66E-08	0.00E+00	1.53E-06	2.70E-06
	Selenium	5.52E-06	2.84E-13	1.28E-13	5.03E-08	2.30E-08	0.00E+00	5.81E-03	1.82E-08	9.02E-04	6.72E-03
	Uranium	3.28E-05	1.94E-07	8.90E-07	2.99E-07	1.37E-06	0.00E+00	1.53E-04	2.09E-03	7.56E-05	2.36E-03
	Vanadium	1.21E-06	2.80E-10	1.27E-09	4.42E-08	2.02E-07	0.00E+00	2.70E-05	3.35E-08	2.73E-05	5.57E-05
	Zinc	3.13E-07	1.29E-12	5.97E-12	2.17E-09	9.92E-09	0.00E+00	1.46E-04	3.45E-07	6.69E-05	2.14E-04
Rec F/H One-year-old (McGowan Lake)		Baseline HQ									
	Cadmium	4.76E-04	6.17E-04	7.39E-06	1.93E-04	2.31E-06	0.00E+00	8.46E-05	1.97E-02	6.29E-01	6.50E-01
	Chromium	5.68E-06	3.02E-06	3.62E-07	1.78E-06	2.13E-07	0.00E+00	1.86E-05	1.72E-05	1.18E-05	5.85E-05
	Cobalt	1.66E-04	3.63E-05	4.35E-07	1.15E-05	1.38E-07	0.00E+00	1.18E-04	1.46E-02	3.78E-02	5.27E-02
	Copper	2.38E-05	4.67E-06	3.36E-07	1.98E-06	1.42E-07	0.00E+00	7.09E-04	2.37E-02	1.01E-01	1.25E-01
	Molybdenum	7.63E-05	6.83E-06	8.18E-08	6.68E-06	8.01E-08	0.00E+00	4.54E-07	5.20E-03	2.73E-01	2.79E-01
	Selenium	9.65E-05	2.66E-05	3.19E-07	5.15E-05	6.17E-07	0.00E+00	2.89E-02	1.87E-02	7.51E-01	7.99E-01
	Uranium	8.23E-04	8.71E-04	1.04E-04	4.39E-04	5.26E-05	0.00E+00	9.75E-04	1.04E-01	1.52E-01	2.59E-01
	Vanadium	1.14E-03	3.13E-03	3.76E-04	2.43E-03	2.92E-04	0.00E+00	6.45E-03	6.21E-03	4.18E-01	4.38E-01
	Zinc	2.28E-05	1.48E-05	1.78E-06	9.24E-06	1.11E-06	0.00E+00	2.71E-03	5.01E-02	5.63E-01	6.16E-01
		Project Total HQ - Future Centuries									
	Cadmium	4.76E-04	6.17E-04	7.39E-06	1.93E-04	2.31E-06	0.00E+00	8.50E-05	1.97E-02	6.29E-01	6.50E-01
	Chromium	5.70E-06	3.02E-06	3.62E-07	1.79E-06	2.14E-07	0.00E+00	1.87E-05	1.72E-05	1.18E-05	5.88E-05
	Cobalt	1.68E-04	3.63E-05	4.35E-07	1.16E-05	1.39E-07	0.00E+00	1.23E-04	1.46E-02	3.78E-02	5.27E-02
	Copper	2.39E-05	4.67E-06	3.36E-07	1.98E-06	1.43E-07	0.00E+00	7.16E-04	2.37E-02	1.01E-01	1.25E-01
	Molybdenum	7.78E-05	6.83E-06	8.18E-08	6.82E-06	8.17E-08	0.00E+00	4.84E-07	5.20E-03	2.73E-01	2.79E-01
	Selenium	1.03E-04	2.66E-05	3.19E-07	5.49E-05	6.58E-07	0.00E+00	3.46E-02	1.87E-02	7.51E-01	8.05E-01
	Uranium	8.59E-04	8.84E-04	1.06E-04	4.59E-04	5.50E-05	0.00E+00	1.12E-03	1.09E-01	1.52E-01	2.64E-01
	Vanadium	1.14E-03	3.13E-03	3.76E-04	2.44E-03	2.92E-04	0.00E+00	6.48E-03	6.21E-03	4.18E-01	4.38E-01
	Zinc	2.32E-05	1.48E-05	1.78E-06	9.40E-06	1.13E-06	0.00E+00	2.87E-03	5.01E-02	5.63E-01	6.16E-01

Human Receptor	COPC	HQ during Future Centuries									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
		Project Incremental HQ - Future Centuries									
	Cadmium	5.67E-07	7.57E-10	8.64E-12	2.30E-07	2.75E-09	0.00E+00	3.37E-07	7.08E-08	2.68E-06	3.89E-06
	Chromium	1.55E-08	0.00E+00	0.00E+00	4.87E-09	5.83E-10	0.00E+00	1.69E-07	0.00E+00	5.12E-08	2.41E-07
	Cobalt	1.98E-06	2.49E-09	2.99E-11	1.37E-07	1.64E-09	0.00E+00	4.72E-06	3.29E-06	9.69E-06	1.98E-05
	Copper	7.09E-08	1.83E-10	1.32E-11	5.88E-09	4.23E-10	0.00E+00	7.03E-06	2.77E-06	3.81E-06	1.37E-05
	Molybdenum	1.54E-06	0.00E+00	0.00E+00	1.35E-07	1.62E-09	0.00E+00	3.06E-08	0.00E+00	1.07E-06	2.78E-06
	Selenium	6.39E-06	1.82E-11	2.27E-13	3.41E-06	4.09E-08	0.00E+00	5.70E-03	4.28E-08	6.10E-04	6.32E-03
	Uranium	3.66E-05	1.27E-05	1.52E-06	1.95E-05	2.34E-06	0.00E+00	1.45E-04	4.91E-03	5.50E-05	5.19E-03
	Vanadium	1.35E-06	1.82E-08	2.18E-09	2.89E-06	3.46E-07	0.00E+00	2.55E-05	7.87E-08	1.52E-05	4.54E-05
	Zinc	4.07E-07	9.91E-11	1.18E-11	1.65E-07	1.97E-08	0.00E+00	1.61E-04	9.42E-07	3.95E-05	2.02E-04
Rec F/H Adult (Russell Lake)		**Baseline HQ**									
	Cadmium	4.26E-04	9.44E-06	4.32E-06	2.95E-06	1.35E-06	0.00E+00	8.94E-05	8.78E-03	2.48E-01	2.57E-01
	Chromium	5.09E-06	4.62E-08	2.11E-07	2.73E-08	1.25E-07	0.00E+00	1.96E-05	7.43E-06	2.02E-05	5.27E-05
	Cobalt	1.49E-04	5.55E-07	2.54E-07	1.76E-07	8.04E-08	0.00E+00	1.25E-04	6.29E-03	1.77E-02	2.42E-02
	Copper	2.13E-05	7.15E-08	1.96E-07	3.02E-08	8.31E-08	0.00E+00	7.49E-04	1.03E-02	5.98E-02	7.08E-02
	Molybdenum	5.61E-05	8.58E-08	3.93E-08	8.40E-08	3.85E-08	0.00E+00	3.94E-07	1.85E-03	8.62E-02	8.81E-02
	Selenium	8.34E-05	3.93E-07	1.80E-07	7.61E-07	3.48E-07	0.00E+00	2.94E-02	7.70E-03	2.89E-01	3.26E-01
	Uranium	7.37E-04	1.33E-05	6.10E-05	6.72E-06	3.08E-05	0.00E+00	1.03E-03	4.55E-02	5.86E-02	1.06E-01
	Vanadium	1.02E-03	4.80E-05	2.20E-04	3.72E-05	1.70E-04	0.00E+00	6.81E-03	3.43E-03	1.72E-01	1.83E-01
	Zinc	1.76E-05	1.95E-07	8.92E-07	1.22E-07	5.56E-07	0.00E+00	2.46E-03	1.88E-02	2.34E-01	2.55E-01
		Project Total HQ - Future Centuries									
	Cadmium	4.26E-04	9.44E-06	4.32E-06	2.95E-06	1.35E-06	0.00E+00	8.96E-05	8.78E-03	2.48E-01	2.57E-01
	Chromium	5.10E-06	4.62E-08	2.11E-07	2.73E-08	1.25E-07	0.00E+00	1.97E-05	7.43E-06	2.03E-05	5.29E-05
	Cobalt	1.50E-04	5.55E-07	2.54E-07	1.77E-07	8.11E-08	0.00E+00	1.29E-04	6.29E-03	1.77E-02	2.42E-02
	Copper	2.14E-05	7.15E-08	1.96E-07	3.03E-08	8.32E-08	0.00E+00	7.54E-04	1.03E-02	5.98E-02	7.09E-02
	Molybdenum	5.70E-05	8.58E-08	3.93E-08	8.53E-08	3.90E-08	0.00E+00	4.14E-07	1.85E-03	8.62E-02	8.81E-02
	Selenium	8.75E-05	3.93E-07	1.80E-07	7.98E-07	3.65E-07	0.00E+00	3.37E-02	7.70E-03	2.90E-01	3.31E-01
	Uranium	7.61E-04	1.34E-05	6.12E-05	6.94E-06	3.18E-05	0.00E+00	1.14E-03	4.61E-02	5.87E-02	1.07E-01

Human Receptor	COPC	HQ during Future Centuries									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Vanadium	1.02E-03	4.80E-05	2.20E-04	3.73E-05	1.71E-04	0.00E+00	6.83E-03	3.43E-03	1.72E-01	1.83E-01
	Zinc	1.78E-05	1.95E-07	8.92E-07	1.23E-07	5.64E-07	0.00E+00	2.57E-03	1.88E-02	2.34E-01	2.55E-01
		Project Incremental HQ - Future Centuries									
	Cadmium	3.77E-07	2.73E-12	9.09E-13	2.61E-09	1.19E-09	0.00E+00	2.64E-07	8.38E-09	2.85E-06	3.50E-06
	Chromium	1.04E-08	0.00E+00	0.00E+00	5.57E-11	2.55E-10	0.00E+00	1.33E-07	0.00E+00	5.85E-08	2.03E-07
	Cobalt	1.35E-06	9.78E-12	4.46E-12	1.60E-09	7.32E-10	0.00E+00	3.80E-06	3.59E-07	1.26E-05	1.81E-05
	Copper	4.84E-08	7.18E-13	1.99E-12	6.85E-11	1.88E-10	0.00E+00	5.66E-06	3.04E-07	4.08E-06	1.01E-05
	Molybdenum	8.64E-07	0.00E+00	0.00E+00	1.29E-09	5.92E-10	0.00E+00	2.02E-08	0.00E+00	1.17E-06	2.06E-06
	Selenium	4.05E-06	8.53E-14	2.84E-14	3.70E-08	1.69E-08	0.00E+00	4.28E-03	4.66E-09	6.71E-04	4.95E-03
	Uranium	2.41E-05	5.19E-08	2.37E-07	2.20E-07	1.00E-06	0.00E+00	1.12E-04	5.58E-04	5.06E-05	7.46E-04
	Vanadium	7.74E-07	7.28E-11	3.20E-10	2.83E-08	1.29E-07	0.00E+00	1.72E-05	8.61E-09	1.82E-05	3.64E-05
	Zinc	2.32E-07	3.27E-13	1.53E-12	1.61E-09	7.36E-09	0.00E+00	1.08E-04	8.75E-08	5.07E-05	1.59E-04
Rec F/H One-year-old (Russell Lake)		Baseline HQ									
	Cadmium	4.76E-04	6.17E-04	7.39E-06	1.93E-04	2.31E-06	0.00E+00	8.46E-05	1.97E-02	6.29E-01	6.50E-01
	Chromium	5.68E-06	3.02E-06	3.62E-07	1.78E-06	2.13E-07	0.00E+00	1.86E-05	1.72E-05	1.17E-05	5.85E-05
	Cobalt	1.66E-04	3.63E-05	4.35E-07	1.15E-05	1.38E-07	0.00E+00	1.18E-04	1.46E-02	3.78E-02	5.27E-02
	Copper	2.38E-05	4.67E-06	3.36E-07	1.98E-06	1.42E-07	0.00E+00	7.09E-04	2.37E-02	1.01E-01	1.25E-01
	Molybdenum	7.63E-05	6.83E-06	8.18E-08	6.68E-06	8.01E-08	0.00E+00	4.54E-07	5.20E-03	2.73E-01	2.79E-01
	Selenium	9.65E-05	2.66E-05	3.19E-07	5.15E-05	6.17E-07	0.00E+00	2.89E-02	1.87E-02	7.51E-01	7.99E-01
	Uranium	8.23E-04	8.71E-04	1.04E-04	4.39E-04	5.26E-05	0.00E+00	9.75E-04	1.04E-01	1.52E-01	2.59E-01
	Vanadium	1.14E-03	3.13E-03	3.76E-04	2.43E-03	2.92E-04	0.00E+00	6.45E-03	6.21E-03	4.18E-01	4.38E-01
	Zinc	2.28E-05	1.48E-05	1.78E-06	9.24E-06	1.11E-06	0.00E+00	2.71E-03	5.01E-02	5.63E-01	6.16E-01
		Project Total HQ - Future Centuries									
	Cadmium	4.76E-04	6.17E-04	7.39E-06	1.93E-04	2.31E-06	0.00E+00	8.49E-05	1.97E-02	6.29E-01	6.50E-01
	Chromium	5.69E-06	3.02E-06	3.62E-07	1.78E-06	2.14E-07	0.00E+00	1.87E-05	1.72E-05	1.18E-05	5.87E-05
	Cobalt	1.67E-04	3.63E-05	4.35E-07	1.16E-05	1.39E-07	0.00E+00	1.22E-04	1.46E-02	3.78E-02	5.27E-02
	Copper	2.39E-05	4.67E-06	3.36E-07	1.98E-06	1.42E-07	0.00E+00	7.14E-04	2.37E-02	1.01E-01	1.25E-01
	Molybdenum	7.75E-05	6.83E-06	8.18E-08	6.79E-06	8.13E-08	0.00E+00	4.77E-07	5.20E-03	2.73E-01	2.79E-01

Human Receptor	COPC	HQ during Future Centuries									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Selenium	1.01E-04	2.66E-05	3.19E-07	5.40E-05	6.47E-07	0.00E+00	3.31E-02	1.87E-02	7.51E-01	8.03E-01
	Uranium	8.50E-04	8.74E-04	1.05E-04	4.53E-04	5.43E-05	0.00E+00	1.08E-03	1.05E-01	1.52E-01	2.61E-01
	Vanadium	1.14E-03	3.13E-03	3.76E-04	2.43E-03	2.92E-04	0.00E+00	6.47E-03	6.21E-03	4.18E-01	4.38E-01
	Zinc	2.31E-05	1.48E-05	1.78E-06	9.36E-06	1.12E-06	0.00E+00	2.83E-03	5.01E-02	5.63E-01	6.16E-01
		Project Incremental HQ - Future Centuries									
	Cadmium	4.21E-07	1.75E-10	2.27E-12	1.71E-07	2.04E-09	0.00E+00	2.50E-07	1.86E-08	2.03E-06	2.89E-06
	Chromium	1.16E-08	0.00E+00	0.00E+00	3.64E-09	4.36E-10	0.00E+00	1.26E-07	0.00E+00	3.87E-08	1.81E-07
	Cobalt	1.51E-06	6.37E-10	7.67E-12	1.05E-07	1.25E-09	0.00E+00	3.60E-06	8.43E-07	7.26E-06	1.33E-05
	Copper	5.40E-08	4.68E-11	3.38E-12	4.48E-09	3.22E-10	0.00E+00	5.36E-06	7.13E-07	2.56E-06	8.69E-06
	Molybdenum	1.18E-06	0.00E+00	0.00E+00	1.03E-07	1.23E-09	0.00E+00	2.33E-08	0.00E+00	8.05E-07	2.11E-06
	Selenium	4.69E-06	3.64E-12	5.68E-14	2.50E-06	3.00E-08	0.00E+00	4.20E-03	1.12E-08	4.52E-04	4.66E-03
	Uranium	2.69E-05	3.39E-06	4.06E-07	1.43E-05	1.72E-06	0.00E+00	1.06E-04	1.31E-03	3.75E-05	1.50E-03
	Vanadium	8.65E-07	4.66E-09	5.53E-10	1.85E-06	2.21E-07	0.00E+00	1.63E-05	2.05E-08	1.01E-05	2.94E-05
	Zinc	3.02E-07	2.55E-11	2.96E-12	1.22E-07	1.47E-08	0.00E+00	1.19E-04	2.38E-07	2.99E-05	1.50E-04
Seasonal Resident Adult (Russell Lake)		**Baseline HQ**									
	Cadmium	4.26E-04	9.44E-06	4.32E-06	2.95E-06	1.35E-06	0.00E+00	8.94E-05	8.78E-03	2.48E-01	2.57E-01
	Chromium	5.09E-06	4.62E-08	2.11E-07	2.73E-08	1.25E-07	0.00E+00	1.96E-05	7.43E-06	2.02E-05	5.27E-05
	Cobalt	1.49E-04	5.55E-07	2.54E-07	1.76E-07	8.04E-08	0.00E+00	1.25E-04	6.29E-03	1.77E-02	2.42E-02
	Copper	2.13E-05	7.15E-08	1.96E-07	3.02E-08	8.31E-08	0.00E+00	7.49E-04	1.03E-02	5.98E-02	7.08E-02
	Molybdenum	5.61E-05	8.58E-08	3.93E-08	8.40E-08	3.85E-08	0.00E+00	3.94E-07	1.85E-03	8.62E-02	8.81E-02
	Selenium	8.34E-05	3.93E-07	1.80E-07	7.61E-07	3.48E-07	0.00E+00	2.94E-02	7.70E-03	2.89E-01	3.26E-01
	Uranium	7.37E-04	1.33E-05	6.10E-05	6.72E-06	3.08E-05	0.00E+00	1.03E-03	4.55E-02	5.86E-02	1.06E-01
	Vanadium	1.02E-03	4.80E-05	2.20E-04	3.72E-05	1.70E-04	0.00E+00	6.81E-03	3.43E-03	1.72E-01	1.83E-01
	Zinc	1.76E-05	1.95E-07	8.92E-07	1.22E-07	5.56E-07	0.00E+00	2.46E-03	1.88E-02	2.34E-01	2.55E-01
		Project Total HQ - Future Centuries									
	Cadmium	4.26E-04	9.44E-06	4.32E-06	2.95E-06	1.35E-06	0.00E+00	8.94E-05	8.78E-03	2.48E-01	2.57E-01
	Chromium	5.10E-06	4.62E-08	2.11E-07	2.73E-08	1.25E-07	0.00E+00	1.96E-05	7.43E-06	2.02E-05	5.28E-05
	Cobalt	1.50E-04	5.55E-07	2.54E-07	1.77E-07	8.11E-08	0.00E+00	1.26E-04	6.29E-03	1.77E-02	2.42E-02

Human Receptor	COPC	HQ during Future Centuries									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Copper	2.14E-05	7.15E-08	1.96E-07	3.03E-08	8.32E-08	0.00E+00	7.50E-04	1.03E-02	5.98E-02	7.08E-02
	Molybdenum	5.70E-05	8.58E-08	3.93E-08	8.53E-08	3.90E-08	0.00E+00	4.00E-07	1.85E-03	8.62E-02	8.81E-02
	Selenium	8.75E-05	3.93E-07	1.80E-07	7.98E-07	3.65E-07	0.00E+00	3.07E-02	7.70E-03	2.89E-01	3.28E-01
	Uranium	7.61E-04	1.34E-05	6.12E-05	6.94E-06	3.18E-05	0.00E+00	1.06E-03	4.57E-02	5.87E-02	1.06E-01
	Vanadium	1.02E-03	4.80E-05	2.20E-04	3.73E-05	1.71E-04	0.00E+00	6.82E-03	3.43E-03	1.72E-01	1.83E-01
	Zinc	1.78E-05	1.95E-07	8.92E-07	1.23E-07	5.64E-07	0.00E+00	2.49E-03	1.88E-02	2.34E-01	2.55E-01
		Project Incremental HQ - Future Centuries									
	Cadmium	3.77E-07	2.73E-12	9.09E-13	2.61E-09	1.19E-09	0.00E+00	7.91E-08	2.79E-09	9.09E-07	1.37E-06
	Chromium	1.04E-08	0.00E+00	0.00E+00	5.57E-11	2.55E-10	0.00E+00	4.00E-08	0.00E+00	1.90E-08	6.98E-08
	Cobalt	1.35E-06	9.78E-12	4.46E-12	1.60E-09	7.32E-10	0.00E+00	1.14E-06	1.08E-07	3.73E-06	6.33E-06
	Copper	4.84E-08	7.18E-13	1.99E-12	6.85E-11	1.88E-10	0.00E+00	1.70E-06	9.13E-08	1.23E-06	3.07E-06
	Molybdenum	8.64E-07	0.00E+00	0.00E+00	1.29E-09	5.92E-10	0.00E+00	6.06E-09	0.00E+00	3.50E-07	1.22E-06
	Selenium	4.05E-06	8.53E-14	2.84E-14	3.70E-08	1.69E-08	0.00E+00	1.28E-03	1.40E-09	2.14E-04	1.50E-03
	Uranium	2.41E-05	5.19E-08	2.37E-07	2.20E-07	1.00E-06	0.00E+00	3.36E-05	1.67E-04	1.57E-05	2.42E-04
	Vanadium	7.74E-07	7.28E-11	3.20E-10	2.83E-08	1.29E-07	0.00E+00	5.17E-06	2.56E-09	6.32E-06	1.24E-05
	Zinc	2.32E-07	3.27E-13	1.53E-12	1.61E-09	7.36E-09	0.00E+00	3.25E-05	2.61E-08	1.69E-05	4.97E-05
Seasonal Resident One-year-old (Russell Lake)		Baseline HQ									
	Cadmium	4.76E-04	6.17E-04	7.39E-06	1.93E-04	2.31E-06	0.00E+00	8.46E-05	1.97E-02	6.29E-01	6.50E-01
	Chromium	5.68E-06	3.02E-06	3.62E-07	1.78E-06	2.13E-07	0.00E+00	1.86E-05	1.72E-05	1.17E-05	5.85E-05
	Cobalt	1.66E-04	3.63E-05	4.35E-07	1.15E-05	1.38E-07	0.00E+00	1.18E-04	1.46E-02	3.78E-02	5.27E-02
	Copper	2.38E-05	4.67E-06	3.36E-07	1.98E-06	1.42E-07	0.00E+00	7.09E-04	2.37E-02	1.01E-01	1.25E-01
	Molybdenum	7.63E-05	6.83E-06	8.18E-08	6.68E-06	8.01E-08	0.00E+00	4.54E-07	5.20E-03	2.73E-01	2.79E-01
	Selenium	9.65E-05	2.66E-05	3.19E-07	5.15E-05	6.17E-07	0.00E+00	2.89E-02	1.87E-02	7.51E-01	7.99E-01
	Uranium	8.23E-04	8.71E-04	1.04E-04	4.39E-04	5.26E-05	0.00E+00	9.75E-04	1.04E-01	1.52E-01	2.59E-01
	Vanadium	1.14E-03	3.13E-03	3.76E-04	2.43E-03	2.92E-04	0.00E+00	6.45E-03	6.21E-03	4.18E-01	4.38E-01
	Zinc	2.28E-05	1.48E-05	1.78E-06	9.24E-06	1.11E-06	0.00E+00	2.71E-03	5.01E-02	5.63E-01	6.16E-01
		Project Total HQ - Future Centuries									
	Cadmium	4.76E-04	6.17E-04	7.39E-06	1.93E-04	2.31E-06	0.00E+00	8.47E-05	1.97E-02	6.29E-01	6.50E-01

Human Receptor	COPC	HQ during Future Centuries									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
	Chromium	5.69E-06	3.02E-06	3.62E-07	1.78E-06	2.14E-07	0.00E+00	1.86E-05	1.72E-05	1.18E-05	5.86E-05
	Cobalt	1.67E-04	3.63E-05	4.35E-07	1.16E-05	1.39E-07	0.00E+00	1.19E-04	1.46E-02	3.78E-02	5.27E-02
	Copper	2.39E-05	4.67E-06	3.36E-07	1.98E-06	1.42E-07	0.00E+00	7.11E-04	2.37E-02	1.01E-01	1.25E-01
	Molybdenum	7.75E-05	6.83E-06	8.18E-08	6.79E-06	8.13E-08	0.00E+00	4.61E-07	5.20E-03	2.73E-01	2.79E-01
	Selenium	1.01E-04	2.66E-05	3.19E-07	5.40E-05	6.47E-07	0.00E+00	3.02E-02	1.87E-02	7.51E-01	8.00E-01
	Uranium	8.50E-04	8.74E-04	1.05E-04	4.53E-04	5.43E-05	0.00E+00	1.01E-03	1.05E-01	1.52E-01	2.60E-01
	Vanadium	1.14E-03	3.13E-03	3.76E-04	2.43E-03	2.92E-04	0.00E+00	6.46E-03	6.21E-03	4.18E-01	4.38E-01
	Zinc	2.31E-05	1.48E-05	1.78E-06	9.36E-06	1.12E-06	0.00E+00	2.74E-03	5.01E-02	5.63E-01	6.16E-01
		Project Incremental HQ - Future Centuries									
	Cadmium	4.21E-07	1.75E-10	2.27E-12	1.71E-07	2.04E-09	0.00E+00	7.49E-08	5.59E-09	5.96E-07	1.27E-06
	Chromium	1.16E-08	0.00E+00	0.00E+00	3.64E-09	4.36E-10	0.00E+00	3.79E-08	0.00E+00	1.21E-08	6.57E-08
	Cobalt	1.51E-06	6.37E-10	7.67E-12	1.05E-07	1.25E-09	0.00E+00	1.08E-06	2.52E-07	2.08E-06	5.03E-06
	Copper	5.40E-08	4.68E-11	3.38E-12	4.48E-09	3.22E-10	0.00E+00	1.61E-06	2.14E-07	7.38E-07	2.62E-06
	Molybdenum	1.18E-06	0.00E+00	0.00E+00	1.03E-07	1.23E-09	0.00E+00	6.99E-09	0.00E+00	2.38E-07	1.52E-06
	Selenium	4.69E-06	3.64E-12	5.68E-14	2.50E-06	3.00E-08	0.00E+00	1.26E-03	1.86E-09	1.39E-04	1.41E-03
	Uranium	2.69E-05	3.39E-06	4.06E-07	1.43E-05	1.72E-06	0.00E+00	3.19E-05	3.93E-04	1.10E-05	4.83E-04
	Vanadium	8.65E-07	4.66E-09	5.53E-10	1.85E-06	2.21E-07	0.00E+00	4.90E-06	6.05E-09	3.55E-06	1.14E-05
	Zinc	3.02E-07	2.55E-11	2.96E-12	1.22E-07	1.47E-08	0.00E+00	3.58E-05	7.08E-08	1.04E-05	4.67E-05
Fisher/Trapper Adult (Russell Lake)		**Baseline HQ**									
	Cadmium	4.26E-04	9.44E-06	4.32E-06	2.95E-06	1.35E-06	0.00E+00	6.15E-04	0.00E+00	2.01E-01	2.02E-01
	Chromium	5.09E-06	4.62E-08	2.11E-07	2.73E-08	1.25E-07	0.00E+00	1.35E-04	0.00E+00	5.51E-04	6.92E-04
	Cobalt	1.49E-04	5.55E-07	2.54E-07	1.76E-07	8.04E-08	0.00E+00	8.61E-04	0.00E+00	7.79E-03	8.80E-03
	Copper	2.13E-05	7.15E-08	1.96E-07	3.02E-08	8.31E-08	0.00E+00	5.15E-03	0.00E+00	2.80E-02	3.32E-02
	Molybdenum	5.61E-05	8.58E-08	3.93E-08	8.40E-08	3.85E-08	0.00E+00	2.71E-06	0.00E+00	4.58E-02	4.59E-02
	Selenium	8.34E-05	3.93E-07	1.80E-07	7.61E-07	3.48E-07	0.00E+00	2.03E-01	0.00E+00	2.77E-01	4.80E-01
	Uranium	7.37E-04	1.33E-05	6.10E-05	6.72E-06	3.08E-05	0.00E+00	7.09E-03	0.00E+00	3.64E-02	4.44E-02
	Vanadium	1.02E-03	4.80E-05	2.20E-04	3.72E-05	1.70E-04	0.00E+00	4.69E-02	0.00E+00	3.68E-01	4.16E-01
	Zinc	1.76E-05	1.95E-07	8.92E-07	1.22E-07	5.56E-07	0.00E+00	1.69E-02	0.00E+00	5.41E-01	5.57E-01

Human Receptor	COPC	HQ during Future Centuries									
		Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
		Project Total HQ - Future Centuries									
	Cadmium	4.26E-04	9.44E-06	4.32E-06	2.95E-06	1.35E-06	0.00E+00	6.17E-04	0.00E+00	2.01E-01	2.02E-01
	Chromium	5.11E-06	4.62E-08	2.11E-07	2.73E-08	1.25E-07	0.00E+00	1.36E-04	0.00E+00	5.51E-04	6.93E-04
	Cobalt	1.51E-04	5.55E-07	2.54E-07	1.78E-07	8.16E-08	0.00E+00	8.87E-04	0.00E+00	7.79E-03	8.83E-03
	Copper	2.14E-05	7.15E-08	1.96E-07	3.04E-08	8.34E-08	0.00E+00	5.19E-03	0.00E+00	2.80E-02	3.32E-02
	Molybdenum	5.76E-05	8.58E-08	3.93E-08	8.62E-08	3.94E-08	0.00E+00	2.85E-06	0.00E+00	4.58E-02	4.59E-02
	Selenium	9.02E-05	3.93E-07	1.80E-07	8.22E-07	3.76E-07	0.00E+00	2.32E-01	0.00E+00	2.79E-01	5.12E-01
	Uranium	7.77E-04	1.34E-05	6.14E-05	7.09E-06	3.24E-05	0.00E+00	7.86E-03	0.00E+00	3.65E-02	4.53E-02
	Vanadium	1.02E-03	4.80E-05	2.20E-04	3.73E-05	1.71E-04	0.00E+00	4.70E-02	0.00E+00	3.68E-01	4.16E-01
	Zinc	1.80E-05	1.95E-07	8.92E-07	1.24E-07	5.69E-07	0.00E+00	1.77E-02	0.00E+00	5.41E-01	5.59E-01
		Project Incremental HQ - Future Centuries									
	Cadmium	6.28E-07	4.55E-12	1.82E-12	4.35E-09	1.99E-09	0.00E+00	1.82E-06	0.00E+00	8.06E-06	1.05E-05
	Chromium	1.73E-08	0.00E+00	0.00E+00	9.28E-11	4.25E-10	0.00E+00	9.19E-07	0.00E+00	2.51E-07	1.19E-06
	Cobalt	2.26E-06	1.63E-11	7.45E-12	2.67E-09	1.22E-09	0.00E+00	2.61E-05	0.00E+00	2.61E-06	3.10E-05
	Copper	8.06E-08	1.20E-12	3.31E-12	1.14E-10	3.14E-10	0.00E+00	3.89E-05	0.00E+00	2.52E-06	4.15E-05
	Molybdenum	1.44E-06	0.00E+00	0.00E+00	2.16E-09	9.87E-10	0.00E+00	1.39E-07	0.00E+00	6.59E-07	2.24E-06
	Selenium	6.76E-06	1.14E-13	5.68E-14	6.16E-08	2.82E-08	0.00E+00	2.94E-02	0.00E+00	2.30E-03	3.17E-02
	Uranium	4.01E-05	8.65E-08	3.96E-07	3.66E-07	1.67E-06	0.00E+00	7.72E-04	0.00E+00	9.41E-05	9.09E-04
	Vanadium	1.29E-06	1.20E-10	5.38E-10	4.71E-08	2.16E-07	0.00E+00	1.19E-04	0.00E+00	1.50E-04	2.70E-04
	Zinc	3.87E-07	5.40E-13	2.56E-12	2.68E-09	1.23E-08	0.00E+00	7.46E-04	0.00E+00	3.13E-04	1.06E-03

Underlined values indicate exceedance of the HQ of 0.2 for a given exposure pathway; **Bolded** values indicate exceedance of the HQ of 1 for all exposure pathways.
HQ = hazard quotient; COPC = constituent of potential concern.

4.4.1.2 Carcinogen Risk

The arsenic ILCR was not predicted to exceed the negligible cancer risk level of 1 in 100,000 for the camp worker, recreational fisher/hunter, and seasonal resident at any locations during the Project phases, as shown in Table 4-17. The recreational fisher/hunter, and seasonal resident were assessed as composite receptors throughout all life stages. The arsenic ILCR is essentially equal to the negligible cancer risk level of 1 in 100,000 for the adult fisher/trapper at Russell Lake during the Project phases. In the future centuries, a permanent resident was assessed instead of a camp worker – the cancer risk was not predicted to exceed the negligible cancer risk level for any of the receptors assessed in the future centuries (Table 4-17).

The main ingestion exposure pathway for arsenic for all human receptors was consumption of local terrestrial animals including muskrat, goose, mallard, moose, moose organs, and caribou, as well as locally caught fish represented in the HHRA by northern pike and white sucker.

The main contribution to the arsenic cancer risk for the fisher/trapper at Russell Lake is from ingestion of caribou. The predicted tissue concentration of arsenic in caribou in the Russell Lake area was 0.07 mg/kg fw, (see Appendix B) compared to a measured average value in barren-ground caribou of 0.02 mg/kg fw or maximum of 0.04 mg/kg fw from the Eastern Athabasca Regional Monitoring Program from 2011 to 2017 (CanNorth, 2018).

The diet assumptions for the fisher/trapper are conservative and are based on engagement with a local fisher/trapper. The diet of the fisher/trapper is representative of one person, who consumes a unique composition and quantity of traditional foods (e.g., ingestion rate of 175 kg/yr of caribou, equivalent to approximately 2 to 3 servings per day). Most people fishing, hunting, and trapping in the LSA and RSA would consume traditional foods more consistent with the average traditional foods consumer diet which was developed from the ERFN country foods study. In comparison, the ERFN country foods study (Table 4-4) indicates a caribou ingestion rate of 2.6 kg/yr (1 to 2 servings per month) and a total game ingestion rate of 21.3 kg/yr. The First Nations Food, Nutrition and Environment Study for Saskatchewan (Chan et al., 2018) indicates a total game ingestion rate of 54.4 kg/yr for the high consumer for the boreal shield. Overall, other local fisher/trappers may prefer consumption of moose over caribou.

The potential for arsenic to represent health risks for consumers of Traditional Foods was assessed for the Eastern Athabasca Region and for the Boreal Shield region of Saskatchewan by CanNorth (2018) and Chan et al. (2018), respectively. The Eastern Athabasca Region HHRA used a high consumer of traditional foods with a caribou ingestion rate of approximately 132 kg/yr (from the Hatchet Lake Dietary Survey [(CanNorth, 2000)]) and concluded that arsenic did not pose a significant risk to consumers of Traditional Foods.

Table 4-17: Estimated Incremental Lifetime Cancer Risk from Arsenic to Human Receptors

Human Receptor	Project Phases Cancer Risk (per 100,000)	Future Centuries Cancer Risk (per 100,000)
Camp Worker	0.1	N/A
Recreational Fisher/Hunter (LA-1)	0.4	0.1
Recreational Fisher/Hunter (Russell Lake)	0.3	0.04
Seasonal Resident (Russell Lake)	0.1	0.01
Fisher/Trapper (Russell Lake)	1.2	0.2
Permanent Resident	N/A	0.1

4.4.1.3 Radiological Risk

The incremental radiation dose to all human receptors in the Project area, LSA, or RSA during all phases of the Project was predicted to be below the dose limit of 1 mSv/yr, as shown in Table 4-18. If a dose constraint of 0.3 mSv/yr is applied, the predicted radiation dose to all human receptors during all phases of the Project was predicted to remain below the dose constraint. Therefore, it is unlikely that there would be significant adverse effects on human receptors as a result of radionuclide releases from the Project.

The predicted highest dose during the Project phases would be to the fisher/trapper at Russell Lake (0.06 mSv/yr for the adult, as shown in Table 4-19). The main contributor to total dose would be from Po-210 due to ingestion of fish from Russell Lake (inlet) and ingestion of animals (mallard and woodland caribou) harvested in the area around Russell Lake who eat from the aquatic environment. The mallard consumes benthic invertebrates and aquatic plants (macrophytes). The woodland caribou consumes aquatic plants (macrophytes) as the aquatic component of its diet.

During the future centuries, the predicted highest dose would be 0.04 mSv/yr to the permanent resident (one-year old) at Whitefish Lake, as shown in Table 4-18.

Overall, since the radiation dose estimates were below the dose limit, no discernable health effects would be anticipated due to exposure of these receptors to radioactive releases from the Project. The presence and concentrations of radionuclides in the receiving environment would be monitored and the associated radiation dose estimates would be periodically reassessed in accordance with the processes outlined in the Environmental Protection Program.

Table 4-18: Summary of All Radiation Doses to Human Receptors during Project Phases

Human Receptor	Location	Maximum Total Incremental Dose (mSv/yr)	% of Dose Limit	% of Dose Constraint
Camp Worker (Adult)	Whitefish Lake	0.03	3%	8%
Recreational Fisher/Hunter (Adult)	McGowan Lake	0.04	4%	12%
Recreational Fisher/Hunter (One-year-old)	McGowan Lake	0.05	5%	16%
Recreational Fisher/Hunter (Adult)	Russell Lake	0.02	2%	8%
Recreational Fisher/Hunter (One-year-old)	Russell Lake	0.03	3%	10%
Seasonal Resident (Adult)	Russell Lake	0.01	1%	4%
Seasonal Resident (One-year-old)	Russell Lake	0.02	2%	6%
Fisher/Trapper (Adult)	Russell Lake	0.06	6%	19%

Note: The dose limit and dose limit for a non-NEW is 1 mSv/yr and the dose constraint is 0.3 mSv/yr. The camp worker is not assessed in the future centuries.

Table 4-19: Summary of Radiation Dose to Limiting Human Receptor – Project Phases

Maximum Incremental Dose (mSv/yr)	Receptor	Location	Largest Contributor to Dose
0.06	Fisher/Trapper	Russell Lake	Po-210 Aquatic Animals

Table 4-20: Summary of All Radiation Doses to Human Receptors during Future Centuries

Human Receptor	Location	Maximum Total Incremental Dose (mSv/yr)	% of Dose Limit	% of Dose Constraint
Permanent Resident (Adult)	Whitefish Lake	0.03	3%	9%
Permanent Resident (One-year-old)	Whitefish Lake	0.04	4%	12%
Recreational Fisher/Hunter (Adult)	McGowan Lake	0.01	1%	3%
Recreational Fisher/Hunter (One-year-old)	McGowan Lake	0.01	1%	5%
Recreational Fisher/Hunter (Adult)	Russell Lake	0.01	1%	2%

Human Receptor	Location	Maximum Total Incremental Dose (mSv/yr)	% of Dose Limit	% of Dose Constraint
Recreational Fisher/Hunter (One-year-old)	Russell Lake	0.01	1%	3%
Seasonal Resident (Adult)	Russell Lake	0.002	0%	1%
Seasonal Resident (One-year-old)	Russell Lake	0.003	0%	1%
Fisher/Trapper (Adult)	Russell Lake	0.01	1%	4%

Note: The public dose limit is 1 mSv/yr and the dose constraint is 0.3 mSv/yr. The camp worker is not assessed in the future centuries.

4.4.1.4 Radon Risk

The maximum incremental radon dose to the camp worker was estimated to be 0.13 mSv/yr during operation. The assessment is conservative in that it assumes that the camp worker spends 100% of the time indoors.

The total incremental dose to the camp worker from all radionuclides in the U-238 decay chain including radon would be 0.16 mSv/year, which is below the dose limit for a non-NEW of 1 mSv/yr (Table 4-21). The estimate of total dose including radon is conservative based on the following assumptions:

- the camp worker spends 100% of their time indoors when on site for exposure to radon (Section 4.2.5.3).
- receptors are exposed to the maximum exposure concentrations at their location for each model scenario and Project phase (Section 4.2.6).
- For radionuclides in the U-238 decay chain (other than radon), the camp worker is also exposed to radionuclides through ingestion (water and food) pathways resulting in a conservative dose when also factoring in the dose from radon indoors.

Table 4-21: Total Radiation Dose to Camp Worker from all Radionuclides including Radon Progeny – Project Phases

Human Receptor	Location	Maximum Total Incremental Dose - U-238 decay chain (mSv/yr)	Maximum Radon Dose (mSv/yr)	Maximum Total Dose (mSv/yr)	% of Dose Limit for non-NEW
Camp Worker (Adult)	Whitefish Lake	0.03	0.13	0.16	16%

4.4.2 Uncertainties in the Risk Characterization

The problem formulation and toxicity and exposure information are combined in the risk characterization step to estimate the potential for human health effects. The uncertainties associated with each of the previous steps of the HHRA are discussed in Section 4.1.6, Uncertainty in Problem Formulation, Section 4.2.6, Uncertainty in Exposure Assessment, and Section 4.3.3, Uncertainty in the Toxicity Assessment. In each step of the HHRA, conservative assumptions were used to address uncertainties. The use of this approach is far more likely to overestimate potential risk than to underestimate risk.

5.0 Ecological Risk Assessment

5.1 Problem Formulation

The problem formulation includes identification of ecological receptors (i.e., VCs) and their characteristics, selection of COPCs (radiological and non-radiological) and other stressors, identification of assessment and measurement endpoints and exposure pathways, and an overall conceptual model for the EcoRA.

5.1.1 Receptor Selection

It is generally an impractical task to assess the effect of radiological and non-radiological emissions on all the species within a natural ecosystem, and specifically within the ecosystem around the Project. Therefore, a representative group of organisms were selected for dose and risk analysis. The organisms were selected as ecological receptors because they are known to exist at the site and in the local study area, are representative of major taxonomic groups or exposure pathways, are listed federally and/or provincially, and/or have a special importance or value to people or other ecological factors.

A preliminary list of ecological receptors for the Project was compiled from the species identified in the Aquatic Baseline Report (Ecometrix, 2020) and Terrestrial Environment, Wildlife and Vegetation Baseline Inventory Report (Omnia, 2020). Species were included in the preliminary list if they were quantified and/or incidentally observed through respective survey methods, except for birds, where only the ten most abundant song birds and area waterfowl, or sensitive bird species are included in the preliminary list.

A representative subset of organisms was selected from each major plant or animal group to be carried forward as ecological receptors. Several factors were considered in the selection process, following the criteria provided in Table 7.1 of CSA N288.6 (2022):

- Availability of chemical analyses for radiological and non-radiological parameters for the species. For example, the southern red-backed vole was selected on this basis;
- Abundance of the species in the study area relative to other species;
- Value or importance to Indigenous communities, based on information from Denison's meeting notes with a local fisher/trapper Mr. Bobby John (KPI Program, 2019);
- Classification as threatened or species of special concern identified by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and listed under the federal Species at Risk Act (SARA) (e.g., woodland caribou);
- Representing a potential exposure pathway to COPCs through releases to the environment; and,

- Availability of scientific information for the receptor that can be used in risk analysis. For example, amphibian and reptiles are relatively less characterized. Therefore, frogs were not included on the ecological receptor list on the basis of limited scientific information for risk assessment. However, the assessment of a fish receptor is considered to be protective of the most sensitive life stage of frogs, which is the tadpole.

The major plant and animal groups were defined based on taxonomy and ecology, so as to represent the different possible pathways of exposure to COPCs. The organisms selected to represent each major group were either individual species of vertebrate organisms, or generic types of plants or invertebrates such as aquatic macrophytes or zooplankton.

Table 5-1 below summarizes the selected ecological receptors for the Denison Project, and the key information used in the selection process. A finalized summary table of all ecological receptors selected for the EcoRA can be found in Table 5-3.

5.1.1.1 Consideration of Species at Risk

Species at Risk (SAR) often lack the information needed for risk assessment, because they are difficult to study. However, some SAR can be represented by other more common species that have similar diets and exposure pathways. For example, the olive-sided flycatcher (SAR) was selected to represent other aerial insectivores, which include the SAR common nighthawk and barn swallow.

Table 5-2 lists the SAR or species of conservation concern that may potentially interact with the Project, which are listed by COSEWIC or under SARA, or ranked “imperiled” or “vulnerable” by the Saskatchewan Conservation Data Centre (SKCDC). The SKCDC rankings are intended to provide support in conservation planning and monitoring of SAR, but protection of species on the list is not regulated. Surrogate species selected to represent each listed species are also provided in Table 5-2.

Table 5-1: List of Ecological Receptors for Wheeler River Project

Representative Species	Selection Criteria					Selection Rationale and Applicable Criteria[1,2,3]
	1	2	3	4	5	
	Major Plant/Animal Group	Facility or Stakeholder Importance*	Ecological Significance**	Socio-Economic Significance***	Exposed to and/or Sensitive to Stressor	
Terrestrial Invertebrates						
Terrestrial Invertebrates (general category)	Terrestrial Invertebrates	Habitat identified in the baseline study.	Food source for other receptors	Not identified	Exposed to atmospheric release through soil	**Selected as VC: 1,2,5**
Aquatic Invertebrates						
Zooplankton (general category)	Zooplankton	Present in lakes / potential discharge locations	Food source for other receptors	Not identified	Exposed to aquatic release through water	**Selected as VC: 1,2,5**
Benthic invertebrates (general category)	Benthic invertebrates	Taxonomy was classified in most lakes surveyed in the studied area. Whole body tissue was collected and analyzed for metal and radionuclides.	Food source for other receptors	Not identified	Exposed to aquatic release through water and sediment.	**Selected as VC: 1,2,5**
Aquatic Plants						
Macrophyte (e.g., *Carex sp.*) (general category)	Aquatic Macrophyte	Present in most surface water bodies.	Food source for other receptors. Provides spawning substrate for some fish species (e.g. Northern Pike)	Provides habitat and food for traditional food fish and animals	Exposed to aquatic release through water and sediment.	**Selected as VC: 1,2,3,4,5**
Phytoplankton (general category)	Phytoplankton	Present in lakes / potential discharge locations	Food source for other receptors	Provides food for traditional food fish	Exposed to aquatic release through water.	**Selected as VC: 1,2,3,4,5**
Terrestrial Plants						
Lichen	Lichen	Observed in the study area. Sampled and analyzed for metals and radionuclides in terrestrial baseline studies.	Primary food source for woodland caribou. Some lichen species are provincially rare.	Provides food for caribou, a species of socio-economic significance.	Exposed to atmospheric release through soil	**Selected as VC: 1,2,3,4,5**
Blueberry (*Vaccinium myrtilloides*)	Shrub	Observed in the study area. Fruit, leaves and stems collected and analyzed for metals and radionuclides.	Food source for other receptors.	Regional traditional food item.	Exposed to atmospheric release through soil	**Selected as VC: 1,2,3,4,5**

Representative Species	Selection Criteria					Selection Rationale and Applicable Criteria[1,2,3]
	1	2	3	4	5	
	Major Plant/Animal Group	Facility or Stakeholder Importance*	Ecological Significance**	Socio-Economic Significance***	Exposed to and/or Sensitive to Stressor	
Labrador tea (*Rhododendron groenlandicum*)	Shrub	Observed in the study area.	Food source for other receptors. Surrogate for leafy plants used in the human diet and rare species observed in the area such as Alaskan clubmoss (ranked S2) and three-seeded sedge (ranked S3).	Harvested regionally for medicinal use (tea)	Exposed to atmospheric release through soil	**Selected as VC: 1,2,3,4,5**
Browse	Shrub	Observed in the study area.	Food source for other receptors.	Not identified	Exposed to atmospheric release through soil	Not selected as a VC, but it is a component of the food web.
Terrestrial Mammals						
Woodland caribou (*Rangifer tarandus caribou*)	Terrestrial herbivore	Observed in the study area.	Threatened status under COSEWIC and SARA for broader regional study area	Harvested regionally as a traditional food item and for fur.	Exposed to atmospheric and aquatic releases through consumption of food (plants and lichens), water and soil.	**Selected as VC: 1,2,3,4,5**
Snowshoe hare (*Lepus americanus*)	Terrestrial herbivore	Observed in the study area.	Food source for other receptors.	Regional traditional food item. Harvested regionally for fur.	Exposed to atmospheric and aquatic releases through food (upland plants), water and soil.	**Selected as VC: 1,2,3,4,5**
Moose (*Alces americanus*)	Terrestrial herbivore	Observed in the study area.	Food source for other receptors.	Regional traditional food item.	Exposed to atmospheric and aquatic releases through food (upland and aquatic plants), water and soil.	**Selected as VC: 1,2,3,4,5**
Red-backed vole (*Myodes gapperi*)	Terrestrial omnivore	Observed in the study area. 124 specimens were analyzed for metals and radionuclides. Surrogate for other small mammals such as dusky shrews, meadow vole.	Food source for other receptors.	Food source for other species. Regional traditional food items and/or traditionally harvested for fur.	Exposed to atmospheric and aquatic releases through food (plants, insects and invertebrates), water and soil	**Selected as VC: 1,2,3,4,5**
Meadow vole (*Microtus pennsylvanicus*)	Terrestrial herbivore	Observed in the study area.	Food source for other receptors.	Traditionally harvested for fur.	Exposed to atmospheric release through food (plants) and soil	Not Selected. Assessment of Red-backed vole is expected to be protective of this species.
Red squirrel	Terrestrial omnivore	Observed in the study area.	Food source for other receptors	Trapped for fur/meat and hunted by indigenous people	Exposed to atmospheric release through food (plants) and soil	

Representative Species	Selection Criteria					Selection Rationale and Applicable Criteria[1,2,3]
	1 Major Plant/Animal Group	2 Facility or Stakeholder Importance*	3 Ecological Significance**	4 Socio-Economic Significance***	5 Exposed to and/or Sensitive to Stressor	
Dusky Shrews (*Sorex monticolus*)	Terrestrial omnivore	Observed in the study area.	Food source for other receptors	Not identified	Exposed to atmospheric release through food (plants) and soil	
Black bear (*Ursus americanus*)	Terrestrial omnivore	Observed in the study area.	Top Omnivore	Regional traditional food item. Harvested regionally for fur.	Exposed to atmospheric and aquatic releases through food (berries, nuts, small mammals, fish, birds), water, sediment and soil.	**Selected as VC: 1,2,3,4,5**
Canada Lynx (*Lynx canadensis*)	Terrestrial carnivore	Observed in the study area.	Top carnivore. Surrogate for other carnivores such as wolf, marten, fisher, and ermine.	Harvested regionally for fur. Small lynx is also consumed as traditional food item.	Exposed to atmospheric and aquatic releases through food (small mammals), water and soil	**Selected as VC: 1,2,3,4,5**
American marten (*Martes americana*)	Terrestrial carnivore	Observed in the study area.	Small mammal, carnivore.	Regional traditional food item. Harvested regionally for fur.	Exposed to atmospheric release through food (small mammals) and soil	Not selected. Assessment of the Canada Lynx is expected to be protective of this species.
Fisher (*Pekania pennanti*)	Terrestrial carnivore	Observed in the study area.	Small mammal, carnivore.	Trapped for fur/meat.	Exposed to atmospheric release through food (small mammals) and soil	
Red fox	Terrestrial carnivore	Observed in the study area.	Small mammal, carnivore.	Trapped for fur/meat and hunted by indigenous people	Exposed to atmospheric release through food (small mammals) and soil	
Ermine (*Mustela erminea*)	Terrestrial carnivore	Observed in the study area.	Small mammal, carnivore.	Trapped for fur/meat.	Exposed to atmospheric release through food (small mammals) and soil	
Grey wolf (*Canis lupus*)	Terrestrial carnivore	Observed in the study area.	Large mammal, top carnivore.	Trapped for fur/meat.	Exposed to atmospheric release through food (small mammals) and soil	
Riparian Mammals						
Muskrat (*Ondatra zibethicus*)	Riparian herbivore	Observed in the study area.	Surrogate for other riparian herbivores such as the beaver.	Regional traditional food item. Harvested regionally for fur.	Exposed to aquatic release through food (aquatic vegetation), water and sediment	**Selected as VC: 1,2,3,4,5**
North American beaver (*Castor canadensis*)	Riparian herbivore	Observed in the study area.	Food source for other receptors	Trapped for fur/meat and hunted by indigenous people	Exposed to aquatic release through food (aquatic vegetation), water and sediment	Not selected. Assessment of the Muskrat is expected to be protective of this species.

Representative Species	Selection Criteria					Selection Rationale and Applicable Criteria[1,2,3]
	1 Major Plant/Animal Group	2 Facility or Stakeholder Importance*	3 Ecological Significance**	4 Socio-Economic Significance***	5 Exposed to and/or Sensitive to Stressor	
American Mink (*Neovison vison*)	Riparian carnivore	Observed in the study area.	Surrogate for other riparian carnivores such as river otter.	Harvested regionally for fur.	Exposed to atmospheric and aquatic releases through food (small mammals, fish, amphibians, insects), water, sediment, and soil.	**Selected as VC: 1,2,3,4,5**
River otter (*Lontra canadensis*)	Riparian carnivore	Observed in the study area.	Small riparian carnivore. SKCDC status S3.	Trapped for fur/meat and hunted by indigenous people	Exposed to atmospheric and aquatic releases through food (small mammals, fish, amphibians, insects), water, sediment, and soil.	Not selected. Assessment of the American Mink is expected to be protective of this species.
Terrestrial Birds*****						
Olive-sided flycatcher (*Contopus cooperi*)	Aerial insectivore	Observed in the study area.	Special concern (COSEWIC) and threatened status (SARA). Surrogate for other small birds and at-risk species, such as barn swallow and common nighthawk.	Not identified	Exposed to atmospheric and aquatic releases through food (flying insects) and water.	**Selected as VC: 1,2,4,5**
Barn swallow (*Hirundo rustica*)	Aerial insectivore	Observed in the study area.	SB, S5M, threatened (COSEWIC)	Not identified	Exposed to atmospheric and aquatic releases through food (flying insects) and water.	Not selected. Assessment of the Olive-sided flycatcher is expected to be protective of this species.
Common Nighthawk (*Chordeiles minor*)	Aerial Insectivore	Observed in the study area.	S4B, S4M, COSEWIC Special Concern, SARA Status Threatened.	Not identified	Exposed to atmospheric and aquatic releases through food (flying insects) and water.	
Bald Eagle (*Haliaeetus leucocephalus*)	Terrestrial carnivore	Observed in the study area.	Surrogate of other raptors	Not identified	Exposed to atmospheric and aquatic releases through food (fish and small mammals), water, sediment, and soil.	**Selected as VC: 1,2, 5**
American Robin (*Turdus migratorius*)	Ground feeding omnivore	Observed in the study area.	Surrogate for other insectivores and ground-feeding birds, such as dark-eyed junco, Hermit thrush, and yellow-rumped warbler.	Not identified	Exposed to atmospheric and aquatic releases through food (seeds, fruits, terrestrial invertebrates), water and soil.	**Selected as VC: 1,2,5**

Representative Species	Selection Criteria					Selection Rationale and Applicable Criteria[1,2,3]
	1 Major Plant/Animal Group	2 Facility or Stakeholder Importance*	3 Ecological Significance**	4 Socio-Economic Significance***	5 Exposed to and/or Sensitive to Stressor	
Dark-eyed junco (*Junco hyemalis*)	Ground feeding omnivore	Observed in the study area.	Breeds within the study area.	Not identified	Exposed to atmospheric release through food (terrestrial invertebrates) and soil	Not selected. Assessment of the American Robin is expected to be protective of this species.
Chipping sparrow (*Spizella passerina*)	Ground feeding omnivore	Observed in the study area.	Breeds within the study area.	Not identified	Exposed to atmospheric release through food (terrestrial invertebrates) and soil	
Yellow-rumped warbler (*Setophaga coronata*)	Tree/shrub feeding insectivore	Observed in the study area.	Breeds within the study area.	Not identified	Exposed to atmospheric release through food (terrestrial invertebrates) and soil	
Fox sparrow (*Passerella iliaca*)	Ground feeding omnivore	Observed in the study area.	Breeds within the study area.	Not identified	Exposed to atmospheric release through food (terrestrial invertebrates) and soil	
Gray jay (*Perisoreus canadensis*)	Ground feeding omnivore	Observed in the study area.	Breeds within the study area.	Not identified	Exposed to atmospheric release through food (terrestrial invertebrates) and soil	
Hermit thrush (*Catharus guttatus*)	Ground feeding omnivore	Observed in the study area.	Breeds within the study area.	Not identified	Exposed to atmospheric release through food (terrestrial invertebrates) and soil	
Lincoln's sparrow (*Melospiza lincolnii*)	Ground feeding omnivore	Observed in the study area.	Breeds within the study area.	Not identified	Exposed to atmospheric release through food (terrestrial invertebrates) and soil	
Ruby-crowned kinglet (*Regulus calendula*)	Tree/shrub feeding insectivore	Observed in the study area.	Breeds within the study area.	Not identified	Exposed to atmospheric release through food (terrestrial invertebrates) and soil	
Canada Goose (*Branta canadensis*)	Ground feeding herbivore	Observed in the study area.	Breeds within the study area.	Regional traditional food item.	Exposed to atmospheric and aquatic releases through food (grass, sedges, berries, seeds), water and soil.	**Selected as VC: 1,2,3,4,5**
Riparian Birds*****						

Representative Species	Selection Criteria					Selection Rationale and Applicable Criteria[1,2,3]
	1 Major Plant/Animal Group	2 Facility or Stakeholder Importance*	3 Ecological Significance**	4 Socio-Economic Significance***	5 Exposed to and/or Sensitive to Stressor	
Lesser Scaup (*Aythya affinis*)	Riparian omnivore	Observed in the study area.	Surrogate for other omnivore ducks and gulls (e.g. bufflehead, mew gull, herring gull, bonaparte's gull, and horned grebe).	Not identified	Exposed to aquatic release through water, food (invertebrates) and sediment.	**Selected as VC: 1,2,5**
Ring-necked duck (*Aythya collaris*)	Riparian omnivore	Observed in the study area.	Food source for other receptors.	Not identified.	Exposed to aquatic release through water, food (invertebrates) and sediment.	Not selected. Assessment of the a Lesser Scaup is expected to be protective of this species.
Bufflehead (*Bucephala albeola*)	Diving bird, riparian omnivore	Observed in the study area.	Food source for other receptors.	Not identified	Exposed to aquatic release through water, food and sediment.	
Herring Gull (*Larus argentatus*)	Gull (riparian omnivore)	Observed in the study area.	S5B, S5M, not threatened. Breeds in the study area.	Hunted by indigenous people.	Exposed to aquatic release through water and food (fish and aquatic invertebrates)	
Bonaparte's Gull (*Chroicocephalus philadelphia*)	Gull (riparian omnivore)	Observed in the study area.	S4B, S4M, not threatened.	Not identified.	Exposed to aquatic release through water and food (fish and aquatic invertebrates)	
Common Tern (*Sterna hirundo*)	Riparian omnivore	Observed in the study area.	S5B, S5M, Not at risk	Not identified.	Exposed to aquatic release through water and aquatic food (fish) and invertebrates.	
Horned Grebe (*Podiceps auritus*)	Diving bird, riparian omnivore	Incidental observation in the study area.	S5B, S5M, COSEWIC Special Concern, SARA Special Concern	Not identified.	Exposed to aquatic release through water, food and sediment.	
Mew Gull (Larus canus)	Gull (riparian omnivore)	Observed in the study area.	S4B, S4M, Not threatened. Breeds in the study area.	Hunted by indigenous people.	Exposed to aquatic release through water, food and sediment.	
Mallard (*Anas platyrhynchos*)	Riparian herbivore	Observed in the study area.	Surrogate for other herbivore duck species (e.g. ring-necked duck).	Regional traditional food item.	Exposed to aquatic release through water, food (aquatic plants and invertebrates) and sediment	**Selected as VC: 1,2,3,4,5**
Common loon (*Gavia immer*)	Piscivore	Observed in the study area.	Surrogate for other fish-eating birds (e.g. common tern, common merganser, and osprey).	Regional traditional food item.	Exposed to aquatic release through water and aquatic food (fish)	**Selected as VC: 1,2,3,4,5**

Representative Species	Selection Criteria					Selection Rationale and Applicable Criteria[1,2,3]
	1	2	3	4	5	
	Major Plant/Animal Group	Facility or Stakeholder Importance*	Ecological Significance**	Socio-Economic Significance***	Exposed to and/or Sensitive to Stressor	
Common merganser (*Mergus merganser*)	Piscivore	Observed in the study area.	Prey on other receptors.	Not identified.	Exposed to aquatic release through water and aquatic food (fish)	Not selected. Assessment of a Loon is expected to be protective of this species.
Osprey (*Pandion haliaetus*)	Piscivore	Observed in the study area (including the nest).	S2B, S2M, not threatened.	Not identified	Exposed to atmospheric and aquatic releases through food (fish and small mammals), water, sediment, and soil.	
Fish******						
Northern Pike (*Esox lucius*)	Pelagic predator fish (Piscivore)	Present in most area lakes and surrounding surface water bodies. Spawning habitat has also been identified within the study area. Fish flesh and bone were analyzed for metal and radionuclides. Age determination has also been done.	Food source for other receptors. Surrogate for all predator fish.	Regional traditional food item. Recreational and commercial fishing documented at Russell Lake.	Exposed to aquatic release through food (fish and other aquatic biota) and water.	**Selected as VC: 1,2,3,4,5**
Lake Trout (*Salvelinus namaycush*)	Pelagic predator fish	Observed in McGowan Lake and Russell Lake. Spawning habitat was observed in the study area.	Food source for other receptors.	Regional traditional food item. Recreational and commercial fishing documented at Russell Lake.	Exposed to aquatic release through food (fish and other aquatic biota) and water.	Not selected. Assessment of the Northern Pike is expected to be protective of this species.
Walleye (*Sander vitreus*)	Pelagic predator fish	Present in most area lakes and streams within the study area. Spawning habitat has also been identified within the study area.	Food source for other receptors.	Regional traditional food item. Commercial fishing is documented at Russell Lake.	Exposed to aquatic release through food (fish and other aquatic biota) and water.	
Yellow Perch (*Perca flavescens*)	Pelagic predator fish	Observed in McGowan Lake and the regional study area.	Food source for other receptors.	Regional traditional food item.	Exposed to aquatic release through food (fish and other aquatic biota) and water.	
White Sucker (*Catostomus commersoni*)	Benthic forage fish	Present in most area lakes and surrounding surface water bodies. Spawning habitat has also been identified within the study area. Fish flesh and bone were analyzed for metal and radionuclides. Age determination has also been done.	Food source for other receptors. Surrogate for all foraging fish.	Regional traditional food item. Recreational and commercial fishing documented at Russell Lake.	Exposed to aquatic release through food (aquatic invertebrates and aquatic plants).	**Selected as VC: 1,2,3,4,5**
Lake Whitefish (*Coregonus clupeaformis*)	Benthopelagic fish	Present in most area lakes and surrounding surface water bodies.	Food source for other receptors.	Regional traditional food item. Commercial fishing is documented at Russell Lake.	Exposed to aquatic release through food (aquatic	Not selected. Assessment of the White Sucker is

Representative Species	Selection Criteria					Selection Rationale and Applicable Criteria[1,2,3]
	1 Major Plant/Animal Group	2 Facility or Stakeholder Importance*	3 Ecological Significance**	4 Socio-Economic Significance***	5 Exposed to and/or Sensitive to Stressor	
					invertebrates and aquatic plants).	expected to be protective of this species.
Slimy Sculpin (representative small fish)	Benthopelagic forage fish	Observed in the Icelander River and other streams within the study area.	Food source for other receptors.	Not identified.	Exposed to aquatic release through food (aquatic invertebrates and aquatic plants).	
Arctic Grayling (*Thymallus arcticus*)	Benthopelagic forage fish	Observed in the Icelander River and other streams within the study area.	Food source for other receptors.	Regional traditional food item.	Exposed to aquatic release through food (aquatic invertebrates and aquatic plants).	
Longnose Sucker (*Catostumus catostumus*)	Benthic forage fish	Observed in McGowan Lake, Icelander River and other streams within the study area.	Food source for other receptors.	Regional traditional food item.	Exposed to aquatic release through food (aquatic invertebrates and aquatic plants).	
Lake Chub (*Couesius plumbeus*)	Benthopelagic forage fish	Observed in Icelander River and other streams within the study area. Spawning habitat has also been identified within the study area.	Food source for other receptors.	Not identified	Exposed to aquatic release through food (aquatic invertebrates and aquatic plants).	
Spottail Shiner (*Notropis hudsonius*)	Benthopelagic forage fish	Present in most area lakes and other surface water bodies in the study area.	Food source for other receptors.	Not identified	Exposed to aquatic release through food (aquatic invertebrates and aquatic plants).	
Ninespine Stickleback (*Pungitius pungitius*)	Benthopelagic forage fish	Observed in the Whitefish Lake, south basin (LA-5), and streams within the study area.	Food source for other receptors.	Not identified	Exposed to aquatic release through food (aquatic invertebrates and aquatic plants).	
Burbot (*Lota lota*)	Benthic predator fish	Observed in Russell Lake and other streams within the study area.	Food source for other receptors.	Regional traditional food item.	Exposed to aquatic release through food (fish and other aquatic biota) and water.	
Amphibians and Reptiles						
Northern Leopard frog (*Lithobates pipiens*)	Frog	Present in the study area.	Listed as a species of concern under SARA and COSEWIC, and is provincially ranked S3 (vulnerable/rare to uncommon)	Not identified	Exposed to aquatic release through surface water, sediment, and prey.	Not selected. A fish model will be used to represent the early sensitive life stages of amphibians (egg and tadpole).
Canadian toad (*Anaxyrus hemiphrys*)	Toad	Present in the study area.	Food source for other receptors.	Not identified	Exposed to aquatic release through surface water, sediment, and prey.	

Representative Species	Selection Criteria					Selection Rationale and Applicable Criteria[1,2,3]
	1	2	3	4	5	
	Major Plant/Animal Group	Facility or Stakeholder Importance*	Ecological Significance**	Socio-Economic Significance***	Exposed to and/or Sensitive to Stressor	
Wood Frogs (*Lithobates sylvaticus*)	Frog	Present in the study area.	Food source for other receptors.	Not identified	Exposed to aquatic release through surface water, sediment, and prey.	
Boreal chorus frogs (*Pseudacris maculata*)	Frog	Present in the study area.	Food source for other receptors.	Not identified	Exposed to aquatic release through surface water, sediment, and prey.	

Notes:
* Information from EcoMetrix (2020) and Omnia (2020).
** Information from EcoMetrix (2020) and Omnia (2020).
***FNFNES (First Nations Food, Nutrition and Environment Study), Hatchet Lake and Uranium City food study results were used to identify VECs that are part of the human traditional/subsistence diet and characterize regional socio-economic significance. Partial information is also from the meeting notes Denison provided with local trapper/fisher Mr. Bobby John.
**** Amphibian species such as wood frogs and boreal chorus frogs were not specified on the list on the basis of limited scientific information for amphibian risk assessment. Amphibian species will be assessed qualitatively in the EcoRA.
***** As there are many birds observed in the study area (36 song birds and 20 water fowls), only the ten most abundant breeding songbirds and aerial waterfowls, as well as all sensitive bird species are included in this table.
Species names that are highlighted and underlined are sensitive or threatened species at risk observed at the Wheeler River Project.
SKCDC: Saskatchewan Conservation Data Center.
COSWIC: Committee on the Status of Endangered Wildlife in Canada.
No observation of bat is documented in the terrestrial baseline report (Omnia, 2019).

References:

1. Omnia Ecological Services (Omnia). 2020. Denison Mines Corporation Wheeler River Project - Terrestrial Environment Wildlife and Vegetation Baseline Inventory.
2. Denison Mines Corp (Denison). 2019. Wheeler River Project Provincial Technical Proposal and Federal Project Description. May.
3. Denison Mines Corp (Denison). 2019. Denison Mines Wheeler River Project Key Person Interview with Bobby John - Meeting Notes. October.

Table 5-2: Species at Risk for the Wheeler River Project and Associated Surrogates

Common Name	Scientific Name	Feeding Behaviour	SKCDC Status	COSEWIC Status	SARA Status	Field Observations	Surrogate species, if not selected as a VC
Mammals							
Woodland Caribou	*Rangifer tarandus caribou*	Terrestrial herbivore	S3	Threatened	Threatened	Only observed in the Regional Study Area	Selected
River Otter	*Lontra canadensis*	Riparian carnivore	S3	N/A	N/A	Eleven observations.	American Mink
Wolverine	*Gulo gulo*	Terrestrial carnivore	S2	Special Concern	Special Concern	Not observed	Canada Lynx
Birds							
Osprey	*Pandion haliaetus*	Piscivore	S2B, S2M	N/A	N/A	8 pairs observed.	Common Loon
Common Nighthawk	*Chordeiles minor*	Aerial insectivore	S4B, S4M	Special Concern	Threatened	Incidentally observed.	Olive-sided Flycatcher
Olive-sided Flycatcher	*Contopus cooperi*	Aerial insectivore	S4B, S4M	Threatened	Threatened	8 pairs observed.	Selected
Barn Swallow	*Hirundo rustica*	Aerial insectivore	S5B, S5M	Threatened	Threatened	4 pairs observed.	Olive-sided Flycatcher
Horned Grebe	*Podiceps auritus*	Aquatic invertebrates/ piscivore	S5B, S5M	Special Concern	Special Concern	One incidental observation.	Lesser Scaup
Short-eared Owl	*Asio flammeus*	Terrestrial carnivore	S3B, S2N	Threatened	Special Concern	Not observed	Bald Eagle
Yellow Rail	*Coturnicops noveboracensis*	Aquatic invertebrates	S3B	Special Concern	Special Concern	Not observed	Lesser Scaup
Rusty Blackbird	*Euphagus carolinus*	Aerial insectivore	S3B, SUN	Special Concern	Special Concern	Not observed	Olive-sided Flycatcher

Notes:
Modified from Table 3-1 (Omnia, 2020)
'N/A' denotes species status not assessed.
SKCDC Rankings:
2: Imperiled/Very rare

3: Vulnerable/Rare to uncommon
4: Apparently secure
5: Secure/Common
M: for a migratory species, rank applies to the transient (migrant) population
B: for a migratory species, applies to the breeding population in the province
N: for a migratory species, applies to the non-breeding population in the province
U: status is uncertain in Saskatchewan because of limited or conflicting information (unrankable)

Table 5-3: List of Ecological Receptors for Wheeler River Project

Category	Representative Species
Terrestrial Invertebrates	Terrestrial Invertebrates
Terrestrial Plants	Lichen
	Blueberry (*Vaccinium myrtilloides*)
	Labrador tea (*Rhododendron groenlandicum*)
Aquatic Invertebrates	Zooplankton (general category)
	Benthic invertebrates
Aquatic Plants	Macrophyte (*e.g., Carex sp.)*
	Phytoplankton
Fish	Northern Pike *(Esox lucius*)
	White Sucker (*Catostomus commersoni*)
Terrestrial Mammals	Woodland caribou (*Rangifer tarandus caribou*)
	Snowshoe hare (*Lepus americanus*)
	Moose (*Alces americanus*)
	Red-backed vole (*Myodes gapperi*)
	Black bear (*Ursus americanus*)
	Canada Lynx (*Lynx canadensis*)
Riparian Mammals	Muskrat (*ondatra zibethicus*)
	American Mink (*Neovision vision*)
Terrestrial Birds	Olive-sided flycatcher (*Contopus cooperi*)
	Bald Eagle (*Haliaeetus leucocephalus*)
	American Robin (*Turdus migratorius*)
	Canada Goose (*Branda canadensis*)
Riparian Birds	Lesser Scaup (*Aythya affinis*)
	Mallard (*Anas platyrhynchos*)
	Common loon (*Gavia immer*)

5.1.2 Receptor Characterization

The following section provides a brief summary of the ecological receptors selected for the EcoRA. For additional information regarding ecological characteristics relevant to receptor exposures, refer to Appendix C of this report.

5.1.2.1 Terrestrial Invertebrates

Soil invertebrates such as earthworms, grubs, arthropods, etc. are important components of terrestrial ecosystems. Invertebrates provide a food source to mammals and birds and the community can reflect the health of the environment.

5.1.2.2 Terrestrial Plants

Lichens are a complex life form that is a symbiotic partnership of two separate organisms, a fungus and an alga. The dominant partner is the fungus, which gives the lichen the majority of its characteristics. The alga can be either a green alga or a blue-green alga, also known as cyanobacteria. Lichen are important indicator species of environmental conditions, as they can absorb atmospheric pollutants, including heavy metals (USFS, 2021).

Blueberries and Labrador Tea are important terrestrial plant species consumed by humans for food or for medicinal purposes (CanNorth, 2017). Berries are also an important food source for many terrestrial bird and mammal species, offering a reliable source of carbohydrates, vitamins and antioxidants.

5.1.2.3 Aquatic Invertebrates

Aquatic invertebrates are an important food item for many species of fish and waterfowl. Benthic invertebrates are often found living on or within sediment. Benthic invertebrates can be used to provide an indication of habitat quality in aquatic environments.

Zooplankton are aquatic microorganisms that include crustaceans, rotifers, insect larvae and aquatic mites. The zooplankton community is composed of both primary consumers, which eat free-floating algae, and secondary consumers, which feed on other zooplankton and microorganisms. Zooplankton are particularly sensitive to changes in the aquatic environment. The effects of environmental disturbances can be perceived through changes in species composition, abundance and body size (US EPA, 2021a).

5.1.2.4 Aquatic Plants

Macrophytes are aquatic plants that grow within or in close proximity to water. They may be emergent (i.e., portions of the plant exist above the water surface), fully submerged or floating. Examples of macrophytes include cattails, hydrilla, water hyacinth and duckweed. Macrophytes provide habitat for fish and other aquatic organisms. They also produce oxygen and are an important food source for fish and wildlife. Macrophytes are an important indicator species, as they tend to quickly respond to changing environmental conditions (US EPA, 2021b).

Phytoplankton are free-floating algae that inhabit the upper sunlit layers of most freshwater and marine environments. They are often associated with freshwater water quality characteristics such as colour and clarity. Phytoplankton are primary producers, and convert solar energy into biologically-useable energy through photosynthesis. They are an important food source for higher organisms, including zooplankton and small fish. Phytoplankton can be used to assess an ecosystem's environmental condition by examining their abundance and community richness (US EPA, 2021c).

5.1.2.5 Fish

The Northern Pike (*Esox lucius*) is a cool-water fish, and tends to live in slower-moving, heavily vegetated rivers or lake bays. Spawning occurs in the spring, immediately following the seasonal ice melt. Northern pike are opportunistic feeders, targeting smaller fish, crayfish, frogs, mice, muskrats and young waterfowl for food. In many regions across Canada, northern pike are considered an important commercial and sport fish species (DFO, 2018).

The White Sucker (*Catostomus commersoni*) is a bottom-feeding, freshwater fish common to North America. They tend to live in shallow lakes and rivers, where they feed on benthic invertebrates, clams, insect larvae and fish eggs. They are an important prey species of northern pike (DFO, 2016).

5.1.2.6 Terrestrial Mammals

The Woodland Caribou (*Rangifer tarandus caribou*) is a herbivorous mammal found in Canada's boreal and open taiga forests. They consume plant materials for sustenance, including tree and ground lichens in winter, and lichens, grasses, sedges, forbs, horsetails and shrub leaves in summer. Woodland caribou are threatened by habitat degradation and fragmentation, and have been classified as "threatened" under the federal *Species at Risk Act, 2002* (NRC, 2021).

The Snowshoe Hare (*Lepus americanus*) is a herbivorous mammal found in coniferous and boreal forests throughout Canada and the United States. They often forage through brush, consuming plant materials such as grasses, flowers, and new growth from trees. Snowshoe hares breed rapidly, and thus maintain a relatively stable population throughout their range. They are an important prey item for larger carnivorous birds and mammals, such as the bald eagle and lynx (NWF, 2021a).

Moose (*Alces americanus*) are the largest members of the deer family, and are common in forested regions across Canada and the United States. In the winter, moose will eat various shrubs and pinecones for sustenance. In summer, moose feed on aquatic plants (macrophytes) both on and below the water's surface. Moose are potentially threatened by habitat degradation and fragmentation, but are not a federally-recognized species at risk (NCC, 2022).

The Red-backed Vole (*Myodes gapperi*) is a small, herbivorous mammal common across forested areas of Canada and the United States. They often consume vegetation, seeds, nuts and fungi, but will occasionally prey on soil invertebrates depending on food availability. They are an important prey item for larger carnivorous birds and mammals (BC Conservation Data Centre, 1993).

The Black Bear (*Ursus americanus*) is a large, omnivorous mammal, and can be found across almost the entirety of the North American continent. They can survive in a variety of habitat types, including both coniferous and deciduous forests and mountainous terrain. Their diet typically consists of plant materials (roots, berries, grass, succulents), fish, invertebrates, and meat, often of young deer, elk or moose (NWF, 2021b).

The Canada Lynx (*Lynx canadensis*) is a medium-sized carnivorous mammal found across Canada's boreal forests. The snowshoe hare composes the majority of the lynx's diet, particularly during the winter months. In summer, lynx will supplement their diet by preying on other small mammals and birds, such as grouse, voles, mice and squirrels. Lynx are resilient and well-adapted to living in areas close to human settlements (CWF, 2022).

5.1.2.7 Riparian Mammals

The Muskrat (*Ondatra zibethicus*) is a semi-aquatic herbivorous mammal well adapted to swimming. Muskrats can occur in high densities in suitable areas with appropriate food and shelter (i.e., cattail marshes). Muskrats are an important prey species of predatory birds and mammals (US EPA, 1993).

The American Mink (*Neovision vision*) is the most abundant carnivorous mammal in North America. They are mostly nocturnal hunters and are opportunistic feeders, preferring small mammals as their main prey, including muskrat. They are often found near aquatic habitats such as streams, rivers and lakes (US EPA, 1993).

5.1.2.8 Terrestrial Birds

The Bald Eagle (*Haliaeetus leucocephalus*) is a carnivorous terrestrial bird of prey. They are primarily carrion feeders, and will consume dead or dying prey species. Bald eagles are opportunistic feeders, scavenging different foods based on their availability and hunting easily-captured prey, such as fish, mammals, and other birds. Bald eagles generally are restricted to coastal areas, lakes, and rivers, although some may winter in areas not associated with water (US EPA, 1993).

The American Robin (*Turdus migratorius*) is a common, medium-sized terrestrial bird. They often consume worms, insects and fruit. They are found living in a variety of habitats, including woodlands, swamps, suburbs, and parks (US EPA, 1993).

The Olive-sided Flycatcher (*Contopus cooperi*) is a medium-sized songbird and aerial insectivore, consuming flying insects over both land and water. It is a migratory species, with approximately half of its breeding range across most of forested Canada, and the remainder in the western and northeastern United States. Olive-sided Flycatcher is a designated threatened species, largely due to its susceptibility to habitat loss, a decline in prey species (insects) from pesticide use, and climate change (COSEWIC, 2018).

The Canada Goose (*Branda canadensis*) is a common herbivorous bird, native to both Arctic and temperate regions of North America. They are a migratory bird species, and tend to overwinter in the United States. They often consume grass, seeds, berries and other terrestrial and aquatic plant materials as food. Canada geese tend to build their nests near water, and prefer secluded areas. They are highly adapted to living near humans and can be often found in parks and greenspaces in urban and suburban areas (ECCC, 2018).

5.1.2.9 Riparian Birds

The Mallard (*Anas platyrhynchos*) is an omnivorous waterfowl species, and primarily feeds on aquatic vegetation, seeds, acorns and grains, and occasionally on fish and other aquatic organisms. While common across North America, populations have experienced a marked declined in the last few decades, primarily due to habitat degradation and drought (US EPA, 1993).

The Lesser Scaup (*Aythya affinis*) is one of the most abundant North American ducks. Lesser scaup are found on larger lakes and bays during the fall and winter but are more common on smaller bodies of water (e.g., ponds) during the spring. Most populations of lesser scaup primarily consume aquatic invertebrates, but are known to consume aquatic plant materials (often seeds) as food availability changes seasonally (US EPA, 1993).

The Common Loon (*Gavia immer*) is a riparian bird that primarily feeds on fish and aquatic invertebrates, and to a lesser extent aquatic vegetation. They are well adapted to swimming and diving to catch and consume prey. Populations of common loon are generally considered to be stable across North America. They require clean and largely undisturbed freshwater lakes for their survival, and thus are potentially susceptible to pollution and human disturbances. Adult loons are occasionally preyed upon by larger raptors such as the bald eagle and osprey. Their eggs and chicks are an important food source for a variety of other birds, mammals and some predatory fish (NWF, 2021c).

5.1.3 Assessment and Measurement Endpoints

Assessment endpoints for the EcoRA are explicit expressions of the environmental values that are to be protected (FCSAP, 2012). Assessment endpoints for the EcoRA should include the ecological receptor and the attribute of the ecological receptor that is to be protected (e.g., abundance, viability of the population) (FCSAP, 2012). The EcoRA assessment endpoints to be evaluated are presented in Table 5-4.

Measurement endpoints for the EcoRA are conceptually related to assessment endpoints and are defined as the specific measures that would be used to judge potential for effect on the attribute of an assessment endpoint (e.g., if we predict an effect on organism growth or reproduction, we can infer a potential for effect on abundance). Measurement endpoints for the EcoRA may include endpoints such as survival, growth, or reproduction. Measurement endpoints for the EcoRA are the foundation for the lines of evidence that are used to estimate risks to ecological receptors (FCSAP, 2012).

In this EcoRA, the assessment endpoints are at the population or community level; however, for species at risk, the assessment endpoint is at the individual level. While exposure and risk estimates always pertain to individuals, for most receptors, when effects on individuals are predicted from constituent levels in a certain location, further discussion of population or community effects (or lack thereof) is appropriate. For species at risk, it is considered that effects on even a single individual represent an effect on the population.

Table 5-4: Assessment Endpoints, Measurement Endpoints, and Lines of Evidence

Ecological Receptor	Level of Protection	Protection Goal	Assessment Endpoint	Lines of Evidence	
				Line of Evidence	Measurement Endpoints and their Interpretation
Fish	Population	Maintenance of fish populations as a source of food for piscivorous fish and wildlife.	Viability of fish populations.	Water chemistry	COPC concentrations in water. Compare to toxicological reference values (low-effect threshold concentrations) for effect on survival, growth, or reproduction.
				Radiological dose	Compare estimated doses of COPCs to growth, survival, and reproduction benchmark values (low-effect threshold doses) relevant to the assessment endpoint.
Aquatic Vegetation	Population	Maintenance of aquatic plant populations as a source of food and cover for wildlife.	Viability of aquatic plant populations.	Water chemistry	COPC concentrations in water. Compare to toxicological reference values (low-effect threshold concentrations) for aquatic plants for effect on survival, growth, or reproduction.
				Radiological dose	Compare estimated doses of COPCs to growth, survival, and reproduction benchmark values (low-effect threshold doses) relevant to the assessment endpoint.

Ecological Receptor	Level of Protection	Protection Goal	Assessment Endpoint	Lines of Evidence	
				Line of Evidence	Measurement Endpoints and their Interpretation
Zooplankton	Community	Maintenance of a diverse zooplankton community as a source of food for fish.	Density, richness, and diversity of zooplankton community.	Water chemistry	COPC concentrations in water. Compare to toxicological reference values (low-effect threshold concentrations) for zooplankton for effect on survival, growth, or reproduction.
				Radiological dose	Compare estimated doses of COPCs to growth, survival, and reproduction benchmark values (low-effect threshold doses) relevant to the assessment endpoint.
Benthic Invertebrates	Community	Maintenance of a diverse benthic invertebrate community as a source of food for fish and wildlife.	Richness, diversity, abundance of benthic invertebrates.	Water chemistry	Compare COPC concentrations to water quality guidelines.
				Sediment chemistry	Compare COPC concentrations to sediment quality guidelines.
				Radiological dose	Compare estimated doses of COPCs to growth, survival, and reproduction benchmark values (low-effect threshold doses) relevant to the assessment endpoint.

Ecological Receptor	Level of Protection	Protection Goal	Assessment Endpoint	Lines of Evidence	
				Line of Evidence	Measurement Endpoints and their Interpretation
Riparian Birds	Population	Maintenance of riparian bird populations.	Viability of riparian bird populations.	Radiological and toxicological doses	Compare estimated doses of COPCs to growth, survival, and reproduction benchmark values (low-effect threshold doses) relevant to the assessment endpoint.
Riparian Mammals	Population	Maintenance of riparian mammal populations.	Viability of riparian mammal populations.	Radiological and toxicological doses	Compare estimated doses of COPCs to growth, survival, and reproduction benchmark values (low-effect threshold doses) relevant to the assessment endpoint.
Terrestrial Invertebrates	Population	Maintenance of terrestrial invertebrate population as a source of food for wildlife.	Viability of terrestrial invertebrate populations.	Soil chemistry	COPC concentrations in soil. Compare COPC concentrations to soil quality guidelines.
				Radiological dose	Compare estimated doses to growth, survival, and reproduction benchmark values (low-effect threshold doses) relevant to the assessment endpoint.
Terrestrial Plants	Population	Maintenance of terrestrial plant	Viability of terrestrial plant populations.	Soil chemistry	COPC concentrations in soil. Compare COPC concentrations to soil quality guidelines.

Ecological Receptor	Level of Protection	Protection Goal	Assessment Endpoint	Lines of Evidence	
				Line of Evidence	Measurement Endpoints and their Interpretation
		population as a source of food for wildlife.		Radiological dose	Compare estimated doses to growth, survival, and reproduction benchmark values (low-effect threshold doses) relevant to the assessment endpoint.
Terrestrial Birds	Population	Maintenance of terrestrial bird populations.	Viability of terrestrial bird populations.	Radiological and toxicological doses	Compare estimated doses of COPCs to growth, survival, and reproduction benchmark values (low-effect threshold doses) relevant to the assessment endpoint.
Terrestrial Mammals	Population	Maintenance of terrestrial mammal populations.	Viability of terrestrial mammal populations.	Radiological and toxicological doses	Compare estimated doses of COPCs to growth, survival, and reproduction benchmark values (low-effect threshold doses) relevant to the assessment endpoint.

Note:
For species at risk, protection is at the individual level, recognizing that effects on even a few individuals represent an effect on the population.
COPC = constituent of potential concern

5.1.4 Selection of Chemical, Radiological, and Other Stressors

The selection of COPCs retained for the EcoRA is presented in Section 3.0 of this report. Chloride and sulphate were identified as COPCs in the aquatic environment, but not in the terrestrial environment. The selection of chemical stressors to evaluate in the EcoRA followed a tiered screening approach to reduce the risk of overlooking any COPCs relevant to ecological health. The selection of COPCs in water was based on the assumption that the main source of aquatic release to Whitefish Lake Middle part will be from the effluent monitoring and release ponds during operation and decommissioning phases. The list of water COPCs is composed of constituents expected to potentially be operational issues or to result in changes to water quality in Whitefish Lake (LA-5) and the downstream environment.

The screening involved a conservative process of comparing the expected treated effluent quality against the selected water quality guidelines protective of ecological health (refer to Table 3-1 in Section 3.0).

No formal screening was conducted for radionuclides. However, since radiation dose to ecological receptors is of public and regulatory interest, the radionuclides in the uranium-238 decay series are carried forward as COPCs for further assessment.

No specific COPCs were identified in air; however, to be sure that exposures were not underestimated in the multi-media pathways analysis, evaluation of potential ecological risk via indirect exposures such as air to soil deposition, soil contact and exposure through the food chain was included for all COPCs identified in water. Exposure to constituents that may deposit from air to surface water was not considered, as that pathway is considered negligible according to CSA N288.1-20.

5.1.5 Selection of Exposure Pathways

Exposure pathways consider the various routes by which radionuclides and/or chemicals may enter the body of the receptor, or for radionuclides, may exert effects from outside the body. Exposures to environmental media may be direct (i.e., by contact) or indirect (i.e., via constituent transport through the food chain).

For each type of ecological receptor, Table 5-5 summarizes the relevant exposure pathways to various environmental media including air, surface water, soil, and sediment. Direct contact or uptake exposure pathways associated with groundwater are assumed to be incomplete, as it is assumed that groundwater is inaccessible to ecological receptors, or negligible relative to other pathways.

Airborne COPCs partition to soil and plants. For most COPCs, ingestion pathways dominate over inhalation and air immersion. The latter pathways are considered minor pathways in the EcoRA, but inhalation was included in the IMPACT model and is thus included in Table 5-5.

For fish, aquatic plants, and aquatic invertebrates, contact with water and constituent uptake from water via bioaccumulation represents the main exposure pathway. Direct contact or uptake from sediment are also considered for benthic invertebrates and bottom-feeding fish. Individual food chain transport pathways are not calculated by the IMPACT model for aquatic organisms because exposures for aquatic receptors are determined using bioaccumulation factors (BAFs) based on surface water concentrations; these BAFs represent all operable exposure pathways. The CSA N288.6-22 recommends the use of BAFs for the estimation of COPC concentrations in plant, invertebrate, and fish tissues based on concentrations in ambient media.

For soil invertebrates and terrestrial plants, the main exposure pathway is through contact with soil and constituent uptake from soil via bioaccumulation. Earthworms and plant roots may have the potential to be exposed to groundwater when groundwater levels are high; however, both earthworms and plants would only be exposed to groundwater occasionally as they do not reside in the saturated zone. Therefore, direct contact with groundwater (for soil invertebrates) and uptake of groundwater (for terrestrial plants) are not quantified in IMPACT.

The dominant exposure pathways for birds and mammals are expected to include uptake of constituents via the ingestion of water, direct contact with or incidental ingestion of soil and/or sediment, and ingestion of food/prey. Direct contact with surface water is also considered to be a complete exposure pathway for riparian mammals and birds.

Table 5-5: Complete Exposure Pathways for All Selected Ecological Receptors to be Assessed using the IMPACT Model

Category	Ecological Receptor	Exposure Pathways	Environmental Media
Terrestrial invertebrates	Terrestrial invertebrates	Direct contact	In Soil
Aquatic invertebrates	Benthic invertebrates	Uptake	In water On sediment
Zooplankton	Zooplankton	Direct contact	In water
Terrestrial plants	Lichen	Direct contact	Air
	Blueberry	Direct contact	In soil
	Labrador tea	Direct contact	In soil
Aquatic plants	Macrophytes	Direct contact	In water On sediment
	Phytoplankton	Direct contact	In water
Fish	Northern pike	Direct contact	In water
	White sucker	Direct contact	In water On sediment
Terrestrial mammals	Woodland caribou	Direct contact	On soil
		Inhalation	Air
		Ingestion	Water Soil

Category	Ecological Receptor	Exposure Pathways	Environmental Media
			Sediment Browse Lichen Macrophytes
	Snowshoe hare	Direct contact	On soil
		Inhalation	Air
		Ingestion	Water Soil Browse Blueberries
	Moose	Direct contact	On soil
		Inhalation	Air
		Ingestion	Water Soil Sediment Browse Macrophytes
	Red-backed vole	Direct contact	On soil
		Inhalation	Air
		Ingestion	Water Soil Browse Blueberries
	Black bear	Direct contact	On soil
		Inhalation	Air
		Ingestion	Water Soil Blueberries Fish (Northern pike)
	Canada lynx	Direct contact	On soil
		Inhalation	Air
		Ingestion	Water Soil Snowshoe hare Red-backed Vole Canada Goose
Riparian mammals	Muskrat	Direct contact	In water On sediment

Category	Ecological Receptor	Exposure Pathways	Environmental Media
		Inhalation	Air
		Ingestion	Water Sediment Benthic invertebrates Macrophytes
	American mink	Direct contact	In water On soil On sediment
		Inhalation	Air
		Ingestion	Water Soil Sediment Benthic invertebrates Muskrat Fish (Northern pike) Mallard
Terrestrial birds	Olive-sided flycatcher	Direct contact	On soil
		Inhalation	Air
		Ingestion	Water Soil Benthic invertebrates Soil invertebrates
	Bald eagle	Direct contact	On soil
		Inhalation	Air
		Ingestion	Water Soil Fish (Northern pike) Mallard
	American robin	Direct contact	On soil
		Inhalation	Air
		Ingestion	Water Soil Soil invertebrates Blueberries
	Canada goose	Direct contact	On soil
		Inhalation	Air
		Ingestion	Water Soil Browse

Category	Ecological Receptor	Exposure Pathways	Environmental Media
Riparian birds	Lesser scaup	Direct contact	In water On sediment
		Inhalation	Air
		Ingestion	Water Sediment Benthic invertebrates Macrophytes
	Mallard	Direct contact	In water On sediment
		Inhalation	Air
		Ingestion	Water Sediment Benthic invertebrates Macrophytes
	Common loon	Direct contact	In water
		Inhalation	Air
		Ingestion	Water Benthic invertebrates Fish (Northern pike)

5.1.6 Ecological Health Conceptual Model

The ecological conceptual site model (CSM) illustrates how receptors are exposed to COPCs. It identifies the source of constituents, constituent transport mechanisms, environmental media, and the exposure pathways to be considered in the assessment for each receptor. Exposure pathways represent the various routes by which radionuclides and/or chemicals may enter the body of the receptor, or (for radionuclides) how they may exert effects from outside the body.

The conceptual site model for the EcoRA is illustrated below in Figure 5-1.

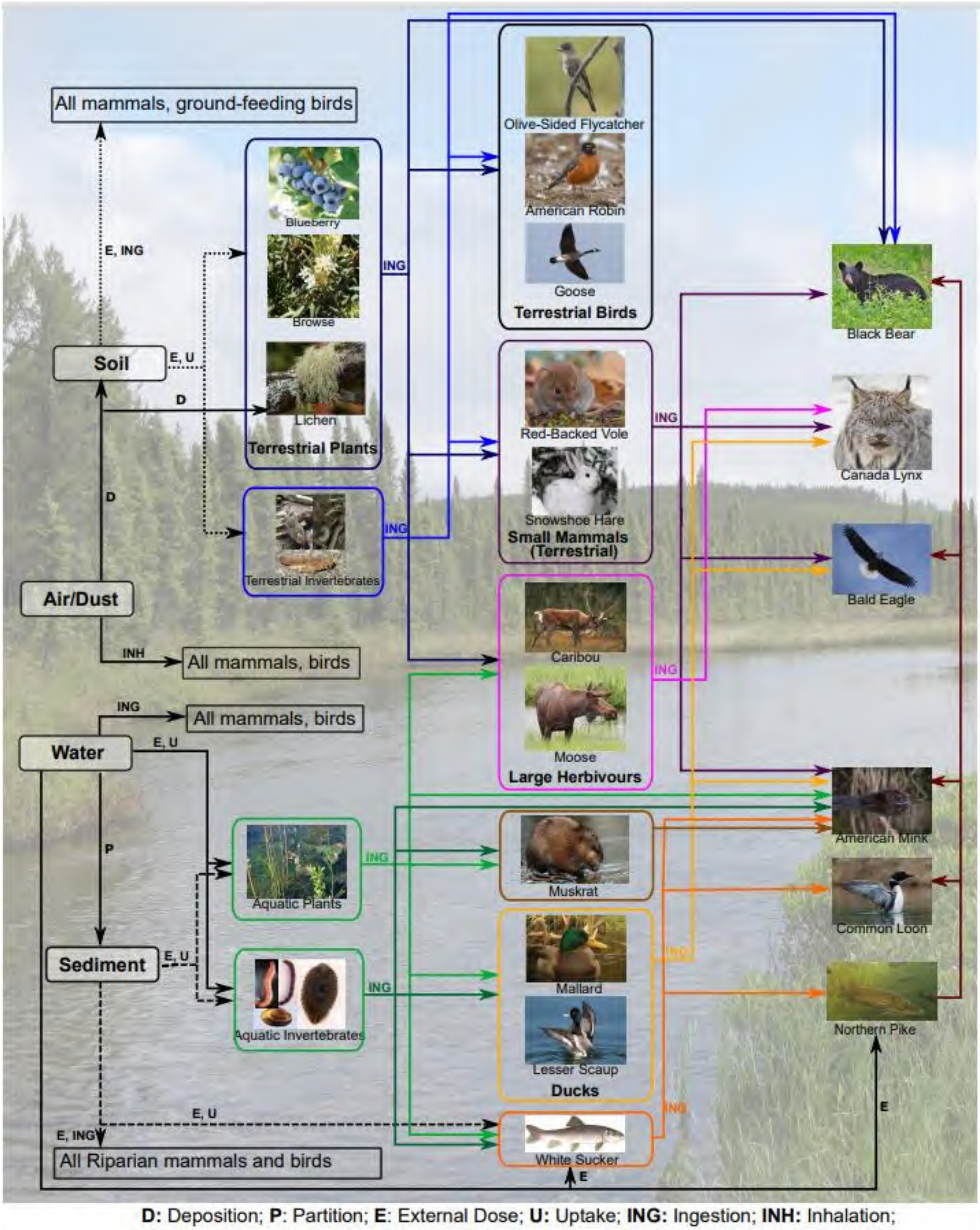


Figure 5-1: Ecological CSM for the Wheeler River Project

5.2 Exposure Assessment

The exposure assessment includes identification of exposure locations and exposure factors for each receptor, explanation of dispersion models, and presentation of exposure concentrations and doses (radiological and non-radiological). Uncertainties are discussed. This section presents the information used in the IMPACT model at a high-level; however, the details of the model will be included in Appendix A to the ERA.

5.2.1 Exposure Locations

The conceptual model assumes that all terrestrial and aquatic receptors are present at Whitefish Lake (LA-5 North), McGowan Lake (LA-1) and the inlet to Russell Lake (Figure 5-2). All terrestrial and aquatic receptors were also assumed to be at Kratchkowsky Lake, which was chosen as a reference location. Separate exposure values were estimated for each receptor in the locations where they were assumed to be present.

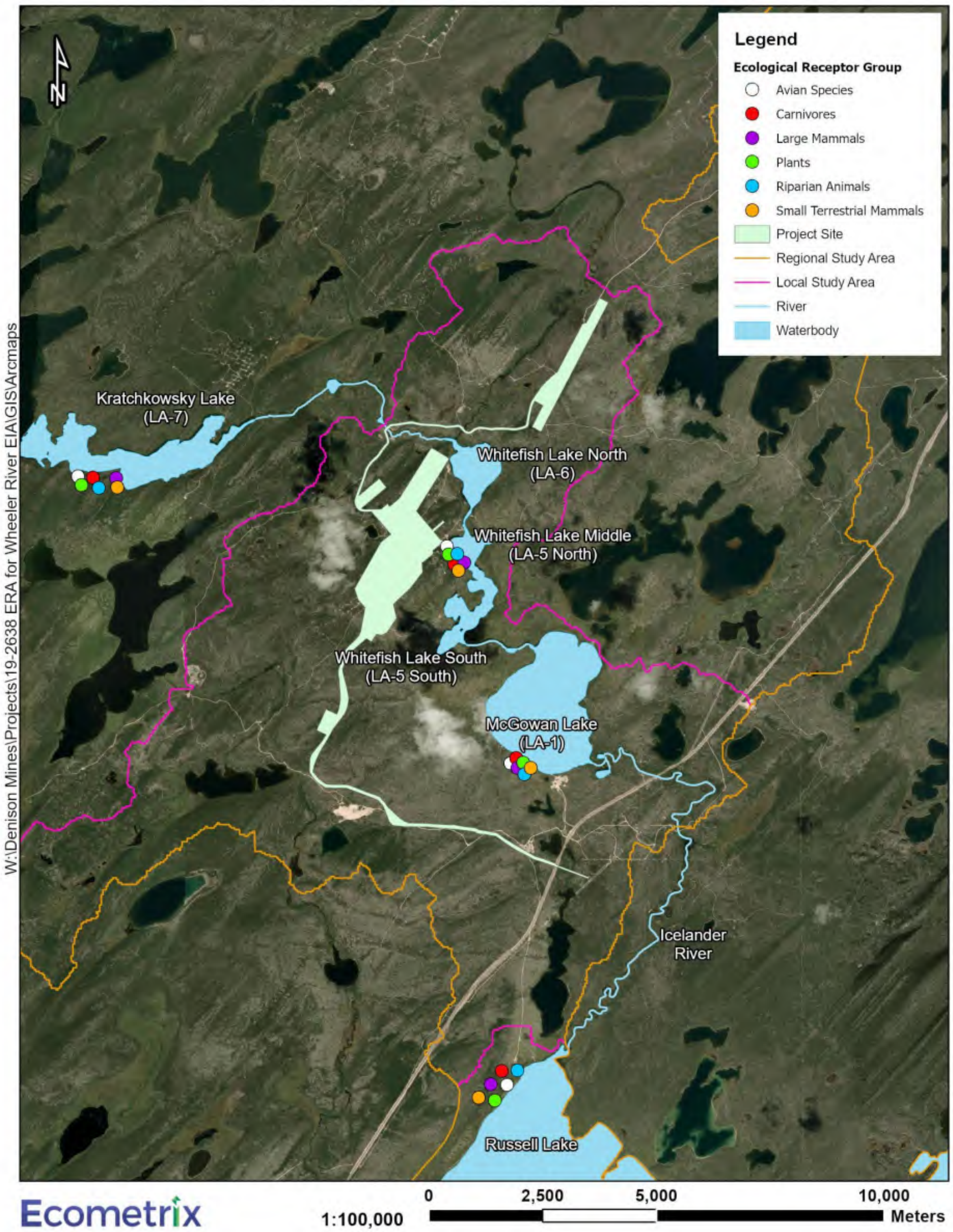


Figure 5-2: Locations of Ecological Receptors Assessed in the Ecological Risk Assessment

5.2.2 Exposure Averaging

Most ecological receptors were assessed assuming 100% residency at the exposure point location. This was the case for aquatic biota, immobile terrestrial biota such as plants and soil invertebrates, and mobile terrestrial mammals and birds that have small home ranges. This assumption was also applied to migratory ecological receptors, such as waterfowl and passerine birds, that spend part of the year away from the LSA and RSA, or ecological receptors that have a small home range while nesting or rearing young. For instance, mallards are not present in the LSA and RSA for over half the year due to migration, but have a small home range during the nesting and rearing season. Therefore, it was conservatively assumed that the mallard has a 100% residency factor on one lake where the young are hatched and reared. Similarly, moose have large annual home ranges but generally remain within small seasonal home ranges of 5 km^2 to 10 km^2 during the summer and winter. For modelling purposes, these animals were associated with one location.

Animals with large home ranges (i.e., greater than 10 km^2), such as the woodland caribou, black bear and bald eagle, interact with several different exposed polygon locations for feeding and water intake. All other receptors have relatively small home ranges (i.e., less than 10 km^2) and were assumed to reside in the same polygon year-round. For modelling purposes, the large home range animals were associated with a central location but with residency factors applied to other adjacent locations depending on the size of their home range. In some cases, a portion of their time in the LSA or RSA may be attributed to time spent at unexposed (reference) locations. For example, due to its large home range of 314 km^2, the bald eagle located near Whitefish Lake was assumed to spend 12.2% of its time at exposed locations and 87.8% of its time at unexposed locations. Further details are provided in Appendix A. The residency assumptions for ecological receptors with large home ranges are summarized in Table 5-6.

Table 5-6: Residency Factors for Terrestrial Ecological Receptors with Potentially Larger Home Ranges

Ecological Receptors	Home Polygon	Waterbody Surface Area (ha)	Total Waterbody Surface Area (ha)	Residency Factor	Water and Feed Source Polygon
Woodland Caribou	LA-7 South	323	323	1	LA-7 South
	LA-5	59	1111	0.06	LA-5
		149		0.13	LA-1
		512		0.46	Russell Lake
		392		0.35	Unexposed Locations
Moose	LA-7 South	-	-	1	LA-7 South
	LA-5	-	-	1	LA-5
	LA-1	-	-	1	LA-1
	Russell Lake	-	-	1	Russell Lake
Black Bear	LA-7 South	323	323	1	LA-7 South
	LA-5	59	1111	0.06	LA-5
		149		0.13	LA-1

Ecological Receptors	Home Polygon	Waterbody Surface Area (ha)	Total Waterbody Surface Area (ha)	Residency Factor	Water and Feed Source Polygon
		512		0.46	Russell Lake
		392		0.35	Unexposed Locations
Mink	LA-7 South	-	-	1	LA-7 South
	LA-5			1	LA-5
	LA-1	-	-	1	LA-1
	Russell Lake	-	-	1	Russell Lake
Bald Eagle	LA-7 South	323	323	1	LA-7 South
	LA-5	59	5872	0.010	LA-5
		149		0.025	LA-1
		512		0.087	Russell Lake
		5153		0.878	Unexposed Locations

5.2.3 Exposure and Dose Calculations

Exposure and dose calculations for ecological receptors were completed using IMPACT version 5.6.0. IMPACT is consistent with the COPC transport equations outlined in CSA N288.1-20 and with the methods of biota dose calculation outlined in CSA N288.6-22 for both non-radiological and radiological COPCs. The equations are presented in Appendix A.

Assessment of radiation exposures to ecological receptors is commonly based on estimation of the effects of the project or site. Assessments consider the radiation dose received from external exposure to radiation as well as the dose received from inhalation and ingestion of radionuclides. The radionuclide intake by ecological receptors from various pathways is converted into a dose that is presented in milligrays per day (mGy/d). The dose for each radionuclide is comprised of an internal dose component, and an external dose component, which is driven by water and sediment.

Assessment of non-radiological exposures to ecological receptors considers the dose received from ingestion of COPCs. This is presented as a dose in mg/kg/d for each pathway. Inhalation for non-radionuclides is not included as no non-radiological air COPCs were identified for further assessment. Additionally, this is consistent with guidance in CSA N288.6-22 which indicates that inhalation exposure is usually minor compared to soil and food ingestion.

The inputs and assumptions used in the IMPACT model for the Project, including receptor characteristics, exposure pathways, and the derivation and identification of site-specific information used in the model are provided in Appendix A. Relevant to the exposure and dose calculations, the IMPACT model report:

- describes the model structure for ecological receptor assessment, specific assumptions made for the Project, and the generic equations used to calculate the transfer of constituents between environmental media and the receptors; and
- presents the development of input parameters and describes the approach used for calibration and validation based on regional monitoring data.

5.2.4 Exposure Factors

Exposure estimates rely on several COPC- and biota-specific exposure factors for the dose calculations. These parameters include body weights and intake rates as well as occupancy factors (OFs), DCFs, BAFs, and transfer factors (TFs).

5.2.4.1 Body Weights and Intake Rates for Ecological Receptors

The body weight and intake rates are required for the calculation of exposure to birds and mammals (Table 5-7). Body weights and intake rates were obtained, in order of preference, from CSA N288.1-20, the US Environmental Protection Agency (USEPA) *Wildlife Exposure Factors Handbook* (US EPA, 1993), and the Federal Contaminated Sites Action Plan *Module 3: Standardization of Wildlife Receptor Characteristics* (FCSAP, 2012). For species not represented in the above sources, additional sources as identified in Table 5-7 were consulted to identify representative body weights, and then feed intake rates were calculated using allometric equations from the USEPA (1993).

Water intake and inhalation rates were determined using allometric equations from the USEPA (1993) for birds and mammals. The incidental ingestion of soil and/or sediment was estimated from feed intake. Incidental ingestion varied from 2% to 10.4% of food intake as dry weight, depending on the biota (Beyer et al., 1994). However, no incidental soil or sediment ingestion was assumed for the common loon, which feeds from the water column.

Table 5-7: Bird and Mammal Body Weights and Intake Rates

Receptor	Body Weight		Total Feed Intake				Dietary Components	Feed Type Fraction		Feed Intake Rate		Dry Weight Fraction [g]	IMPACT Intake Group	Feed Intake by Group		Intake of Soil [m]	Intake of Sediment [m]	Intake of Soil & Sediment [j]	Basis of the Soil and Sediment Intake Value	Total Soil/ Sediment Intake [k]	Water Intake [l]	Inhalation Rate	
	kg	Source	kg dw/d	Source	kg fw/d	Source		fw	dw	kg dw/d	kg fw/d	unitless		kg dw/d	kg fw/d	%	%	%		kg dw/d	L/d	m^3/d	source
Woodland Caribou	180.0	e	3.817	l	11.327	-	Browse	0.50	0.30	1.133	5.664	0.20	Terrestrial Plants	2.968	7.929	5.3	1.5	6.8	Bison	0.260	10.602	34.774	l
							Lichen	0.20	0.48	1.835	2.265	0.81											
							Macrophytes	0.30	0.22	0.850	3.398	0.25	Aquatic Plants	0.850	3.398								
Snowshoe Hare	1.8	c	0.110	c	0.475	-	Browse	0.90	0.78	0.086	0.428	0.20	Terrestrial Plants	0.110	0.475	3.7	0	3.7	Average of small mammals	0.004	0.168	0.900	c,l
							Berries (Blueberry)	0.10	0.22	0.024	0.048	0.52											
Moose	400.0	b	8.000	b	38.095	-	Browse	0.80	0.76	6.095	30.476	0.20	Terrestrial Plants	6.095	30.476	1.5	0.5	2.0	Moose	0.160	21.751	65.869	l
							Macrophytes	0.20	0.24	1.905	7.619	0.25	Aquatic Plants	1.905	7.619								
Southern Red-Backed Vole	0.03	a, i	0.004	-	0.012	a, i	Berries (Blueberry)	0.60	0.79	0.004	0.007	0.52	Terrestrial Plants	0.004	0.012	2.4	0	2.4	Meadow vole	0.0001	0.005	0.048	a
							Browse	0.40	0.21	0.001	0.005	0.20											
Black Bear	102.5	f	3.075	b	7.053	-	Berries (Blueberry)	0.70	0.83	2.546	4.937	0.52	Terrestrial Plants	2.546	4.937	2.9	0	2.9	Average of large mammals	0.090	6.387	22.162	l
							Fish (Northern Pike)	0.30	0.17	0.529	2.116	0.25	Aquatic Animals	0.529	2.116								
Canada Lynx	14.0	n	0.601	l	2.038	-	Showshoe hare	0.80	0.81	0.489	1.630	0.30	Terrestrial Animals	0.601	2.038	2.8	0	2.8	Red fox	0.017	1.065	4.508	l
							Small Mammals (represented by Vole)	0.15	0.14	0.082	0.306	0.27											
							Terrestrial Birds (Goose)	0.05	0.05	0.031	0.102	0.30											
Muskrat	1.2	a	0.088	-	0.352	a	Macrophytes	0.80	0.80	0.070	0.282	0.25	Aquatic Plants	0.070	0.282	0	3.3	3.3	Mallard	0.003	0.114	0.590	a
							Benthic Invertebrates	0.20	0.20	0.018	0.070	0.25	Aquatic Animals	0.018	0.070								
Mink	1.0	a	0.045	-	0.161	a	Fish (Northern Pike)	0.30	0.27	0.012	0.048	0.25	Aquatic Animals	0.018	0.072	2.6	0.4	3.1	Average of mallard and Lynx	0.001	0.101	0.440	a
							Benthic Invertebrates	0.15	0.14	0.006	0.024	0.25											
							Small Mammals (Muskrat)	0.45	0.49	0.022	0.072	0.30	Terrestrial Animals	0.026	0.088								
							Birds (Mallard)	0.10	0.11	0.005	0.016	0.30											
Canada Goose	3.7	c	0.023	-	0.115	a	Browse	1.00	1.00	0.023	0.115	0.20	Terrestrial Plants	0.023	0.115	8.2	0	8.2	Canada goose	0.002	0.142	0.082	c
Olive-Sided Flycatcher	0.03	d	0.008	-			Soil Invertebrates (Earthworms)	0.90	0.86	0.007	0.039	0.17	Terrestrial Plants	0.007	0.039	8.9	1.5	10.4	American woodcock	0.001	0.006	0.058	l
							Benthic Invertebrates	0.10	0.14	0.001	0.004	0.25	Aquatic Animals	0.001	0.004								
Bald Eagle	5.8	a		-	0.691	a	Fish (Northern Pike)	0.80	0.77	0.138	0.553	0.25	Aquatic Animals	0.138	0.553	9.3	0	9.3	Wild turkey	0.051	0.191	1.310	a
							Riparian birds (Mallard)	0.20	0.23	0.041	0.138	0.30	Terrestrial Animals	0.041	0.138								
American Robin	0.1	a			0.202	a, h	Fruit (Berries)	0.60	0.82	0.062	0.121	0.52	Terrestrial Plants	0.076	0.202	10.4	0	10.4	American woodcock	0.008	0.013	0.142	l
							Soil Invertebrates (Earthworms)	0.40	0.18	0.014	0.081	0.17											
Lesser Scaup	0.8	a	0.063	a			Benthic Invertebrates	0.90	0.90	0.056	0.226	0.25	Aquatic Animals	0.056	0.226	0	3.3	3.3	Mallard	0.002	0.051	0.350	a
							Macrophytes	0.10	0.10	0.006	0.025	0.25	Aquatic Plants	0.006	0.250								
Mallard	1.1	c	0.060	c	0.240	-	Macrophytes	0.25	0.25	0.015	0.060	0.25	Aquatic Plants	0.015	0.060	0	3.3	3.3	Mallard	0.002	0.064	0.020	c
							Benthic Invertebrates	0.75	0.75	0.045	0.180	0.25	Aquatic Animals	0.045	0.180								
Common Loon	5.3	b	0.159	b	0.636	-	Fish (Northern Pike)	0.90	0.90	0.143	0.572	0.25	Aquatic Animals	0.159	0.636	0	0	0	negligible	0	0.180	1.477	l
							Benthic Invertebrates	0.10	0.10	0.016	0.064	0.25											

Notes:

[a] USEPA (1993). Body weights, ingestion rates and inhalation rates of adults or all groups (adults and juveniles) are an average of the listed values. If only a range is given, the upper limit of the range is used. Values for the southern red-backed vole was based on the meadow vole

[b] FCSAP Ecological Risk Assessment Guidance, Module 3: Standardization of Wildlife Receptor Characteristics (March 2012)

[c] CSA Standard N288.1-20 (March 2020), Clause 7.7.4.2, and Table A.5d

[d] Environment Canada. 2015. Recovery Strategy for Olive-sided Flycatcher (*Contopus cooperi*) in Canada; average for adult male/female weight range of 31 to 34 g.

[e] COSEWIC Assessment and Update Status Report on the Woodland Caribou (2002). Body weight calculated as a mean of the male and female upper range.

[f] Hinterland Who's Who. 2007. Average of males and females from http://www.hww.ca/en/wildlife/mammals/black-bear.html

[g] Moisture/dry weight fraction values are based on Beresford *et al,* 2008 (soil invertebrate - assume earthworm); Omnia 2019 (blueberries, lichen and small mammal - assuming vole); and CSA Standard N288.1-20 (all other receptors). The blueberry value is based on the fruit only.

[h] The total feed intake for the American Robin was used in the absence of a species-specific value.

[i] The body weight and total feed intake for the Meadow Vole was used in the absence of a species-specific value.

[j] Beyer *et al* , 1994

[k] Intake of Soil & Sediment (kg dw/d) = Total Feed Intake (kg dw/d) x Intake of Soil & Sediment (%)/100.

[l] Calculated using allometric equations in USEPA (1993)

[m] The % intake of soil or sediment is calculated from the combined % intake of soil and sediment, weighted to the relative proportions of terrestrial vs. aquatic dietary components for each receptor, based on the following equations.
Intake of Soil (%) = Total Intake of Soil & Sediment (%) x Feed Type Fraction Terrestrial. Intake of Sediment (%) = Total Intake of Soil & Sediment (%) x Feed Type Fraction Aquatic.

[n] U.S.FWS (Fish and Wildlife Service), 2017. Species Status Assessment for the Canada Lynx (Lynxcanadensis), Contiguous United States Distinct Population Segment. Version 1.0 - Final, October 2017. Lakewood, Colorado.

fw = fresh weight; dw = dry weight

5.2.4.2 Occupancy Factors, Dose Coefficients, Bioaccumulation Factors, and Transfer Factors

Short descriptions of the role of OFs, DCFs, BAFs, and TFs are provided in Table 5-8. Additional details and the numeric factors are presented in Appendix A.

Table 5-8: Exposure Factors Used in the IMPACT Model for the Wheeler River ERA

Exposure Factor	Description	Appendix A
OFs	An OF is defined as the fraction of time the receptor species spends in or on various media. The OFs are based on the experience and judgment of the risk assessor and the known behaviour of the receptor. The OFs for air, soil/sediment, soil/sediment surface, and water were used in the model.	Section 2.3.3.2, Occupancy Factor
DCFs	The DCFs represent the dose-equivalent rate per unit concentration of a radionuclide in the environment (or tissue) for a particular mode of exposure. The model used DCFs for external and internal exposures to radionuclides. Aquatic DCFs were based on values published by the ICRP for aquatic plants and northern pike (ICRP 2008), and were calculated with the ERICA Tool (Brown et al. 2008) for benthic invertebrates, zooplankton, and whitefish DCFs. Terrestrial plant and invertebrate DCFs were based on values published by the ICRP (ICRP 2008). Terrestrial animal DCFs follow the approach of ICRP (ICRP 2008).	Section 3.6.3, Dose Coefficients for Aquatic Receptors Section 3.7.3, Dose Coefficients for Terrestrial Plants and Invertebrates Section 3.7.6, Dose Coefficients for Terrestrial Animals, Birds, and Humans
TFs and BAFs	The TFs are the ratio of concentration in an animal to the animal's daily intake of a COPC. BAFs are the ratio of concentration in an organism to the concentration in an environmental medium. The TFs and BAFs are generally COPC- and biota-specific. Aquatic BAFs were generally obtained from CSA N288.1-20 and IAEA (2010), and from publicly available regional data from other uranium mine sites in northern Saskatchewan. The soil-to-plant BAFs were derived from regional data from Northern Saskatchewan. An allometric equation (transfer proportional to a -3/4 power of body weight) (CSA N288.6-22) was applied to transfer factors available for beef and poultry from CSA N288.1-20, IAEA (2010), or NCRP (1996) to estimate the	Section 3.6.1, Aquatic Bioaccumulation Factors Section 3.7.1, Soil-to-Plant Transfer Section 3.7.4, Ingestion Transfer Factors for Terrestrial Receptors Section 3.7.5, Inhalation Transfer Factors for Terrestrial Receptors

Exposure Factor	Description	Appendix A
	ingestion transfer factors for the mammal and bird receptors, respectively. Inhalation TFs for terrestrial receptors were calculated from the ingestion transfer factor by adjusting the ingestion transfer factor by a COPC-specific inhalation/ingestion ratio (II) from CSA N288.1-20.	

IAEA = International Atomic Energy Agency; BAF = bioaccumulation factor; OF = occupancy factor; TF = transfer factor; DCF = dose coefficient factor; NCRP = National Council on Radiation Protection and Measurements; ICRP = International Commission on Radiological Protection; CSA = Canadian Standards Association; COPC = constituent of potential concern.

5.2.5 Exposure Point Concentrations and Doses

This subsection presents the estimated non-radiological and radiological doses to aquatic and terrestrial ecological receptors due to releases from the Project during all phases of the Project. The results are presented as a total dose which includes both baseline and Project contributions. While non-radiological and radiological doses were predicted in IMPACT over the life of the Project, the maximum doses are represented in this section. The estimated non-radiological and radiological concentrations in environmental media and biota tissue concentrations are shown in Appendix B.

5.2.5.1 Non-radiological Dose

Non-radiological dose was only calculated for birds and mammals, as effects to aquatic animals (fish and invertebrates) and plants and soil invertebrates are assessed based on concentrations and not doses.

The estimated non-radiological doses to the selected birds and mammals during the Project phases are shown by COPC in Table 5-9. The doses shown represent the maximum dose by COPC over the assessment period, which is during the operation phase for the Project. The results are presented as a total dose which includes both baseline and Project contributions. The non-radiological dose to birds and mammals during the future centuries is also shown in Table 5-9.

Table 5-9: Estimated Non-radiological Project Total Doses to Ecological Receptors – Project Phases and Future Centuries

Biota		Location	Maximum Non-radiological Dose During Project Phases (mg/kg/d)											
			As	Cd	Cl-	Co	Cr	Cu	Mo	SO4	Se	U	V	Zn
			Arsenic	Cadmium	Chloride	Cobalt	Chromium	Copper	Molybdenum	Sulphate	Selenium	Uranium	Vanadium	Zinc
Terrestrial Animals	Black Bear	Reference (Kratchkowsky Lake)	4.84E-03	5.32E-04	2.01E-02	2.27E-03	3.90E-03	1.47E-01	1.75E-03	4.28E-02	5.43E-03	1.20E-03	4.72E-03	3.69E-01
		Whitefish Lake	4.86E-03	5.33E-04	1.57E-01	2.27E-03	3.97E-03	1.48E-01	2.32E-03	9.39E-01	1.52E-02	2.07E-03	4.89E-03	3.73E-01
	Canada Lynx	Reference (Kratchkowsky Lake)	1.61E-02	2.50E-03	2.44E-02	5.64E-04	6.54E-03	3.38E-01	5.49E-04	5.20E-02	2.87E-02	5.81E-04	1.02E-02	1.43E+01
		Whitefish Lake	1.62E-02	2.50E-03	4.65E-01	5.70E-04	6.64E-03	3.48E-01	2.43E-03	2.93E+00	2.91E-02	6.46E-03	1.04E-02	1.43E+01
		McGowan Lake	1.61E-02	2.50E-03	3.18E-01	5.66E-04	6.56E-03	3.39E-01	1.76E-03	1.97E+00	2.88E-02	1.37E-03	1.02E-02	1.43E+01
		Russell Lake Inlet	1.61E-02	2.50E-03	2.47E-01	5.65E-04	6.55E-03	3.38E-01	1.46E-03	1.51E+00	2.88E-02	8.02E-04	1.02E-02	1.43E+01
	Mink	Reference (Kratchkowsky Lake)	1.05E-02	7.71E-04	3.25E-02	1.04E-03	1.37E-02	1.46E-01	6.42E-04	6.81E-02	1.44E-02	7.02E-04	1.39E-02	3.17E-01
		Whitefish Lake	1.33E-02	9.39E-04	6.18E-01	1.20E-03	1.68E-02	1.83E-01	8.68E-02	3.83E+00	1.26E-01	6.74E-03	3.43E-02	4.62E-01
		McGowan Lake	1.16E-02	8.80E-04	4.23E-01	1.15E-03	1.57E-02	1.72E-01	6.23E-02	2.58E+00	8.23E-02	3.00E-03	2.19E-02	4.01E-01
		Russell Lake Inlet	1.11E-02	8.51E-04	3.29E-01	1.12E-03	1.52E-02	1.66E-01	4.74E-02	1.97E+00	6.45E-02	2.20E-03	1.89E-02	3.77E-01
	Moose	Reference (Kratchkowsky Lake)	2.47E-03	1.06E-03	1.78E-02	1.18E-03	1.84E-03	5.89E-02	7.36E-04	3.75E-02	5.98E-04	6.51E-04	4.20E-03	1.68E-01
		Whitefish Lake	2.82E-03	1.10E-03	3.40E-01	1.28E-03	2.08E-03	6.12E-02	1.06E-02	2.11E+00	2.44E-03	1.80E-02	9.84E-03	1.73E-01
		McGowan Lake	2.60E-03	1.08E-03	2.33E-01	1.24E-03	1.98E-03	5.96E-02	7.49E-03	1.42E+00	1.67E-03	3.48E-03	6.25E-03	1.70E-01
		Russell Lake Inlet	2.55E-03	1.08E-03	1.81E-01	1.22E-03	1.95E-03	5.94E-02	5.84E-03	1.08E+00	1.37E-03	1.73E-03	5.49E-03	1.70E-01
	Moose Organs	Reference (Kratchkowsky Lake)	2.47E-03	1.06E-03	1.78E-02	1.18E-03	1.84E-03	5.89E-02	7.36E-04	3.75E-02	5.98E-04	6.51E-04	4.20E-03	1.68E-01
		McGowan Lake	2.60E-03	1.08E-03	2.33E-01	1.24E-03	1.98E-03	5.96E-02	7.49E-03	1.42E+00	1.67E-03	3.48E-03	6.25E-03	1.70E-01
		Russell Lake Inlet	2.55E-03	1.08E-03	1.81E-01	1.22E-03	1.95E-03	5.94E-02	5.84E-03	1.08E+00	1.37E-03	1.73E-03	5.49E-03	1.70E-01
	Muskrat	Reference (Kratchkowsky Lake)	2.56E-02	1.21E-03	3.84E-02	4.50E-03	1.59E-02	3.72E-02	1.02E-03	6.70E-02	2.98E-03	1.81E-03	4.09E-02	1.20E-01
		Whitefish Lake	3.34E-02	1.86E-03	7.31E-01	5.67E-03	2.07E-02	4.88E-02	1.84E-01	3.77E+00	3.21E-02	2.48E-02	1.45E-01	1.78E-01
		McGowan Lake	2.87E-02	1.62E-03	5.00E-01	5.26E-03	1.91E-02	4.47E-02	1.29E-01	2.54E+00	2.03E-02	1.60E-02	8.07E-02	1.53E-01
		Russell Lake Inlet	2.75E-02	1.51E-03	3.89E-01	5.06E-03	1.82E-02	4.28E-02	9.81E-02	1.94E+00	1.55E-02	1.21E-02	6.61E-02	1.43E-01
	Snowshoe Hare	Reference (Kratchkowsky Lake)	6.76E-03	3.71E-03	3.04E-02	4.09E-03	8.23E-03	2.53E-01	3.19E-03	6.49E-02	2.24E-03	2.73E-03	1.30E-02	6.87E-01
		Whitefish Lake	6.78E-03	3.72E-03	5.80E-01	4.13E-03	8.31E-03	2.60E-01	5.51E-03	3.65E+00	2.30E-03	5.98E-02	1.32E-02	6.89E-01
		McGowan Lake	6.76E-03	3.71E-03	3.97E-01	4.09E-03	8.25E-03	2.54E-01	4.67E-03	2.46E+00	2.27E-03	1.02E-02	1.30E-02	6.88E-01
		Russell Lake Inlet	6.76E-03	3.71E-03	3.08E-01	4.09E-03	8.24E-03	2.53E-01	4.30E-03	1.88E+00	2.26E-03	4.75E-03	1.30E-02	6.87E-01
	Southern Red-Backed Vole	Reference (Kratchkowsky Lake)	1.58E-01	2.40E-02	4.49E-02	9.13E-02	2.70E-02	6.31E+00	7.48E-02	9.57E-02	6.19E-02	4.17E-02	3.16E-02	1.56E+01
		Whitefish Lake	1.58E-01	2.40E-02	8.55E-01	9.18E-02	2.73E-02	6.52E+00	7.87E-02	5.38E+00	6.23E-02	5.43E-01	3.23E-02	1.57E+01
		McGowan Lake	1.58E-01	2.40E-02	5.85E-01	9.13E-02	2.70E-02	6.33E+00	7.70E-02	3.62E+00	6.20E-02	1.08E-01	3.17E-02	1.56E+01
		Russell Lake Inlet	1.58E-01	2.40E-02	4.54E-01	9.13E-02	2.70E-02	6.31E+00	7.65E-02	2.77E+00	6.19E-02	5.93E-02	3.17E-02	1.56E+01
	WoodLand Caribou	Reference (Kratchkowsky Lake)	5.33E-03	1.60E-03	1.99E-02	2.17E-03	2.09E-02	4.10E-02	1.35E-03	4.05E-02	1.53E-03	1.74E-03	1.70E-02	2.12E-01
		Whitefish Lake	5.55E-03	1.63E-03	1.56E-01	2.22E-03	2.12E-02	4.24E-02	1.04E-02	8.87E-01	2.52E-03	5.15E-02	1.96E-02	2.14E-01
	Canada Goose	Reference (Kratchkowsky Lake)	7.66E-04	5.49E-04	1.24E-02	4.51E-04	1.78E-03	2.35E-02	3.28E-04	2.64E-02	2.16E-04	3.80E-04	2.73E-03	6.71E-02
		Whitefish Lake	7.63E-04	5.49E-04	0.00E+00	4.51E-04	1.77E-03	2.41E-02	3.27E-04	0.00E+00	2.16E-04	7.94E-03	2.74E-03	6.72E-02
		McGowan Lake	7.66E-04	5.49E-04	1.61E-01	4.52E-04	1.78E-03	2.35E-02	9.29E-04	9.99E-01	2.25E-04	1.38E-03	2.74E-03	6.71E-02
		Russell Lake Inlet	7.66E-04	5.49E-04	1.25E-01	4.52E-04	1.78E-03	2.35E-02	7.78E-04	7.63E-01	2.22E-04	6.53E-04	2.74E-03	6.71E-02
	Bald Eagle	Reference (Kratchkowsky Lake)	1.01E-02	3.34E-03	1.07E-02	2.67E-03	3.40E-02	6.28E-02	1.05E-03	2.28E-02	2.18E-02	3.52E-03	4.53E-02	1.91E-01
		Whitefish Lake	1.01E-02	3.34E-03	2.43E-02	2.67E-03	3.40E-02	6.36E-02	1.45E-03	1.12E-01	3.07E-02	3.98E-03	4.55E-02	1.95E-01
	Olive-Sided Flycatcher	Reference (Kratchkowsky Lake)	2.82E-02	1.72E-01	5.95E-02	1.27E-02	1.34E-01	1.02E+00	1.53E-02	1.27E-01	4.15E-02	1.28E-02	1.25E-01	2.35E+00
		Whitefish Lake	3.01E-02	1.73E-01	0.00E+00	1.33E-02	1.41E-01	1.17E+00	3.72E-01	0.00E+00	7.37E-02	2.75E-01	1.40E-01	2.49E+00
		McGowan Lake	2.90E-02	1.72E-01	7.76E-01	1.31E-02	1.39E-01	1.12E+00	2.74E-01	4.81E+00	6.19E-02	4.93E-02	1.31E-01	2.44E+00
		Russell Lake Inlet	2.87E-02	1.72E-01	6.02E-01	1.30E-02	1.37E-01	1.10E+00	2.12E-01	3.67E+00	5.64E-02	2.38E-02	1.29E-01	2.42E+00
		Reference (Kratchkowsky Lake)	4.43E-03	7.86E-05	1.09E-02	3.76E-04	5.54E-03	9.10E-02	2.11E-04	2.33E-02	2.08E-02	1.03E-04	2.33E-03	1.85E-01

Biota		Location	Maximum Non-radiological Dose During Project Phases (mg/kg/d)											
			As	Cd	Cl-	Co	Cr	Cu	Mo	SO4	Se	U	V	Zn
			Arsenic	Cadmium	Chloride	Cobalt	Chromium	Copper	Molybdenum	Sulphate	Selenium	Uranium	Vanadium	Zinc
	Common Loon	Whitefish Lake	5.49E-03	1.17E-04	2.09E-01	4.63E-04	7.52E-03	1.16E-01	3.60E-02	1.31E+00	1.73E-01	1.69E-03	8.94E-03	2.76E-01
		McGowan Lake	4.73E-03	1.03E-04	1.43E-01	4.35E-04	6.75E-03	1.08E-01	2.58E-02	8.84E-01	1.13E-01	1.02E-03	4.58E-03	2.37E-01
		Russell Lake Inlet	4.57E-03	9.68E-05	1.11E-01	4.21E-04	6.41E-03	1.04E-01	1.96E-02	6.75E-01	8.96E-02	7.68E-04	3.75E-03	2.22E-01
	Mallard	Reference (Kratchkowsky Lake)	2.33E-02	1.61E-03	2.32E-02	4.50E-03	4.22E-02	7.73E-01	3.38E-03	3.89E-02	6.71E-03	1.57E-03	3.04E-02	4.91E-01
		Whitefish Lake	3.07E-02	2.39E-03	4.42E-01	5.50E-03	5.47E-02	9.67E-01	5.76E-01	2.19E+00	6.05E-02	2.00E-02	1.03E-01	6.77E-01
		McGowan Lake	2.64E-02	2.12E-03	3.02E-01	5.20E-03	5.06E-02	9.12E-01	4.13E-01	1.47E+00	4.07E-02	1.32E-02	6.01E-02	6.12E-01
		Russell Lake Inlet	2.52E-02	1.98E-03	2.35E-01	5.03E-03	4.84E-02	8.79E-01	3.14E-01	1.13E+00	3.15E-02	1.00E-02	4.92E-02	5.80E-01
	American Robin	Reference (Kratchkowsky Lake)	1.39E-01	1.34E-01	4.07E-02	7.19E-02	2.86E-01	3.73E+00	5.54E-02	8.67E-02	6.44E-02	5.27E-02	3.83E-01	9.73E+00
		Whitefish Lake	1.39E-01	1.34E-01	0.00E+00	7.23E-02	2.86E-01	3.86E+00	5.57E-02	0.00E+00	6.47E-02	5.22E-01	3.83E-01	9.76E+00
		McGowan Lake	1.39E-01	1.34E-01	5.31E-01	7.20E-02	2.86E-01	3.75E+00	5.74E-02	3.29E+00	6.45E-02	1.14E-01	3.83E-01	9.74E+00
		Russell Lake Inlet	1.39E-01	1.34E-01	4.12E-01	7.19E-02	2.86E-01	3.74E+00	5.69E-02	2.51E+00	6.44E-02	6.92E-02	3.83E-01	9.74E+00
	Lesser Scaup	Reference (Kratchkowsky Lake)	4.05E-02	2.95E-03	2.72E-02	1.11E-02	7.12E-02	1.37E+00	5.83E-03	4.27E-02	1.26E-02	2.76E-03	5.85E-02	9.28E-01
		Whitefish Lake	5.30E-02	4.43E-03	5.19E-01	1.37E-02	9.24E-02	1.71E+00	1.00E+00	2.40E+00	1.18E-01	3.71E-02	2.06E-01	1.29E+00
		McGowan Lake	4.55E-02	3.90E-03	3.54E-01	1.29E-02	8.54E-02	1.61E+00	7.17E-01	1.62E+00	7.83E-02	2.40E-02	1.16E-01	1.16E+00
		Russell Lake Inlet	4.35E-02	3.64E-03	2.76E-01	1.24E-02	8.17E-02	1.55E+00	5.45E-01	1.24E+00	6.04E-02	1.82E-02	9.46E-02	1.10E+00

Biota		Location	Maximum Non-radiological Dose During Future Centuries (mg/kg/d)											
			As	Cd	Cl-	Co	Cr	Cu	Mo	SO4	Se	U	V	Zn
			Arsenic	Cadmium	Chloride	Cobalt	Chromium	Copper	Molybdenum	Sulphate	Selenium	Uranium	Vanadium	Zinc
Terrestrial Animals	Black Bear	Reference (Kratchkowsky Lake)	4.74E-03	5.32E-04	2.01E-02	2.27E-03	3.88E-03	1.47E-01	1.75E-03	4.28E-02	5.31E-03	1.20E-03	4.68E-03	3.68E-01
		Whitefish Lake	4.74E-03	5.32E-04	2.26E-02	2.27E-03	3.89E-03	1.47E-01	1.75E-03	4.37E-02	5.69E-03	1.25E-03	4.68E-03	3.69E-01
	Canada Lynx	Reference (Kratchkowsky Lake)	1.61E-02	2.50E-03	2.44E-02	5.64E-04	6.54E-03	3.38E-01	5.49E-04	5.20E-02	2.87E-02	5.81E-04	1.02E-02	1.43E+01
		Whitefish Lake	1.61E-02	2.50E-03	3.14E-02	5.66E-04	6.54E-03	3.38E-01	5.50E-04	5.46E-02	2.87E-02	7.82E-04	1.02E-02	1.43E+01
		McGowan Lake	1.61E-02	2.50E-03	2.97E-02	5.65E-04	6.54E-03	3.38E-01	5.50E-04	5.40E-02	2.87E-02	6.07E-04	1.02E-02	1.43E+01
		Russell Lake Inlet	1.61E-02	2.50E-03	2.85E-02	5.64E-04	6.54E-03	3.38E-01	5.50E-04	5.35E-02	2.87E-02	5.88E-04	1.02E-02	1.43E+01
	Mink	Reference (Kratchkowsky Lake)	1.01E-02	7.70E-04	3.25E-02	1.04E-03	1.37E-02	1.46E-01	6.42E-04	6.81E-02	1.40E-02	7.00E-04	1.36E-02	3.11E-01
		Whitefish Lake	1.05E-02	7.72E-04	4.18E-02	1.08E-03	1.38E-02	1.47E-01	6.88E-04	7.14E-02	1.81E-02	9.24E-04	1.37E-02	3.38E-01
		McGowan Lake	1.03E-02	7.72E-04	3.96E-02	1.07E-03	1.38E-02	1.47E-01	6.76E-04	7.06E-02	1.67E-02	7.59E-04	1.37E-02	3.30E-01
		Russell Lake Inlet	1.02E-02	7.71E-04	3.79E-02	1.06E-03	1.37E-02	1.47E-01	6.68E-04	7.00E-02	1.60E-02	7.33E-04	1.37E-02	3.25E-01
	Moose	Reference (Kratchkowsky Lake)	2.42E-03	1.06E-03	1.78E-02	1.18E-03	1.84E-03	5.89E-02	7.36E-04	3.75E-02	5.94E-04	6.50E-04	4.06E-03	1.68E-01
		Whitefish Lake	2.46E-03	1.06E-03	2.30E-02	1.20E-03	1.85E-03	5.90E-02	7.41E-04	3.93E-02	6.50E-04	7.86E-04	4.08E-03	1.68E-01
		McGowan Lake	2.43E-03	1.06E-03	2.17E-02	1.19E-03	1.84E-03	5.89E-02	7.40E-04	3.89E-02	6.31E-04	6.78E-04	4.07E-03	1.68E-01
		Russell Lake Inlet	2.43E-03	1.06E-03	2.08E-02	1.19E-03	1.84E-03	5.89E-02	7.39E-04	3.85E-02	6.21E-04	6.63E-04	4.07E-03	1.68E-01
	Moose Organs	Reference (Kratchkowsky Lake)	2.42E-03	1.06E-03	1.78E-02	1.18E-03	1.84E-03	5.89E-02	7.36E-04	3.75E-02	5.94E-04	6.50E-04	4.06E-03	1.68E-01
		McGowan Lake	2.43E-03	1.06E-03	2.17E-02	1.19E-03	1.84E-03	5.89E-02	7.40E-04	3.89E-02	6.31E-04	6.78E-04	4.07E-03	1.68E-01
		Russell Lake Inlet	2.43E-03	1.06E-03	2.08E-02	1.19E-03	1.84E-03	5.89E-02	7.39E-04	3.85E-02	6.21E-04	6.63E-04	4.07E-03	1.68E-01
	Muskrat	Reference (Kratchkowsky Lake)	2.50E-02	1.20E-03	3.84E-02	4.48E-03	1.58E-02	3.70E-02	1.02E-03	6.70E-02	2.93E-03	1.80E-03	3.92E-02	1.17E-01
		Whitefish Lake	2.59E-02	1.21E-03	4.94E-02	4.72E-03	1.60E-02	3.75E-02	1.11E-03	7.02E-02	3.90E-03	2.20E-03	3.96E-02	1.27E-01
		McGowan Lake	2.54E-02	1.21E-03	4.68E-02	4.66E-03	1.60E-02	3.73E-02	1.09E-03	6.95E-02	3.57E-03	2.07E-03	3.94E-02	1.24E-01
		Russell Lake Inlet	2.52E-02	1.21E-03	4.48E-02	4.62E-03	1.59E-02	3.73E-02	1.07E-03	6.89E-02	3.40E-03	2.00E-03	3.93E-02	1.22E-01
	Snowshoe Hare	Reference (Kratchkowsky Lake)	6.75E-03	3.71E-03	3.04E-02	4.09E-03	8.23E-03	2.53E-01	3.19E-03	6.49E-02	2.24E-03	2.73E-03	1.30E-02	6.87E-01
		Whitefish Lake	6.75E-03	3.71E-03	3.92E-02	4.10E-03	8.23E-03	2.53E-01	3.19E-03	6.81E-02	2.24E-03	3.46E-03	1.30E-02	6.88E-01
		McGowan Lake	6.75E-03	3.71E-03	3.71E-02	4.09E-03	8.23E-03	2.53E-01	3.19E-03	6.73E-02	2.24E-03	2.83E-03	1.30E-02	6.87E-01
		Russell Lake Inlet	6.75E-03	3.71E-03	3.56E-02	4.09E-03	8.23E-03	2.53E-01	3.19E-03	6.68E-02	2.24E-03	2.76E-03	1.30E-02	6.87E-01

Biota	Location	Maximum Non-radiological Dose During Future Centuries (mg/kg/d)											
		As	Cd	Cl-	Co	Cr	Cu	Mo	SO4	Se	U	V	Zn
		Arsenic	Cadmium	Chloride	Cobalt	Chromium	Copper	Molybdenum	Sulphate	Selenium	Uranium	Vanadium	Zinc
Southern Red-Backed Vole	Reference (Kratchkowsky Lake)	1.58E-01	2.40E-02	4.49E-02	9.13E-02	2.70E-02	6.31E+00	7.48E-02	9.57E-02	6.19E-02	4.17E-02	3.16E-02	1.56E+01
	Whitefish Lake	1.58E-01	2.40E-02	5.77E-02	9.15E-02	2.70E-02	6.31E+00	7.48E-02	1.00E-01	6.19E-02	5.56E-02	3.16E-02	1.56E+01
	McGowan Lake	1.58E-01	2.40E-02	5.47E-02	9.13E-02	2.70E-02	6.31E+00	7.48E-02	9.92E-02	6.19E-02	4.35E-02	3.16E-02	1.56E+01
	Russell Lake Inlet	1.58E-01	2.40E-02	5.24E-02	9.13E-02	2.70E-02	6.31E+00	7.48E-02	9.84E-02	6.19E-02	4.22E-02	3.16E-02	1.56E+01
WoodLand Caribou	Reference (Kratchkowsky Lake)	5.27E-03	1.60E-03	1.99E-02	2.17E-03	2.09E-02	4.10E-02	1.35E-03	4.05E-02	1.52E-03	1.74E-03	1.68E-02	2.12E-01
	Whitefish Lake	5.30E-03	1.60E-03	2.23E-02	2.18E-03	2.09E-02	4.10E-02	1.36E-03	4.13E-02	1.56E-03	1.77E-03	1.69E-02	2.12E-01
Canada Goose	Reference (Kratchkowsky Lake)	7.65E-04	5.49E-04	1.24E-02	4.51E-04	1.78E-03	2.35E-02	3.28E-04	2.64E-02	2.16E-04	3.80E-04	2.73E-03	6.71E-02
	Whitefish Lake	7.61E-04	5.48E-04	0.00E+00	4.48E-04	1.76E-03	2.35E-02	3.24E-04	0.00E+00	2.14E-04	4.82E-04	2.72E-03	6.71E-02
	McGowan Lake	7.65E-04	5.49E-04	1.51E-02	4.51E-04	1.78E-03	2.35E-02	3.28E-04	2.74E-02	2.16E-04	3.93E-04	2.73E-03	6.71E-02
	Russell Lake Inlet	7.65E-04	5.49E-04	1.44E-02	4.51E-04	1.78E-03	2.35E-02	3.28E-04	2.71E-02	2.16E-04	3.84E-04	2.73E-03	6.71E-02
Bald Eagle	Reference (Kratchkowsky Lake)	9.63E-03	3.34E-03	1.07E-02	2.67E-03	3.39E-02	6.26E-02	1.05E-03	2.28E-02	2.13E-02	3.52E-03	4.51E-02	1.88E-01
	Whitefish Lake	9.64E-03	3.34E-03	1.09E-02	2.67E-03	3.39E-02	6.27E-02	1.06E-03	2.29E-02	2.17E-02	3.54E-03	4.51E-02	1.89E-01
Olive-Sided Flycatcher	Reference (Kratchkowsky Lake)	2.82E-02	1.72E-01	5.95E-02	1.27E-02	1.34E-01	1.02E+00	1.53E-02	1.27E-01	4.15E-02	1.28E-02	1.25E-01	2.35E+00
	Whitefish Lake	2.84E-02	1.72E-01	0.00E+00	1.28E-02	1.34E-01	1.03E+00	1.55E-02	0.00E+00	4.28E-02	1.63E-02	1.25E-01	2.39E+00
	McGowan Lake	2.83E-02	1.72E-01	7.25E-02	1.28E-02	1.34E-01	1.02E+00	1.55E-02	1.32E-01	4.24E-02	1.33E-02	1.25E-01	2.38E+00
	Russell Lake Inlet	2.83E-02	1.72E-01	6.95E-02	1.28E-02	1.34E-01	1.02E+00	1.54E-02	1.31E-01	4.21E-02	1.30E-02	1.25E-01	2.37E+00
Common Loon	Reference (Kratchkowsky Lake)	3.91E-03	7.84E-05	1.09E-02	3.75E-04	5.47E-03	9.09E-02	2.11E-04	2.33E-02	2.02E-02	1.01E-04	2.11E-03	1.81E-01
	Whitefish Lake	4.06E-03	7.89E-05	1.41E-02	3.95E-04	5.54E-03	9.21E-02	2.30E-04	2.45E-02	2.56E-02	1.23E-04	2.13E-03	1.97E-01
	McGowan Lake	3.97E-03	7.87E-05	1.33E-02	3.90E-04	5.52E-03	9.18E-02	2.25E-04	2.42E-02	2.39E-02	1.16E-04	2.11E-03	1.92E-01
	Russell Lake Inlet	3.95E-03	7.86E-05	1.28E-02	3.87E-04	5.51E-03	9.16E-02	2.22E-04	2.40E-02	2.29E-02	1.12E-04	2.11E-03	1.89E-01
Mallard	Reference (Kratchkowsky Lake)	2.32E-02	1.61E-03	2.32E-02	4.50E-03	4.22E-02	7.73E-01	3.38E-03	3.89E-02	6.70E-03	1.57E-03	3.00E-02	4.90E-01
	Whitefish Lake	2.40E-02	1.62E-03	2.99E-02	4.73E-03	4.27E-02	7.83E-01	3.68E-03	4.08E-02	8.93E-03	1.91E-03	3.03E-02	5.33E-01
	McGowan Lake	2.35E-02	1.62E-03	2.83E-02	4.67E-03	4.26E-02	7.81E-01	3.61E-03	4.04E-02	8.18E-03	1.80E-03	3.01E-02	5.19E-01
	Russell Lake Inlet	2.34E-02	1.62E-03	2.71E-02	4.63E-03	4.25E-02	7.79E-01	3.55E-03	4.00E-02	7.79E-03	1.74E-03	3.01E-02	5.12E-01
American Robin	Reference (Kratchkowsky Lake)	1.39E-01	1.34E-01	4.07E-02	7.19E-02	2.86E-01	3.73E+00	5.54E-02	8.67E-02	6.44E-02	5.27E-02	3.83E-01	9.73E+00
	Whitefish Lake	1.39E-01	1.34E-01	0.00E+00	7.21E-02	2.86E-01	3.74E+00	5.54E-02	0.00E+00	6.44E-02	7.14E-02	3.83E-01	9.74E+00
	McGowan Lake	1.39E-01	1.34E-01	4.96E-02	7.19E-02	2.86E-01	3.73E+00	5.54E-02	9.00E-02	6.44E-02	5.51E-02	3.83E-01	9.73E+00
	Russell Lake Inlet	1.39E-01	1.34E-01	4.75E-02	7.19E-02	2.86E-01	3.73E+00	5.54E-02	8.92E-02	6.44E-02	5.33E-02	3.83E-01	9.73E+00
Lesser Scaup	Reference (Kratchkowsky Lake)	3.97E-02	2.94E-03	2.72E-02	1.10E-02	7.11E-02	1.37E+00	5.83E-03	4.27E-02	1.25E-02	2.74E-03	5.64E-02	9.25E-01
	Whitefish Lake	4.12E-02	2.96E-03	3.51E-02	1.16E-02	7.20E-02	1.38E+00	6.35E-03	4.48E-02	1.67E-02	3.35E-03	5.69E-02	1.00E+00
	McGowan Lake	4.03E-02	2.95E-03	3.32E-02	1.15E-02	7.18E-02	1.38E+00	6.22E-03	4.43E-02	1.53E-02	3.15E-03	5.66E-02	9.80E-01
	Russell Lake Inlet	4.01E-02	2.95E-03	3.18E-02	1.14E-02	7.16E-02	1.38E+00	6.13E-03	4.40E-02	1.45E-02	3.04E-03	5.65E-02	9.66E-01

5.2.5.2 Radiological Dose

The estimated radiation doses to aquatic and terrestrial ecological receptors during the Project phases and the future centuries are shown in Table 5-10. The doses shown represent the maximum total dose from all radionuclides over the assessment period. The dose breakdown by radionuclide is shown in Appendix B. The results are presented as a total dose which includes both baseline and Project contributions.

The maximum predicted dose during the Project phases for terrestrial and riparian biota is to lichen near Whitefish Lake (0.99 mGy/d), and the main contributors to total dose are from uranium-234 and uranium-238 in air that deposits to lichen. The maximum predicted dose for aquatic biota is to zooplankton at Whitefish Lake (0.10 mGy/d), and the main contributor to total dose is from polonium-210 in water.

The maximum predicted dose during the future centuries to aquatic biota is to zooplankton (0.08 mGy/d) in Whitefish Lake from polonium-210 in water. The maximum predicted dose during the future centuries to terrestrial and riparian biota is to the scaup (0.05 mGy/d) who eats aquatic animals from Whitefish Lake. For terrestrial plants the dose during the future centuries is 0.22 mGy/d for lichen at all locations, due to background concentrations of polonium-210 in lichen.

Table 5-10: Estimated Radiological Project Total Doses to Ecological Receptors – Project Phases and Future Centuries

Biota		Location	Maximum Radiological Dose During Project Phases (mGy/d)							Maximum Radiological Dose During Future Centuries (mGy/d)						
			Uranium-238	Uranium-234	Thorium-230	Radium-226	Lead-210	Polonium-210	Total Dose	Uranium-238	Uranium-234	Thorium-230	Radium-226	Lead-210	Polonium-210	Total Dose
Aquatic Plants	Macrophytes	Reference (Kratchkowsky Lake)	1.13E-05	1.28E-05	1.53E-03	3.08E-03	6.21E-05	1.35E-03	**6.04E-03**	1.09E-05	1.24E-05	1.52E-03	3.01E-03	5.27E-05	1.15E-03	**5.75E-03**
		Whitefish Lake North (LA-6)	1.10E-05	1.25E-05	1.53E-03	3.04E-03	5.68E-05	1.23E-03	**5.88E-03**	1.09E-05	1.24E-05	1.52E-03	3.01E-03	5.27E-05	1.15E-03	**5.75E-03**
		Whitefish Lake Middle (LA-5 North)	2.06E-04	2.35E-04	2.82E-03	3.71E-03	8.35E-05	1.43E-03	**8.48E-03**	1.33E-05	1.51E-05	1.56E-03	3.45E-03	6.05E-05	1.31E-03	**6.42E-03**
		Whitefish Lake South (LA-5 South)	1.96E-04	2.23E-04	2.80E-03	3.63E-03	8.24E-05	1.54E-03	**8.47E-03**	1.32E-05	1.50E-05	1.56E-03	3.44E-03	5.91E-05	1.29E-03	**6.37E-03**
		McGowan Lake (LA-1)	1.21E-04	1.38E-04	2.37E-03	3.41E-03	6.67E-05	1.33E-03	**7.44E-03**	1.25E-05	1.42E-05	1.55E-03	3.32E-03	5.56E-05	1.21E-03	**6.16E-03**
		Russell Lake Inlet	9.04E-05	1.03E-04	2.16E-03	3.31E-03	6.40E-05	1.32E-03	**7.04E-03**	1.20E-05	1.37E-05	1.55E-03	3.24E-03	5.45E-05	1.18E-03	**6.05E-03**
	Phytoplankton	Reference (Kratchkowsky Lake)	1.13E-05	1.28E-05	1.53E-03	3.07E-03	6.15E-05	1.35E-03	**6.04E-03**	1.09E-05	1.24E-05	1.52E-03	3.01E-03	5.21E-05	1.15E-03	**5.75E-03**
		Whitefish Lake North (LA-6)	1.10E-05	1.25E-05	1.53E-03	3.03E-03	5.62E-05	1.23E-03	**5.87E-03**	1.09E-05	1.24E-05	1.52E-03	3.01E-03	5.21E-05	1.15E-03	**5.75E-03**
		Whitefish Lake Middle (LA-5 North)	2.06E-04	2.35E-04	2.82E-03	3.70E-03	8.26E-05	1.43E-03	**8.47E-03**	1.33E-05	1.51E-05	1.56E-03	3.45E-03	5.98E-05	1.31E-03	**6.41E-03**
		Whitefish Lake South (LA-5 South)	1.96E-04	2.23E-04	2.80E-03	3.63E-03	8.15E-05	1.54E-03	**8.47E-03**	1.32E-05	1.50E-05	1.56E-03	3.43E-03	5.84E-05	1.29E-03	**6.37E-03**
		McGowan Lake (LA-1)	1.21E-04	1.38E-04	2.37E-03	3.41E-03	6.60E-05	1.33E-03	**7.43E-03**	1.25E-05	1.42E-05	1.55E-03	3.31E-03	5.50E-05	1.21E-03	**6.16E-03**
		Russell Lake Inlet	9.04E-05	1.03E-04	2.16E-03	3.31E-03	6.33E-05	1.32E-03	**7.04E-03**	1.20E-05	1.37E-05	1.55E-03	3.24E-03	5.39E-05	1.18E-03	**6.04E-03**
Aquatic Animals	Benthic Invertebrate	Reference (Kratchkowsky Lake)	4.94E-09	6.45E-09	2.00E-08	8.13E-05	3.95E-05	1.79E-09	**1.21E-04**	4.94E-09	6.44E-09	2.00E-08	8.13E-05	3.95E-05	1.79E-09	**1.21E-04**
		Whitefish Lake North (LA-6)	4.94E-09	6.44E-09	2.00E-08	8.13E-05	3.95E-05	1.79E-09	**1.21E-04**	4.94E-09	6.44E-09	2.00E-08	8.13E-05	3.95E-05	1.79E-09	**1.21E-04**
		Whitefish Lake Middle (LA-5 North)	6.10E-08	7.96E-08	3.31E-08	9.45E-05	5.88E-05	2.62E-09	**1.53E-04**	6.04E-09	7.88E-09	2.06E-08	9.32E-05	4.53E-05	2.05E-09	**1.39E-04**
		Whitefish Lake South (LA-5 South)	5.84E-08	7.62E-08	3.29E-08	9.39E-05	5.49E-05	2.45E-09	**1.49E-04**	5.99E-09	7.82E-09	2.06E-08	9.28E-05	4.43E-05	2.01E-09	**1.37E-04**
		McGowan Lake (LA-1)	4.06E-08	5.30E-08	2.95E-08	9.02E-05	4.67E-05	2.10E-09	**1.37E-04**	5.67E-09	7.40E-09	2.04E-08	8.96E-05	4.17E-05	1.89E-09	**1.31E-04**
		Russell Lake Inlet	3.10E-08	4.04E-08	2.72E-08	8.79E-05	4.37E-05	1.98E-09	**1.32E-04**	5.47E-09	7.15E-09	2.03E-08	8.75E-05	4.08E-05	1.85E-09	**1.28E-04**
	Northern pike	Reference (Kratchkowsky Lake)	4.47E-06	5.09E-06	3.96E-05	2.29E-04	2.20E-06	6.93E-04	**9.74E-04**	4.31E-06	4.90E-06	3.94E-05	2.24E-04	1.87E-06	5.87E-04	**8.62E-04**
		Whitefish Lake North (LA-6)	4.38E-06	4.98E-06	3.94E-05	2.26E-04	2.01E-06	6.33E-04	**9.10E-04**	4.31E-06	4.90E-06	3.94E-05	2.24E-04	1.87E-06	5.87E-04	**8.62E-04**
		Whitefish Lake Middle (LA-5 North)	8.18E-05	9.31E-05	7.28E-05	2.76E-04	2.96E-06	7.35E-04	**1.26E-03**	5.27E-06	6.00E-06	4.04E-05	2.57E-04	2.14E-06	6.74E-04	**9.84E-04**
		Whitefish Lake South (LA-5 South)	7.79E-05	8.87E-05	7.23E-05	2.70E-04	2.92E-06	7.90E-04	**1.30E-03**	5.23E-06	5.95E-06	4.04E-05	2.56E-04	2.09E-06	6.59E-04	**9.68E-04**
		McGowan Lake (LA-1)	4.81E-05	5.48E-05	6.12E-05	2.54E-04	2.37E-06	6.82E-04	**1.10E-03**	4.95E-06	5.63E-06	4.02E-05	2.47E-04	1.97E-06	6.20E-04	**9.20E-04**
		Russell Lake Inlet	3.59E-05	4.08E-05	5.58E-05	2.46E-04	2.27E-06	6.75E-04	**1.06E-03**	4.78E-06	5.44E-06	4.00E-05	2.41E-04	1.93E-06	6.06E-04	**8.99E-04**
	White sucker	Reference (Kratchkowsky Lake)	3.33E-06	3.89E-06	2.96E-05	1.91E-04	2.02E-06	5.30E-05	**2.83E-04**	3.21E-06	3.74E-06	2.94E-05	1.87E-04	1.76E-06	4.49E-05	**2.70E-04**
		Whitefish Lake North (LA-6)	3.26E-06	3.80E-06	2.95E-05	1.88E-04	1.88E-06	4.84E-05	**2.75E-04**	3.21E-06	3.74E-06	2.94E-05	1.87E-04	1.76E-06	4.49E-05	**2.70E-04**
		Whitefish Lake Middle (LA-5 North)	6.10E-05	7.11E-05	5.45E-05	2.29E-04	2.76E-06	5.61E-05	**4.75E-04**	3.93E-06	4.58E-06	3.02E-05	2.14E-04	2.02E-06	5.15E-05	**3.06E-04**
		Whitefish Lake South (LA-5 South)	5.80E-05	6.77E-05	5.41E-05	2.25E-04	2.70E-06	6.04E-05	**4.68E-04**	3.90E-06	4.54E-06	3.02E-05	2.13E-04	1.98E-06	5.04E-05	**3.04E-04**
		McGowan Lake (LA-1)	3.59E-05	4.18E-05	4.57E-05	2.12E-04	2.21E-06	5.21E-05	**3.89E-04**	3.68E-06	4.30E-06	3.00E-05	2.06E-04	1.86E-06	4.74E-05	**2.93E-04**
		Russell Lake Inlet	2.67E-05	3.12E-05	4.17E-05	2.05E-04	2.11E-06	5.16E-05	**3.59E-04**	3.56E-06	4.15E-06	2.99E-05	2.01E-04	1.82E-06	4.63E-05	**2.87E-04**
	Zooplankton	Reference (Kratchkowsky Lake)	2.22E-05	2.59E-05	3.29E-03	4.70E-03	3.44E-05	7.43E-02	**8.24E-02**	2.14E-05	2.50E-05	3.27E-03	4.60E-03	2.91E-05	6.30E-02	**7.09E-02**
		Whitefish Lake North (LA-6)	2.17E-05	2.53E-05	3.28E-03	4.64E-03	3.14E-05	6.79E-02	**7.59E-02**	2.14E-05	2.50E-05	3.27E-03	4.60E-03	2.91E-05	6.30E-02	**7.09E-02**
		Whitefish Lake Middle (LA-5 North)	4.06E-04	4.74E-04	6.05E-03	5.66E-03	4.62E-05	7.88E-02	**9.14E-02**	2.62E-05	3.05E-05	3.36E-03	5.27E-03	3.34E-05	7.22E-02	**8.10E-02**
		Whitefish Lake South (LA-5 South)	3.87E-04	4.51E-04	6.01E-03	5.55E-03	4.56E-05	8.48E-02	**9.72E-02**	2.60E-05	3.03E-05	3.36E-03	5.25E-03	3.27E-05	7.07E-02	**7.93E-02**
		McGowan Lake (LA-1)	2.39E-04	2.79E-04	5.08E-03	5.22E-03	3.69E-05	7.31E-02	**8.40E-02**	2.46E-05	2.87E-05	3.34E-03	5.07E-03	3.07E-05	6.65E-02	**7.50E-02**
		Russell Lake Inlet	1.78E-04	2.08E-04	4.63E-03	5.06E-03	3.54E-05	7.23E-02	**8.25E-02**	2.37E-05	2.77E-05	3.32E-03	4.95E-03	3.01E-05	6.50E-02	**7.33E-02**
Terrestrial Plants	Blueberries	Reference (Kratchkowsky Lake)	2.46E-04	2.80E-04	2.11E-04	1.62E-02	6.20E-05	9.60E-03	**2.66E-02**	2.46E-04	2.80E-04	2.11E-04	1.62E-02	6.20E-05	9.60E-03	**2.66E-02**
		Whitefish Lake (LA-5)	2.05E-03	2.33E-03	2.11E-04	1.62E-02	6.20E-05	9.60E-03	**3.04E-02**	3.36E-04	3.83E-04	2.11E-04	1.62E-02	6.20E-05	9.60E-03	**2.68E-02**
		McGowan Lake (LA-1)	4.83E-04	5.49E-04	2.11E-04	1.62E-02	6.20E-05	9.60E-03	**2.71E-02**	2.58E-04	2.93E-04	2.11E-04	1.62E-02	6.20E-05	9.60E-03	**2.66E-02**
		Russell Lake Inlet	3.09E-04	3.52E-04	2.11E-04	1.62E-02	6.20E-05	9.60E-03	**2.67E-02**	2.49E-04	2.83E-04	2.11E-04	1.62E-02	6.20E-05	9.60E-03	**2.66E-02**
	Browse	Reference (Kratchkowsky Lake)	2.16E-04	2.46E-04	1.03E-04	6.74E-03	3.16E-04	3.69E-03	**1.13E-02**	2.16E-04	2.46E-04	1.03E-04	6.74E-03	3.16E-04	3.69E-03	**1.13E-02**
		Whitefish Lake (LA-5)	7.48E-03	8.52E-03	1.03E-04	6.74E-03	3.16E-04	3.69E-03	**2.69E-02**	2.52E-04	2.87E-04	1.03E-04	6.74E-03	3.16E-04	3.69E-03	**1.14E-02**
		McGowan Lake (LA-1)	1.17E-03	1.33E-03	1.03E-04	6.74E-03	3.16E-04	3.69E-03	**1.34E-02**	2.20E-04	2.51E-04	1.03E-04	6.74E-03	3.16E-04	3.69E-03	**1.13E-02**
		Russell Lake Inlet	4.70E-04	5.35E-04	1.03E-04	6.74E-03	3.16E-04	3.69E-03	**1.19E-02**	2.17E-04	2.47E-04	1.03E-04	6.74E-03	3.16E-04	3.69E-03	**1.13E-02**

Biota		Location	Maximum Radiological Dose During Project Phases (mGy/d)							Maximum Radiological Dose During Future Centuries (mGy/d)						
			Uranium-238	Uranium-234	Thorium-230	Radium-226	Lead-210	Polonium-210	Total Dose	Uranium-238	Uranium-234	Thorium-230	Radium-226	Lead-210	Polonium-210	Total Dose
	Labrador Tea	Reference (Kratchkowsky Lake)	1.21E-03	1.38E-03	1.03E-04	6.74E-03	3.16E-04	3.69E-03	**1.34E-02**	1.21E-03	1.38E-03	1.03E-04	6.74E-03	3.16E-04	3.69E-03	**1.34E-02**
		Whitefish Lake (LA-5)	6.49E-02	7.39E-02	1.03E-04	6.74E-03	3.16E-04	3.69E-03	**1.50E-01**	1.25E-03	1.42E-03	1.03E-04	6.74E-03	3.16E-04	3.69E-03	**1.35E-02**
		McGowan Lake (LA-1)	9.57E-03	1.09E-02	1.03E-04	6.74E-03	3.16E-04	3.69E-03	**3.13E-02**	1.22E-03	1.39E-03	1.03E-04	6.74E-03	3.16E-04	3.69E-03	**1.35E-02**
		Russell Lake Inlet	3.45E-03	3.92E-03	1.03E-04	6.74E-03	3.16E-04	3.69E-03	**1.82E-02**	1.22E-03	1.38E-03	1.03E-04	6.74E-03	3.16E-04	3.69E-03	**1.35E-02**
	Lichen	Reference (Kratchkowsky Lake)	6.37E-04	7.24E-04	7.32E-04	9.05E-03	1.81E-03	2.03E-01	**2.16E-01**	6.37E-04	7.24E-04	7.32E-04	9.05E-03	1.81E-03	2.03E-01	**2.16E-01**
		Whitefish Lake (LA-5)	3.62E-01	4.11E-01	7.32E-04	9.05E-03	1.81E-03	2.03E-01	**9.88E-01**	6.37E-04	7.24E-04	7.32E-04	9.05E-03	1.81E-03	2.03E-01	**2.16E-01**
		McGowan Lake (LA-1)	4.80E-02	5.46E-02	7.32E-04	9.05E-03	1.81E-03	2.03E-01	**3.18E-01**	6.37E-04	7.24E-04	7.32E-04	9.05E-03	1.81E-03	2.03E-01	**2.16E-01**
		Russell Lake Inlet	1.33E-02	1.51E-02	7.32E-04	9.05E-03	1.81E-03	2.03E-01	**2.43E-01**	6.37E-04	7.24E-04	7.32E-04	9.05E-03	1.81E-03	2.03E-01	**2.16E-01**
	Terrestrial Invertebrate	Reference (Kratchkowsky Lake)	1.41E-04	1.61E-04	1.15E-04	4.85E-03	1.22E-05	1.33E-03	**6.61E-03**	1.41E-04	1.61E-04	1.15E-04	4.85E-03	1.22E-05	1.33E-03	**6.61E-03**
		Whitefish Lake (LA-5)	6.92E-03	7.88E-03	1.15E-04	4.85E-03	1.22E-05	1.33E-03	**2.11E-02**	1.50E-04	1.71E-04	1.15E-04	4.85E-03	1.22E-05	1.33E-03	**6.62E-03**
		McGowan Lake (LA-1)	1.03E-03	1.17E-03	1.15E-04	4.85E-03	1.22E-05	1.33E-03	**8.51E-03**	1.43E-04	1.62E-04	1.15E-04	4.85E-03	1.22E-05	1.33E-03	**6.61E-03**
		Russell Lake Inlet	3.79E-04	4.31E-04	1.15E-04	4.85E-03	1.22E-05	1.33E-03	**7.11E-03**	1.42E-04	1.61E-04	1.15E-04	4.85E-03	1.22E-05	1.33E-03	**6.61E-03**
Terrestrial Animals	Black Bear	Reference (Kratchkowsky Lake)	2.15E-06	2.45E-06	2.09E-06	8.38E-04	2.10E-06	9.90E-04	**1.84E-03**	2.15E-06	2.45E-06	2.09E-06	8.38E-04	2.09E-06	9.86E-04	**1.83E-03**
		Whitefish Lake (LA-5)	3.68E-06	4.19E-06	2.13E-06	8.38E-04	2.10E-06	9.90E-04	**1.84E-03**	2.23E-06	2.54E-06	2.10E-06	8.38E-04	2.09E-06	9.87E-04	**1.83E-03**
	Canada Lynx	Reference (Kratchkowsky Lake)	3.96E-07	4.60E-07	1.08E-06	6.67E-04	3.40E-06	3.42E-04	**1.01E-03**	3.96E-07	4.60E-07	1.08E-06	6.67E-04	3.40E-06	3.42E-04	**1.01E-03**
		Whitefish Lake (LA-5)	4.39E-06	5.06E-06	1.11E-06	6.67E-04	3.40E-06	3.42E-04	**1.02E-03**	5.33E-07	6.19E-07	1.08E-06	6.67E-04	3.40E-06	3.42E-04	**1.02E-03**
		McGowan Lake (LA-1)	9.31E-07	1.08E-06	1.10E-06	6.67E-04	3.40E-06	3.42E-04	**1.02E-03**	4.14E-07	4.81E-07	1.08E-06	6.67E-04	3.40E-06	3.42E-04	**1.01E-03**
		Russell Lake Inlet	5.46E-07	6.33E-07	1.09E-06	6.67E-04	3.40E-06	3.42E-04	**1.02E-03**	4.01E-07	4.65E-07	1.08E-06	6.67E-04	3.40E-06	3.42E-04	**1.01E-03**
	Mink	Reference (Kratchkowsky Lake)	2.40E-07	2.73E-07	2.76E-06	6.46E-05	2.77E-07	8.90E-04	**9.59E-04**	2.39E-07	2.72E-07	2.76E-06	6.45E-05	2.74E-07	8.87E-04	**9.55E-04**
		Whitefish Lake (LA-5)	2.32E-06	2.64E-06	4.29E-06	7.32E-05	3.89E-07	1.28E-03	**1.36E-03**	3.15E-07	3.59E-07	2.82E-06	7.21E-05	3.08E-07	1.01E-03	**1.09E-03**
		McGowan Lake (LA-1)	1.02E-06	1.17E-06	3.86E-06	7.03E-05	3.17E-07	1.04E-03	**1.11E-03**	2.59E-07	2.95E-07	2.81E-06	6.98E-05	2.87E-07	9.35E-04	**1.01E-03**
		Russell Lake Inlet	7.48E-07	8.52E-07	3.60E-06	6.88E-05	3.01E-07	9.75E-04	**1.05E-03**	2.51E-07	2.85E-07	2.80E-06	6.85E-05	2.82E-07	9.16E-04	**9.88E-04**
	Moose	Reference (Kratchkowsky Lake)	3.71E-06	4.22E-06	5.20E-06	8.25E-04	2.52E-06	9.41E-04	**1.78E-03**	3.70E-06	4.22E-06	5.18E-06	8.24E-04	2.44E-06	9.30E-04	**1.77E-03**
		Whitefish Lake (LA-5)	1.23E-04	1.40E-04	8.41E-06	8.39E-04	2.73E-06	9.78E-04	**2.09E-03**	4.36E-06	4.97E-06	5.29E-06	8.34E-04	2.51E-06	9.49E-04	**1.80E-03**
		McGowan Lake (LA-1)	2.02E-05	2.30E-05	7.29E-06	8.33E-04	2.57E-06	9.52E-04	**1.84E-03**	3.80E-06	4.33E-06	5.26E-06	8.31E-04	2.47E-06	9.37E-04	**1.78E-03**
		Russell Lake Inlet	8.61E-06	9.80E-06	6.77E-06	8.31E-04	2.54E-06	9.46E-04	**1.80E-03**	3.74E-06	4.26E-06	5.24E-06	8.29E-04	2.46E-06	9.34E-04	**1.78E-03**
	Moose Organs	Reference (Kratchkowsky Lake)	6.55E-06	7.46E-06	1.40E-03	5.97E-04	4.25E-05	9.41E-06	**2.07E-03**	6.55E-06	7.45E-06	1.40E-03	5.97E-04	4.00E-05	9.31E-06	**2.06E-03**
		McGowan Lake	3.58E-05	4.07E-05	1.98E-03	6.02E-04	4.41E-05	9.53E-06	**2.71E-03**	6.73E-06	7.66E-06	1.42E-03	6.01E-04	4.09E-05	9.38E-06	**2.09E-03**
		Russell Lake Inlet	1.52E-05	1.73E-05	1.83E-03	6.01E-04	4.32E-05	9.47E-06	**2.52E-03**	6.61E-06	7.53E-06	1.41E-03	6.00E-04	4.06E-05	9.35E-06	**2.08E-03**
	Muskrat	Reference (Kratchkowsky Lake)	6.39E-07	7.27E-07	1.18E-05	2.92E-04	2.02E-06	6.38E-04	**9.46E-04**	6.34E-07	7.21E-07	1.17E-05	2.89E-04	1.80E-06	6.07E-04	**9.10E-04**
		Whitefish Lake (LA-5)	8.72E-06	9.92E-06	2.15E-05	3.47E-04	2.80E-06	8.52E-04	**1.24E-03**	7.75E-07	8.82E-07	1.20E-05	3.31E-04	2.06E-06	6.96E-04	**1.04E-03**
		McGowan Lake (LA-1)	5.59E-06	6.36E-06	1.81E-05	3.24E-04	2.23E-06	7.11E-04	**1.07E-03**	7.28E-07	8.28E-07	1.19E-05	3.18E-04	1.90E-06	6.40E-04	**9.74E-04**
		Russell Lake Inlet	4.24E-06	4.82E-06	1.65E-05	3.15E-04	2.13E-06	6.77E-04	**1.02E-03**	7.03E-07	8.00E-07	1.19E-05	3.11E-04	1.86E-06	6.27E-04	**9.53E-04**
	Snowshoe Hare	Reference (Kratchkowsky Lake)	3.45E-06	3.93E-06	1.96E-06	1.07E-03	4.05E-06	8.65E-04	**1.95E-03**	3.45E-06	3.93E-06	1.96E-06	1.07E-03	4.05E-06	8.65E-04	**1.95E-03**
		Whitefish Lake (LA-5)	1.02E-04	1.17E-04	1.98E-06	1.07E-03	4.05E-06	8.65E-04	**2.16E-03**	4.16E-06	4.75E-06	1.96E-06	1.07E-03	4.05E-06	8.65E-04	**1.95E-03**
		McGowan Lake (LA-1)	1.64E-05	1.87E-05	1.97E-06	1.07E-03	4.05E-06	8.65E-04	**1.97E-03**	3.54E-06	4.04E-06	1.96E-06	1.07E-03	4.05E-06	8.65E-04	**1.95E-03**
		Russell Lake Inlet	6.92E-06	7.89E-06	1.97E-06	1.07E-03	4.05E-06	8.65E-04	**1.95E-03**	3.47E-06	3.96E-06	1.96E-06	1.07E-03	4.05E-06	8.65E-04	**1.95E-03**
	Southern Red-Backed Vole	Reference (Kratchkowsky Lake)	1.47E-05	1.67E-05	6.56E-06	3.88E-03	8.24E-06	5.81E-03	**9.74E-03**	1.47E-05	1.67E-05	6.56E-06	3.88E-03	8.24E-06	5.81E-03	**9.74E-03**
		Whitefish Lake (LA-5)	2.65E-04	3.01E-04	6.57E-06	3.88E-03	8.24E-06	5.81E-03	**1.03E-02**	1.90E-05	2.17E-05	6.56E-06	3.88E-03	8.24E-06	5.81E-03	**9.75E-03**
		McGowan Lake (LA-1)	4.75E-05	5.41E-05	6.57E-06	3.88E-03	8.24E-06	5.81E-03	**9.81E-03**	1.53E-05	1.74E-05	6.56E-06	3.88E-03	8.24E-06	5.81E-03	**9.74E-03**
		Russell Lake Inlet	2.35E-05	2.67E-05	6.56E-06	3.88E-03	8.24E-06	5.81E-03	**9.76E-03**	1.48E-05	1.69E-05	6.56E-06	3.88E-03	8.24E-06	5.81E-03	**9.74E-03**
	Woodland Caribou	Reference (Kratchkowsky Lake)	3.34E-06	3.81E-06	6.25E-06	6.81E-04	1.20E-05	6.24E-03	**6.95E-03**	3.34E-06	3.81E-06	6.24E-06	6.80E-04	1.19E-05	6.23E-03	**6.94E-03**
		Whitefish Lake (LA-5)	8.19E-05	9.32E-05	7.30E-06	6.86E-04	1.20E-05	6.26E-03	**7.14E-03**	3.40E-06	3.87E-06	6.28E-06	6.85E-04	1.19E-05	6.24E-03	**6.95E-03**
	Canada Goose	Reference (Kratchkowsky Lake)	1.39E-05	1.59E-05	4.00E-07	5.61E-04	3.17E-06	7.77E-04	**1.37E-03**	1.39E-05	1.59E-05	4.00E-07	5.61E-04	3.17E-06	7.77E-04	**1.37E-03**
		Whitefish Lake (LA-5)	4.23E-04	4.82E-04	3.95E-07	5.61E-04	3.17E-06	7.76E-04	**2.25E-03**	1.67E-05	1.90E-05	3.95E-07	5.61E-04	3.17E-06	7.76E-04	**1.38E-03**
		McGowan Lake (LA-1)	6.78E-05	7.72E-05	4.04E-07	5.61E-04	3.17E-06	7.77E-04	**1.49E-03**	1.43E-05	1.63E-05	4.01E-07	5.61E-04	3.17E-06	7.77E-04	**1.37E-03**

Biota	Location	Maximum Radiological Dose During Project Phases (mGy/d)							Maximum Radiological Dose During Future Centuries (mGy/d)						
		Uranium-238	Uranium-234	Thorium-230	Radium-226	Lead-210	Polonium-210	Total Dose	Uranium-238	Uranium-234	Thorium-230	Radium-226	Lead-210	Polonium-210	Total Dose
	Russell Lake Inlet	2.84E-05	3.23E-05	4.03E-07	5.61E-04	3.17E-06	7.77E-04	**1.40E-03**	1.40E-05	1.60E-05	4.00E-07	5.61E-04	3.17E-06	7.77E-04	**1.37E-03**
Bald Eagle	Reference (Kratchkowsky Lake)	4.93E-05	5.61E-05	3.13E-06	3.72E-05	5.32E-07	7.06E-03	**7.21E-03**	4.93E-05	5.61E-05	3.13E-06	3.72E-05	5.27E-07	6.99E-03	**7.14E-03**
	Whitefish Lake (LA-5)	5.58E-05	6.35E-05	3.14E-06	3.73E-05	5.32E-07	7.12E-03	**7.28E-03**	4.96E-05	5.64E-05	3.13E-06	3.72E-05	5.27E-07	7.02E-03	**7.17E-03**
Olive-Sided Flycatcher	Reference (Kratchkowsky Lake)	1.29E-04	1.47E-04	5.91E-06	1.59E-04	1.07E-06	1.23E-02	**1.28E-02**	1.29E-04	1.47E-04	5.91E-06	1.59E-04	1.07E-06	1.23E-02	**1.28E-02**
	Whitefish Lake (LA-5)	4.95E-03	5.64E-03	7.77E-06	1.61E-04	1.16E-06	1.59E-02	**2.67E-02**	1.47E-04	1.67E-04	5.98E-06	1.61E-04	1.10E-06	1.35E-02	**1.40E-02**
	McGowan Lake (LA-1)	7.70E-04	8.76E-04	7.27E-06	1.61E-04	1.11E-06	1.37E-02	**1.55E-02**	1.32E-04	1.50E-04	5.97E-06	1.60E-04	1.08E-06	1.28E-02	**1.32E-02**
	Russell Lake Inlet	3.05E-04	3.47E-04	6.94E-06	1.60E-04	1.09E-06	1.31E-02	**1.40E-02**	1.30E-04	1.48E-04	5.96E-06	1.60E-04	1.08E-06	1.26E-02	**1.30E-02**
Common Loon	Reference (Kratchkowsky Lake)	1.43E-06	1.63E-06	1.11E-06	1.90E-05	1.82E-07	3.14E-03	**3.16E-03**	1.40E-06	1.59E-06	1.11E-06	1.90E-05	1.77E-07	3.07E-03	**3.10E-03**
	Whitefish Lake (LA-5)	2.39E-05	2.72E-05	1.86E-06	2.22E-05	2.66E-07	4.42E-03	**4.49E-03**	1.70E-06	1.94E-06	1.14E-06	2.17E-05	2.03E-07	3.53E-03	**3.55E-03**
	McGowan Lake (LA-1)	1.41E-05	1.60E-05	1.65E-06	2.11E-05	2.11E-07	3.60E-03	**3.65E-03**	1.60E-06	1.82E-06	1.14E-06	2.09E-05	1.87E-07	3.24E-03	**3.27E-03**
	Russell Lake Inlet	1.05E-05	1.20E-05	1.52E-06	2.05E-05	1.99E-07	3.41E-03	**3.45E-03**	1.55E-06	1.76E-06	1.13E-06	2.04E-05	1.83E-07	3.18E-03	**3.20E-03**
Mallard	Reference (Kratchkowsky Lake)	1.46E-05	1.66E-05	1.09E-05	7.92E-05	1.33E-06	2.66E-02	**2.67E-02**	1.46E-05	1.66E-05	1.09E-05	7.90E-05	1.28E-06	2.65E-02	**2.66E-02**
	Whitefish Lake (LA-5)	1.85E-04	2.11E-04	1.82E-05	9.24E-05	1.93E-06	3.88E-02	**3.93E-02**	1.79E-05	2.03E-05	1.12E-05	9.05E-05	1.47E-06	3.04E-02	**3.05E-02**
	McGowan Lake (LA-1)	1.22E-04	1.39E-04	1.61E-05	8.78E-05	1.54E-06	3.12E-02	**3.15E-02**	1.68E-05	1.91E-05	1.11E-05	8.71E-05	1.35E-06	2.80E-02	**2.81E-02**
	Russell Lake Inlet	9.31E-05	1.06E-04	1.49E-05	8.55E-05	1.45E-06	2.93E-02	**2.96E-02**	1.62E-05	1.84E-05	1.10E-05	8.50E-05	1.32E-06	2.74E-02	**2.75E-02**
American Robin	Reference (Kratchkowsky Lake)	4.34E-04	4.93E-04	1.29E-05	1.28E-03	8.36E-06	3.62E-02	**3.84E-02**	4.34E-04	4.93E-04	1.29E-05	1.28E-03	8.36E-06	3.62E-02	**3.84E-02**
	Whitefish Lake (LA-5)	6.70E-03	7.62E-03	1.29E-05	1.28E-03	8.36E-06	3.62E-02	**5.18E-02**	5.70E-04	6.48E-04	1.29E-05	1.28E-03	8.36E-06	3.62E-02	**3.87E-02**
	McGowan Lake (LA-1)	1.26E-03	1.43E-03	1.29E-05	1.28E-03	8.36E-06	3.62E-02	**4.01E-02**	4.51E-04	5.14E-04	1.29E-05	1.28E-03	8.36E-06	3.62E-02	**3.84E-02**
	Russell Lake Inlet	6.53E-04	7.43E-04	1.29E-05	1.28E-03	8.36E-06	3.62E-02	**3.89E-02**	4.38E-04	4.99E-04	1.29E-05	1.28E-03	8.36E-06	3.62E-02	**3.84E-02**
Lesser Scaup	Reference (Kratchkowsky Lake)	2.37E-05	2.70E-05	2.25E-05	1.45E-04	3.17E-06	4.30E-02	**4.32E-02**	2.36E-05	2.68E-05	2.24E-05	1.44E-04	2.91E-06	4.27E-02	**4.29E-02**
	Whitefish Lake (LA-5)	3.19E-04	3.62E-04	3.85E-05	1.71E-04	4.47E-06	6.24E-02	**6.33E-02**	2.89E-05	3.28E-05	2.30E-05	1.65E-04	3.34E-06	4.90E-02	**4.93E-02**
	McGowan Lake (LA-1)	2.06E-04	2.34E-04	3.36E-05	1.61E-04	3.57E-06	5.02E-02	**5.08E-02**	2.71E-05	3.08E-05	2.29E-05	1.59E-04	3.07E-06	4.51E-02	**4.53E-02**
	Russell Lake Inlet	1.56E-04	1.78E-04	3.09E-05	1.57E-04	3.38E-06	4.72E-02	**4.77E-02**	2.62E-05	2.98E-05	2.28E-05	1.55E-04	3.01E-06	4.41E-02	**4.44E-02**

5.2.6 Uncertainties in Exposure Assessment

For the exposure assessment it was conservatively assumed that ecological receptors would be exposed to the maximum exposure concentrations at their location. The duration of exposure was assumed to be sufficient for each receptor to be in equilibrium with their environment. This resulted in conservatively high:

- direct exposure estimates for aquatic biota exposed to COPCs in water, and terrestrial plants and soil invertebrates exposed to COPCs in soil;
- predicted uptakes of COPCs by ecological receptors in the food chain; and
- estimated doses of COPCs to ecological receptors through the food chain.

The assumptions to address uncertainties in the exposure assessment are anticipated to produce conservative exposure estimates for ecological receptors. The risk that the exposure assessment underestimates potential exposure of ecological receptors to COPCs from the Project is low. That said, the following provides more detail about assessment uncertainty and how it was addressed.

5.2.6.1 Uncertainties in Uptake and Exposure Factors

Wildlife exposure factors, such as intake rates and diets, are a potential source of uncertainty. Reputable sources were used for these factors, and the factors are considered to be representative of the organisms assessed. Feed, water, and inhalation intake rates were obtained or calculated based on the following primary sources: Federal Contaminated Sites Action Plan (FCSAP, 2012; Sample and Suter, 1994; US EPA, 1993). These documents have undergone several stages of review and are considered appropriate literature values for use in this assessment; therefore, the uncertainty in these values is considered acceptable.

Bioaccumulation factors were used to calculate uptake into tissues (fish, invertebrates, plants). The BAFs were derived from regional biota and water data for a number of aquatic biota in this assessment. There is inherent uncertainty in using field data to calculate BAFs from metal concentrations in tissues of aquatic biota and surface water concentrations, because the actual exposure history of the organisms is unknown. Unless it is known that a metal concentration in surface water is at a steady state for an extended period of time, the use of tissue and water concentrations sampled at the same time from the same location may not reflect the average exposure of an organism. In addition, as a result of physiological control, intracellular storage and different excretion mechanisms, biota have an ability to actively regulate the body burden of many metals and maintain homeostatic control over a range of exposures (Chapman et al., 1996; Hamilton and Mehrle, 1986; Wood and Port, 2000). These homeostatic controls can produce a non-linear relationship between the steady-state tissue concentration and the environmental exposure (Newman and Unger, 2002). As a result, the validity of assuming a linear relationship between water and tissue concentrations is an area of uncertainty. In most cases it is difficult to assess whether non-linear relationships may exist; therefore, linear relationships are assumed by default (with the exception of selenium where a non-linear BAF was used). These complicating issues do not diminish the importance of BAFs in assessing the environmental hazard associated with metals.

5.2.6.2 Uncertainties in Dose Coefficients

Dose coefficients were obtained from reputable sources for reference organisms, but have not been derived specifically for all the organisms assessed. Dose coefficients for surrogate organisms were often used. They were selected with attention to similar body size and exposure habits and are believed to adequately represent the organism assessed. Dose coefficients for each receptor were not adjusted for body size and dimensions, which represents a possible source of uncertainty. For the maximum exposed receptors, the dose is primarily delivered through alpha emissions as over 95% of the dose can be attributed to polonium-210 in tissue. The geometry-scaling factor of alpha particles is 1 for all organisms and geometries; as such, geometry assumptions are expected to have very little effect on the total radiation dose.

5.3 Effects Assessment

5.3.1 Toxicological Benchmarks

For assessment of non-radiological COPCs, a TRV was used. A TRV is a toxicological index associating specific effects with a level of exposure to a chemical. The TRVs for aquatic biota are based on concentrations in water, while TRVs for mammals and birds are weight-normalized daily oral doses.

Arsenic, cadmium, chloride, chromium, cobalt, copper, molybdenum, selenium, sulphate, uranium, and zinc were identified as COPCs for further evaluation in the EcoRA for aquatic biota Arsenic, cadmium, chromium, cobalt, copper, molybdenum, selenium, uranium, and zinc were also evaluated in the EcoRA for terrestrial biota.

No COPCs in air were identified for further evaluation of potential risks for ecological health; therefore, TRVs for direct contact with air were not included in the toxicity assessment. Deposition of COPCs in dust to soil was evaluated; however, no COPCs in soil were identified for further evaluation; therefore, toxicity via direct contact with COPCs in soil for plants and soil invertebrates was not included in the toxicity assessment.

5.3.1.1 Toxicity Reference Values for Aquatic Biota

Water concentration-based TRVs for aquatic biota are based on chronic effects from long-term exposures. They are concentrations below which health risks to receptors are not anticipated. The TRVs were derived for aquatic biota in six categories: forage fish (lake whitefish), predator fish (northern pike), zooplankton, benthic invertebrates, phytoplankton, and aquatic plants.

The selected TRVs were 20% Effect Concentrations (i.e., EC_{20} values), which are concentrations at which only 20% of the test organisms respond. The EC_{20} value was preferred because 20% is near the level at which effects become statistically discernible or measurable in both laboratory and field studies (EC and HC, 2003; Suter, 1996), and therefore can be reliably reproduced.

However, chronic EC_{20} values are not always readily available; therefore, a protocol shown in Table 5-11 was established to derive chronic EC_{20} values from available data.

Table 5-11: Procedure for Adjusting Test Endpoints to Chronic 20% Effect Concentration

Test Endpoint [(a)]	Adjustment to Chronic EC_{20}
Chronic EC_{10}	Multiply by 2
Chronic EC_{25}	Multiply by 2/2.5
Chronic EC_{30}	Multiply by 2/3
Chronic EC_{50}	Multiply by 2/5
Chronic LC_{25}	Multiply by 0.5
Chronic LC_{50}	Divide by 4

a) IC endpoints were treated as EC endpoints.
EC = effect concentration; LC = lethal concentration; IC = inhibition concentration.

Toxicity data for effect endpoints involving growth, reproduction, and survival were selected because they are considered to be relevant to the persistence of aquatic populations. Chronic toxicity data were preferred, and acute data were only considered when chronic data were not sufficient (a minimum of 2 values required). If 20 or more chronic EC_{20} values were available in each taxonomic group, a 5th percentile of the EC_{20} values was used as a selected TRV. If there were less than 20 chronic EC_{20} values, the lowest EC_{20} was used as a selected TRV for the taxonomic category. Calculated values that fell below the CCME or provincial guideline were not considered appropriate as TRVs for aquatic biota and the CCME or provincial values were selected in their place. The selected TRVs for aquatic biota groups are summarized in Table 5-12. For aquatic TRVs that were based on the lowest chronic EC_{20} value, the reference is provided in Table 5-12.

In some cases, site-specific modifying factors (ambient conditions) may influence the toxicity of a chemical. For example, these modifying factors include water hardness for copper. In these cases, the TRV must be appropriate to the ambient condition.

The USEPA Ecotoxicology Database (ECOTOX) was generally used for the selection of TRVs for aquatic organisms. There were sufficient data available from ECOTOX to derive TRVs for arsenic, cadmium, copper and zinc. There were limited data available in the ECOTOX database pertaining to the effects of the other COPCs on aquatic biota. The TRVs for chloride and chromium were obtained from the CCME (CCME, 2011a, 2008). The TRVs for cobalt were selected from a recently published review of toxicological data (Stubblefield et al., 2020), in which a species sensitivity distribution approach was used. The TRVs for molybdenum were obtained from the Saskatchewan Water Quality Guideline (WSA, 2017). The TRVs for selenium in fish were estimated using the US EPA criteria of 11.3 mg/kg dw muscle (US EPA, 2021d) and converting to a water based TRV using a species-specific water to fish bioaccumulation factor. The TRVs for selenium for zooplankton and benthic invertebrates were the lowest observed ECs obtained from literature (Crane et al., 1992). The TRVs for sulphate were obtained from the BC MOE (BC MOE, 2013). The TRVs for uranium were derived from data available from toxicological reports (Liber et al., 2007; VST, 2004).

Table 5-12: Selected Toxicity Reference Values for Aquatic Biota

COPC	Biotic Group	TRV	Unit	Rationale	Data Source
Arsenic	Forage fish	0.123	mg/L	Lowest estimated chronic EC_{20} (survival)	ECOTOX (Birge et al., 1979)
	Predator fish	0.630	mg/L	5th percentile of estimated chronic EC_{20} distribution (n=50)	ECOTOX
	Zooplankton	0.340	mg/L	Lowest estimated chronic EC_{20} (intoxication)	ECOTOX (May-Passino and Novak, 1987)
	Benthic invertebrates	0.122	mg/L	5th percentile of estimated chronic EC_{20} distribution (n=27)	ECOTOX
	Phytoplankton	0.0192	mg/L	Lowest estimated chronic EC_{20} (growth)	ECOTOX (Vocke et al., 1980)
	Aquatic plants	0.252	mg/L	Lowest estimated chronic EC_{20} (population)	ECOTOX (Jenner and Janssen-Mommen, 1993)
Cadmium[(b)]	Forage Fish	0.00029	mg/L	5th percentile of estimated chronic EC_{20} (n=35)	ECOTOX
	Predator Fish	0.00036	mg/L	5th percentile of estimated chronic EC_{20} (n=73)	ECOTOX
	Zooplankton	0.00015	mg/L	5th percentile of estimated chronic EC_{20} (n=25)	ECOTOX
	Benthic Invertebrates	0.00048	mg/L	5th percentile of estimated chronic EC_{20} (n=49)	ECOTOX
	Phytoplankton	0.0025	mg/L	lowest estimated EC_{20} value	ECOTOX
	Aquatic Plants[(a)]	0.00763	mg/L	LOEC	ECOTOX (Sajwan and Ornes, 1994)
Chloride	Forage fish	693	mg/L	Chronic LOEC (survival)	(Birge et al., 1985; CCME, 2011a)
	Predator fish	989	mg/L	Chronic EC_{25} (reproduction)	(Beak International Inc, 1999; CCME, 2011a)
	Zooplankton	421	mg/L	Chronic EC_{25} (reproduction)	(CCME, 2011a; J. R. F. Elphick et al., 2011)
	Benthic invertebrates	421	mg/L	Chronic EC_{25} (growth)	(Bartlett, 2009; CCME, 2011a)
	Phytoplankton	6,066	mg/L	Chronic MATC (growth)	(CCME, 2011a; Kessler, 1974)
	Aquatic plants	3,150	mg/L	Chronic EC_{50} (population)	(Buckley et al., 1996; CCME, 2011a)
Chromium	Forage Fish	0.53	mg/L	Chronic value for the fathead minnow in hard water of 0.53 mg/L	(US EPA, 1985) cited in (CCME, 2008)
	Predator Fish	0.105	mg/L	60-day post hatch study with rainbow trout (*Oncorhynchus mykiss*)	(Sauter et al., 1976) cited in (CCME, 2008)
	Zooplankton	0.01	mg/L	Significant reduction in reproduction of Daphnia magna after 96-hours	(Trabalka and Gehrs, 1977) cited in (CCME, 2008)
	Benthic Invertebrates	2.2	mg/L	96-h LC_{50} with the mayfly (*Ephemerella subvaria*)	(CCME, 2008)
	Phytoplankton	0.02	mg/L	Photosynthesis inhibition in natural populations of river algae (*Chlorella pyrenoidosa, Chlamydomonas reinhardii*)	(Zarafonetis and Hampton, 1974) cited in (CCME, 2008)

COPC	Biotic Group	TRV	Unit	Rationale	Data Source
	Aquatic Plants	0.02	mg/L	TRV for phytoplankton used as surrogate for aquatic plants	
Cobalt	Forage fish	0.409	mg/L	Lowest chronic EC_{20} (survival)	(Stubblefield et al., 2020)
	Predator fish	2.495	mg/L	Lowest chronic EC_{20} (biomass)	(Stubblefield et al., 2020)
	Zooplankton	0.0111	mg/L	Lowest chronic EC_{20} (reproduction)	(Stubblefield et al., 2020)
	Benthic invertebrates	0.0176	mg/L	Lowest chronic EC_{20} (growth)	(Stubblefield et al., 2020)
	Phytoplankton	0.046	mg/L	Lowest estimated EC_{20} (growth)	(Stubblefield et al., 2020)
	Aquatic plants	0.0098	mg/L	lowest estimated EC_{20} (growth)	(Stubblefield et al., 2020)
Copper[b,c,d,f]	Forage fish	0.002	mg/L	5th percentile of estimated chronic EC_{20} distribution (n=237)	ECOTOX
	Predator fish	0.003	mg/L	5th percentile of estimated chronic EC_{20} distribution (n=89)	ECOTOX
	Zooplankton	*0.002*	mg/L	5th percentile of estimated chronic EC_{20} distribution (n=117)	ECOTOX; CCME
	Benthic invertebrates	*0.002*	mg/L	5th percentile of estimated chronic EC_{20} distribution (n=264)	ECOTOX; CCME
	Phytoplankton[a]	0.0092	mg/L	5th percentile of estimated chronic EC_{20} distribution (n=101)	ECOTOX
	Aquatic plants[a]	0.038	mg/L	5th percentile of estimated chronic EC_{20} distribution (n=28)	ECOTOX
Molybdenum	Forage fish	31	mg/L	Saskatchewan Water Quality Guideline	(WSA, 2017)
	Predator fish	80	mg/L	lowest estimated EC_{20} value	ECOTOX; (Goettl et al., 1976; McConnell, 1977)
	Zooplankton	31	mg/L	Saskatchewan Water Quality Guideline	(WSA, 2017)
	Benthic invertebrates	31	mg/L	Saskatchewan Water Quality Guideline	(WSA, 2017)
	Phytoplankton	31	mg/L	Saskatchewan Water Quality Guideline	(WSA, 2017)
	Aquatic plants	31	mg/L	Saskatchewan Water Quality Guideline	(WSA, 2017)
Selenium[g]	Forage Fish	0.00063 842	mg/L	TRV for White Sucker was estimated using the US EPA (2021) criteria of 11.3 mg/kg dw muscle and converted to a waterbase TRV using a species-specific water to fish bioaccumulation factor of 4425 and a default dry content of 0.25.	(US EPA, 2021d)
	Predator Fish	0.00088 163	mg/L	TRV for Northern Pike was estimated using the US EPA (2021) criteria of 11.3 mg/kg dw muscle and	(US EPA, 2021d)

COPC	Biotic Group	TRV	Unit	Rationale	Data Source
				converted to a waterbase TRV using a species-specific water to fish bioaccumulation factor of 949 and a default dry content of 0.25.	
	Zooplankton	0.01	mg/L	LOEC	(Crane et al., 1992)
	Benthic Invertebrates	0.01	mg/L	LOEC	(Crane et al., 1992)
	Phytoplankton	0.0797	mg/L	5th percentile of estimated chronic EC_{20} (n=25)	ECOTOX
	Aquatic Plants	0.68	mg/L	lowest estimated EC_{20} value	ECOTOX; (Jenner and Janssen-Mommen, 1993)
Sulphate	Forage fish	2,999	mg/L	Lowest chronic EC_{25} (biomass)	(BC MOE, 2013); PESC data
	Predator fish	502	mg/L	Lowest chronic LC_{25} (survival)	(BC MOE, 2013); PESC data
	Zooplankton	425	mg/L	Lowest chronic EC_{25} (reproduction)	(BC MOE, 2013; J. R. Elphick et al., 2011)
	Benthic invertebrates	730	mg/L	Lowest chronic LC_{25} (survival)	(BC MOE, 2013); PESC data
	Phytoplankton	2,660	mg/L	Lowest chronic EC_{25} (cell yield)	(BC MOE, 2013; J. R. Elphick et al., 2011)
	Aquatic plants	2,310	mg/L	Lowest chronic EC_{10} (frond increase)	(BC MOE, 2013); PESC data
Uranium[e]	Forage fish	1.50	mg/L	Lowest estimated chronic EC_{20} (growth)	(Liber et al., 2007; VST, 2004)
	Predator fish	0.550	mg/L	Lowest estimated chronic EC_{20} (growth)	(Liber et al., 2007; VST, 2004)
	Zooplankton	0.060	mg/L	Lowest estimated chronic EC_{20} (growth)	(Liber et al., 2007; VST, 2004)
	Benthic invertebrates	0.027	mg/L	Lowest estimated chronic EC_{20} (growth)	(Liber et al., 2007; VST, 2004)
	Phytoplankton	0.440	mg/L	Geometric mean of 2 EC_{25} values	(Liber et al., 2007; VST, 2004)
	Aquatic plants	5.50	mg/L	Geometric mean of 2 EC_{25} values	(Liber et al., 2007; VST, 2004)
Vanadium	Forage Fish	0.08	mg/L	lowest chronic value for all aquatic organisms	(Suter and Tsao, 1996)
	Predator Fish	0.08	mg/L	lowest chronic value for all aquatic organisms	(Suter and Tsao, 1996)
	Zooplankton	1.9	mg/L	lowest chronic value for Daphnids	(Suter and Tsao, 1996)
	Benthic Invertebrates	0.08	mg/L	lowest chronic value for all aquatic organisms	(Suter and Tsao, 1996)
	Phytoplankton	0.08	mg/L	lowest chronic value for all aquatic organisms	(Suter and Tsao, 1996)
	Aquatic Plants	0.08	mg/L	lowest chronic value for all aquatic organisms	(Suter and Tsao, 1996)
Zinc[b,d]	Forage Fish	0.035	mg/L	Lowest estimated chronic EC_{20}	ECOTOX
	Predator Fish	*0.032*	mg/L	5th percentile of estimated chronic EC_{20} (n=39)	ECOTOX
	Zooplankton	*0.03*	mg/L	Lowest estimated chronic EC_{20}	ECOTOX

COPC	Biotic Group	TRV	Unit	Rationale	Data Source
	Benthic Invertebrates	*0.03*	mg/L	Lowest estimated chronic EC_{20}	ECOTOX
	Phytoplankton[(a)]	*0.03*	mg/L	5th percentile of estimated chronic EC_{20} (n=46)	ECOTOX
	Aquatic Plants	0.116	mg/L	Lowest estimated chronic EC_{20}	ECOTOX

a) Study specific hardness data was not available for the adjustment of TRVs.
b) The TRV is hardness dependent and is presented as dissolved metal in soft water (hardness of 25 mg $CaCO_3$/L).
c) Hardness dependent TRVs are presented for hardness of 25 mg $CaCO_3$/L and may be converted to reflect specific site hardness conditions using the equations presented.
d) The TRVs presented in italics are CCME guidelines used as a default when estimated TRVs are below the recommended guideline.
e) The TRVs are based on hardness of 60 mg/L, other than phytoplankton which is based on hardness of 120 mg/L.
f) Copper TRVs, calculated using the Federal Environmental Quality Guideline (FEQG) are included in Section 6.3.2.
g) Selenium TRVs for fish calculated using the Federal Environmental Quality Guideline (FEQG) are included in Section 6.3.1.EC_{XX} = effect concentration for XX% response; LOEC = lowest observed effect concentration; MATC = maximum acceptable toxicant concentration; $CaCO_3$ = calcium carbonate; TRV = toxicity reference value; PESC = Pacific Environmental Science Centre; CCME = Canadian Council of Ministers of the Environment.

5.3.1.1.1 Arsenic

The TRVs for arsenic were estimated chronic EC_{20} values that were selected based on EC_{50} and lethal concentration (LC_{50}) values obtained from the USEPA ECOTOX database (Table 5-12). The minimum adjusted EC_{20} value was selected as the TRV for aquatic plants, phytoplankton, zooplankton and forage fish. For benthic invertebrates and predator fish, the TRV was selected as the 5th percentile of the adjusted chronic EC20 values. The results suggest that phytoplankton, benthic invertebrates, and forage fish are the aquatic organisms most sensitive to arsenic exposure while predator fish are the least sensitive.

5.3.1.1.2 Cadmium

Water hardness can have a major influence on cadmium toxicity to aquatic biota. The toxicity data were adjusted to chronic EC_{20} and were hardness adjusted to soft water (hardness of 25 mg $CaCO_3$/L) with equations from the U.S. Geological Survey (USGS, 2006). According to the USGS (2006), the cadmium hardness-dependent criterion continuous concentration (CCC) can be calculated from the following:

$$CC = e^{0.6247 \times ln(hardness) - 3.384} \times (1.101672 - ln(hardness) \times 0.041838)$$

The second term in the equation above is a conversion factor (CF) which converts the total metal concentration to a dissolved metal concentration. For studies on chronic toxicity of cadmium to aquatic biota that reported the hardness of the water, H1 (in mg/L $CaCO_3$), the CCC for the hardness used in the study was calculated. The CCC values for two hardness levels provide a ratio that can be used to adjust an EC_{20} at the test hardness (H1) to an EC_{20} at some standard hardness (H2), which is relevant to the site, using the following relationship:

$$EC_{20}H2 = \frac{CCC_{H2}}{CCC_{H1}} \times EC_{20}H1$$

The lowest hardness adjusted chronic EC_{20} values are considered conservative and are deemed appropriate as TRVs at different hardness levels. Therefore, the TRVs for forage fish, predator fish, freshwater zooplankton, benthic invertebrates and phytoplankton are presented as dissolved cadmium in soft water with hardness of 25 mg $CaCO_3$/L (Table 5-12). No study specific hardness data were available for TRV adjustment for aquatic plants. A lower LOEC of 0.00763 mg/L for cadmium was applied based on a chronic study of duckweed growth (Sajwan and Ornes, 1994). The more conservative LOEC value is considered appropriate as the TRV for aquatic plants.

The results suggest that zooplankton is the aquatic organism most sensitive to cadmium exposure while aquatic plants are the least sensitive.

5.3.1.1.3 Chloride

Toxicity records were taken from data selected by CCME (CCME, 2011a) to derive the Canadian Water Quality Guideline value for the protection of freshwater aquatic life. The studies met the minimum primary or secondary requirements for data quality. No EC_{20} concentrations were available from the CCME data. Low effect levels including EC_{25}, LOEC, and maximum acceptable toxicant concentration were selected preferentially, and the lowest for each aquatic group were selected (Table 5-12). The results suggest that benthic invertebrates and zooplankton are the most sensitive to chloride exposure while phytoplankton are the least sensitive.

5.3.1.1.4 Chromium

Limited data were available in the USEPA ECOTOX database pertaining to the effects of chromium exposure on aquatic biota. The toxicity data for chromium was obtained from the CCME (CCME, 2008) which provides guidelines for the protection of freshwater aquatic life. Based on U.S. EPA data (US EPA, 1985) cited in CCME (CCME, 2008), the chronic value for the fathead minnow (*Pimephales promelas*) in hard water was selected as the TRV for forage fish. A maximum acceptable concentration of 0.105 mg/L based on a 60-day post hatch study with rainbow trout (*Oncorhynchus mykiss*) (Sauter et al., 1976) was selected as the TRV for predator fish. The TRV for zooplankton was based on the chromium exposure resulting in significant reduction in reproduction of *Daphnia magna* after 96-hours (Trabalka and Gehrs, 1977). The lowest 96-h LC_{50} value for mayfly (*Ephemerella subvaria*) was selected as the TRV for benthic invertebrates, without adjustment, based on CCME (CCME, 2008). The TRVs for phytoplankton and aquatic plants were selected based on the chromium concentration at which the photosynthesis in natural populations of river algae (*Chlorella pyrenoidosa, Chlamydomonas reinhardii*) was inhibited (Zarafonetis and Hampton, 1974).

The results suggest that zooplankton, phytoplankton and aquatic plants are the aquatic organisms most sensitive to chromium exposure while benthic invertebrates are the least sensitive.

5.3.1.1.5 Cobalt

The TRVs for cobalt are chronic EC_{20} values for aquatic animal groups and estimated chronic EC_{20} values for aquatic plant groups from (Stubblefield et al., 2020). Stubblefield et at. (2020) conducted a series of acute and chronic toxicity tests with the primary objective to generate data needed to derive international water quality guidelines for cobalt based on USEPA and European Union requirements. Early life stage tests were conducted on three fish species, one zooplankton species, three aquatic invertebrate species, one alga, and one aquatic macrophyte. The study produced chronic EC_{20} values for the aquatic animal species and chronic EC_{10} values for aquatic plants. The TRVs for phytoplankton and aquatic plants were derived from EC_{10} values using a factor of 2 to adjust to an EC_{20} (Table 5-12). The results suggest that zooplankton, benthic invertebrates, and macrophytes are among the most sensitive to cobalt and fish is the least sensitive.

5.3.1.1.6 Copper

The TRVs for copper for forage fish, predator fish, phytoplankton, and aquatic plants are estimated chronic EC_{20} values. They were estimated based on EC_{10}, EC_{25}, EC_{30}, EC_{50}, LC_{25}, LC_{50}, inhibition concentration (IC_{10}), IC_{25}, and IC_{50} values obtained from the USEPA ECOTOX database. In the case of zooplankton and benthic invertebrates, the derived TRVs were lower than the existing CCME guideline values; therefore, the CCME values were selected as the TRVs because the CCME guidelines are considered protective of all life forms of aquatic species in Canada.

According to the U.S. EPA (US EPA, 2007a), the copper hardness-dependent criterion continuous concentration (CCC) can be calculated from the following:

$$CCC = e^{0.8545 \times ln(hardness) - 1.702} \times 0.96$$

A conversion factor of 0.96 was used to convert the total mean concentration of copper to a dissolved copper concentration. The selected TRVs are summarized in Table 5-12 for dissolved copper in soft water conditions (hardness of 25 mg $CaCO_3$/L) using the same equation describing the relationship of the CCC values for two hardness levels which is discussed above for cadmium TRV adjustment. No study specific hardness data was available for TRV adjustment for phytoplankton and aquatic plants.

The EC_{20} values derived for copper, based on a hardness of 25 mg $CaCO_3$/L, were compared to the CCME water quality guidelines for the same hardness condition prior to selecting the appropriate TRVs (Table 5-12). The results suggest that zooplankton, benthic invertebrates, forage fish, and predator fish are the aquatic organisms most sensitive to copper exposure while aquatic plants are the least sensitive.

Additional copper TRVs, calculated using the Federal Environmental Guideline (FEQG), are included in Section 6.3.2.

5.3.1.1.7 Molybdenum

For forage fish, zooplankton, benthic invertebrates, phytoplankton, and aquatic plants, the Saskatchewan Water Security Agency water quality objective (WQO) for the protection of aquatic life (WSA, 2017) was selected as the TRV for molybdenum. The WQO is based on current understanding of aquatic toxicity of molybdenum to fresh-water aquatic organisms as discussed in Section 3.1.1. The TRV for predator fish is the lowest of three estimated chronic EC_{20} values, derived from LC_{50} values for rainbow trout (*Oncorhynchus mykiss),* obtained from the USEPA ECOTOX database. The selected TRV is from (Goettl et al., 1976) and was republished in 1977 by McConnell (McConnell, 1977), who provided detailed documentation as to the methods used to generate the data (cited in (Tetra Tech Inc., 2008)).

5.3.1.1.8 Selenium

The TRVs for selenium for fish were estimated using the US EPA criteria of 11.3 mg/kg dw muscle (US EPA, 2021d) and converting to a water based TRV using a species-specific water to fish bioaccumulation factor. The LOEC of 0.01 mg/L based on multi-generational mesocosm studies (Crane et al., 1992) is recommended as the TRV for zooplankton and benthic invertebrates. There were 25 chronic toxicity records for phytoplankton obtained from the USEPA ECOTOX database. The 5^{th} percentile of estimated chronic EC_{20} values (derived from EC_{50} values) is deemed appropriate as a TRV for freshwater phytoplankton. The lowest estimated chronic EC_{20} for aquatic plants is derived from EC_{50} values based on a 14-day laboratory test on duckweed (Jenner and Janssen-Mommen, 1993). The results suggest that forage fish and predator fish are the aquatic organisms most sensitive to selenium exposure while aquatic plants are the least sensitive.

Additional selenium TRVs were considered for whole body fish and egg-ovary using the ECCC (2022) published FEQG in Section 6.3.1.

5.3.1.1.9 Sulphate

Toxicity records were taken from data selected by the British Columbia Ministry of Environment (BC MOE, 2013) to derive British Columbia’s Ambient Water Quality Guideline value for sulphate for the protection of freshwater aquatic life. The BC MOE used data from the Pacific Environmental Science Centre and Dr. Chris Kennedy (Simon Fraser University) and Elphick et al. ((J. R. Elphick et al., 2011)). The tests selected by BC MOE were conducted over a range of hardness levels. The BC MOE determined that, though dose-response curves of many organisms were influenced by water hardness, a consistent relationship among the species could not be established. The selected TRVs are LC_{25} or EC_{25} values, except for the aquatic plant TRV, which is an EC_{10} value (Table 5-12). The results suggest that aquatic animals are generally more sensitive to sulphate exposure than aquatic plants.

5.3.1.1.10 Uranium

Limited data were available in the USEPA ECOTOX database pertaining to the effects of uranium exposure on aquatic biota. Data were instead obtained from two reports (Liber et al., 2007; VST, 2004) that investigated the toxicity of uranium to aquatic biota in Northern Saskatchewan. The TRVs for uranium are all estimated chronic EC_{20} values, derived from EC_{25}, EC_{50} and LC_{25}, LC_{50}, IC_{25}, and IC_{50} values.

While uranium speciation and toxicity in fresh water are strongly determined by water characteristics such as hardness, pH, and temperature, the CCME (CCME, 2011b) does not consider that there is sufficient information available to quantitatively evaluate the influence of these factors. Therefore, the CCME recommends a water quality guideline for uranium that is not hardness dependent. The TRVs in Table 5-12 are therefore considered appropriate for use across a range of hardness and may be conservative for hard water environments because they were derived from tests conducted under soft water conditions (water hardness of 60 mg $CaCO_3$/L),except for phytoplankton which was based on a study using water hardness of 120 mg/L. The results suggest that zooplankton and benthic invertebrates are more sensitive to uranium exposure, and phytoplankton and aquatic plants are less sensitive.

5.3.1.1.11 Vanadium

Limited data were available in the USEPA ECOTOX database pertaining to the effects of vanadium exposure on aquatic biota. The toxicity data for vanadium was obtained from a report that recommends toxicological benchmarks for screening COPCs for effects on aquatic biota (Suter and Tsao, 1996). Based on the recommendation by Suter and Tsao (1996), the lowest chronic value for Daphnids was selected as the vanadium TRV for zooplankton, and the lowest chronic value for all aquatic organisms was conservatively selected as the vanadium TRV for the other aquatic groups.

5.3.1.1.12 Zinc

The TRVs for zinc were the lowest or 5th percentile of estimated chronic EC_{20} values, which were based on EC_{50} and LC_{50} values obtained from the USEPA ECOTOX database (Table 5-12).

Hardness is known to affect zinc toxicity. An increase in hardness results in a decrease in zinc toxicity. For zinc, the effect of hardness on fish toxicity may be due to changes in fish gills rather than metal speciation. According to the U.S. EPA, the zinc hardness-dependent criterion continuous concentration (CCC) can be calculated from the following:

$$CCC = e^{0.8473 \times ln(hardness) + 0.884} \times 0.986$$

A conversion factor of 0.986 was used to convert the total mean concentration of zinc to a dissolved zinc concentration. The selected TRVs are summarized in Table 5-12 for dissolved copper in soft water conditions (hardness of 25 mg $CaCO_3$/L) using the same equation describing the relationship of the CCC values for two hardness levels which is discussed above for cadmium TRV adjustment. No study specific hardness data were available for TRV adjustment for phytoplankton.

In the case of predator fish, zooplankton, benthic invertebrates and phytoplankton, the derived TRVs were lower than the existing CCME guideline values; therefore, the CCME values were selected as the TRVs because the CCME guidelines are considered protective of all life forms of aquatic species in Canada.

5.3.1.2 Toxicity Reference Values for Terrestrial Biota

Chronic dose-based TRVs for non-radiological COPCs were derived for birds and mammals based on endpoints (i.e., growth and reproduction) considered relevant for assessing the health of wildlife populations. Lowest observed adverse effect levels (LOAEL) were selected for each COPC. The LOAEL is the lowest exposure level at which the response of a test species in a toxicity study was statistically discernible. The LOAELs were used in the ERA to identify a threshold of exposure below which adverse effects are not expected. Exceeding a LOAEL does not mean that effects would necessarily occur; rather, it means that effects may occur. Particularly in large populations, localized effects on a few individuals can be compensated such that there is no discernible effect on the population as a whole.

The selected TRVs, shown in Table 5-13, are chronic daily intakes that are not expected to cause adverse effects to a particular ecological receptor. Where the TRV is based a single LOAEL, the specific reference is provided in Table 5-14 to Table 5-23.

Toxicity data for bird and mammal species were preferentially selected from the USEPA ecological soil screening levels (Eco-SSL) database (US EPA, 2005a). There were no data available in the USEPA Eco-SSL database pertaining to the effects of uranium exposure, so TRVs were derived from data available in toxicological reports previously used in risk assessments for uranium mines in northern Saskatchewan. Toxicity reference values were derived from the selected data for several test species of avian and mammalian wildlife. When possible, a test species was selected with a close taxonomic relationship to the ecological receptor in the risk assessment, such as within the same order, family, genus, or species. If there were several potential test species relevant to an ecological receptor, consideration was given to similar diet and body size. A sensitive test species of the same class was selected to represent an ecological receptor when no data were available for species with a closer taxonomic relationship.

Table 5-13: Selected Toxicity Reference Values for Terrestrial Biota

Ecological Receptor	Constituent of Potential Concern (mg/kg/d)									
	Arsenic	Cadmium	Chromium	Cobalt	Copper	Molybdenum	Selenium	Uranium	Vanadium	Zinc
Mammals										
Black bear	3.1	103	91.1	13.4	11.5	2.6	0.21	5.6	2.18	35
Woodland caribou	14.4	5.7	91.1	13.4	1.5	4.1	0.33	5.6	2.18	76
Snowshoe hare	3.0	0.9	91.1	13.4	45.7	30.0	0.21	5.6	2.18	35
Lynx	3.1	103	91.1	13.4	11.5	2.6	0.21	5.6	2.18	35
Mink	3.1	103	91.1	13.4	11.5	2.6	0.21	5.6	2.18	35
Moose	14.4	5.7	91.1	13.4	1.5	4.1	0.33	5.6	2.18	76
Muskrat	14.2	6.8	91.1	13.4	119	3.8	0.63	5.6	2.18	249
Meadow vole	20.7	1.9	91.1	27.9	296	2.6	0.77	5.6	2.18	4395
Birds										
Bald eagle	3.6	4.4	75.4	14.1	27.0	20.8	0.68	16	0.49	123
Common loon	3.6	4.4	75.4	14.1	27.0	20.8	0.59	16	0.49	123
Mallard	5.1	25.6	2.8	14.1	75.2	20.8	1.29	16	0.49	63
Canada goose	3.6	4.4	75.4	14.1	27.0	20.8	0.59	16	0.49	123
Olive-sided Flycatcher	3.6	4.4	75.4	14.1	27.0	20.8	0.59	16	0.49	123
American Robin	3.6	4.4	75.4	14.1	27.0	20.8	0.59	16	0.49	123
Scaup	5.1	25.6	2.8	14.1	75.2	20.8	1.29	16	0.49	63

5.3.1.2.1 Arsenic

A summary of the TRVs selected for mammalian and avian species for arsenic is shown in Table 5-14.

Mammalian Toxicity Reference Values

Data for growth and reproduction for mammalian species were obtained from the Eco-SSL document for arsenic exposure (US EPA, 2005b). The data were based on a total of 14 LOAEL values from studies with dogs, goats, guinea pigs, mice, pigs, rabbits, and rats. The geometric means of the LOAELs within species ranged from 0.84 mg/kg/d for a guinea pig to 20.7 mg/kg/d for a mouse. Each of the species mean values of LOAEL can be considered as a TRV for arsenic for other mammals. In the event that a species has no closely related test species, the second lowest LOAEL value of 3.0 mg/kg/d for rabbit and dog can be used as a conservative default for the arsenic TRV. Although this LOAEL is not the minimum of the species LOAELs, it was selected over the minimum LOAEL of 0.84 mg/kg/d for guinea pig because the latter value was essentially at the same level as the minimum NOAEL from the same dataset. Of the total 14 LOAEL values used to derive the species LOAELs only two are below 3.0 mg/kg/d. As such, the LOAEL of 3.0 mg/kg/d was selected as the default LOAEL as it is more representative of the LOAEL data overall.

Avian Toxicity Reference Values

Data for growth and reproduction for avian species were obtained from the Eco-SSL document for arsenic exposure (US EPA, 2005b). The document was based on studies with chickens and ducks. After review of the data, two LOAEL values were retained for ducks and one was retained for chicken. The selected avian TRVs are 3.6 mg/kg/d for chickens based on a single LOAEL value, and 5.1 mg/kg/d for ducks based on the geometric mean of two LOAEL values.

Table 5-14: Summary of Selected Toxicity Reference Values for Mammal and Bird Test Species – Arsenic

Test Species	TRV (mg/kg/d)	Rationale
Mammal		
Dog (*Canis familiaris*)	3.1	Geometric mean of two LOAELs for the species
Goat (*Capra hircus*)	14.4	Geometric mean of two LOAELs for the species
Guinea pig (*Cavia porcellus*)	0.84	Single LOAEL for the species (Hunder et al., 1999)
Mouse (*Mus musculus*)	20.7	Geometric mean of three LOAELs for the species
Pig (*Sus scrofa*)	9.4	Single LOAEL for the species (Morrison and Chavez, 1983)
Rabbit (*Oryctolagus cuniculus*)	3.0	Single LOAEL for the species (Nemec et al., 1998)
Rat (*Rattus norvegicus*)	14.2	Geometric mean of four LOAELs for the species
Bird		
Mallard duck (*Anas platyrhynchos*)	5.1	Geometric mean of two LOAELs for the species
Chicken (*Gallus* sp.)	3.6	Single LOAEL for the species (Howell and Hill, 1978)

LOAEL = lowest observed adverse effect level; TRV = toxicity reference value.

5.3.1.2.2 Cadmium

A summary of the TRVs selected for mammalian and avian species for cadmium is shown in Table 5-15.

Mammalian Toxicity Reference Values

There were 7 mammal species represented in the Eco-SSL database with growth or reproduction endpoints, and with LOAEL only or LOAEL plus NOAEL reported (US EPA, 2005c). The species mean values of NOAELs were in the range of 0.45 mg/kg/day for sheep to 4.05 mg/kg/day for pig. The species mean values of LOAELs were in the range of 0.9 mg/kg/day for sheep to 103 mg/kg/day for shrew. Each of the species mean values of LOAEL (Table 5-15) can be used as a surrogate TRV for other similar species in ecological risk assessment. If none of the test species are similar to the wildlife species of interest, the lowest LOAEL of 0.9 mg/kg/day can be used as a conservative default mammalian TRV for cadmium.

Avian Toxicity Reference Values

There were 3 species of birds represented in the Eco-SSL database with growth and reproduction endpoints, and with only LOAELs or paired LOAELs and NOAELs reported (US EPA, 2005c). A geometric mean of NOAEL or LOAEL was calculated for each species. Each of the species mean values of LOAEL (Table 5-15) can be used as a surrogate TRV for other similar species in ecological risk assessment. If none of the test species are similar to species of interest, the minimum LOAEL of 4.38 mg/kg/day can be used as a conservative default avian TRV for cadmium.

Table 5-15: Summary of Selected Toxicity Reference Values for Mammal and Bird Test Species – Cadmium

Test Species	TRV (mg/kg/d)	Rationale
Mammal		
Bank vole *(Microtus* sp)	1.9	Single LOAEL for the species (Swiergosz et al., 1998)
Shrew (*Sorex araneus*)	103	Single LOAEL for the species (Dodds-Smith et al., 1992)
Pig (*Sus scrofa*)	10.5	Geometric mean of four LOAEL for the species
Rat (R*attus norvegicus*)	6.8	Geometric mean of fifty-one LOAEL for the species
Sheep (*Ovis aires*)	0.9	Single LOAEL for the species (Doyle et al., 1974)
Cattle (*Bos taurus*)	5.7	Single LOAEL for the species (Lynch et al., 1976)
Mouse (*Mus musculus*)	9.6	Geometric mean of ten LOAEL for the species
Bird		
Chicken (*Gallus sp*)	4.4	Geometric mean of nineteen LOAEL for the species
Japanese Quail (*Coturnix japonica*)	11.3	Geometric mean of five LOAEL for the species;
Mallard (*Anas platyrhynchos*)	25.6	Geometric mean of three LOAEL for the species

LOAEL = lowest observed adverse effect level; TRV = toxicity reference value.

5.3.1.2.3 Chromium

A summary of the TRVs selected for mammalian and avian species for trivalent chromium is shown in Table 5-16.

Mammalian Toxicity Reference Values

Data for reproduction for one mammalian species was obtained from the Eco-SSL document for chromium exposure (US EPA, 2005d). A single NOAEL value was provided, based studies with the mouse.

Avian Toxicity Reference Values

Data for reproduction for two avian species were obtained from the Eco-SSL document for chromium exposure (US EPA, 2005d). Two LOAEL values were provided, based on studies with chicken and duck, respectively.

Table 5-16: Summary of Selected Toxicity Reference Values for Mammal and Bird Test Species – Chromium

Test Species	TRV (mg/kg/d)	Rationale
Mammal		
Mouse (*Mus musculus*)	91.1	Single NOAEL for the species (Elbetieha and Al-Hamood, 1997)
Bird		
Black Duck *(Anas rubripes)*	2.8	Single LOAEL for the species (Haseltine et al., 1986)
Chicken (*Gallus sp*)	75.4	Single LOAEL for the species (Meluzzi et al., 1996)

LOAEL = lowest observed adverse effect level; TRV = toxicity reference value.

5.3.1.2.4 Cobalt

A summary of the TRVs selected for mammalian and avian species for cobalt is shown in Table 5-17.

Mammalian Toxicity Reference Values

Two mammal species were represented in the Eco-SSL database with growth or reproduction endpoints and with LOAEL values reported (US EPA, 2005e). The species geometric mean values of LOAELs ranged from 13 mg/kg/d for rat to 28 mg/kg/d for mouse, from 6 and 7 LOAEL values respectively.

Avian Toxicity Reference Values

Data for growth and reproduction for avian species were obtained from the Eco-SSL database for cobalt exposure (US EPA, 2005a). The document was based on studies with chickens and ducks. Eight LOAEL values were retained for chicken and no LOAELs were retained for ducks because the LOAEL value was associated with high mortality. The selected avian TRV is 14 mg/kg/d for chickens based on the geometric mean of eight LOAEL values.

Table 5-17: Summary of Selected Toxicity Reference Values for Mammal and Bird Test Species – Cobalt

Test Species	TRV (mg/kg/d)	Rationale
Mammal		
Mouse (*Mus musculus*)	27.9	Geometric mean of six LOAELs for the species
Rat (*Rattus norvegicus*)	13.4	Geometric mean of seven LOAELs for the species
Bird		
Chicken (*Gallus* sp.)	14.1	Geometric mean of eight LOAELs for the species

LOAEL = lowest observed adverse effect level; TRV = toxicity reference value.

5.3.1.2.5 Copper

A summary of the TRVs selected for mammalian and avian species for copper is shown in Table 5-18.

Mammalian Toxicity Reference Values

The mammalian data for growth and reproduction were obtained from the data presented in the Eco-SSL document for copper exposure (US EPA, 2007b). The data were based on studies with goats, minks, mice, pigs, rabbits, rats, and sheep. The TRVs for goat, rabbit, and sheep are each based on a single LOAEL value. The TRVs for mink, mouse, pig, and rat are geometric means of the LOAEL data for each test species. For rats, the geometric mean of the NOAEL values was larger than the geometric mean of the LOAEL values, due to the larger dataset for the LOAEL values. For this species, the LOAEL was therefore derived only from the studies that had both LOAEL and NOAEL values. The geometric mean of the LOAELs ranged from 1.47 mg/kg/d for a goat to 296 mg/kg/d for a mouse. In the event that a species had no closely related test species, the LOAEL of 8.8 mg/kg/d for pig was used as the default mammalian TRV. It is not the lowest LOAEL; however, it can be used as the default mammalian TRV as it is the lowest species LOAEL above the lowest NOAEL from the same dataset.

Avian Toxicity Reference Values

The avian data for growth and reproduction were obtained from the data presented in the Eco-SSL document for copper exposure (US EPA, 2007b). The data were based on studies with chickens, ducks, and turkeys. The geometric means of the LOAELs within species were selected to serve as the TRVs. The geometric means of the LOAELs for chickens, ducks, and turkeys were 34.9 mg/kg/d, 75.2 mg/kg/d, and 27 mg/kg/d respectively, based on 78, 3, and 9 LOAEL values, respectively. These values were used as TRVs for other similar species in the EcoRA.

Table 5-18: Summary of Selected Toxicity Reference Values for Mammal and Bird Test Species – Copper

Test Species	TRV (mg/kg/d)	Rationale
Mammal		
Goat (*Capra hircus*)	1.5	Single LOAEL for the species (Solaiman et al., 2001)
Mink *(Neovison vison*)	11.5	Geometric mean of two LOAELs for the species
Mouse (*Mus musculus*)	296	Geometric mean of five LOAELs for the species
Pig (*Sus scrofa*)	8.8	Geometric mean of four LOAELs for the species
Rabbit (*Oryctolagus cuniculus*)	45.7	Single LOAEL for the species (Grobner et al., 1986)
Rat (*Rattus norvegicus*)	119	Geometric mean of five LOAELs for the species
Sheep (*Ovis aires*)	3.0	Single LOAEL for the species (Ortolani et al., 2003)
Bird		
Chicken (*Gallus* sp.)	34.9	Geometric mean of 78 LOAELs for the species
Duck (*Anas platyrhynchos*)	75.2	Geometric mean of three LOAELs for the species
Turkey (*Meleagris gallopavo*)	27.0	Geometric mean of nine LOAELs for the species

LOAEL = lowest observed adverse effect level; TRV = toxicity reference value.

5.3.1.2.6 Molybdenum

A summary of the TRVs selected for mammalian and avian species for molybdenum is shown in Table 5-19.

Mammalian Toxicity Reference Values

The selected TRVs for mammals are from studies with reported LOAEL values for growth and reproduction endpoints. Relevant LOAEL values for molybdenum were obtained from literature for four mammal species: rabbit (*Oryctolagus cunculus*), mouse (*Mus musculus*), cow (*Bos taurus*), and rat (*Rattus norvegicus*). The TRVs for rabbit, mouse, and cow are based on one LOAEL value and the TRV for rat is the geometric mean of two LOAEL values. The TRVs range from 2.6 mg/kg/d for a mouse to 30 mg/kg/d for a rabbit. In the event that a species had no closely related test species, the LOAEL of 2.6 mg/kg/d for the mouse was used as the default mammalian TRV.

Avian Toxicity Reference Values

The selected TRVs for birds are from studies with reported LOAEL values for growth and reproduction endpoints. Relevant LOAEL values for molybdenum were obtained from literature for two avian species: chicken (*Gallus* sp.) and turkey (*Meleagris gallopavo*). The TRV for chicken is the geometric mean of three LOAEL values and the TRV for turkey is based on one LOAEL value from Underwood (1971). The TRVs range from 21 mg/kg/d for a turkey to 39 mg/kg/d for a chicken. In the event that a species had no closely related test species, the LOAEL of 21 mg/kg/d for turkey was used as the default avian TRV.

Table 5-19: Summary of Selected Toxicity Reference Values for Mammal and Bird Test Species – Molybdenum

Test Species	TRV (mg/kg/d)	Rationale
Mammal		
Rabbit (*Oryctolagus cunculus*)	30	Single LOAEL for the species (Arrington and Davis, 1953)
Mouse (*Mus musculus*)	2.6	Single LOAEL for the species (Schroeder and Mitchener, 1971)
Cow (*Bos taurus*)	4.1	Single LOAEL for the species (Thomas and Moss, 1951)
Rat (*Rattus norvegicus*)	3.8	Geometric mean of two LOAELs for the species
Bird		
Chicken (*Gallus domesticus*)	38.6	Geometric mean of three LOAELs for the species
Turkey (*Melagris gallopavo*)	20.8	Single LOAEL for the species (Underwood, 1971)

LOAEL = lowest observed adverse effect level; TRV = toxicity reference value.

5.3.1.2.7 Selenium

A summary of the TRVs selected for mammalian and avian species for selenium is shown in Table 5-20.

Mammalian Toxicity Reference Values

There were seven mammal species represented in the Eco-SSL database with growth or reproduction endpoints, and with LOAEL only or LOAEL plus NOAEL reported (US EPA, 2007c). The species mean values of NOAELs were in the range of 0.17 mg/kg/day for cattle and pig to 0.93 mg/kg/day for mouse. The species mean values of LOAELs were in the range of 0.21 mg/kg/day for dog to 1.53 mg/kg/day for mouse. Each of the species mean values of LOAEL (Table 5-20) can be used as a surrogate TRV for other similar species in ecological risk assessment. If none of the test species are similar to the wildlife species of interest, the lowest LOAEL of 0.21 mg/kg/day can be used as a conservative default mammalian TRV for selenium.

Avian Toxicity Reference Values

Five species of birds are represented in the Eco-SSL database with growth and reproduction endpoints, and with LOAEL only or paired LOAEL and NOAEL reported(US EPA, 2007c). A geometric mean of NOAEL or LOAEL for the records relating to growth and reproduction endpoints was calculated for each species. The geometric means of NOAEL were 0.36 and 1.18 mg/kg/day for chicken and mallard, respectively. The geometric means of LOAELs were in a range of 0.59 mg/kg/day for chicken to 4.49 mg/kg/day for owl. Each of the species mean values of LOAEL (Table 5-20) can be used as a surrogate TRV for other similar species. If none of the test species are similar to species of interest, the lowest LOAEL of 0.59 mg/kg/day can be used as a conservative default avian TRV for selenium.

Table 5-20: Summary of Selected Toxicity Reference Values for Mammal and Bird Test Species – Selenium

Test Species	TRV (mg/kg/d)	Rationale
Mammal		
Cattle (*Bos taurus*)	0.33	Single LOAEL for the species (Jenkins and Hidiroglou, 1986)
Dog (*Canis familiaris*)	0.21	Single LOAEL for the species (Rhian and Moxon, 1943)
Hamster (*Mesocricetus auratus*)	0.77	Geometric mean of seven LOAEL for the species
Mouse (*Mus musculus*)	1.53	Geometric mean of twenty-three LOAEL for the species
Pig (*Sus scrofa*)	0.33	Geometric mean of twenty-one LOAEL for the species
Pronghorn (*Antilocapra americana*)	0.49	Single LOAEL for the species (Raisbeck et al., 1996)
Rat (*Rattus norvegicus*)	0.63	Geometric mean of sixty-nine LOAEL for the species
Bird		
Black-crowned night-heron (*Nycticorax nycticorax*)	0.68	Single LOAEL for the species (Smith et al., 1988)
Chicken (*Gallus sp*)	0.59	Geometric mean of thirty-two LOAEL for the species
Japanese Quail (*Coturnix japonica*)	0.75	Geometric mean of six LOAEL for the species
Mallard (*Anas platyrhynchos*)	1.29	Geometric mean of twenty LOAEL for the species
Owl (*Megascops asio*)	4.49	Single LOAEL for the species (Wiemeyer and Hoffman, 1996)

LOAEL = lowest observed adverse effect level; TRV = toxicity reference value.

5.3.1.2.8 Uranium

A summary of the TRVs selected for mammalian and avian species for uranium is shown in Table 5-21.

Mammalian Toxicity Reference Values

There is no Eco-SSL document for uranium. Previous risk assessments have used TRVs for mammalian exposure to uranium derived from Oak Ridge National Laboratory (ORNL) data (Sample et al., 1996). The Sample et al. (1996) data for mammalian species were based on a study by (Paternain et al., 1989) related to reproduction in mice. Sample et al. derived a LOAEL of 6.13 mg/kg/d from the study. The TRV quoted by the authors contains a small unit conversion error. Instead of 6.13 mg/kg/d as reported, the value should be 5.6 mg/kg/d. The difference arises from Sample's use of uranyl acetate molecular weight rather that uranyl acetate dehydrates molecular weight in converting the molecular dose to uranium dose. The correct value (5.6 mg/kg/d) can be found in the ATSDR toxicity profile for uranium. It represents the oral dose (to parents) at which viability of F1 offspring was reduced. Since the LOAEL value from (Paternain et al., 1989) is the only mammalian data available, this LOAEL value of 5.6 mg/kg/d was selected for evaluating uranium toxicity to mammalian species.

Avian Toxicity Reference Values

No data were available in the Eco-SSL database related to uranium exposure in avian species. Previous risk assessments used TRVs for avian exposure to uranium derived from the ORNL data (Sample et al., 1996). The data were based on a previous study (Haseltine and Sileo, 1983) describing mortality, body weight, liver, and kidney effects in ducks; Sample et al. derived a NOAEL of 16 mg/kg/d, but no LOAEL from the study. There are no other avian data available for uranium. The study used powdered metallic uranium. Uranium in this form would likely be oxidized to ionic form in the gut since uranium is strongly reducing in aqueous systems (Durante and Pugliese, 2002). Uranium in the environment similarly exists in an oxidized ionic form. Solubility differences among ionic forms in the gut can be bounded. The ICRP (ICRP, 1994) has determined that some oxidized species in the gut may be an order of magnitude less soluble than the most soluble species. Any reduced solubility in the gut would be offset by the fact that a NOAEL value is used in the absence of a LOAEL value. Since the NOAEL value (Haseltine and Sileo, 1983) is the only avian data available, this NOAEL value of 16 mg/kg/d was selected as the TRV for evaluating uranium toxicity to avian species.

Table 5-21: Summary of Selected Toxicity Reference Values for Mammal and Bird Test Species – Uranium

Test Species	TRV (mg/kg/d)	Rationale
Mammal		
Mouse (*Mus musculus*)	5.6	(Paternain et al., 1989), from (Sample et al., 1996)
Bird		
Black duck (*Anas rubripes*)	16	(Haseltine and Sileo, 1983), from (Sample et al., 1996)

TRV = toxicity reference value.

5.3.1.2.9 Vanadium

A summary of the TRVs selected for mammalian and avian species for vanadium is shown in Table 5-22.

Mammalian Toxicity Reference Values

The data for Mammalian species were obtained from the data presented in the Eco-SSL document for vanadium exposure (US EPA, 2005f). The selected TRVs for mammals are from studies with rat with reported LOAEL values for reproduction endpoints.

Avian Toxicity Reference Values

The data for avian species were obtained from the data presented in the Eco-SSL document for vanadium exposure (US EPA, 2005f). The selected TRVs for avian species are from studies with chickens with reported LOAEL values for growth endpoints.

Table 5-22: Summary of Selected Toxicity Reference Values for Mammal and Bird Test Species – Vanadium

Test Species	TRV (mg/kg/d)	Rationale
Mammal		
Rat (*Rattus norvegicus*)	2.18	Single LOAEL for the species (Domingo et al., 1986)
Bird		
Chicken (*Gallus sp*)	0.49	Single LOAEL for the species (Phillips et al., 1982)

LOAEL = lowest observed adverse effect level; TRV = toxicity reference value.

5.3.1.2.10 Zinc

A summary of the TRVs selected for mammalian and avian species for zinc is shown in Table 5-23.

Mammalian Toxicity Reference Values

The data for growth and reproduction for mammalian species were obtained from the data presented in the Eco-SSL document for zinc exposure (US EPA, 2007d). The data were based on studies with cattle, mice, pigs, rats and sheep; these species served as the surrogates for mammalian wildlife. The geometric means of the NOAEL and LOAEL data were calculated for each surrogate species. The geometric mean of the NOAELs ranged from 15.5 mg/kg/day for a pig to 585 mg/kg/day for a mouse. The geometric mean of the LOAELs ranged from 35 mg/kg/day for sheep to 4,395 mg/kg/day for a mouse. Each of the species mean values of LOAEL (Table 5-23) can be used as a surrogate TRV for other similar species in ecological risk assessment. In the event that none of the species are similar, the lowest LOAEL of 35 mg/kg/day can be used as a conservative default for the zinc TRV for mammals.

Avian Toxicity Reference Values

The data for growth and reproduction for avian species were obtained from the data presented in the Eco-SSL document for zinc exposure (US EPA, 2007d). The data were based predominantly on studies with chickens, with some studies with Japanese quails, mallard ducks and turkeys; these four species served as the surrogates for avian wildlife. The geometric means of the LOAEL and NOAEL data were calculated for each species. None of the studies for ducks presented in the Eco-SSL document reported both LOAEL and NOAEL data; therefore, no NOAEL for ducks was calculated. The geometric means of the NOAELs ranged from 61 mg/kg/day for a Japanese quail to 148 mg/kg/day for a turkey, and the geometric means of the LOAELs ranged from 63 mg/kg/day for a duck to 297 mg/kg/day for a turkey. Each of the geometric mean values of LOAEL for zinc (Table 5-23) can be used as a surrogate TRV for other similar species. In the event that none of the species are similar, the LOAEL of 123 mg/kg/day can be selected as the default TRV for avian species. The minimum LOAEL of 63 mg/kg/day was not selected as the default TRV because this value is equivalent to the minimum NOAEL of 61 mg/kg/day. Of the 52 LOAEL values obtained from the Eco SSL data, only 12 (i.e., 23%) are below 100 mg/kg/day. Additionally, the minimum LOAEL is less than half of the LOAEL value derived by Sample et al. (Sample et al., 1996), therefore it was not selected as the default TRV.

Table 5-23: Summary of Selected Toxicity Reference Values for Mammal and Bird Test Species – Zinc

Test Species	TRV (mg/kg/d)	Rationale
Mammal		
Cattle (*Bos taurus*)	76	Single LOAEL for the species (Miller et al., 1989)
Mouse (*Mus musculus*)	4395	Geometric mean of five LOAEL for the species
Pig (*Sus scrofa*)	90	Geometric mean of four LOAEL for the species
Rat (*Rattus norvegicus*)	249	Geometric mean of seventeen LOAEL for the species
Sheep (*Ovis aries*)	35	Geometric mean of two LOAEL for the species
Bird		
Chicken (*Gallus sp*)	179	Geometric mean of forty-seven LOAEL for the species
Japanese quail (*Cotumix japonica*)	123	Geometric mean of two LOAEL for the species
Mallard duck (*Anas platyrhynchos*)	63	Geometric mean of two LOAEL for the species
Turkey (*Maleagris gallopavo*)	297	Single LOAEL for the species (Vohra and Kratzer, 1968)

LOAEL = lowest observed adverse effect level; TRV = toxicity reference value.

5.3.2 Radiation Benchmarks

Radiation dose benchmarks of 0.4 mGy/h (9.6 mGy/d) and 0.1 mGy/h (2.4 mGy/d) (UNSCEAR, 2008) were selected for the assessment of effects on aquatic biota and terrestrial biota, respectively, as recommended in the CSA N288.6-22 standard (CSA, 2022) . This is a total dose benchmark, therefore the dose to biota due to each radionuclide of concern is summed to compare against this benchmark.

The aquatic biota considered by United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) are organisms such as fish and benthic invertebrates that reside in water. Birds and mammals with riparian habits are considered to be terrestrial biota. Dose calculations in this ERA follow the same convention.

Exceedance of the aquatic or terrestrial dose benchmarks is considered to indicate the potential for adverse effects to occur, and the need for more detailed assessment.

5.3.3 Uncertainties in the Effects Assessment

Uncertainties associated with the estimation of ecotoxicological effect levels for COPCs are inherent in the ERA process. Many uncertainties are associated with the use of literature-based TRVs. These uncertainties may include: extrapolation of results from laboratory tests to the field, differences in sensitivity between the test organism and resident organisms, laboratory conditions that are not representative of field conditions, and the form of the COPC used in toxicity testing, which may not be representative of the form that would be found at the Project.

The use of TRVs from laboratory studies tends to be conservative because these studies are typically chemical-specific and use highly bioavailable forms of the COPC studied. In field situations, the chemical form of the same COPC may be less bioavailable, and toxicity-modifying factors may be present that were not acting in laboratory tests.

The EC_{20} values were used for aquatic biota to reduce uncertainty by representing a standard threshold level of low magnitude effects. Depending on the size of the available dataset, selection of the 5^{th} percentile or lowest EC_{20} value as the TRV for an aquatic biota group was intended to reduce the likelihood that risks would be underestimated.

There is inherent uncertainty associated with the use of LOAEL values as TRVs for birds and mammals as these values are not precisely related to a particular magnitude of effect. However, LOAEL values have widespread use in the risk assessment community and the science is not currently available to change this approach to TRVs. Defaulting to the most conservative TRV for ecological receptors that are not closely related taxonomically to the test species was meant to reduce the likelihood that risks would be underestimated.

5.4 Risk Characterization

Risk assessment is the process of estimating the likelihood of undesirable effects on ecological health resulting from exposure to chemical or radiological constituents. Three components must be present for risks to ecological health to exist:

- The COPC must be present at concentrations sufficient to cause a possible adverse effect.
- A receptor must be present.
- There must be a complete exposure pathway by which the receptor can come into contact with the COPC

5.4.1 Risk Estimation and Discussion

Risk characterization is the process in the EcoRA that integrates the results from the exposure and effects assessments to estimate the risk of adverse effects on ecological receptors. The risk characterization also evaluates the uncertainties associated with the overall conclusion of risk.

The hazard quotient (HQ) is a simple approach that provides a quantitative estimate of overall risk. The HQ is the ratio between the exposure estimate and a TRV:

$$HQ = \frac{Exposure\ (Dose)\ Estimate}{TRV}$$

If the HQ is less than or equal to 1, this suggests low risk to the ecological receptor because exposure estimates are below levels known to cause adverse effects. If the HQ is greater than 1, adverse effects may be possible, and further investigation of the assumptions of the exposure and effects assessments could be considered to reduce the conservatism inherent in the EcoRA. Risk assessment is often an iterative process of refining information, and the identified risk in the first iteration is often an artefact of conservative assumptions. If further evaluation under more realistic assumptions confirms the risk, this information can be used to inform mitigation to avoid, eliminate, or reduce the source of the risk.

5.4.1.1 Non-radiological Risk

The predicted total HQs (baseline and Project) for all aquatic and terrestrial ecological receptors at all assessed locations during the Project phases and in the future centuries are shown in Table 5-24. The HQs represent the maximum HQ over the life of the Project for relevant COPCs, which is a conservative representation of risk. Additional copper HQ values for some aquatic ecological receptors are presented in Section 6.3.2 using TRVs re-evaluated from the copper FEQG. Additional evaluation of selenium in fish (whole body and egg-ovary) is presented in Section 6.3.1 using TRVs from the selenium FEQG.

No significant adverse effect on either aquatic or terrestrial populations or communities as a result of releases from the Project are predicted during the Project phases.

The predicted total HQs are less than 1 for terrestrial and riparian receptors for all non-radiological COPCs during all phases of the Project and the future centuries, including for invertebrates, vegetation, mammals, and birds. This includes receptors residing and feeding in and around Whitefish Lake, McGowan Lake, and Russell Lake (exposure locations) as well as Kratchkowsky Lake (a reference location).

Since there are no exceedances of TRVs (all HQs less than 1) for birds and mammals, individual SAR would also be considered protected.

The predicted total HQs are less than 1 for aquatic receptors for all non-radiological COPCs, except copper, during all phases of the Project and the future centuries, including aquatic plants, invertebrates and fish (including northern pike and white sucker). This includes receptors at Whitefish Lake, McGowan Lake, and Russell Lake (exposure locations) as well as Kratchkowsky Lake (a reference location). When copper is re-evaluated using updated TRVs as shown in Section 6.3.2, under baseline conditions as well as the future centuries, copper HQs for all aquatic organisms are less than 1 with the exception of predator fish in Whitefish Lake, and benthic invertebrates at all locations where HQs are slightly above 1. Using predicted operational site conditions for hardness of 9 mg/L and pH of 7 during periods of treated effluent discharge, copper HQs for all aquatic organisms are less than 1 at all downstream locations, indicating no adverse effects to aquatic organisms from facility related copper (Section 6.3.2).

For assessment of risk to benthic invertebrates, risk was calculated based on toxicity benchmarks as water concentrations. However, considering that benthic invertebrates also reside in sediment, a comparison of predicted sediment concentrations against sediment toxicity benchmarks was warranted. This only applied to molybdenum and selenium in sediment, as no other COPC exceeded sediment screening values (Table 3-6). Molybdenum and selenium in sediment in Whitefish Lake (LA-5) were predicted to exceed the REF screening values from Burnett-Seidel and Liber (2013), but were predicted to be below the NE2 values in Whitefish Lake and all other downstream locations. Concentrations below the NE2 values indicate that benthic invertebrate community metrics (abundance, richness, and evenness) downstream of discharges are not expected to differ significantly (i.e., by 20%) from those observed at natural background conditions.

Table 5-24: Estimated Non-radiological Total Risk to Ecological Receptors – Project Phases and Future Centuries

Biota		Location	Maximum HQs during Project Phases											
			Arsenic	Cadmium	Chloride	Cobalt	Chromium	Copper	Molybdenum	Sulphate	Selenium	Uranium	Vanadium	Zinc
Aquatic Plants[(a)]	Macrophytes	Reference (Kratchkowsky Lake)	4.73E-04	3.13E-03	1.02E-04	1.04E-02	2.65E-02	1.64E-02	3.47E-06	2.98E-04	4.93E-05	5.67E-06	2.09E-03	6.03E-03
		Whitefish Lake North	4.37E-04	3.08E-03	1.02E-04	1.03E-02	2.62E-02	1.63E-02	3.46E-06	2.98E-04	4.83E-05	5.55E-06	1.93E-03	5.94E-03
		Whitefish Lake Middle	5.81E-04	5.23E-03	1.95E-03	1.31E-02	3.73E-02	2.16E-02	7.84E-04	1.67E-02	6.37E-04	1.04E-04	8.38E-03	9.16E-03
		Whitefish Lake South	5.91E-04	5.08E-03	1.94E-03	1.31E-02	3.65E-02	2.15E-02	7.73E-04	1.67E-02	6.07E-04	9.94E-05	7.06E-03	8.91E-03
		McGowan Lake	5.00E-04	4.31E-03	1.33E-03	1.21E-02	3.27E-02	1.97E-02	5.09E-04	1.13E-02	3.81E-04	6.14E-05	4.10E-03	7.77E-03
		Russell Lake Inlet	4.85E-04	3.96E-03	1.04E-03	1.17E-02	3.09E-02	1.89E-02	3.82E-04	8.61E-03	2.87E-04	4.57E-05	3.36E-03	7.24E-03
	Phytoplankton	Reference (Kratchkowsky Lake)	6.21E-03	9.53E-03	5.31E-05	2.21E-03	2.65E-02	6.76E-02	3.47E-06	2.58E-04	4.21E-04	7.09E-05	2.09E-03	2.33E-02
		Whitefish Lake North	5.73E-03	9.37E-03	5.31E-05	2.20E-03	2.62E-02	6.74E-02	3.46E-06	2.58E-04	4.12E-04	6.94E-05	1.93E-03	2.30E-02
		Whitefish Lake Middle	7.63E-03	1.59E-02	1.01E-03	2.80E-03	3.73E-02	8.94E-02	7.84E-04	1.45E-02	5.43E-03	1.31E-03	8.38E-03	3.54E-02
		Whitefish Lake South	7.76E-03	1.54E-02	1.01E-03	2.78E-03	3.65E-02	8.88E-02	7.73E-04	1.45E-02	5.18E-03	1.24E-03	7.06E-03	3.44E-02
		McGowan Lake	6.57E-03	1.31E-02	6.93E-04	2.59E-03	3.27E-02	8.15E-02	5.09E-04	9.78E-03	3.25E-03	7.68E-04	4.10E-03	3.00E-02
		Russell Lake Inlet	6.36E-03	1.20E-02	5.38E-04	2.49E-03	3.09E-02	7.79E-02	3.82E-04	7.47E-03	2.45E-03	5.72E-04	3.36E-03	2.80E-02
Aquatic Animals[(a)]	Benthic Invertebrate	Reference (Kratchkowsky Lake)	7.10E-04	4.68E-02	7.66E-04	5.70E-03	2.30E-04	3.07E-01	3.42E-06	9.42E-04	3.11E-03	1.07E-03	1.54E-03	2.20E-02
		Whitefish Lake North	7.10E-04	4.68E-02	7.66E-04	5.70E-03	2.30E-04	3.07E-01	3.42E-06	9.42E-04	3.11E-03	1.07E-03	1.54E-03	2.20E-02
		Whitefish Lake Middle	9.38E-04	6.89E-02	1.45E-02	6.90E-03	2.99E-04	3.84E-01	5.80E-04	5.28E-02	2.74E-02	1.33E-02	5.11E-03	3.02E-02
		Whitefish Lake South	8.96E-04	6.79E-02	1.45E-02	6.88E-03	2.96E-04	3.82E-01	5.70E-04	5.25E-02	2.63E-02	1.27E-02	4.58E-03	2.98E-02
		McGowan Lake	8.05E-04	6.13E-02	9.87E-03	6.57E-03	2.77E-04	3.62E-01	4.17E-04	3.52E-02	1.86E-02	8.84E-03	3.05E-03	2.74E-02
		Russell Lake Inlet	7.69E-04	5.75E-02	7.77E-03	6.36E-03	2.65E-04	3.49E-01	3.17E-04	2.73E-02	1.44E-02	6.75E-03	2.50E-03	2.60E-02
	Northern pike	Reference (Kratchkowsky Lake)	1.89E-04	6.62E-02	3.26E-04	4.07E-05	5.05E-03	2.07E-01	1.34E-06	1.37E-03	3.80E-02	5.67E-05	2.09E-03	2.19E-02
		Whitefish Lake North	1.75E-04	6.51E-02	3.26E-04	4.06E-05	4.99E-03	2.07E-01	1.34E-06	1.37E-03	3.72E-02	5.55E-05	1.93E-03	2.15E-02
		Whitefish Lake Middle	2.33E-04	1.10E-01	6.21E-03	5.16E-05	7.10E-03	2.74E-01	3.04E-04	7.70E-02	4.91E-01	1.04E-03	8.38E-03	3.32E-02
		Whitefish Lake South	2.36E-04	1.07E-01	6.18E-03	5.13E-05	6.95E-03	2.72E-01	3.00E-04	7.67E-02	4.68E-01	9.94E-04	7.06E-03	3.23E-02
		McGowan Lake	2.00E-04	9.10E-02	4.25E-03	4.77E-05	6.23E-03	2.50E-01	1.97E-04	5.18E-02	2.93E-01	6.14E-04	4.10E-03	2.82E-02
		Russell Lake Inlet	1.94E-04	8.37E-02	3.30E-03	4.59E-05	5.88E-03	2.39E-01	1.48E-04	3.96E-02	2.22E-01	4.57E-04	3.36E-03	2.63E-02
	White sucker	Reference (Kratchkowsky Lake)	9.03E-04	8.10E-02	4.65E-04	2.47E-04	9.90E-04	3.10E-01	3.46E-06	2.29E-04	5.16E-02	2.04E-05	1.95E-03	1.97E-02
		Whitefish Lake North	8.47E-04	8.00E-02	4.65E-04	2.47E-04	9.80E-04	3.09E-01	3.45E-06	2.29E-04	5.07E-02	2.01E-05	1.84E-03	1.95E-02
		Whitefish Lake Middle	1.13E-03	1.31E-01	8.85E-03	3.10E-04	1.37E-03	4.04E-01	7.33E-04	1.29E-02	6.16E-01	3.47E-04	7.56E-03	2.92E-02
		Whitefish Lake South	1.13E-03	1.28E-01	8.81E-03	3.09E-04	1.34E-03	4.02E-01	7.22E-04	1.28E-02	5.87E-01	3.31E-04	6.44E-03	2.85E-02
		McGowan Lake	9.69E-04	1.10E-01	6.05E-03	2.89E-04	1.21E-03	3.72E-01	4.86E-04	8.65E-03	3.77E-01	2.09E-04	3.84E-03	2.52E-02
		Russell Lake Inlet	9.35E-04	1.02E-01	4.71E-03	2.78E-04	1.15E-03	3.56E-01	3.66E-04	6.63E-03	2.86E-01	1.56E-04	3.14E-03	2.36E-02
	Zooplankton	Reference (Kratchkowsky Lake)	3.51E-04	1.59E-01	7.66E-04	9.14E-03	5.30E-02	3.11E-01	3.47E-06	1.62E-03	3.35E-03	5.20E-04	8.80E-05	2.33E-02
		Whitefish Lake North	3.24E-04	1.56E-01	7.66E-04	9.12E-03	5.24E-02	3.10E-01	3.46E-06	1.62E-03	3.28E-03	5.09E-04	8.14E-05	2.30E-02
		Whitefish Lake Middle	4.31E-04	2.65E-01	1.46E-02	1.16E-02	7.46E-02	4.11E-01	7.84E-04	9.10E-02	4.33E-02	9.57E-03	3.53E-04	3.54E-02
		Whitefish Lake South	4.38E-04	2.57E-01	1.45E-02	1.15E-02	7.30E-02	4.08E-01	7.73E-04	9.06E-02	4.12E-02	9.11E-03	2.97E-04	3.44E-02
		McGowan Lake	3.71E-04	2.18E-01	9.99E-03	1.07E-02	6.54E-02	3.75E-01	5.09E-04	6.12E-02	2.59E-02	5.63E-03	1.73E-04	3.00E-02
		Russell Lake Inlet	3.59E-04	2.01E-01	7.75E-03	1.03E-02	6.17E-02	3.58E-01	3.82E-04	4.68E-02	1.95E-02	4.19E-03	1.41E-04	2.80E-02

Biota		Location	Maximum HQs during Project Phases											
			Arsenic	Cadmium	Chloride	Cobalt	Chromium	Copper	Molybdenum	Sulphate	Selenium	Uranium	Vanadium	Zinc
Terrestrial Animals	Black Bear	Reference (Kratchkowsky Lake)	1.59E-03	5.16E-06	0.00E+00	1.70E-04	4.28E-05	1.27E-02	6.73E-04	0.00E+00	2.60E-02	2.15E-04	2.17E-03	1.06E-02
		Whitefish Lake	1.59E-03	5.17E-06	0.00E+00	1.70E-04	4.36E-05	1.28E-02	8.93E-04	0.00E+00	7.27E-02	3.70E-04	2.24E-03	1.07E-02
	Canada Lynx	Reference (Kratchkowsky Lake)	5.28E-03	2.43E-05	0.00E+00	4.21E-05	7.18E-05	2.94E-02	2.11E-04	0.00E+00	1.37E-01	1.04E-04	4.67E-03	4.09E-01
		Whitefish Lake	5.30E-03	2.43E-05	0.00E+00	4.25E-05	7.28E-05	3.03E-02	9.33E-04	0.00E+00	1.39E-01	1.15E-03	4.75E-03	4.10E-01
		McGowan Lake	5.28E-03	2.43E-05	0.00E+00	4.23E-05	7.20E-05	2.95E-02	6.78E-04	0.00E+00	1.38E-01	2.45E-04	4.68E-03	4.09E-01
		Russell Lake Inlet	5.28E-03	2.43E-05	0.00E+00	4.22E-05	7.19E-05	2.94E-02	5.61E-04	0.00E+00	1.38E-01	1.43E-04	4.67E-03	4.09E-01
	Mink	Reference (Kratchkowsky Lake)	3.43E-03	7.48E-06	0.00E+00	7.74E-05	1.51E-04	1.27E-02	2.47E-04	0.00E+00	6.87E-02	1.25E-04	6.37E-03	9.08E-03
		Whitefish Lake	4.38E-03	9.12E-06	0.00E+00	8.93E-05	1.84E-04	1.59E-02	3.34E-02	0.00E+00	6.04E-01	1.20E-03	1.57E-02	1.32E-02
		McGowan Lake	3.79E-03	8.54E-06	0.00E+00	8.58E-05	1.73E-04	1.50E-02	2.39E-02	0.00E+00	3.94E-01	5.36E-04	1.00E-02	1.15E-02
		Russell Lake Inlet	3.65E-03	8.26E-06	0.00E+00	8.38E-05	1.67E-04	1.44E-02	1.82E-02	0.00E+00	3.09E-01	3.92E-04	8.69E-03	1.08E-02
	Moose	Reference (Kratchkowsky Lake)	1.71E-04	1.85E-04	0.00E+00	8.80E-05	2.02E-05	3.93E-02	1.80E-04	0.00E+00	1.81E-03	1.16E-04	1.93E-03	2.21E-03
		Whitefish Lake	1.96E-04	1.92E-04	0.00E+00	9.53E-05	2.28E-05	4.08E-02	2.58E-03	0.00E+00	7.38E-03	3.21E-03	4.52E-03	2.27E-03
		McGowan Lake	1.81E-04	1.89E-04	0.00E+00	9.24E-05	2.18E-05	3.98E-02	1.83E-03	0.00E+00	5.05E-03	6.21E-04	2.87E-03	2.24E-03
		Russell Lake Inlet	1.77E-04	1.88E-04	0.00E+00	9.12E-05	2.14E-05	3.96E-02	1.42E-03	0.00E+00	4.15E-03	3.09E-04	2.52E-03	2.23E-03
	Moose Organs	Reference (Kratchkowsky Lake)	1.71E-04	1.85E-04	0.00E+00	8.80E-05	2.02E-05	3.93E-02	1.80E-04	0.00E+00	1.81E-03	1.16E-04	1.93E-03	2.21E-03
		McGowan Lake	1.81E-04	1.89E-04	0.00E+00	9.24E-05	2.18E-05	3.98E-02	1.83E-03	0.00E+00	5.05E-03	6.21E-04	2.87E-03	2.24E-03
		Russell Lake Inlet	1.77E-04	1.88E-04	0.00E+00	9.12E-05	2.14E-05	3.96E-02	1.42E-03	0.00E+00	4.15E-03	3.09E-04	2.52E-03	2.23E-03
	Muskrat	Reference (Kratchkowsky Lake)	1.81E-03	1.79E-04	0.00E+00	3.36E-04	1.74E-04	3.12E-04	2.69E-04	0.00E+00	4.75E-03	3.24E-04	1.88E-02	4.80E-04
		Whitefish Lake	2.35E-03	2.75E-04	0.00E+00	4.23E-04	2.27E-04	4.10E-04	4.84E-02	0.00E+00	5.13E-02	4.43E-03	6.64E-02	7.14E-04
		McGowan Lake	2.02E-03	2.39E-04	0.00E+00	3.93E-04	2.09E-04	3.76E-04	3.40E-02	0.00E+00	3.24E-02	2.85E-03	3.70E-02	6.14E-04
		Russell Lake Inlet	1.94E-03	2.22E-04	0.00E+00	3.78E-04	2.00E-04	3.59E-04	2.58E-02	0.00E+00	2.47E-02	2.16E-03	3.03E-02	5.74E-04
	Snowshoe Hare	Reference (Kratchkowsky Lake)	2.25E-03	4.08E-03	0.00E+00	3.05E-04	9.04E-05	5.53E-03	1.06E-04	0.00E+00	1.07E-02	4.88E-04	5.96E-03	1.97E-02
		Whitefish Lake	2.26E-03	4.09E-03	0.00E+00	3.08E-04	9.13E-05	5.69E-03	1.84E-04	0.00E+00	1.10E-02	1.07E-02	6.04E-03	1.97E-02
		McGowan Lake	2.25E-03	4.08E-03	0.00E+00	3.06E-04	9.06E-05	5.55E-03	1.56E-04	0.00E+00	1.08E-02	1.83E-03	5.97E-03	1.97E-02
		Russell Lake Inlet	2.25E-03	4.08E-03	0.00E+00	3.06E-04	9.05E-05	5.54E-03	1.43E-04	0.00E+00	1.08E-02	8.49E-04	5.97E-03	1.97E-02
	Southern Red-Backed Vole	Reference (Kratchkowsky Lake)	7.62E-03	1.28E-02	0.00E+00	3.27E-03	2.96E-04	2.13E-02	2.88E-02	0.00E+00	8.08E-02	7.45E-03	1.45E-02	3.56E-03
		Whitefish Lake	7.63E-03	1.28E-02	0.00E+00	3.29E-03	3.00E-04	2.20E-02	3.03E-02	0.00E+00	8.14E-02	9.70E-02	1.48E-02	3.57E-03
		McGowan Lake	7.62E-03	1.28E-02	0.00E+00	3.27E-03	2.97E-04	2.14E-02	2.96E-02	0.00E+00	8.09E-02	1.92E-02	1.45E-02	3.56E-03
		Russell Lake Inlet	7.62E-03	1.28E-02	0.00E+00	3.27E-03	2.96E-04	2.13E-02	2.94E-02	0.00E+00	8.08E-02	1.06E-02	1.45E-02	3.56E-03
	WoodLand Caribou	Reference (Kratchkowsky Lake)	3.70E-04	2.79E-04	0.00E+00	1.62E-04	2.30E-04	2.74E-02	3.30E-04	0.00E+00	4.63E-03	3.10E-04	7.79E-03	2.80E-03
		Whitefish Lake	3.85E-04	2.84E-04	0.00E+00	1.66E-04	2.33E-04	2.83E-02	2.54E-03	0.00E+00	7.65E-03	9.19E-03	8.98E-03	2.82E-03
	Canada Goose	Reference (Kratchkowsky Lake)	2.13E-04	1.25E-04	0.00E+00	3.19E-05	2.36E-05	8.69E-04	1.57E-05	0.00E+00	3.66E-04	2.37E-05	5.58E-03	5.45E-04
		Whitefish Lake	2.12E-04	1.25E-04	0.00E+00	3.20E-05	2.34E-05	8.91E-04	1.57E-05	0.00E+00	3.67E-04	4.96E-04	5.61E-03	5.46E-04

Biota		Location	Maximum HQs during Project Phases											
			Arsenic	Cadmium	Chloride	Cobalt	Chromium	Copper	Molybdenum	Sulphate	Selenium	Uranium	Vanadium	Zinc
		McGowan Lake	2.13E-04	1.25E-04	0.00E+00	3.20E-05	2.37E-05	8.72E-04	4.46E-05	0.00E+00	3.81E-04	8.65E-05	5.60E-03	5.46E-04
		Russell Lake Inlet	2.13E-04	1.25E-04	0.00E+00	3.20E-05	2.36E-05	8.70E-04	3.74E-05	0.00E+00	3.76E-04	4.08E-05	5.59E-03	5.46E-04
	Bald Eagle	Reference (Kratchkowsky Lake)	2.80E-03	7.63E-04	0.00E+00	1.89E-04	4.50E-04	2.33E-03	5.06E-05	0.00E+00	3.23E-02	2.20E-04	9.26E-02	1.56E-03
		Whitefish Lake	2.81E-03	7.64E-04	0.00E+00	1.89E-04	4.52E-04	2.36E-03	6.94E-05	0.00E+00	4.54E-02	2.49E-04	9.31E-02	1.58E-03
	Olive-Sided Flycatcher	Reference (Kratchkowsky Lake)	7.84E-03	3.93E-02	0.00E+00	8.99E-04	1.77E-03	2.92E-02	5.67E-04	0.00E+00	7.03E-02	8.03E-04	2.56E-01	1.91E-02
		Whitefish Lake	8.36E-03	3.94E-02	0.00E+00	9.43E-04	1.87E-03	3.36E-02	1.38E-02	0.00E+00	1.25E-01	1.72E-02	2.86E-01	2.02E-02
		McGowan Lake	8.05E-03	3.93E-02	0.00E+00	9.27E-04	1.84E-03	3.22E-02	1.02E-02	0.00E+00	1.05E-01	3.08E-03	2.68E-01	1.98E-02
		Russell Lake Inlet	7.97E-03	3.93E-02	0.00E+00	9.19E-04	1.82E-03	3.15E-02	7.84E-03	0.00E+00	9.56E-02	1.49E-03	2.64E-01	1.97E-02
	Common Loon	Reference (Kratchkowsky Lake)	1.23E-03	1.80E-05	0.00E+00	2.66E-05	7.35E-05	3.37E-03	1.01E-05	0.00E+00	3.53E-02	6.44E-06	4.77E-03	1.51E-03
		Whitefish Lake	1.52E-03	2.67E-05	0.00E+00	3.27E-05	9.98E-05	4.30E-03	1.73E-03	0.00E+00	2.93E-01	1.05E-04	1.83E-02	2.25E-03
		McGowan Lake	1.31E-03	2.36E-05	0.00E+00	3.08E-05	8.95E-05	4.01E-03	1.24E-03	0.00E+00	1.92E-01	6.40E-05	9.37E-03	1.93E-03
		Russell Lake Inlet	1.27E-03	2.21E-05	0.00E+00	2.98E-05	8.50E-05	3.85E-03	9.43E-04	0.00E+00	1.52E-01	4.80E-05	7.68E-03	1.80E-03
	Mallard	Reference (Kratchkowsky Lake)	4.57E-03	6.31E-05	0.00E+00	3.21E-04	1.51E-02	1.03E-02	1.62E-04	0.00E+00	5.20E-03	9.80E-05	6.22E-02	7.83E-03
		Whitefish Lake	6.02E-03	9.34E-05	0.00E+00	3.93E-04	1.95E-02	1.29E-02	2.76E-02	0.00E+00	4.69E-02	1.25E-03	2.10E-01	1.08E-02
		McGowan Lake	5.17E-03	8.28E-05	0.00E+00	3.71E-04	1.81E-02	1.21E-02	1.98E-02	0.00E+00	3.15E-02	8.24E-04	1.23E-01	9.76E-03
		Russell Lake Inlet	4.94E-03	7.76E-05	0.00E+00	3.59E-04	1.73E-02	1.17E-02	1.51E-02	0.00E+00	2.44E-02	6.27E-04	1.01E-01	9.25E-03
	American Robin	Reference (Kratchkowsky Lake)	3.87E-02	3.05E-02	0.00E+00	5.09E-03	3.79E-03	1.38E-01	2.66E-03	0.00E+00	1.09E-01	3.29E-03	7.82E-01	7.91E-02
		Whitefish Lake	3.87E-02	3.06E-02	0.00E+00	5.12E-03	3.80E-03	1.43E-01	2.68E-03	0.00E+00	1.10E-01	3.27E-02	7.84E-01	7.94E-02
		McGowan Lake	3.87E-02	3.05E-02	0.00E+00	5.09E-03	3.79E-03	1.39E-01	2.75E-03	0.00E+00	1.09E-01	7.15E-03	7.82E-01	7.92E-02
		Russell Lake Inlet	3.87E-02	3.05E-02	0.00E+00	5.09E-03	3.79E-03	1.38E-01	2.73E-03	0.00E+00	1.09E-01	4.32E-03	7.82E-01	7.91E-02
	Lesser Scaup	Reference (Kratchkowsky Lake)	7.95E-03	1.15E-04	0.00E+00	7.91E-04	2.54E-02	1.82E-02	2.80E-04	0.00E+00	9.74E-03	1.72E-04	1.20E-01	1.48E-02
		Whitefish Lake	1.04E-02	1.73E-04	0.00E+00	9.77E-04	3.30E-02	2.27E-02	4.81E-02	0.00E+00	9.17E-02	2.32E-03	4.21E-01	2.06E-02
		McGowan Lake	8.92E-03	1.52E-04	0.00E+00	9.18E-04	3.05E-02	2.14E-02	3.44E-02	0.00E+00	6.07E-02	1.50E-03	2.36E-01	1.85E-02
		Russell Lake Inlet	8.53E-03	1.42E-04	0.00E+00	8.86E-04	2.92E-02	2.06E-02	2.62E-02	0.00E+00	4.68E-02	1.14E-03	1.94E-01	1.75E-02

Biota		Location	Maximum HQs during Future Centuries											
			Arsenic	Cadmium	Chloride	Cobalt	Chromium	Copper	Molybdenum	Sulphate	Selenium	Uranium	Vanadium	Zinc
Aquatic Plants[(a)]	**Macrophytes**	Reference (Kratchkowsky Lake)	4.10E-04	3.05E-03	1.02E-04	1.03E-02	2.59E-02	1.63E-02	3.45E-06	2.98E-04	4.75E-05	5.46E-06	1.82E-03	5.87E-03
		Whitefish Lake North	4.10E-04	3.05E-03	1.02E-04	1.03E-02	2.59E-02	1.63E-02	3.45E-06	2.98E-04	4.75E-05	5.46E-06	1.82E-03	5.87E-03
		Whitefish Lake Middle	4.25E-04	3.07E-03	1.32E-04	1.09E-02	2.63E-02	1.65E-02	3.76E-06	3.12E-04	6.33E-05	6.68E-06	1.84E-03	6.38E-03
		Whitefish Lake South	4.23E-04	3.06E-03	1.31E-04	1.08E-02	2.63E-02	1.65E-02	3.75E-06	3.12E-04	6.26E-05	6.63E-06	1.83E-03	6.36E-03
		McGowan Lake	4.16E-04	3.06E-03	1.25E-04	1.07E-02	2.62E-02	1.64E-02	3.68E-06	3.09E-04	5.80E-05	6.28E-06	1.83E-03	6.22E-03
		Russell Lake Inlet	4.14E-04	3.06E-03	1.19E-04	1.06E-02	2.61E-02	1.64E-02	3.62E-06	3.06E-04	5.52E-05	6.06E-06	1.82E-03	6.13E-03
	Phytoplankton	Reference (Kratchkowsky Lake)	5.38E-03	9.26E-03	5.31E-05	2.20E-03	2.59E-02	6.72E-02	3.45E-06	2.58E-04	4.05E-04	6.83E-05	1.82E-03	2.27E-02

Biota		Location	Maximum HQs during Future Centuries											
			Arsenic	Cadmium	Chloride	Cobalt	Chromium	Copper	Molybdenum	Sulphate	Selenium	Uranium	Vanadium	Zinc
		Whitefish Lake North	5.38E-03	9.26E-03	5.31E-05	2.20E-03	2.59E-02	6.72E-02	3.45E-06	2.58E-04	4.05E-04	6.83E-05	1.82E-03	2.27E-02
		Whitefish Lake Middle	5.58E-03	9.32E-03	6.84E-05	2.31E-03	2.63E-02	6.81E-02	3.76E-06	2.71E-04	5.40E-04	8.36E-05	1.84E-03	2.47E-02
		Whitefish Lake South	5.55E-03	9.32E-03	6.82E-05	2.31E-03	2.63E-02	6.81E-02	3.75E-06	2.71E-04	5.34E-04	8.29E-05	1.83E-03	2.46E-02
		McGowan Lake	5.47E-03	9.30E-03	6.48E-05	2.28E-03	2.62E-02	6.79E-02	3.68E-06	2.68E-04	4.95E-04	7.84E-05	1.83E-03	2.40E-02
		Russell Lake Inlet	5.43E-03	9.29E-03	6.21E-05	2.26E-03	2.61E-02	6.77E-02	3.62E-06	2.66E-04	4.71E-04	7.57E-05	1.82E-03	2.37E-02
Aquatic Animals[(a)]	Benthic Invertebrate	Reference (Kratchkowsky Lake)	7.10E-04	4.68E-02	7.66E-04	5.70E-03	2.30E-04	3.07E-01	3.42E-06	9.42E-04	3.11E-03	1.07E-03	1.54E-03	2.20E-02
		Whitefish Lake North	7.10E-04	4.68E-02	7.66E-04	5.70E-03	2.30E-04	3.07E-01	3.42E-06	9.42E-04	3.11E-03	1.07E-03	1.54E-03	2.20E-02
		Whitefish Lake Middle	7.36E-04	4.71E-02	9.85E-04	6.00E-03	2.33E-04	3.11E-01	3.73E-06	9.87E-04	4.14E-03	1.31E-03	1.55E-03	2.39E-02
		Whitefish Lake South	7.33E-04	4.71E-02	9.83E-04	6.00E-03	2.33E-04	3.11E-01	3.73E-06	9.87E-04	4.09E-03	1.30E-03	1.55E-03	2.39E-02
		McGowan Lake	7.21E-04	4.70E-02	9.33E-04	5.93E-03	2.33E-04	3.10E-01	3.65E-06	9.77E-04	3.79E-03	1.23E-03	1.55E-03	2.33E-02
		Russell Lake Inlet	7.17E-04	4.70E-02	8.94E-04	5.88E-03	2.32E-04	3.09E-01	3.60E-06	9.68E-04	3.61E-03	1.19E-03	1.54E-03	2.30E-02
	Northern pike	Reference (Kratchkowsky Lake)	1.64E-04	6.43E-02	3.26E-04	4.05E-05	4.94E-03	2.06E-01	1.34E-06	1.37E-03	3.67E-02	5.46E-05	1.82E-03	2.13E-02
		Whitefish Lake North	1.64E-04	6.43E-02	3.26E-04	4.05E-05	4.94E-03	2.06E-01	1.34E-06	1.37E-03	3.67E-02	5.46E-05	1.82E-03	2.13E-02
		Whitefish Lake Middle	1.70E-04	6.47E-02	4.19E-04	4.26E-05	5.01E-03	2.09E-01	1.46E-06	1.44E-03	4.88E-02	6.68E-05	1.84E-03	2.31E-02
		Whitefish Lake South	1.69E-04	6.47E-02	4.18E-04	4.26E-05	5.00E-03	2.09E-01	1.45E-06	1.44E-03	4.83E-02	6.63E-05	1.83E-03	2.30E-02
		McGowan Lake	1.67E-04	6.46E-02	3.97E-04	4.21E-05	4.99E-03	2.08E-01	1.43E-06	1.42E-03	4.47E-02	6.28E-05	1.83E-03	2.25E-02
		Russell Lake Inlet	1.66E-04	6.45E-02	3.81E-04	4.17E-05	4.98E-03	2.08E-01	1.40E-06	1.41E-03	4.26E-02	6.06E-05	1.82E-03	2.22E-02
	White sucker	Reference (Kratchkowsky Lake)	8.06E-04	7.93E-02	4.65E-04	2.47E-04	9.74E-04	3.09E-01	3.44E-06	2.29E-04	5.01E-02	1.98E-05	1.75E-03	1.93E-02
		Whitefish Lake North	8.06E-04	7.93E-02	4.65E-04	2.47E-04	9.74E-04	3.09E-01	3.44E-06	2.29E-04	5.01E-02	1.98E-05	1.75E-03	1.93E-02
		Whitefish Lake Middle	8.36E-04	7.97E-02	5.99E-04	2.60E-04	9.86E-04	3.13E-01	3.75E-06	2.40E-04	6.68E-02	2.43E-05	1.77E-03	2.10E-02
		Whitefish Lake South	8.32E-04	7.97E-02	5.97E-04	2.59E-04	9.86E-04	3.13E-01	3.75E-06	2.40E-04	6.61E-02	2.41E-05	1.76E-03	2.09E-02
		McGowan Lake	8.19E-04	7.96E-02	5.67E-04	2.56E-04	9.82E-04	3.12E-01	3.67E-06	2.38E-04	6.12E-02	2.28E-05	1.76E-03	2.04E-02
		Russell Lake Inlet	8.14E-04	7.95E-02	5.43E-04	2.54E-04	9.80E-04	3.11E-01	3.62E-06	2.36E-04	5.82E-02	2.20E-05	1.75E-03	2.02E-02
	Zooplankton	Reference (Kratchkowsky Lake)	3.04E-04	1.54E-01	7.66E-04	9.10E-03	5.19E-02	3.09E-01	3.45E-06	1.62E-03	3.23E-03	5.01E-04	7.66E-05	2.27E-02
		Whitefish Lake North	3.04E-04	1.54E-01	7.66E-04	9.10E-03	5.19E-02	3.09E-01	3.45E-06	1.62E-03	3.23E-03	5.01E-04	7.66E-05	2.27E-02
		Whitefish Lake Middle	3.15E-04	1.55E-01	9.85E-04	9.58E-03	5.26E-02	3.13E-01	3.76E-06	1.70E-03	4.30E-03	6.13E-04	7.73E-05	2.47E-02
		Whitefish Lake South	3.14E-04	1.55E-01	9.83E-04	9.57E-03	5.26E-02	3.13E-01	3.75E-06	1.70E-03	4.26E-03	6.08E-04	7.72E-05	2.46E-02
		McGowan Lake	3.09E-04	1.55E-01	9.33E-04	9.46E-03	5.24E-02	3.12E-01	3.68E-06	1.68E-03	3.94E-03	5.75E-04	7.69E-05	2.40E-02
		Russell Lake Inlet	3.07E-04	1.55E-01	8.94E-04	9.37E-03	5.23E-02	3.11E-01	3.62E-06	1.66E-03	3.76E-03	5.55E-04	7.68E-05	2.37E-02
Terrestrial Animals	Black Bear	Reference (Kratchkowsky Lake)	1.55E-03	5.16E-06	0.00E+00	1.70E-04	4.26E-05	1.27E-02	6.73E-04	0.00E+00	2.54E-02	2.15E-04	2.15E-03	1.06E-02
		Whitefish Lake	1.55E-03	5.16E-06	0.00E+00	1.70E-04	4.27E-05	1.27E-02	6.73E-04	0.00E+00	2.72E-02	2.22E-04	2.15E-03	1.06E-02
	Canada Lynx	Reference (Kratchkowsky Lake)	5.28E-03	2.43E-05	0.00E+00	4.21E-05	7.18E-05	2.94E-02	2.11E-04	0.00E+00	1.37E-01	1.04E-04	4.67E-03	4.09E-01
		Whitefish Lake	5.28E-03	2.43E-05	0.00E+00	4.22E-05	7.18E-05	2.94E-02	2.11E-04	0.00E+00	1.37E-01	1.40E-04	4.67E-03	4.09E-01
		McGowan Lake	5.28E-03	2.43E-05	0.00E+00	4.22E-05	7.18E-05	2.94E-02	2.11E-04	0.00E+00	1.37E-01	1.08E-04	4.67E-03	4.09E-01
		Russell Lake Inlet	5.28E-03	2.43E-05	0.00E+00	4.21E-05	7.18E-05	2.94E-02	2.11E-04	0.00E+00	1.37E-01	1.05E-04	4.67E-03	4.09E-01
	Mink	Reference (Kratchkowsky Lake)	3.32E-03	7.48E-06	0.00E+00	7.74E-05	1.50E-04	1.27E-02	2.47E-04	0.00E+00	6.72E-02	1.25E-04	6.26E-03	8.92E-03

Biota	Location	Maximum HQs during Future Centuries											
		Arsenic	Cadmium	Chloride	Cobalt	Chromium	Copper	Molybdenum	Sulphate	Selenium	Uranium	Vanadium	Zinc
	Whitefish Lake	3.43E-03	7.50E-06	0.00E+00	8.03E-05	1.52E-04	1.28E-02	2.64E-04	0.00E+00	8.66E-02	1.65E-04	6.29E-03	9.68E-03
	McGowan Lake	3.37E-03	7.49E-06	0.00E+00	7.95E-05	1.51E-04	1.28E-02	2.60E-04	0.00E+00	8.01E-02	1.36E-04	6.27E-03	9.44E-03
	Russell Lake Inlet	3.35E-03	7.49E-06	0.00E+00	7.90E-05	1.51E-04	1.28E-02	2.57E-04	0.00E+00	7.67E-02	1.31E-04	6.27E-03	9.31E-03
Moose	Reference (Kratchkowsky Lake)	1.68E-04	1.85E-04	0.00E+00	8.79E-05	2.02E-05	3.93E-02	1.80E-04	0.00E+00	1.80E-03	1.16E-04	1.86E-03	2.21E-03
	Whitefish Lake	1.71E-04	1.85E-04	0.00E+00	8.93E-05	2.03E-05	3.93E-02	1.81E-04	0.00E+00	1.97E-03	1.40E-04	1.87E-03	2.22E-03
	McGowan Lake	1.69E-04	1.85E-04	0.00E+00	8.89E-05	2.02E-05	3.93E-02	1.80E-04	0.00E+00	1.91E-03	1.21E-04	1.87E-03	2.22E-03
	Russell Lake Inlet	1.69E-04	1.85E-04	0.00E+00	8.87E-05	2.02E-05	3.93E-02	1.80E-04	0.00E+00	1.88E-03	1.18E-04	1.87E-03	2.21E-03
Muskrat	Reference (Kratchkowsky Lake)	1.76E-03	1.78E-04	0.00E+00	3.35E-04	1.74E-04	3.11E-04	2.69E-04	0.00E+00	4.67E-03	3.22E-04	1.80E-02	4.69E-04
	Whitefish Lake	1.83E-03	1.79E-04	0.00E+00	3.52E-04	1.76E-04	3.15E-04	2.93E-04	0.00E+00	6.22E-03	3.93E-04	1.81E-02	5.10E-04
	McGowan Lake	1.79E-03	1.79E-04	0.00E+00	3.48E-04	1.75E-04	3.14E-04	2.87E-04	0.00E+00	5.70E-03	3.69E-04	1.81E-02	4.97E-04
	Russell Lake Inlet	1.78E-03	1.78E-04	0.00E+00	3.45E-04	1.75E-04	3.13E-04	2.83E-04	0.00E+00	5.42E-03	3.57E-04	1.80E-02	4.90E-04
Snowshoe Hare	Reference (Kratchkowsky Lake)	2.25E-03	4.08E-03	0.00E+00	3.05E-04	9.04E-05	5.53E-03	1.06E-04	0.00E+00	1.07E-02	4.88E-04	5.96E-03	1.97E-02
	Whitefish Lake	2.25E-03	4.08E-03	0.00E+00	3.06E-04	9.04E-05	5.54E-03	1.06E-04	0.00E+00	1.07E-02	6.18E-04	5.96E-03	1.97E-02
	McGowan Lake	2.25E-03	4.08E-03	0.00E+00	3.05E-04	9.04E-05	5.53E-03	1.06E-04	0.00E+00	1.07E-02	5.05E-04	5.96E-03	1.97E-02
	Russell Lake Inlet	2.25E-03	4.08E-03	0.00E+00	3.05E-04	9.04E-05	5.53E-03	1.06E-04	0.00E+00	1.07E-02	4.93E-04	5.96E-03	1.97E-02
Southern Red-Backed Vole	Reference (Kratchkowsky Lake)	7.62E-03	1.28E-02	0.00E+00	3.27E-03	2.96E-04	2.13E-02	2.88E-02	0.00E+00	8.08E-02	7.45E-03	1.45E-02	3.56E-03
	Whitefish Lake	7.62E-03	1.28E-02	0.00E+00	3.27E-03	2.96E-04	2.13E-02	2.88E-02	0.00E+00	8.08E-02	9.92E-03	1.45E-02	3.56E-03
	McGowan Lake	7.62E-03	1.28E-02	0.00E+00	3.27E-03	2.96E-04	2.13E-02	2.88E-02	0.00E+00	8.08E-02	7.77E-03	1.45E-02	3.56E-03
	Russell Lake Inlet	7.62E-03	1.28E-02	0.00E+00	3.27E-03	2.96E-04	2.13E-02	2.88E-02	0.00E+00	8.08E-02	7.54E-03	1.45E-02	3.56E-03
WoodLand Caribou	Reference (Kratchkowsky Lake)	3.66E-04	2.79E-04	0.00E+00	1.62E-04	2.30E-04	2.74E-02	3.30E-04	0.00E+00	4.62E-03	3.10E-04	7.73E-03	2.79E-03
	Whitefish Lake	3.68E-04	2.79E-04	0.00E+00	1.63E-04	2.30E-04	2.74E-02	3.31E-04	0.00E+00	4.73E-03	3.16E-04	7.73E-03	2.80E-03
Canada Goose	Reference (Kratchkowsky Lake)	2.13E-04	1.25E-04	0.00E+00	3.19E-05	2.36E-05	8.69E-04	1.57E-05	0.00E+00	3.65E-04	2.37E-05	5.58E-03	5.45E-04
	Whitefish Lake	2.11E-04	1.25E-04	0.00E+00	3.17E-05	2.33E-05	8.69E-04	1.55E-05	0.00E+00	3.63E-04	3.01E-05	5.57E-03	5.45E-04
	McGowan Lake	2.13E-04	1.25E-04	0.00E+00	3.20E-05	2.36E-05	8.69E-04	1.57E-05	0.00E+00	3.66E-04	2.46E-05	5.58E-03	5.45E-04
	Russell Lake Inlet	2.13E-04	1.25E-04	0.00E+00	3.20E-05	2.36E-05	8.69E-04	1.57E-05	0.00E+00	3.66E-04	2.40E-05	5.58E-03	5.45E-04
Bald Eagle	Reference (Kratchkowsky Lake)	2.67E-03	7.63E-04	0.00E+00	1.89E-04	4.50E-04	2.32E-03	5.06E-05	0.00E+00	3.15E-02	2.20E-04	9.22E-02	1.53E-03
	Whitefish Lake	2.68E-03	7.63E-04	0.00E+00	1.89E-04	4.50E-04	2.32E-03	5.07E-05	0.00E+00	3.21E-02	2.21E-04	9.22E-02	1.53E-03
Olive-Sided Flycatcher	Reference (Kratchkowsky Lake)	7.83E-03	3.93E-02	0.00E+00	8.99E-04	1.77E-03	2.92E-02	5.67E-04	0.00E+00	7.03E-02	8.03E-04	2.56E-01	1.91E-02
	Whitefish Lake	7.89E-03	3.93E-02	0.00E+00	9.08E-04	1.78E-03	2.94E-02	5.73E-04	0.00E+00	7.26E-02	1.02E-03	2.56E-01	1.94E-02
	McGowan Lake	7.86E-03	3.93E-02	0.00E+00	9.06E-04	1.78E-03	2.93E-02	5.72E-04	0.00E+00	7.18E-02	8.33E-04	2.56E-01	1.93E-02
	Russell Lake Inlet	7.85E-03	3.93E-02	0.00E+00	9.04E-04	1.78E-03	2.93E-02	5.71E-04	0.00E+00	7.14E-02	8.12E-04	2.56E-01	1.93E-02
Common Loon	Reference (Kratchkowsky Lake)	1.09E-03	1.79E-05	0.00E+00	2.65E-05	7.26E-05	3.37E-03	1.01E-05	0.00E+00	3.43E-02	6.29E-06	4.31E-03	1.47E-03
	Whitefish Lake	1.13E-03	1.80E-05	0.00E+00	2.80E-05	7.35E-05	3.41E-03	1.10E-05	0.00E+00	4.35E-02	7.69E-06	4.35E-03	1.60E-03
	McGowan Lake	1.10E-03	1.80E-05	0.00E+00	2.76E-05	7.32E-05	3.40E-03	1.08E-05	0.00E+00	4.04E-02	7.22E-06	4.33E-03	1.56E-03

Biota		Location	Maximum HQs during Future Centuries											
			Arsenic	Cadmium	Chloride	Cobalt	Chromium	Copper	Molybdenum	Sulphate	Selenium	Uranium	Vanadium	Zinc
		Russell Lake Inlet	1.10E-03	1.80E-05	0.00E+00	2.74E-05	7.31E-05	3.39E-03	1.06E-05	0.00E+00	3.88E-02	6.97E-06	4.32E-03	1.54E-03
	Mallard	Reference (Kratchkowsky Lake)	4.54E-03	6.30E-05	0.00E+00	3.21E-04	1.51E-02	1.03E-02	1.62E-04	0.00E+00	5.19E-03	9.78E-05	6.14E-02	7.82E-03
		Whitefish Lake	4.72E-03	6.33E-05	0.00E+00	3.38E-04	1.53E-02	1.04E-02	1.77E-04	0.00E+00	6.92E-03	1.20E-04	6.19E-02	8.50E-03
		McGowan Lake	4.62E-03	6.32E-05	0.00E+00	3.34E-04	1.52E-02	1.04E-02	1.73E-04	0.00E+00	6.34E-03	1.12E-04	6.16E-02	8.28E-03
		Russell Lake Inlet	4.59E-03	6.31E-05	0.00E+00	3.31E-04	1.52E-02	1.04E-02	1.70E-04	0.00E+00	6.04E-03	1.08E-04	6.15E-02	8.16E-03
	American Robin	Reference (Kratchkowsky Lake)	3.87E-02	3.05E-02	0.00E+00	5.09E-03	3.79E-03	1.38E-01	2.66E-03	0.00E+00	1.09E-01	3.29E-03	7.82E-01	7.91E-02
		Whitefish Lake	3.87E-02	3.05E-02	0.00E+00	5.10E-03	3.79E-03	1.38E-01	2.66E-03	0.00E+00	1.09E-01	4.46E-03	7.82E-01	7.92E-02
		McGowan Lake	3.87E-02	3.05E-02	0.00E+00	5.09E-03	3.79E-03	1.38E-01	2.66E-03	0.00E+00	1.09E-01	3.45E-03	7.82E-01	7.91E-02
		Russell Lake Inlet	3.87E-02	3.05E-02	0.00E+00	5.09E-03	3.79E-03	1.38E-01	2.66E-03	0.00E+00	1.09E-01	3.33E-03	7.82E-01	7.91E-02
	Lesser Scaup	Reference (Kratchkowsky Lake)	7.78E-03	1.15E-04	0.00E+00	7.89E-04	2.54E-02	1.82E-02	2.80E-04	0.00E+00	9.69E-03	1.71E-04	1.15E-01	1.47E-02
		Whitefish Lake	8.08E-03	1.16E-04	0.00E+00	8.31E-04	2.57E-02	1.84E-02	3.05E-04	0.00E+00	1.29E-02	2.09E-04	1.16E-01	1.60E-02
		McGowan Lake	7.91E-03	1.15E-04	0.00E+00	8.21E-04	2.56E-02	1.83E-02	2.99E-04	0.00E+00	1.18E-02	1.97E-04	1.16E-01	1.56E-02
		Russell Lake Inlet	7.86E-03	1.15E-04	0.00E+00	8.13E-04	2.56E-02	1.83E-02	2.94E-04	0.00E+00	1.13E-02	1.90E-04	1.16E-01	1.54E-02

(a) - Aquatic receptor TRVs for copper have been calculated using the FEQG and are included in Section 6.3.2.
n/a = not applicable; HQ = hazard quotient.

5.4.1.2 Radiological Risk

An HQ is not typically calculated for radiological risk; however, a comparison of the total radiological dose (baseline plus Project) against the ecological dose benchmarks is presented.

There were no predicted exceedances of the 2.4 mGy/d radiation dose benchmark for terrestrial and riparian biota or the 9.6 mGy/d radiation dose benchmark for aquatic biota in the Project area, LSA, or RSA during any phase of the Project (Table 5-25) or in the future centuries (Table 5-26). This includes Whitefish Lake, McGowan Lake, and Russell Lake as exposure locations as well as Kratchkowsky Lake as a reference location. All predicted doses are well below the radiation dose benchmarks.

During the Project phases, the maximum predicted total dose for terrestrial and riparian biota is to lichen near Whitefish Lake (0.99 mGy/d), and the main contributors to total dose are from uranium-234 and uranium-238 in air that deposits to lichen. The maximum predicted total dose for aquatic biota is to zooplankton at Whitefish Lake (0.10 mGy/d), and the main contributor to total dose is from polonium-210 in tissue.

During the future centuries, the maximum predicted dose to aquatic biota is to zooplankton (0.08 mG/d) in Whitefish Lake from polonium-210 in water. The maximum predicted dose during the future centuries to terrestrial and riparian biota is to the scaup (0.05 mGy/d) who eats aquatic animals from Whitefish Lake. For terrestrial plants the dose during the future centuries is 0.22 mGy/d for lichen at all locations, due to background concentrations of polonium-210 in the soil.

Overall, it is unlikely that there would be significant adverse effects on terrestrial or aquatic populations or communities as a result of radionuclide releases from the Project.

Table 5-25: Summary of Total Radiation Doses to Limiting Ecological Receptors – Project Phases

Category	Maximum Total Dose [(a)] (mGy/d)	Receptor	Location	Largest Contributor and Pathway to Dose	Dose Benchmark (mGy/d)
Aquatic Plants	0.01	Macrophytes	Whitefish Lake Middle	Ra-226 Water to tissue (internal)	9.6
Aquatic Animals	0.10	Zooplankton	Whitefish Lake South	Po-210 Water to tissue (internal)	9.6
Terrestrial Plants	0.99	Lichen	On-site near Whitefish Lake	U-234 Soil to tissue (internal)	2.4
Terrestrial Animals	0.06	Lesser Scaup	Whitefish Lake	Po-210 Aquatic animals ingestion (internal)	2.4

Note:
(a) Total radiation dose includes the baseline dose and the Project dose combined.

Table 5-26: Summary of Total Radiation Doses to Limiting Ecological Receptors – Future Centuries

Category	Maximum Total Dose [(a)] (mGy/d)	Receptor	Location	Largest Contributor and Pathway to Dose	Dose Benchmark (mGy/d)
Aquatic Plants	0.01	Macrophytes	Whitefish Lake Middle	Ra-226 Water to tissue (internal)	9.6
Aquatic Animals	0.08	Zooplankton	Whitefish Lake Middle	Po-210 Water to tissue (internal)	9.6
Terrestrial Plants	0.22	Lichen	All locations	Po-210 tissue (internal)	2.4
Terrestrial Animals	0.05	Lesser Scaup	Whitefish Lake	Po-210 Aquatic animals ingestion (internal)	2.4

Note:
(a) Total radiation dose includes the baseline dose and the Project dose combined.

5.4.2 Uncertainties in the Risk Characterization

Since the risk characterization is dependent on the problem formulation and the exposure and effects assessments, any uncertainty identified in these assessments propagates uncertainty into the risk estimates. In general, the uncertainties are expected to cause an overestimation, not an underestimation of risk due to the conservative approaches employed in the ERA, including the use of:

- maximum predicted concentrations for COPCs in media for each exposure scenario;
- exposure of ecological receptors to COPCs in the environment for chronic periods of time and during sensitive life stages; and
- effect levels based on low-effect threshold concentrations and doses.

The assumptions to address uncertainties in the ERA are anticipated to produce overly conservative estimates of risk, as discussed below.

For the calculation of risk to environmental receptors, there are uncertainties associated with the use of literature-based TRVs. These uncertainties may include: extrapolation of results from laboratory tests to the field, differences in sensitivity between the test organism and resident organisms, laboratory conditions that are not representative of field conditions, and the form of the COPC used in toxicity testing which may not be representative of the form found at the site.

The use of TRVs from laboratory studies tends to be conservative because these studies are typically chemical-specific and use highly bioavailable forms of the COPC. In field situations, the chemical form of the COPC may be less bioavailable, and toxicity-modifying factors may be present that were not acting in laboratory tests.

There is inherent uncertainty associated with the use of LOAEL values as TRVs as these values are not precisely related to biologically relevant thresholds and do not provide information about the actual magnitude of effects in the reported studies. However, LOAEL values have widespread use in the risk assessment community and the science is not currently available to change this approach to TRVs.

Taken together, these approaches are anticipated to produce a risk characterization that has not underestimated risk; the resulting HQs are either overestimates or realistic estimates of risk, both of which are considered acceptable.

6.0 Quality Assurance and Updated Risk Characterization

6.1 Quality Assurance

Throughout the planning and preparation of the ERA, all staff worked under the Ecometrix ISO 9001:2015 certified Quality Management System. All work was internally reviewed and verified. Reviews included verification of input data in the IMPACT files against the source documents and verification of selected results with independent calculation spreadsheets, as well as review of report content. Comments have been addressed as appropriate by report revisions. The review process has been documented through a paper trail of review comments and responses. Examples of the independent calculation spreadsheets are provided in Appendix B.

The software used for the ERA was IMPACT 5.6.0, a dynamic version of the model and was tailored to align with the guidance in CSA standards N288.6-22 (CSA, 2022) and N288.1-20 (CSA, 2020). It contains differential equations for COPC transport, allowing for non-steady-state conditions, whereas N288.1 contains the corresponding steady-state equations. When utilizing IMPACT for this Project, all inputs to IMPACT were checked, along with an overall verification of IMPACT scenario files. Checks were performed on data and calculations to verify that transcription errors and formula errors, if any, were caught and addressed. Checks of the model structure, algorithms and functions have been made repeatedly throughout the model development history as it has been used in several related applications that underwent multiple layers of review.

The ERICA Tool, version 1.3.1, was used as a source of biota dose coefficients. Its parameters, including dose coefficients, have been subject to validation through numerous intercomparison exercises, as described by Brown et al., (Brown et al., 2016, 2003, 2008) and have generally compared well with other sources. The intercomparisons of dose coefficients are described by Vives I Batlle et al. (Vives i Batlle et al., 2011, 2007). The external dose predictions for small mammals have been validated against dosimetric measurements (Beresford et al., 2008). The code and database are updated from time to time, as described in its documented version history.

The ERA utilized environmental monitoring data collected as part of the baseline monitoring program which followed either Ecometrix' Quality Management System for the monitoring conducted by Ecometrix or the Quality Management System for Denison's other subcontractors. The data collected during the baseline monitoring program was considered valid and appropriate for use in the ERA. The ERA was reviewed and accepted by Denison in accordance with Denison's QA requirements.

6.2 Sensitivity Analysis

A sensitivity analysis of key model parameters was undertaken to understand the degree to which the results or conclusions of the risk assessment would vary if these parameters differed from what was assumed.

6.2.1 Woodland Caribou Diet

The food source for the woodland caribou in the winter is terrestrial or arboreal lichens; terrestrial and aquatic vegetation are also food sources in the remainder of the year. For the ecological risk assessment, a low lichen diet (LLD) comprised of 50% browse, 20% lichen and 30% macrophytes was assumed to represent the year-round diet for woodland caribou (woodland caribou LLD). Research has noted that arboreal lichen could make up 70% of the caribou's winter diet (MNRW, 2006). To ensure that woodland caribou who may have higher consumption rates of lichen remains protected, a high lichen diet (HLD) comprised of 70% lichen, 20% browse and 10% macrophytes was assumed as a sensitivity case for woodland caribou who may have higher consumption rates of lichen (woodland caribou HLD).

The predicted maximum HQs for non-radiological risk and the maximum radiological dose for radiological COPCs for both woodland caribou models are shown in Table 6-1 and Table 6-2. Compared with the woodland caribou LLD, the predicted maximum HQs for the woodland caribou HLD generally increased by 5 to 81% with the exception of copper and molybdenum where the HQ decreased by 4 to 22% due to the copper and molybdenum concentration in lichen being lower than in browse. However, all HQs for woodland caribou HLD are below the benchmark of 1 for all non-radiological COPCs. The predicted maximum total radiological dose for the woodland caribou HLD increased by 65% compared to that for the woodland caribou LLD. However, the total dose for woodland caribou HLD is still far below the radiation dose benchmark of 2.4 mGy/d for terrestrial biota, as recommended in CSA N288.6-22.

Table 6-1: Non-radiological Risk to Woodland Caribou during Project Phases

Biota	Location	Maximum HQs during Project Phases				
		Arsenic	Cadmium	Cobalt	Chromium	Copper
WoodLand Caribou LLD	Reference (Kratchkowsky Lake)	3.70E-04	2.79E-04	1.62E-04	2.30E-04	2.74E-02
	Whitefish Lake	3.85E-04	2.84E-04	1.66E-04	2.33E-04	2.83E-02
WoodLand Caribou HLD	Reference (Kratchkowsky Lake)	3.90E-04	3.28E-04	2.00E-04	3.72E-04	2.15E-02
	Whitefish Lake	4.06E-04	3.33E-04	2.04E-04	3.76E-04	2.29E-02
Biota	**Location**	**Molybdenum**	**Selenium**	**Uranium**	**Vanadium**	**Zinc**
WoodLand Caribou LLD	Reference (Kratchkowsky Lake)	3.30E-04	4.63E-03	3.10E-04	7.79E-03	2.80E-03
	Whitefish Lake	2.54E-03	7.65E-03	9.19E-03	8.98E-03	2.82E-03
WoodLand Caribou HLD	Reference (Kratchkowsky Lake)	4.50E-04	6.41E-03	4.20E-04	9.97E-03	3.53E-03
	Whitefish Lake	2.43E-03	8.40E-03	1.66E-02	1.10E-02	3.54E-03

Table 6-2: Maximum Radiological Doses to Woodland Caribou during Project Phases

Biota	Location	Maximum Radiological Dose During Project Phases (mGy/d)						
		Uranium-238	Uranium-234	Thorium-230	Radium-226	Lead-210	Polonium-210	Total Dose
WoodLand Caribou LLD	Reference (Kratchkowsky Lake)	3.34E-06	3.81E-06	6.25E-06	6.81E-04	1.20E-05	6.24E-03	**6.95E-03**
	Whitefish Lake	8.19E-05	9.32E-05	7.30E-06	6.86E-04	1.20E-05	6.26E-03	**7.14E-03**
WoodLand Caribou HLD	Reference (Kratchkowsky Lake)	3.61E-06	4.12E-06	4.44E-06	6.05E-04	1.99E-05	1.09E-02	**1.15E-02**
	Whitefish Lake	1.43E-04	1.62E-04	4.74E-06	6.09E-04	1.99E-05	1.09E-02	**1.18E-02**

6.2.2 Effluent Discharge Rate

One of the key model parameters is the effluent discharge rate. As described in Section 3.1, treated effluent will be released to Whitefish Lake Middle (LA-5) via a discharge line with a diffuser at the end to promote effluent mixing within the lake. Effluent will be released at a discharge rate of 36.5 m^3/hr (10.1 L/s) as the EA case. The maximum upper bound discharge rate is 81 m^3/hr (22.5 L/s). The reasonable upper bound effluent quality during the phases where effluent will be released is summarized in Table 3-2 – effluent quality is assumed to be constant over that time period.

In this ERA, surface water quality modeling was completed using IMPACT version 5.6.0 with treated effluent released to Whitefish Lake Middle at an expected discharge rate of 36.5 m^3/h during the operation and decommissioning phases of the Project. If the effluent was released at the maximum upper bound discharge rate of 81 m^3/hr, the maximum concentrations of COPCs in Whitefish Lake Middle and its downstream waterbodies will increase up to 120%.

*increase (%) = 100 * (modelled max concentration at upper bound discharge rate - modelled max concentration at expected discharge rate) / modelled max concentration at expected discharge rate.*

Figure 6-1 shows the maximum concentrations of COPCs in surface water at the expected and upper bound discharge rate. Compared to the maximum concentrations in surface water at the expected discharge rate, the maximum concentrations of COPCs in surface water at the upper bound discharge rate will increase 10 – 44% for arsenic, 29 – 51% for cadmium, 109 – 113% for chloride, 14 – 26% for cobalt, 20 – 38% for chromium, 17 – 30% for copper, 119 – 120% for molybdenum, 116 – 117% for sulphate, 101 – 111% for selenium, 107 – 113% for uranium, 53 – 95% for vanadium, 24 – 45% for zinc, 107 – 113% for uranium-238 and uranium-234, 36 – 55% for thorium-230, 12 – 24% for radium-226, 12 – 53% for lead-210, and 6 – 13% for polonium-210, respectively. If treated effluent is released at the maximum upper bound discharge rate, cadmium concentration in Whitefish Middle/South and McGowan Lake (LA-1) would exceed its surface water quality guideline of 0.00004 mg/L, and chromium concentration in Whitefish Middle/South would slightly exceed its surface water quality guideline of 0.001 mg/L. The modelled concentrations of other COPCs are expected to be below their corresponding surface water quality guidelines.

Figure 6-2 shows the resulting maximum concentrations of COPCs in sediment at the expected and upper bound discharge rate. Compared to the maximum concentrations in sediment at the expected discharge rate, the maximum concentrations of COPCs in sediment at the upper bound discharge rate will increase –10 - 30% for arsenic, 23 - 38% for cadmium, 13 - 21% for cobalt, 16 - 27% for chromium, 15 - 24% for copper, 119 -120% for molybdenum, 95 - 106% for selenium, 102 - 110% for uranium, 47 -84% for vanadium, 19 - 33% for zinc, 102 -110% for uranium-238 and uranium-234, 32 - 47% for thorium-230, 9 - 17% for radium-226, 12 - 40% for lead-210, and 12 - 39% for polonium-210, respectively. If treated effluent was released at the maximum upper bound discharge rate, the modelled concentrations of all COPCs are expected to be below their corresponding sediment quality guidelines, with the exception of cadmium, molybdenum, selenium and vanadium.

This is a conservative prediction as it assumes effluent is released during decommissioning at the same upper bound flow and quality as during operations. For cadmium, the predicted maximum sediment quality at the expected discharge rate is 0.497 mg/kg dw in Whitefish Lake Middle, which is below the selected interim sediment quality guideline (ISQG) value of 0.6 mg/kg dw. However, the predicted maximum sediment quality at the upper bound discharge rate is 0.688 mg/kg dw in Whitefish Lake Middle and 0.647 mg/kg dw in Whitefish Lake South, which exceeds the ISQG value but is below the probable effect level (PEL) of 3.5 mg/kg dw.

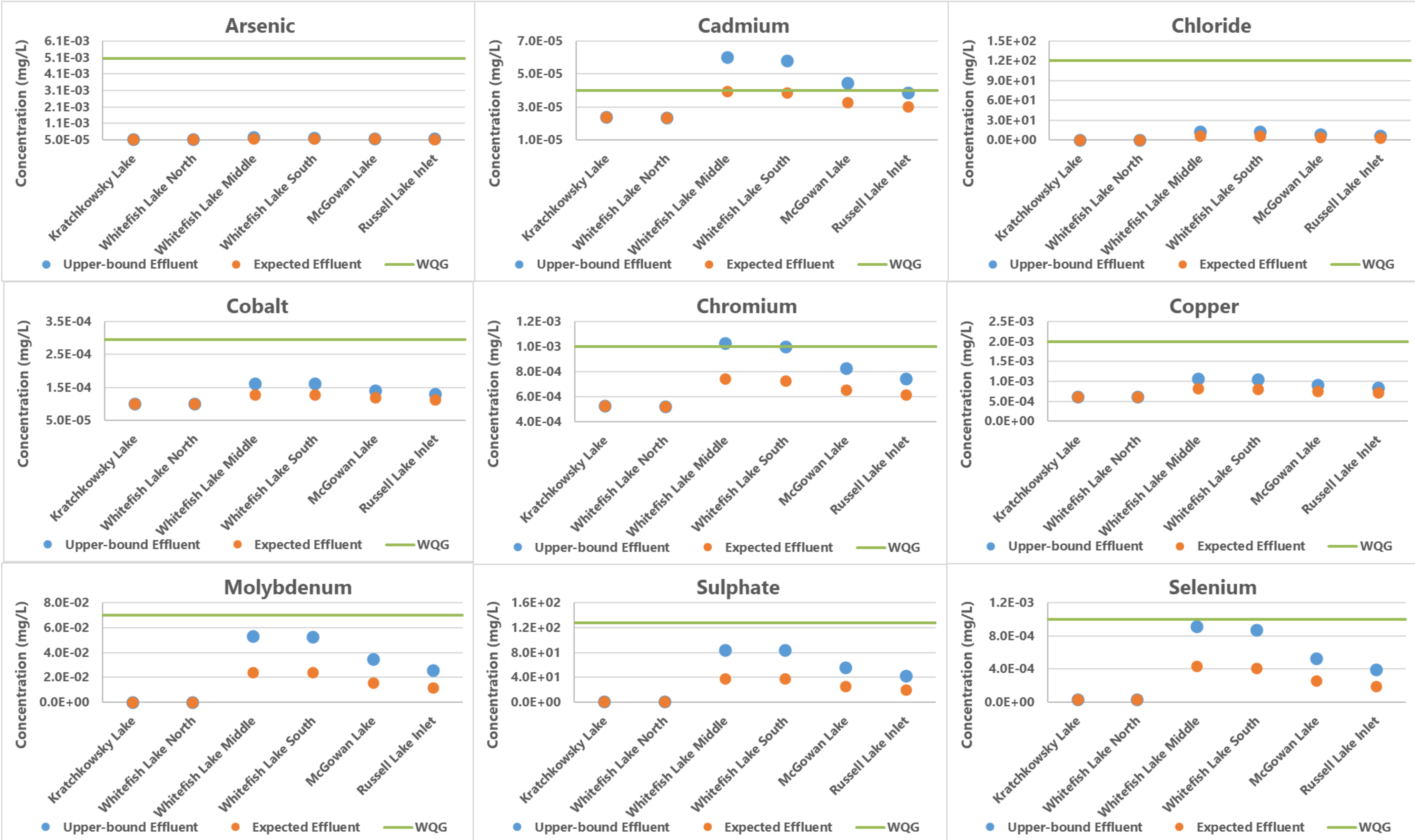
The predicted maximum molybdenum concentration in sediment is predicted to be 57.2 mg/kg dw in Whitefish Lake Middle at the expected discharge rate and 125 mg/kg dw in Whitefish Lake Middle at the upper bound discharge rate. Both values are above its reference (REF) value of 23 mg/kg dw, but below its no-effect (NE2) sediment quality benchmark of 245 mg/kg dw.

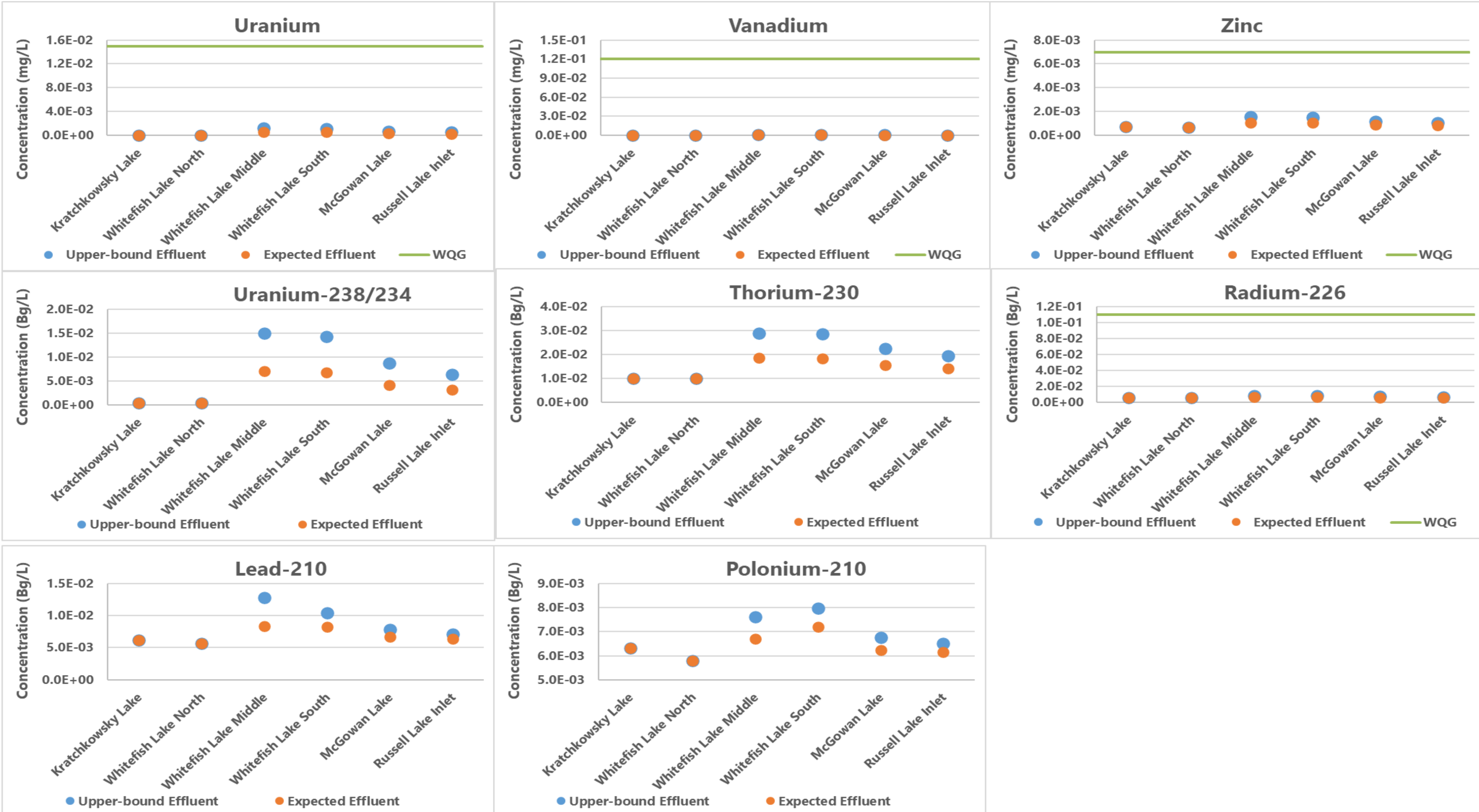
The maximum selenium concentration in sediment is 5.48 mg/kg dw in Whitefish Lake Middle at the expected discharge rate and 11.3 mg/kg dw in Whitefish Lake Middle at the upper bound discharge rate. Both values are above its REF value of 3.6 mg/kg dw, but below its NE2 value of 30 mg/kg dw.

The predicted maximum concentration of vanadium in sediment at the end of decommissioning is 37.2 mg/kg dw in Whitefish Lake Middle at the expected discharge rate and 68.5 mg/kg dw in Whitefish Lake Middle at the upper bound discharge rate. Both values are higher than the REF value of 35.1 mg/kg dw and the lowest effect level (LEL) of 35.2 mg/kg dw but are well below the severe effect level (SEL) of 160 mg/kg dw.

The REF values refer to locations upstream of mining or milling activities or located within separate but nearby drainages. Exceedance of a REF value indicates that sediment downstream of the proposed discharge is elevated compared to natural background (Burnett-Seidel and

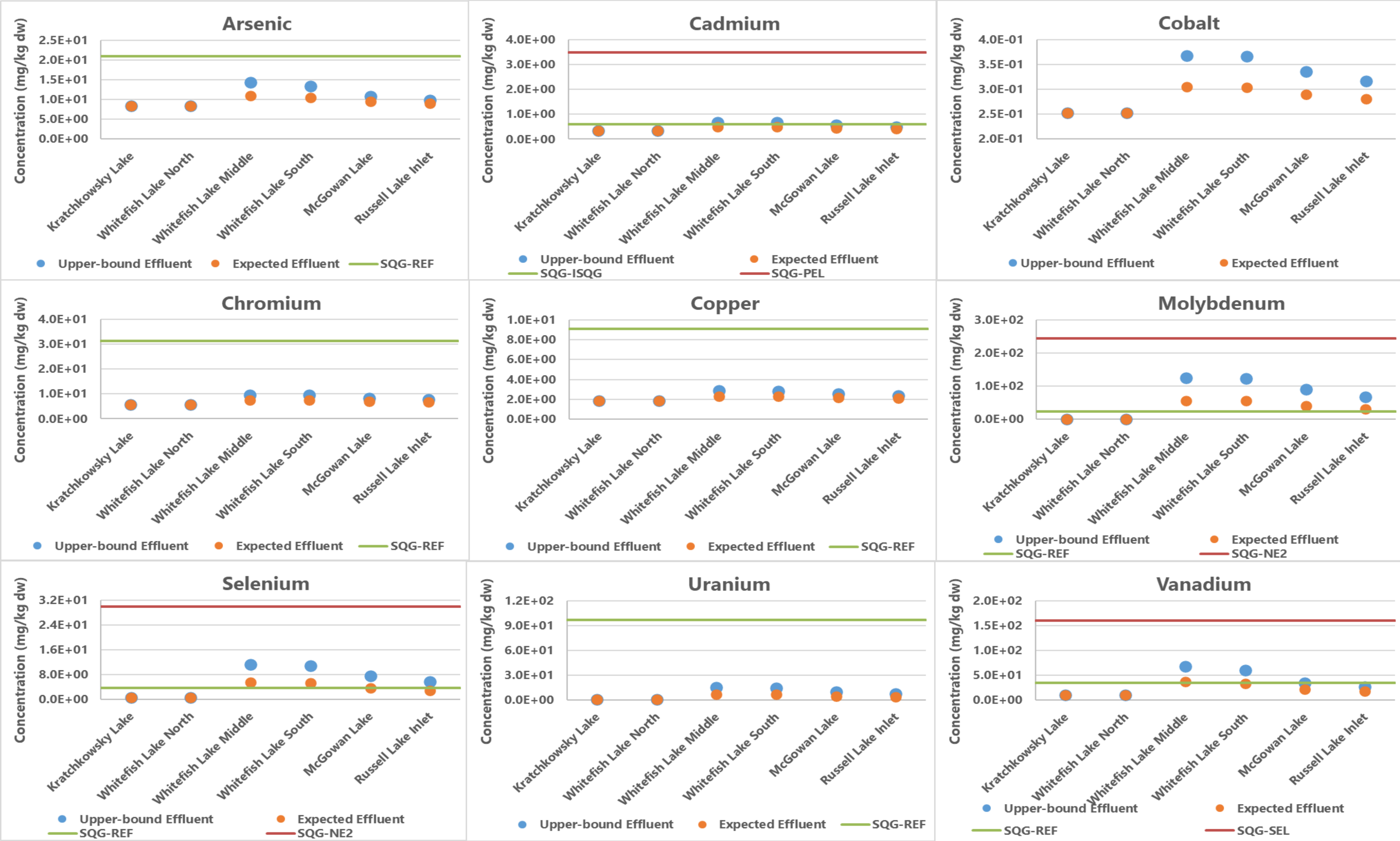
Liber, 2013). The predicted sediment concentration for exceedances of a REF or LEL value are not indicative of adverse effects to benthic communities but do suggest that further investigation may be warranted. The LEL represents a concentration in sediment that the majority of benthic organisms can tolerate, whereas the SEL represents a concentration in sediment that the majority of benthic organisms cannot tolerate (Persaud et al., 1993). The NE2 values refer to exposed (lightly contaminated) areas with elevated concentrations but no significant effect on benthic invertebrate abundance, richness, and evenness. Concentrations below the NE2 values indicate that benthic invertebrate community metrics (abundance, richness, and evenness) downstream of discharges are not expected to differ significantly (less than 20% difference) from those observed at natural background conditions. The predicted exceedances in sediment concentrations for cadmium, molybdenum, selenium and vanadium are all below their PEL or NE2 or SEL values, therefore, adverse effects to benthic communities are not anticipated under the upper bound discharge scenarios.

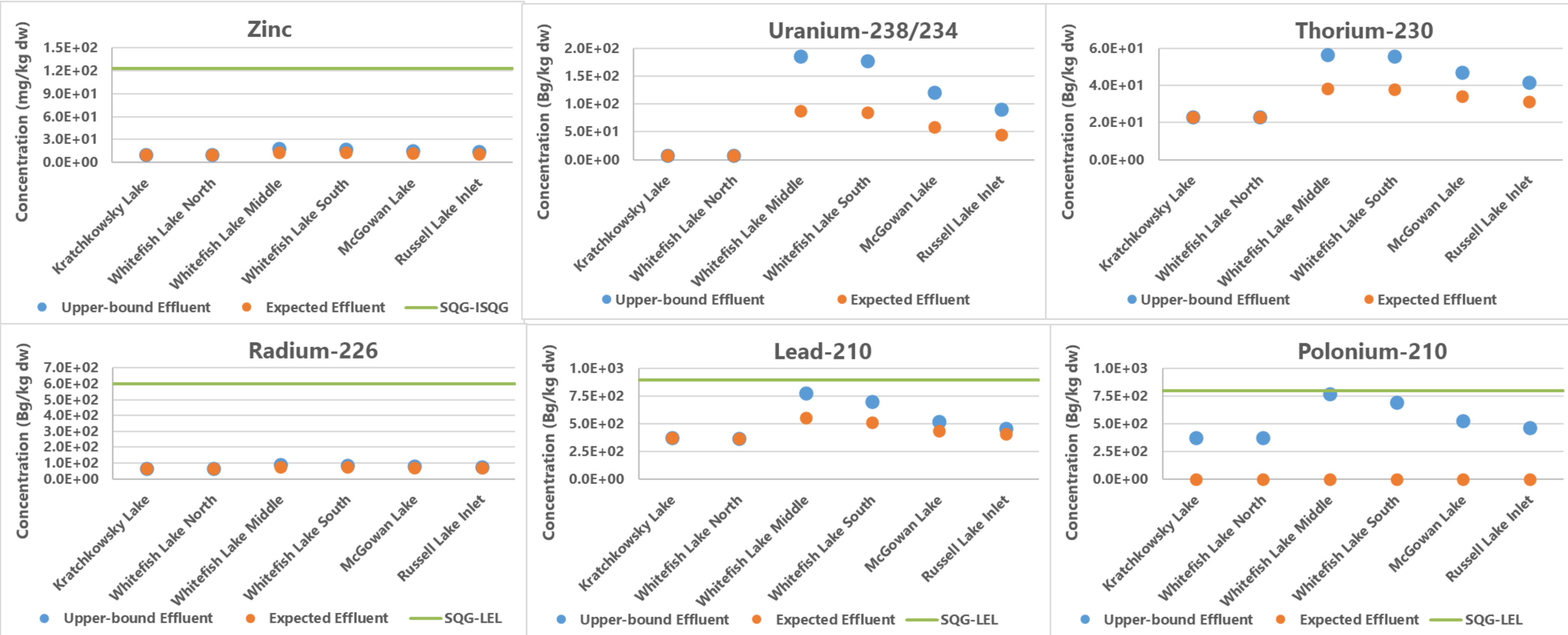

Arsenic
Concentration (mg/L)
6.1E-03
5.1E-03
4.1E-03
3.1E-03
2.1E-03
1.1E-03
5.0E-05
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Upper-bound Effluent
Expected Effluent
WQG
Cadmium
Concentration (mg/L)
7.0E-05
5.0E-05
3.0E-05
1.0E-05
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Upper-bound Effluent
Expected Effluent
WQG
Chloride
Concentration (mg/L)
1.5E+02
1.2E+02
9.0E+01
6.0E+01
3.0E+01
0.0E+00
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Upper-bound Effluent
Expected Effluent
WQG
Cobalt
Concentration (mg/L)
3.5E-04
2.5E-04
1.5E-04
5.0E-05
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Upper-bound Effluent
Expected Effluent
WQG
Chromium
Concentration (mg/L)
1.2E-03
1.0E-03
8.0E-04
6.0E-04
4.0E-04
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Upper-bound Effluent
Expected Effluent
WQG
Copper
Concentration (mg/L)
2.5E-03
2.0E-03
1.5E-03
1.0E-03
5.0E-04
0.0E+00
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Upper-bound Effluent
Expected Effluent
WQG
Molybdenum
Concentration (mg/L)
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Upper-bound Effluent
Expected Effluent
WQG
Sulphate
Concentration (mg/L)
1.6E+02
1.2E+02
8.0E+01
4.0E+01
0.0E+00
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Upper-bound Effluent
Expected Effluent
WQG
Selenium
Concentration (mg/L)
1.2E-03
8.0E-04
4.0E-04
0.0E+00
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Upper-bound Effluent
Expected Effluent
WQG



WQG = Water Quality Guideline. The WQG is the green line and is consistent with the selected screening values shown in Table 3-1.

Figure 6-1: Comparison of Maximum Concentrations of COPCs in Surface Water at the Expected and Upper Bound Discharge Rate


Arsenic
Concentration (mg/kg dw)
2.5E+01
2.0E+01
1.5E+01
1.0E+01
5.0E+00
0.0E+00
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Upper-bound Effluent
Expected Effluent
SQG-REF
Cadmium
Concentration (mg/kg dw)
4.0E+00
3.0E+00
2.0E+00
1.0E+00
0.0E+00
Upper-bound Effluent
Expected Effluent
SQG-ISQG
SQG-PEL
Cobalt
Concentration (mg/kg dw)
4.0E-01
3.5E-01
3.0E-01
2.5E-01
2.0E-01
Upper-bound Effluent
Expected Effluent
Chromium
Concentration (mg/kg dw)
4.0E+01
3.0E+01
2.0E+01
1.0E+01
0.0E+00
Upper-bound Effluent
Expected Effluent
SQG-REF
Copper
Concentration (mg/kg dw)
1.0E+01
8.0E+00
6.0E+00
4.0E+00
2.0E+00
0.0E+00
Upper-bound Effluent
Expected Effluent
SQG-REF
Molybdenum
Concentration (mg/kg dw)
3.0E+02
2.0E+02
1.0E+02
0.0E+00
Upper-bound Effluent
Expected Effluent
SQG-REF
SQG-NE2
Selenium
Concentration (mg/kg dw)
3.2E+01
2.4E+01
1.6E+01
8.0E+00
0.0E+00
Upper-bound Effluent
Expected Effluent
SQG-REF
SQG-NE2
Uranium
Concentration (mg/kg dw)
1.2E+02
9.0E+01
6.0E+01
3.0E+01
0.0E+00
Upper-bound Effluent
Expected Effluent
SQG-REF
Vanadium
Concentration (mg/kg dw)
2.0E+02
1.5E+02
1.0E+02
5.0E+01
0.0E+00
Upper-bound Effluent
Expected Effluent
SQG-REF
SQG-SEL



SQG = Sediment Quality Guideline. The SQG with the green line is consistent with the selected sediment screening values (REF or ISQG or LEL) shown in Table 3-6. The SQG with the red line is the upper sediment quality values (NE2 or SEL or PEL) shown in Table 3-6.

Figure 6-2: Comparison of maximum concentrations of COPCs in sediment at expected and upper bound discharge rate

6.3 Updated Risk Characterization for Selenium and Copper

An updated risk characterization for selenium and copper was undertaken due to additional evaluation criteria being published since the initiation of the ERA.

6.3.1 Selenium in Fish Tissue

The TRV for selenium in fish used in Section 5.3.1 was the US EPA criterion of 11.3 mg/kg dw muscle (US EPA, 2021d). ECCC has published a FEQG for selenium of 6.7 µg/g dw for whole body and 14.7 µg/g dw for egg-ovary. This section re-evaluates the assessment of selenium in fish tissue using the FEQG guidance (ECCC, 2022).

The whole-body concentrations were recalculated from the predicted selenium in muscle tissue concentrations (Appendix B, Table B.5), using site-specific moisture content and the species-specific US EPA (2021d) conversion factors. The values used for moisture content and conversion factors for muscle to whole body and egg-ovary to whole body are shown in Table 6-3 below. The resulting whole-body concentrations (Table 6-4) do not exceed either EPA (2021d) or ECCC (2022) guidelines for whole-body tissue, which are 8.5 µg/g dw and 6.7 µg/g dw, respectively, and therefore the conclusions of the ERA are unchanged.

Table 6-3: Moisture Content and Conversion Factors used for Selenium Calculations

Fish Species	Moisture Content (Aquatic Baseline Studies, Appendix 8-D, Table A-17)	Muscle:Whole Body (Table B-4, B-5, US EPA 2021d)	Egg-Ovary:Muscle (Table B-3, US EPA 2021d)
Northern Pike	77.98	1.27	1.88
White Sucker	76.55	1.34	1

Table 6-4: Calculated Whole Body and Egg-Ovary

			FEQG (µg/g dw)	6.7	14.7
Fish Species		Muscle	Muscle	Whole Body	Egg-Ovary
	Lake	µg/g fw	µg/g dw	µg/g dw	µg/g dw
Northern Pike	Reference	1.89E-01	8.58E-01	0.68	1.61
	Whitefish Lake North	1.86E-01	8.45E-01	0.67	1.59
	Whitefish Lake Middle	1.57E+00	7.13E+00	5.61	13.40
	Whitefish Lake South	1.51E+00	6.86E+00	5.40	12.89
	McGowan Lake	1.02E+00	4.63E+00	3.65	8.71
	Russell Lake	8.12E-01	3.69E+00	2.90	6.93
White Sucker	Reference	1.46E-01	6.23E-01	0.46	0.62
	Whitefish Lake North	1.43E-01	6.10E-01	0.46	0.61
	Whitefish Lake Middle	1.74E+00	7.42E+00	5.54	7.42
	Whitefish Lake South	1.66E+00	7.08E+00	5.28	7.08
	McGowan Lake	1.06E+00	4.52E+00	3.37	4.52
	Russell Lake	8.06E-01	3.44E+00	2.57	3.44

6.3.1.1 Uncertainty Evaluation for Northern Pike Bioaccumulation Factor

Selenium BAFs were derived using regional data of measured fish tissue and water concentration data. Using measured fish tissue data and measured water concentrations to develop the BAF incorporates the selenium bioaccumulation through the food chain and would represent the transfer (enrichment function and trophic transfer).

Tissue data were available for northern pike, cisco, lake trout, longnose sucker, lake whitefish, white sucker, lake chub, and spottail shiner. The data comparisons resulted in the following conclusions:

- The same BAF can be applied to a fish species at different lakes;
- The BAF values for longnose sucker, cisco, and lake trout were not significantly different from those for northern pike; therefore; data from these species were combined to derive a BAF for northern pike;
- The BAF values for lake whitefish and white sucker were significantly different ($p<0.05$) from that for northern pike; and
- The BAF values for lake chub and spottail shiner were not significantly different ($p>0.05$) from each other; therefore, data for these two species were combined to derive a BAF for small-bodied fish.

Most of the data from fish species evaluated demonstrated a linear relationship between fish tissue and water concentrations. The linear regression line was shown to underestimate selenium in northern pike tissue at low water concentrations. Therefore, a non-linear relationship was adopted for northern pike, where the BAF = $949x^{0.827}$ (x is in units of µg/L). As shown in Figure 6-3, the linear (dotted line) and power function (solid red curve) are quite similar except where the water concentrations were less than 0.001 mg/L. The R^2 values for the linear and power function are similar but the better fit at the lower water concentration values provided a basis for selecting the power function as the preferred model for the northern pike. Correlation analyses of the tissue and water concentration data for selenium indicated that a significant relationship ($p<0.05$) existed between the water and tissue concentrations in northern pike, white sucker, lake whitefish and small-bodied fish.

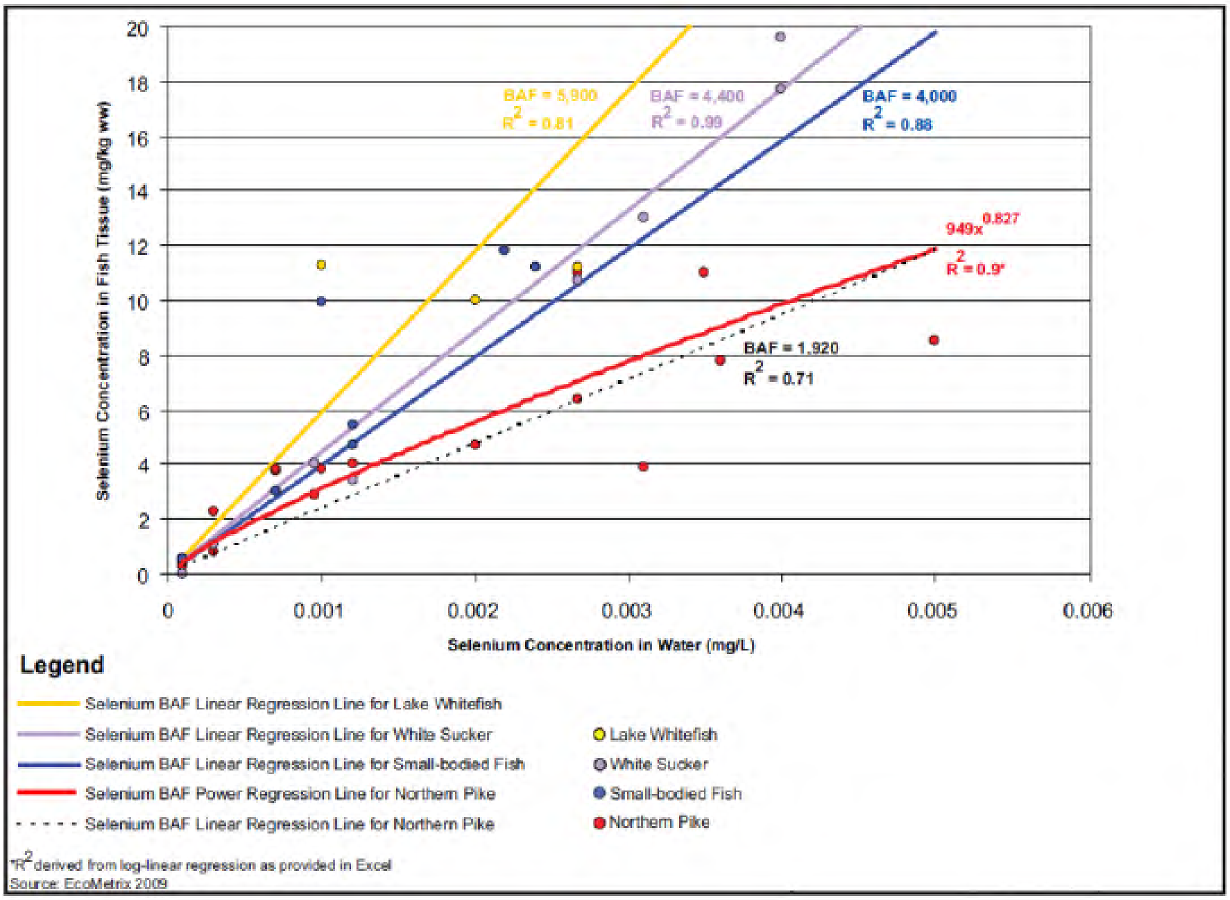


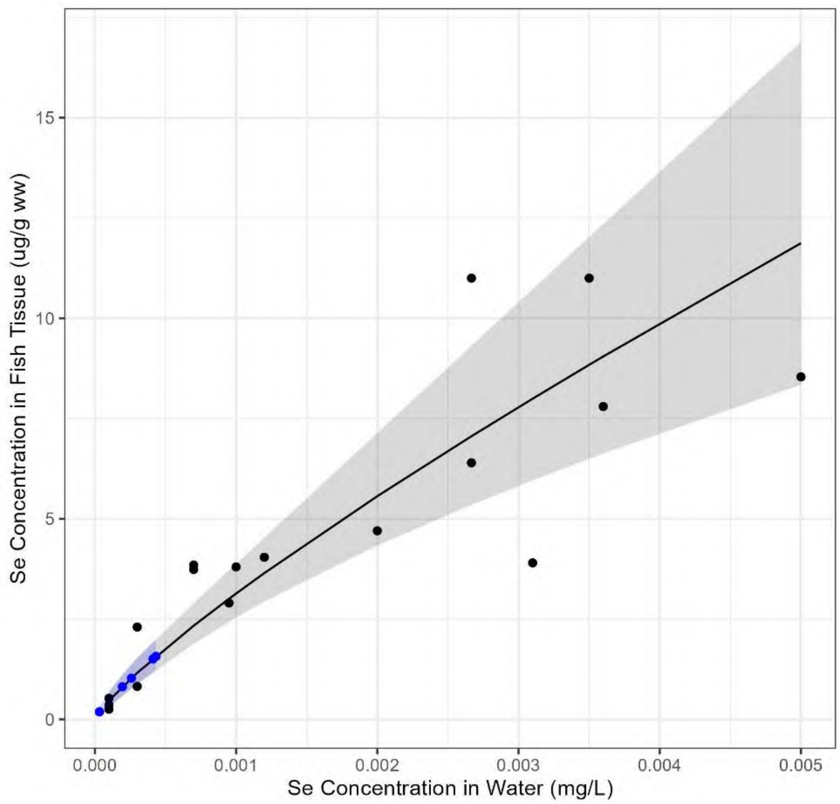
Figure 6-3: Development of Regional Fish BAFs for Selenium in Saskatchewan

To evaluate the range of uncertainty in the northern pike BAF, a power-regression (log-log) of the water and fish tissue selenium data was used to generate the expected relationship between selenium in water and selenium in tissue. The model was a good fit to the data (R^2 = 0.88). The regression equation ($y = ax^b$) was:

$Se_{[tissue;\ \mu g/g\ ww]} = a \times Se_{[water;\ mg/L]}{}^{b}$,

where the 95% confidence interval for '*a*' was 295–3060 and for '*b*' was 0.66–0.99.

The predicted mean response and confidence ribbon for those values are shown in Figure 6-4 and Table 6-5. Analysis was completed in *R v.* 4.4.4 using base functions (e.g., *lm()* and associated *predict()*). Plots were generated using *ggplot v.* 3.5.5.



Note: Blue dots are Wheeler River predictions, black dots are regional data

Figure 6-4: Predicted Mean Response and Confidence Ribbon – Selenium in Northern Pike

Table 6-5: Predicted Mean Lower and Upper Northern Pike Tissue Selenium Concentrations

	Water Concentration LA-5	Fish Muscle Tissue (Mean Value)	Fish Muscle Tissue (Low Value)	Fish Muscle Tissue (Upper Value)
Lake	**mg/L**	**µg/g fw**	**µg/g fw**	**µg/g fw**
Reference	3.35E-05	1.89E-01	1.06E-01	3.36E-01
Whitefish Lake North	3.28E-05	1.86E-01	1.04E-01	3.31E-01
Whitefish Lake Middle	4.33E-04	1.57E+00	1.23E+00	2.00E+00
Whitefish Lake South	4.12E-04	1.51E+00	1.18E+00	1.93E+00
McGowan Lake	2.59E-04	1.02E+00	7.65E-01	1.37E+00
Russell Lake	1.95E-04	8.12E-01	5.85E-01	1.12E+00

Using the range of the uncertainty in the northern pike BAF (from Table 6-5), fish muscle tissue selenium concentrations were calculated for the various lakes, using site-specific moisture content and the species-specific US EPA (2021d) conversion factors (see Table 6-3).

For reference, as indicated previously the whole body tissue and egg-ovary concentrations do not exceed the FEQGs (ECCC, 2022) for the mean BAF (Table 6-4). As shown in Table 6-6, the resulting whole-body tissue and egg-ovary concentrations do not exceed the FEQGs (ECCC, 2022) for the BAF lower range of uncertainty. At the upper range of the BAF, the egg-ovary concentration in Whitefish Lake exceeds the whole-body guideline of 6.7 µg/g dw and the egg-ovary guideline of 14.7 µg/g dw from ECCC (2022). At all other lakes the predicted whole-body and egg-ovary concentrations are below the selenium guidelines.

The results of the ERA and EIS are interpreted based on the expected mean BAF. Based on the expected selenium BAF, no significant adverse effects are predicted to northern pike from exposure to selenium. The uncertainty results provide a range (lower and upper) around the risk; however, there are numerous conservative assumptions in the overall assessment that would indicate the expected BAF is sufficiently conservative.

Table 6-6: Calculated Whole Body and Egg-Ovary Selenium Concentrations – Range of Uncertainty

FEQG (µg/g dw)						6.7	6.7	14.7	14.7
	Water Concent-ration	Fish Muscle Tissue (Lower Value)	Fish Muscle Tissue (Upper Value)	Fish Muscle Tissue (Lower Value)	Fish Muscle Tissue (Upper Value)	Whole Body (Lower Value) (b)	Whole Body (Upper Value) (b)	Egg-Ovary (Lower Value) (c)	Egg-Ovary (Upper Value) (c)
Lake	**mg/L**	**µg/g fw**	**µg/g fw**	**µg/g dw**	**µg/g dw**	**µg/g dw**	**µg/g dw**	**µg/g dw**	**µg/g dw**
Reference	3.35E-05	1.06E-01	3.36E-01	4.82E-01	1.53E+00	0.38	1.20	0.91	2.87
Whitefish Lake North	3.28E-05	1.04E-01	3.31E-01	4.72E-01	1.50E+00	0.37	1.18	0.89	2.83
Whitefish Lake Middle	4.33E-04	1.23E+00	2.00E+00	5.59E+00	9.07E+00	4.40	**7.14**	10.51	**17.06**
Whitefish Lake South	4.12E-04	1.18E+00	1.93E+00	5.35E+00	8.74E+00	4.21	**6.88**	10.05	**16.44**
McGowan Lake	2.59E-04	7.65E-01	1.37E+00	3.48E+00	6.24E+00	2.74	4.91	6.54	11.73
Russell Lake	1.95E-04	5.85E-01	1.12E+00	2.66E+00	5.10E+00	2.09	4.02	5.00	9.59

Notes:

(a) The site-specific moisture content for northern pike of 77.98% was used to convert from fresh weight to dry weight.

(b) A Muscle:Whole Body ratio of 1.27 was used for northern pike from Table B-4, B-5, US EPA 2021d.

(c) An Egg-Ovary:Muscle ratio of 1.88 was used for northern pike from Table B-3, US EPA 2021d.

Bold indicates exceedance of the selenium guideline.

6.3.2 Copper Aquatic Toxicity Reference Values

Since initiation of the ERA, ECCC has developed an updated FEQG for copper for protection of freshwater aquatic life based on the biotic ligand model (BLM) (ECCC, 2021). The FEQG is calculated based on site-specific concentrations of DOC, hardness, temperature and pH.

As identified in Section 5.3.1.1, TRVs for copper were obtained from the US EPA Ecotoxicology Database (ECOTOX) for aquatic organisms. The selected TRVs were 20% Effect Concentrations (i.e., EC_{20} values), which are concentrations at which only 20% of the test organisms respond. The TRVs used in the ERA for HQ calculations are shown in Table 5-12.

The TRVs for aquatic organisms have been re-evaluated using the FEQG and the BLM. The BLM was run based on baseline site-specific conditions (hardness of 5.26 mg/L, DOC of 2.24 mg/L, pH of 6.61, temperature of 13°C). The test species and concentrations identified as used to generate the BLM were evaluated to develop TRVs for the applicable biotic groups. The most restrictive effect concentration for each biotic group was identified. The test endpoint was either an EC_{10} or an IC_{10}. Based on the protocol identified in Table 5-11, the EC_{10} (or IC_{10}) was multiplied by 2 to obtain an EC_{20}, which was then utilized as the TRV. A summary of the TRVs for baseline conditions is identified in Table 6-7.

Considering that while the facility is in operation and during periods of treated effluent discharge it is expected that hardness in the receiving environment will increase to approximately 9 mg/L and pH will increase to approximately 7, the BLM was re-run under those conditions and the TRVs were re-evaluated based on the test species and concentrations used to generate the BLM. The copper TRVs under site conditions are presented in Table 6-8.

Table 6-7: Copper Toxicity Reference Values from Baseline Conditions BLM

COPC	Biotic Group	TRV	Unit	Rationale	Data Source
Copper	Forage fish	0.00517	mg/L	Fathead minnow, growth (IC_{10} = 0.0026 mg/L)	FEQG BLM
	Predator fish	0.000776	mg/L	White sturgeon, growth (EC_{10} = 0.0004 mg/L)	FEQG BLM
	Zooplankton	0.000886	mg/L	Daphnia magna, reproduction (EC_{10} = 0.0004 mg/L)	FEQG BLM
	Benthic invertebrates	0.000417	mg/L	Pond snail, growth (EC_{10} = 0.0002 mg/L)	FEQG BLM
	Phytoplankton	0.00913	mg/L	Rotifer, intrinsic (EC_{10} = 0.0046 mg/L)	FEQG BLM
	Aquatic plants	0.0212	mg/L	Duckweed, root length (EC_{10} = 0.01 mg/L)	FEQG BLM

Notes:
BLM based on hardness of 5.26 mg/L, DOC of 2.24 mg/L, pH of 6.61, temperature of 13°C.
TRV is an EC_{20}, adjusted from an EC_{10} or IC_{10}.

Table 6-8: Copper Toxicity Reference Values from Site Conditions BLM

COPC	Biotic Group	TRV	Unit	Rationale	Data Source
Copper	Forage fish	0.0104	mg/L	Fathead minnow, growth (IC_{10} = 0.005 mg/L)	FEQG BLM
	Predator fish	0.0018	mg/L	White sturgeon, growth (EC_{10} = 0.001 mg/L)	FEQG BLM
	Zooplankton	0.00205	mg/L	Daphnia magna, reproduction (EC_{10} = 0.001 mg/L)	FEQG BLM
	Benthic invertebrates	0.00098	mg/L	Pond snail, growth (EC_{10} = 0.0005 mg/L)	FEQG BLM
	Phytoplankton	0.0174	mg/L	Rotifer, intrinsic (EC_{10} = 0.009 mg/L)	FEQG BLM
	Aquatic plants	0.0153	mg/L	Duckweed, root length (EC_{10} = 0.008 mg/L)	FEQG BLM

Notes:
BLM based on hardness of 9 mg/L, DOC of 2.24 mg/L, pH of 7, temperature of 13°C.
TRV is an EC_{20}, adjusted from an EC_{10} or IC_{10}.

The hazard quotients (HQs) for aquatic organisms were re-evaluated using both sets of TRVs, baseline conditions and site conditions during operation where hardness and pH are increased (Table 6-9). Consistent with Section 5.4.1, an HQ less than or equal to 1 suggests low risk to the ecological receptor, and an HQ above 1 needs further investigation to determine if adverse effects are possible. Conservatively using baseline conditions, HQs for all aquatic organisms are less than 1 with the exception of predator fish in Whitefish Lake, and benthic invertebrates at all locations where HQs are slightly above 1. As such, further consideration was given to changes in site conditions when the facility is in operation.

Using predicted site conditions for hardness and pH, HQs for all aquatic organisms are less than 1 at all downstream locations, indicating no adverse effects to aquatic organisms from facility related copper during periods of treated effluent discharge. It is relevant to consider all aspects of the receiving environment, and this includes induced hardness and pH since the scenario being evaluated only occurs during periods of effluent discharge. This approach is used in other jurisdictions (e.g., water licences in northern Canada issued through local water boards) and therefore the concept of induced hardness is not unique.

The copper predictions are considered conservative based on the following assumptions:

- Baseline concentrations of copper are predominantly below the detection limit, indicating that baseline concentrations of copper are likely overestimated in the ERA.
- Based on the effluent quality and quantity released to Whitefish Lake, the maximum copper concentration in Whitefish Lake and downstream waterbodies was evaluated as part of the HQ. This is a conservative assumption.
- Once the facility is operational, site conditions will change which includes increased hardness and pH; therefore, the predicated HQs under baseline conditions are considered conservative and overestimate risk.

Table 6-9: Re-Evaluated Hazard Quotients for Copper in Aquatic Organisms

Location	Maximum Copper Concentration in Water (mg/L)	Hazard Quotients (unitless) – Baseline Conditions						Hazard Quotients (unitless) – Site Operation Conditions					
		Forage Fish	Predator Fish	Zooplankton	Benthic Invertebrate	Phyto-plankton	Aquatic Plants	Forage Fish	Predator Fish	Zooplankton	Benthic Invertebrate	Phytoplankton	Aquatic Plants
Kratchkowsky Lake (reference) [1]	6.22E-04	0.12	0.80	0.70	**1.49**	0.07	0.03	0.12	0.80	0.70	**1.49**	0.07	0.03
Whitefish Lake North	6.20E-04	0.12	0.80	0.70	**1.49**	0.07	0.03	0.06	0.34	0.30	0.63	0.04	0.04
Whitefish Lake Middle	8.22E-04	0.16	**1.06**	0.93	**1.97**	0.09	0.04	0.08	0.46	0.40	0.84	0.05	0.05
Whitefish Lake South	8.17E-04	0.16	**1.05**	0.92	**1.96**	0.09	0.04	0.08	0.45	0.40	0.83	0.05	0.05
McGowan Lake	7.50E-04	0.14	0.97	0.85	**1.80**	0.08	0.04	0.07	0.42	0.37	0.76	0.04	0.05
Icelander River	7.49E-04	0.14	0.97	0.84	**1.80**	0.08	0.04	0.07	0.42	0.37	0.76	0.04	0.05
Russell Lake Inlet	7.17E-04	0.14	0.92	0.81	**1.72**	0.08	0.03	0.07	0.40	0.35	0.73	0.04	0.05

Note:
Bold and shaded value indicates hazard quotient greater than 1.
[1] Kratchkowsky Lake is a reference lake located upstream of the effluent discharge point, and as such, the site operation conditions were the same as baseline conditions.

7.0 Conclusions and Recommendations

The selection of human and ecological receptors for inclusion in the ERA was informed by Indigenous and Local Knowledge, information from baseline studies, as well as professional judgement. The assumptions made for the Traditional Foods diet (i.e., amounts consumed and food types) was informed by an existing ERFN country foods study and through engagement with a local fisher/trapper.

The ERA focused on COPCs that exceeded screening values in air and water based on predicted atmospheric releases and aqueous releases (treated effluent) from the Wheeler River Project. The final list of COPCs included: arsenic, cadmium, chromium, cobalt, copper, molybdenum, selenium, uranium, vanadium, zinc, sulphate, chloride, and total dissolved solids.

Radionuclides of the uranium-238 series, including radon, were included as COPCs because these constituents are of public interest.

7.1 Human Health Risk Assessment

The HHRA estimated dose and risk during all Project phases to the following receptors: camp worker, seasonal resident, recreational fisher/hunter, fisher/trapper, and during future centuries to the future permanent resident. The future centuries reflect the time period over which the highest constituent concentrations in groundwater are predicted to migrate towards and interact with surface water post-restoration (i.e. beyond the Project timeline of 0-38 years).

During Post-Decommissioning, the Project area could be accessed intermittently by members of the public for various land use purposes. Any risks to these members of the public would be less than those assessed for the camp work and therefore the Project area would be safe for periodic land use during this period.

7.1.1 Non-radiological Human Health Risk Assessment

For assessment of non-carcinogens, risk was estimated based on Project total HQs (includes the Project risk in addition to the baseline risk) and Project incremental HQs (includes the Project risk only with baseline component removed). Project incremental HQs were compared to a benchmark HQ value of 0.2 because total background exposures (e.g. store-bought foods) were not included in the incremental HQ. This approach is consistent with Health Canada's guidance on human health preliminary quantitative risk assessment (Health Canada, 2021a).

The Project incremental HQ was predicted to remain below 0.2 for human receptors for all non-carcinogens and all pathways during all phases of the Project, with the exception of selenium for the fisher/trapper at Russell Lake from the fish ingestion pathway. The traditional foods diet for the fisher/trapper is conservative as it assumes a high annual fish consumption rate of 183 kg/yr (approximately 1 to 2 servings per day) and assumes that all fish consumed in the diet is obtained from the Project area. The diet of the fisher/trapper is representative of one person, who consumes a unique composition and quantity of traditional foods. Most people fishing, hunting, and trapping in the LSA and RSA would consume traditional foods more consistent with the average traditional foods consumer diet which was developed from the ERFN country foods study (CanNorth, 2017). During the future centuries there are no precited exceedances of the HQ benchmark (HQ<0.2) for human receptors, including the permanent resident, for any non-carcinogens.

The results are also discussed in terms of the total Project HQ (baseline plus Project). Since the Project total HQ includes background contributions from store-bought foods, a benchmark HQ value of 1 was considered. The Project total HQs for the fisher/trapper for selenium are predicted to be equal to or greater than 1. Since the Project incremental HQs for the fish ingestion pathway for selenium are predicted to be above 0.2, this indicates that the Project is expected to contribute to selenium in the environment and the food chain.

For assessment of risk for carcinogens (arsenic), the ILCR was estimated and compared against the cancer risk level of 1 in 100,000 recommended by Health Canada (Health Canada, 2021a). Incremental cancer risk was predicted to remain below the negligible cancer risk level of 1 in 100,000 for the camp worker, recreational fisher/hunter, and seasonal resident during the Project phases. The incremental cancer risk was predicted to be essentially equal to the negligible cancer risk level of 1 in 100,000 for the adult fisher/trapper at Russell Lake. These findings for the fisher/trapper are based on the conservative assumption of high consumption of Traditional Foods including fish and caribou in the LSA and RSA. As indicated above, the diet of the fisher/trapper is representative of one person, who consumes a unique composition and quantity of traditional foods. During the future centuries the cancer risk was not predicted to exceed the negligible cancer risk level of 1 in 100,000 for any human receptors, including the permanent resident.

7.1.2 Radiological Human Health Risk Assessment

The incremental radiation dose to all human receptors during all Project phases is predicted to be below the regulatory public dose limit of 1 mSv/yr and the dose constraint of 0.3 mSv/yr during all Project phases and in the future centuries. The maximum incremental radiological dose is predicted to be 0.06 mSv/yr to the fisher/trapper at Russell Lake. The total incremental dose to the camp worker from all radionuclides in the U-238 decay chain including radon would be 0.16 mSv/year, which is below the dose limit for a non-NEW of 1 mSv/yr.

Overall, since the radiation dose estimates would be below the dose limit, no discernable health effects are anticipated due to exposure of these receptors to radioactive releases from the Project.

7.2 Ecological Risk Assessment

The EcoRA estimated dose and risk to representative aquatic and terrestrial receptors during all Project phases and the future centuries. The future centuries reflect the time period over which the highest constituent concentrations in groundwater are predicted to migrate towards and interact with surface water post-restoration (i.e. beyond the Project timeline of 0-38 years).

Species at risk were either assessed directly or were represented by other more common species that have similar diets and exposure pathways.

7.2.1 Non-radiological Ecological Risk Assessment

The potential for ecological effects was assessed by comparing exposure levels to toxicological benchmarks and was characterized quantitatively in terms of total HQs. A total HQ greater than 1 indicates adverse effects may be possible for a given ecological receptor and further investigation would be warranted.

No significant adverse effect on either aquatic or terrestrial populations or communities, as a result of releases from the Project, are predicted during the Project phases or during the future centuries. All estimated total HQs for all COPCs, except copper, for all ecological receptors are predicted to remain below the HQ benchmark of 1. Under baseline conditions as well as the future centuries, copper HQs for all aquatic organisms are less than 1 with the exception of predator fish in Whitefish Lake, and benthic invertebrates at all locations where HQs are slightly above 1. Using operational site conditions for hardness and pH, copper HQs for all aquatic organisms are less than 1 at all downstream locations, indicating no adverse effects to aquatic organisms from facility related copper (Section 6.3.2). Since there are no total HQs above 1 for birds and mammals, individual species at risk would also be considered protected.

7.2.2 Radiological Ecological Risk Assessment

Radiation dose benchmarks of 9.6 mGy/d and 2.4 mGy/d (UNSCEAR, 2008) were selected for the assessment of effects on aquatic biota and terrestrial biota, respectively, as recommended in CSA N288.6-22.

There were no predicted exceedances of the 9.6 mGy/d radiation dose benchmark for aquatic biota or the 2.4 mGy/d radiation dose benchmark for terrestrial and riparian biota during any Project phase or during the future centuries.

Since there were no predicted exceedances of the respective dose benchmarks for any of the aquatic or terrestrial receptors, individual species at risk would also be considered protected.

Overall, it is unlikely that there would be potential adverse effects on terrestrial or aquatic populations or communities as a result of radionuclide releases from the Project.

7.3 Monitoring and Follow-up

The ERA was developed based on best available information for the Project, including baseline monitoring data, assumptions on source-terms, and Traditional Foods diet (intake rates and food types).

Monitoring should focus on collecting data to verify ERA model predictions, as well as provide data to improve model predictions as the Project begins. Recommended monitoring would support Denison's environmental protection framework with the goal of reducing uncertainty over time through an iterative process:

Air quality: With the exception of uranium, there were no predicted exceedances of annual screening values for any constituents, indicating that unacceptable chronic effects from direct exposure to air are not expected. Uranium exceeded its annual screening value at the on-site ecological receptor location, but not at the camp. Some short-term exceedances, based on maximum predicted concentrations, were predicted to occur at the camp and at the fence line for nitrogen dioxide (1 hour) and particulate matter (24 hour), and for uranium in TSP and PM_{10}. The predicted exceedances would be infrequent, short-term, and limited spatially. Any public visits to these locations would be very infrequent. Unacceptable levels of risk are not expected from infrequent, short-term exposures to these constituents in air. However, it is recommended that these constituents be monitored in accordance with provincial and federal guidelines and standards (i.e., CAAQS) as part of any Air Emissions Monitoring Plan. Additionally, for NO_2, monthly collection of passive samplers will be performed.

Environmental monitoring: Denison is implementing an Environmental Monitoring Program consistent with requirements and guidance in CSA N288.4-19: *Environmental monitoring programs at nuclear facilities and uranium mines and mills* (CSA, 2019). Monitoring would focus on providing data to verify the predictions made by the ERA, to refine the models used in the ERA, and to reduce the uncertainty in the predictions made by the ERA. The Environmental Monitoring Program should include collection of surface water, sediment, and soil samples as well as fish tissue samples, benthic invertebrate tissue samples, and country foods such as blueberries. Monitoring locations would be focused in the area of Whitefish Lake, McGowan Lake and Russell Lake. Monitoring constituents would include those identified as COPCs in the ERA, including metals and uranium-238 series radionuclides, and chloride and sulphate in lake waters. However, monitoring could extend to include other constituents for other purposes, such as meeting regulatory requirements for monitoring, or addressing constituents of public interest based on experience at other uranium mines and process plants.

8.0 References

Alberta, 2021. Alberta Ambient Air Quality Objectives [WWW Document]. Ambient Air Quality Objectives and supporting documents. URL https://www.alberta.ca/ambient-air-quality-objectives.aspx#jumplinks-5

Arrington, L.R., Davis, G.K., 1953. Molybdenum toxicity in the rabbit. J. Nutr. 51, 295–304.

ATSDR, 2007. Toxicological Profile for Arsenic.

ATSDR, 2004. Toxicological Profile for Cobalt [WWW Document]. URL http://www.atsdr.cdc.gov/toxprofiles/tp33.pdf

Bartlett, A., 2009. An assessment of the chronic toxicity of sodium chloride to Hyalella azteca (Unpublished data presented at the 1st International Conference on Urban Drainage and Road Salt Management in Cold Climates: Advances In Best Practices.). University of Waterloo.

BC Conservation Data Centre, 1993. Species Summary: Myodes gapperi [WWW Document]. BC Ministry of Environment.

BC MECCS, 2020. 2020. B.C. Source Drinking Water Quality Guidelines: Guideline Summary.

BC MOE, 2013. Ambient Water Quality Guideline for Sulphate. Technical Appendix. Update. BC Ministry of Environment. Water Protection & Sustainability Branch.

Beak International Inc, 1999. Ecotoxicology test results (Unpublished report for M.S. Evans). Environment Canada, National Water Research Institute.

Beresford, N.A., Gaschak, S., Barnett, C.L., Howard, B.J., Chizhevsky, I., Stromman, G., Oughton, D.H., Wright, S.M., Maksimenko, A., Copplestone, D., 2008. Estimating the exposure of small mammals at three sites within the Chernobyl exclusion zone – a test application of the ERICA Tool. Journal of Environmental Radioactivity. Journal of Environmental Radioactivity 1496–1502.

Beyer, W.N., Connor, E., Gerould, S., 1994. Estimates of Soil Ingestion by Wildlife. J. Wildl. Manage. 58.

Birge, W.J., Black, J.A., Westerman, A.G., Short, T.M., Taylor, S.B., Bruser, D.M., Wallingford, E.D., 1985. Recommendations on numerical values for regulating iron and chloride concentrations for the purpose of protecting warm water species of aquatic life in the Commonwealth of Kentucky. Memorandum of Agreement No. 5429. Kentucky Natural Resources and Environmental Protection Cabinet, Lexington.

Birge, W.J., Hudson, J.E., Black, J.A., Wasterman, A.G., 1979. Embryo-larval Bioassays on Inorganic Coal Elements and In Situ Biomonitoring of Coal-waste Effluents, in: Surface Mining and Fish/Wildlife Needs in the Eastern United States. Fish and Wildlife Service, Office of Biological Services, pp. 97–104.

Brown, J., Alfonso, B., Avila, R., Beresford, N.A., Copplestone, N.A., Hosseini, A., 2016. A new version of the ERICA tool to facilitate impact assessments of radioactivity on wild plants and animals. Journal of Environmental Radioactivity 153, 141–148.

Brown, J., Strand, P., Hosseini, A., Borretzen, P., 2003. Handbook for Assessment of the Exposure of Biota to Ionising Radiation from Radionuclides in the Environment.

Brown, J.E., Alfonso, B., Avila, R., Beresford, N.A., Copplestone, D., Prohl, G., Ulanovsky, A., 2008. The ERICA Tool. Journal of Environmental Radioactivity 99, 1371–1383.

Buckley, J.A., Rustagi, K.P., Laughlin, J.D., 1996. Response of Lemna minor to sodium chloride and a statistical analysis of continuous measurements for EC50 and 95% confidence limits calculation. Bulletin of Environmental Contamination and Toxicology 57, 1003–1008.

Burnett-Seidel, C., Liber, K., 2013. Derivation of no-effect and reference-level sediment quality values for application at Saskatchewan uranium operations. Environ. Monit. Assess. 185, 9481–9494.
Cal OEHHA, 2000. Proposed Action Level for Vanadium. California Office of Environmental Health Hazard Assessment.
CanNorth, 2018. Human Health Risk Assessment for the Eastern Athabasca Basin. Final Report. October.
CanNorth, 2017. English River First Nation Country Foods Study – Final Report (No. Project No. 2147). Canada North Environmental Services.
CanNorth, 2000. Hatchet Lake Dietary Survey – Field Report (No. Project No. 2147). Canada North Environmental Services.
CCME, 2020. Guidance Document on Achievement Determination for Canadian Ambient Air Quality Standards for Nitrogen Dioxide. PN 1608.
CCME, 2011a. Canadian Water Quality Guidelines for the Protection of Aquatic Life. Chloride Ion (Scientific Criteria Document No. PN 1460). Canadian Council of Mininsters of the Environment, Winnipeg.
CCME, 2011b. Canadian Water Quality Guideline for the Protection of Aquatic Life. Uranium. Canadian Council of Mininsters of the Environment.
CCME, 2008. Canadian Water Quality Guidelines.
CCME, 2007. A protocol for the derivation of water quality guidelines for the protection of aquatic life 2007. Canadian Council of Ministers of the Environment.
CCME, 1999a. Canadian Sediment Quality Guidelines for the Protection of Freshwater Aquatic Life (updated September 2007). Canadian Council of Ministers of the Environment.
CCME, 1999b. Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health: Thallium 1999. Canadian Council of Ministers of the Environment.
CCME, 1995. Protocol for the Derivation of Canadian Sediment Quality Guidelines for the Protection of Aquatic Life (No. CCME EPC-98E). Canadian Council of Ministers of the Environment.
Chan, L., Receveur, O., Sadik, T., Schwartz, H., Ing, A., Fediuk, K., Tikhonov, C., 2018. First Nations Food, Nutrition and Environment Study (FNFNES): Results from Saskatchewan (2015). University of Ottawa, Ottawa.
Chapman, P.M., Allen, H.E., Z'Graggen, M.N., 1996. Evaluation of bioaccumulation factors in regulating metals. Environ. Sci. Technol. 30, 448A-452A.
Chen, C.J., Chuang, Y.C., Lin, T.M., Wu, H.Y., 1985. Malignant neoplasms among residents of a blackfoot disease-endemic area in Taiwan: High-arsenic artesian well water and cancers. Cancer Research 45, 5895–5899.
CNSC, 2020. Environmental Protection. Environmental Principles, Assessments and Protection Measures. REGDOC-2.9.1, Version 1.2. Canadian Nuclear Safety Commission.
COSEWIC, 2018. Olive-sided Flycatcher (Contopus cooperi): COSEWIC Assessment and Status Report 2018. Committee on the Status of Endangered Wildlife in Canada, Ottawa.
Crane, M., Flower, T., Holmes, D., Watson, S., 1992. The toxicity of selenium in experimental freshwater ponds. Arch. Environ. Contam. Toxicol. 23, 440–452.
CSA, 2022. N288.6:22. Environmental risk assessments for nuclear facilities and uranium mines and mills. Canadian Standards Association.
CSA, 2020. Guidelines for modelling radionuclide environmental transport, fate, and exposure associated with the normal operation of nuclear facilities (No. CSA N288.1-20). Canadian Standards Association.
CSA, 2019. Environmental monitoring programs at nuclear facilities and uranium mines and mills. CSA N288.4-19.

CSA, 2012. Environmental risk assessments at Class I nuclear facilities and uranium mines and mills (No. CSA N288.6-12). Canadian Standards Association.

CWF, 2022. Canada Lynx [WWW Document]. The Canadian Wildlife Federation.

Davis, J.E., Fields, J.P., 1958. Experimental production of polycythemia in humans by administration of cobalt chloride. Proc Soc Exp Biol Med 99, 493–495.

Denison, 2019. Wheeler River Project - Provincial Technical Proposal and Federal Project Description. Denison Mines Corp.

DFO, 2018. Northern Pike [WWW Document]. Fisheries and Oceans Canada.

DFO, 2016. White Sucker [WWW Document]. Fisheries and Oceans Canada.

Dodds-Smith, M.E., Johnson, M.S., Thompson, D.J., 1992. Trace metal accumulation by the shrew sorex araneus. ii. tissue distribution in kidney and liver. Ecotoxicol Environ Saf. 24, 118–130.

Domingo, J.L., Paternain, J.L., Llobet, J.M., Corbella, J., 1986. Effects of vanadium on reproduction, gestation, parturition and lactation in rats upon oral administration. Life Sciences 39, 819–824.

Doyle, J.J., Pfander, W.H., Grebing, S.E., Pierce, J.O., 1974. Effect of dietary cadmium on growth, cadmium absorption and cadmium tissue levels in growing lambs. J. Nutr. 104, 160–166.

Durante, M., Pugliese, M., 2002. Estimates of radiological risk from depleted uranium weapons in war scenarios. Health Physics 82, 14–20.

EC and HC, 2003. Priority Substances List Assessment Report: Releases of Radionuclides from Nuclear Facilities (Impact on Non- Human Biota) (PSL2). Environment Canada and Health Canada.

EC and HC, 1993. Priority Substances List Assessment Report for Arsenic and its Compounds. Environment Canada and Health Canada, Ottawa.

ECCC, 2022. Federal Environmental Quality Guidelines Selenium. Environment and Climate Change Canada.

ECCC, 2021. Federal Environmental Quality Guidelines Copper. Environment and Climate Change Canada.

ECCC, 2018. Canada and Cackling Geese: Management and Population Control in Southern Canada. Canadian Wildlife Service, Environment Canada.

Ecometrix, 2022. Numerical Modelling: Post-Decommissioning Evaluation (Report prepared for Denison Mines Corporation). Ecometrix Incorporated.

Ecometrix, 2020. Wheeler River Project: Baseline Aquatic Environment Study (Report prepared for Denison Mines Corporation). Ecometrix Incorporated.

Elbetieha, A., Al-Hamood, M.H., 1997. Long-term exposure of male and female mice to trivalent and hexavalent chromium compounds: effect on fertility. Toxicology 116, 39–47.

Elphick, J.R., Davies, M., Gilron, G., Canaria, E.C., 2011. An aquatic toxicological evaluation of sulfate: The case for considering hardness as a modifying factor in setting water quality guidelines. Environ. Toxicol. Chem. 30, 247–253.

Elphick, J.R.F., Bergh, K.D., Bailey, H.C., 2011. Chronic toxicity of chloride to freshwater species: effects of hardness and implications for water quality guidelines. Environmental Toxicology and Chemistry 30, 239–249.

ERFN, 2011. English River First Nation, Aboriginal Traditional Knowledge Summary Report. Compiled by Environment Canada. English River First Nation.

ERFN, SVS, 2022a. Wheeler River Project – Summary of Health and Socio-Economic Study Results (Prepared for English River First Nation). English River First Nation (ERFN); Shared Value Solutions (SVS).

ERFN, SVS, 2022b. Wheeler River Project – Summary of Traditional Knowledge Study Results (Prepared for English River First Nation No. Project No. 2147). English River First Nation (ERFN); Shared Value Solutions (SVS).

FCSAP, 2012. Ecological Risk Assessment Guidance, Module 3: Standardization of Wildlife Receptor Characteristics. Environment Canada, Vancouver, B.C.

Gilman, A.P., Villeneuve, D.C., Secours, V.E., Yagminas, A.P., Tracy, B.L., Quinn, J.M., Valli, V.E., Wiles, R.J., Moss, M.A., 1998. Uranyl nitrate: 28-day and 91-day toxicity studies in the Sprague-Dawley rat. Toxicological Science 41, 117–128.

Goettl, J.P.Jr., Davies, P.H., Sinley, J.R., 1976. Water Pollution Studies, in: D.B.Cope (Ed.), Colorado Fish.Res.Rev.1972-1975, DOW-R-R-F72-75, Colorado Div.of Wildl. Boulder, pp. 68–75.

Government of Saskatchewan, 2015. Table 20: Saskatchewan Ambient Air Quality Standards.

Grobner, M.A., Cheeke, P.R., Patton, N.M., 1986. Effect of Dietary Copper and Oxytetracycline on Growth and Mortality of Weanling Rabbits. Journal of Applied Rabbit Research 9, 46–53.

Hamilton, S.J., Mehrle, P.M., 1986. Metallothionein in fish: review of its importance in assessing stress from metal contaminants. Transactions of the American Fisheries Society 115, 596–609.

Haseltine, S.D., Sileo, L., 1983. Response of American Black Ducks to Dietary Uranium: A Proposed Substitute for Lead Shot. Journal of Wildlife Management 47, 1124–1129.

Haseltine, S.D., Sileo, L., Hoffman, D.J., Mulhern, B.M., 1986. Effects of chromium on reproduction and growth of black ducks. Unpublished (Cited in Eisler, 1986 & Custer Et Al., 1986).

Health Canada, 2021a. Federal Contaminated Site Risk Assessment in Canada: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA). Version 3.0.

Health Canada, 2021b. Federal Contaminated Site Risk Assessment in Canada: Toxicological Reference Values (TRVs) Version 3.0.

Health Canada, 2020. Guidelines for Canadian Drinking Water Quality - Summary Table. September 2020.

Health Canada, 2019a. Guidelines for Canadian Drinking Water Quality: Guideline Technical Document—Copper. Health Canada, Ottawa.

Health Canada, 2019b. Guidelines for Canadian Drinking Water Quality: Guideline Technical Document—Uranium. Health Canada, Healthy Environments and Consumer Safety Branch, Ottawa.

Health Canada, 2018. Guidance for Evaluating Human Health Impacts in Environmental Assessments: Country Foods. Report No. H129- 54/5- 2018E-PDF.

Health Canada, 2016a. Guidance for evaluating Human Health Impacts in Environmental Assessment: Air Quality. Health Canada.

Health Canada, 2016b. Human Health Risk Assessment for Ambient Nitrogen Dioxide. Health Canada, Healthy Environments and Consumer Safety Branch.

Health Canada, 2016c. Human Health Risk Assessment for Coarse Particulate Matter. Health Canada. Healthy Environments and Consumer Safety Branch.

Health Canada, 2013. Interim Guidance on Human Health Risk Assessment for Short-Term Exposure to Carcinogens at Contaminated Sites. Federal Contaminated Sites Risk Assessment in Canada.

Health Canada, 2011. Canadian Guidelines for the Management of Naturally Occurring Radioactive Materials (NORM). Prepared by the Canadian NORM Working Group of the Federal Provincial Territorial Radiation Protection Committee.

Health Canada, 2010a. Federal Contaminated Site Risk Assessment in Canada, Part I: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA), Version 2.0. Contaminated Sites Program. Health Canada.

Health Canada, 2010b. Federal Contaminated Site Risk Assessment in Canada. Part VI: Guidance on Human Health Detailed Quantitative Radiological Risk Assessment (DQRARAD). Health Canada.

Health Canada, 2010c. Part II: Health Canada Toxicological Reference Values (TRVs) and Chemical-Specific Factors, Version 2.0. September.

Health Canada, 2006. Guidelines for Canadian Drinking Water Quality: Guideline Technical Document—Arsenic. Health Canada, Healthy Environments and Consumer Safety Branch, Ottawa.

Health Canada, 2004. Canadian Community Health Survey Cycle 2.2, Nutrition (2004) - A Guide to Accessing and Interpreting the Data (No. No. 4627). Office of Nutrition Policy and Promotion, Health Canada, Ottawa, ON.

Health Canada, 1998. National Ambient Air Quality Objectives for Particulate Matter. Executive Summary. Part 1: Science Assessment Document. Health Canada.

Health Canada, 1991. Guidelines for Canadian Drinking Water Quality: Guideline Technical Document—Total Dissolved Solids (TDS).

Hesterberg TW, Bunn WB, McClellan RO, Hamade AK, Long CM, Valberg PA, 2009. Critical review of the human data on short-term nitrogen dioxide (NO2) exposures: evidence for NO2 no-effect levels. Critical Reviews in Toxicology 39, 743–81.

Howell, G.O., Hill, C.H., 1978. Biological Interaction of Selenium with Other Trace Elements in Chicks. Environ. Health Perspect. 25, 147–150.

Hunder, G., Schaper, J., Ademuyiwa, O., Elsenhans, B., 1999. Species Differences in Arsenic-mediated Renal Copper Accumulation: A Comparison between Rats, Mice and Guinea Pigs. Hum. Exp. Toxicol. 18, 699–705.

ICRP, 2008. Environmental Protection - the Concept and Use of Reference Animals and Plants, ICRP Publication 108. International Commission on Radiological Protection.

ICRP, 2003. Basic Anatomical and Physiological Data for Use in Radiological Protection: Reference Values (No. Publication 89). International Commission on Radiological Protection.

ICRP, 1994. Dose Coefficients for Intakes of Radionuclides by Workers., Publication 68. Annals of the ICRP 24(4). International Commission on Radiological Protection.

IOM, 2001. Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc. Food and Nutrition Board of the Institute of Medicine of the National Academies, Washington, D.C.

IOM, 2000. Dietary Reference Intakes for Vitamin C, Vitamin E, Selenium and Carotenoids. Food and Nutrition Board of the Institute of Medicine of the National Academies, Washington, D.C.

Ivankovic, S., Preussmann, R., 1975. Absence of toxic and carcinogenic effects after administration of high doses of chromic oxide pigment in subacute and long-term feeding experiments in rats. Food and Cosmetics Toxicology 13, 347351.

Jenkins, K.J., Hidiroglou, M., 1986. Tolerance of the preruminant calf for selenium in milk replacer. J Dairy Sci. 69, 1865–1870.

Jenner, H.A., Janssen-Mommen, J.P.M., 1993. Duckweed Lemna minor as a tool for testing toxicity of coal residues and polluted sediments. Arch. Environ. Contam. Toxicol. 25, 3–11.

Kessler, E., 1974. Physiological and biochemical contributions to the taxonomy of the genus Chlorella. IX: Salt tolerance as a taxonomic character. Archives of Microbiology 100, 51–56.

KML, NVP, 2022a. Kineepik Métis Local #9 Kineepik Valued Ecosystem Components (KML Pre-statement for Denison EIS). Kineepik Métis Local (KML); Northern Village of Pinehouse Lake (NVP).

KML, NVP, 2022b. Response to the Environment Impact Assessment. (For the Proposed Ministry of Highways 914 Extension Project.). Kineepik Métis Local (KML); Northern Village of Pinehouse Lake (NVP).

KPI Program, 2020. Cabin owner survey conducted by Denison Mines. February 14-24, 2020. Key Person Interview Program (KPI Program).
KPI Program, 2019. Interview with the English River First Nation trapper conducted by Denison Mines (Notes finalized January 2, 2020.). Key Person Interview Program (KPI Program).
KPI Program, 2018. ERFN Patuanak Reserve workshop conducted by Denison Mines. Key Person Interview Program (KPI Program).
Laird, B.D., Chan, H.N., 2013. Bioacessibility of metals in fish, shellfish, wild game, and seaweed harvested in British Columbia, Canada. Food and Chemical Toxicology 58, 381–387.
Liber, K.S., deRosemond, S., Budnick, K., 2007. Uranium Toxicity to Regionally-Representative Algae and Invertebrate Species. Toxicology Centre, University of Saskatchewan, for AREVA Resources Inc. and Cameco Corporation.
Lynch, G.P., Smith, D.F., Fisher, M., Pike, T.L., Weinland, B.T., 1976. Physiological responses of calves to cadmium and lead. J. Anim. Sci. 42, 410–421.
May-Passino, D.R.M., Novak, A.J., 1987. Toxicity of arsenate and DDT to the Cladoceran Bosmina longirostris. Bull.Environ.Contam.Toxicol. 33, 325–329.
McConnell, R.P., 1977. Toxicity of molybdenum to rainbow trout under laboratory conditions., in: Chappell, W.R. and K.K. Peterson (Eds.). Molybdenum in the Environment. Volume 2. The Geochemistry, Cycling, and Industrial Uses of Molybdenum. Marcel Dekker, New York.
MECP, 2020. Ontario's Ambient Air Quality Criteria. Ministry of the Environment, Conservation and Parks.
MECP, 2011. Rationale for the Development of Soil and Ground Water Standards for Use at Contaminated Sites in Ontario. Standards Development Branch. Ontario Ministry of the Environment, Conservation and Parks.
Meluzzi, A., Simoncini, F., Sirri, F., Vandi, L., Giordani, G., 1996. Feeding hens diets supplemented with heavy metals (chromium, nickel and lead). Archiv Fuer Gefluegelkunde 60, 119–125.
Miller, W.J., Amos, H.E., Gentry, R.P., Blackmon, D.M., Durrance, R.M., Crowe, C.T., Fielding, A.S., Neathery, M.W., 1989. Long-term feeding of high zinc sulfate diets to lactating and gestating dairy cows. J. Dairy Sci. 72, 1499–1508.
Morales, K.H., Ryan, L., Kuo, T.L., Wu, M.M., Chen, C.J., 2000. Risk of internal cancers from arsenic in drinking water. Environmental Health Perspectives 108, 655–661.
Morrison, L.L., Chavez, E.R., 1983. Selenium-arsenic Interaction in the Weanling Pig. Canadian Journal of Animal Science 63, 239–246.
NCC, 2022. Moose [WWW Document]. Nature Conservancy Canada.
Nemec, M.D., Holson, J.F., Farr, C.H., Hood, R.D., 1998. Developmental Toxicity Assessment of Arsenic Acid in Mice and Rabbits. Reprod. Toxicol. 12, 647–658.
Newman, M.C., Unger, M.A., 2002. Fundamentals of Ecotoxicology, 2nd ed. CRC/Lewis Press, Boca Raton, FL.
NRC, 2021. Woodland caribou – boreal population [WWW Document]. Natural Resources Canada.
NWF, 2021a. Snowshoe Hare [WWW Document]. The National Wildlife Federation.
NWF, 2021b. Black Bear [WWW Document]. The National Wildlife Federation.
NWF, 2021c. Common Loon [WWW Document]. The National Wildlife Federation.
Olivares, M., Pizarro, F., Speisky, H., Lönnerdal, B., Uauy, R., 1998. Copper in Infant Nutrition: Safety of World Health Organization Provisional Guideline Value for Copper Content of Drinking Water. Journal of Pediatric Gastroenterology and Nutrition 26, 251–257.
Omnia, 2020. Denison Mines Corporation Wheeler River Project - Terrestrial Environment Wildlife and Vegetation Baseline Inventory. Omnia Ecological Services.

Ontario MOE, 2011. Ontario Air Standards for Uranium and Uranium Compounds. Ontario Ministry of Environment. Technical Assessment and Standards Development Branch.

Ortolani, E.L., Machado, C.H., Sucupira, M.C.A., 2003. Assessment of Some Clinical and Laboratory Variables for Early Diagnosis of Cumulative Copper Poisoning in Sheep. Vet. Hum. Toxicol. 45, 289.

Paternain, J.L., Domingo, J.L., Ortega, A., Llobet, J.M., 1989. The Effects of Uranium on Reproduction, Gestation, and Postnatal Survival in Mice. Ecotoxicol. Env. Saf. 17, 291–296.

Persaud, D., Jaagumagi, R., Hayton, A., 1993. Guidelines for the Protection and Management of Aquatic Sediment Quality of Ontario. Ministry of Environment and Energy. Ontario.

Phillips, T.D., Nechay, B.R., Neldon, S.L., Kubena, L.F., Heidelbaugh, N.D., Shepherd, E.C., Stein, A.F., Hayes, A.W., 1982. Vanadium-induced inhibition of renal sodium, potassium adenosinetriphosphatase in the chicken after chronic dietary exposure. J. Toxicol. Environ. Health 9, 651–661.

Raisbeck, M.F., O'toole, D., Schamber, R.A., Belden, E.L., Robinson, L.J., 1996. Toxicologic evaluation of a high-selenium hay diet in captive pronghorn antelope (Antilocapra americana). J. Wild. Dis. 32, 9–16.

Rhian, M., Moxon, A.L., 1943. Chronic selenium poisoning in dogs and its prevention by arsenic. J. Pharmacol. Exp. Ther. 78, 249.

Richardson, G.M., 1997. Compendium of Canadian Human Exposure Factors for Risk Assessment. Ottawa: O'Connor Associates Environmental Inc.

Sajwan, K.S., Ornes, W.H., 1994. Phytoavailability and bioaccumulation of cadmium in duckweed plants. J. Environ. Sci. Health. A 29, 1035–1044.

Sample, B.E., Opresko, D.M., Suter, G.W.I., 1996. Toxicological Benchmarks for Wildlife: 1996 Revision. United States Department of Energy.

Sample, B.E., Suter, G.W.I., 1994. Estimating Exposure of Terrestrial Wildlife to Contaminants (No. ES/ER/TM-125). Oak Ridges National Laboratory.

Sauter, S., Buxton, K.S., Macek, K.J., Petrocelli, S.R., 1976. Effects of Exposure to Heavy Metals on Selected Fresh Water Fish. Toxicity of Copper, Cadmium, Chromium and Lead to Eggs and Fry of Seven Fish Species (No. EPA-600/3-76-105). U.S. Environmental Protection Agency, Duluth, Minesota.

Schroeder, H.A., Mitchener, M., 1971. Toxic effects of trace elements on the reproduction of mice and rats. Arch. Environ. Health. 23, 102–106.

Smith, J.S., Heinz, G.H., Hoffman, D.J., Spann, J.W., Krynitsky, A.J., 1988. Reproduction in black-crowned night-herons fed selenium. Lake Reservoir Manage 4, 175–180.

Solaiman, S.G., Maloney, M.A., Qureshi, M.A., Davis, G., D'Andrea, G., 2001. Effects of High Copper Supplements on Performance, Health, Plasma Copper and Enzymes in Goats. Small Ruminant Research 41, 127–139.

Stubblefield, W.A., Van Genderen, E., Cardwell, A.S., Heijerick, D.G., Janssen, C.R., De Schamphelaere, A.C., 2020. Acute and Chronic Toxicity of Cobalt to Freshwater Organisms: Using a Species Sensitivity Distribution Approach to Establish International Water Quality Standards. Environmental Toxicology and Chemistry 39, 799–811.

Suter, G.W., Tsao, C.L., 1996. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota (No. ES/ER/TM-96/R2).

Suter, G.W.I., 1996. Risk Characterization for Ecological Risk Assessment of Contaminated Sites. Oak Ridge National Laboratory, Oak Ridge.

Swiergosz, R., Zakrzewska, M., Sawicka Kapusta, K., Bacia, K., Janowska, I., 1998. Accumulation of cadmium in and its effect on bank vole tissues after chronic exposure. Ecotoxicol. Environ. Saf. 41, 130–136.

TCEQ, 2016. Effects Screening Levels (ESLs) Used in the Review of Air Permitting Data [WWW Document]. Texas Commission on Environmental Quality. URL https://www.tceq.texas.gov/toxicology/esl/list_main.html (accessed 10.28.20).
Tetra Tech Inc., 2008. Aquatic Life Water Quality Criteria for Molybdenum, July 9, 2008. Prepared for Nevada Division of Environmental Protection. Bureau of Water Quality Planning.
Thomas, J.W., Moss, S., 1951. The effect of orally administered molybdenum on growth, spermatogenesis and testes histology of young dairy bulls. J. Dairy Sci. 34, 929–934.
Thompson, P.A., Kurias, J., Mihok, S., 2005. Derivation and use of sediment quality guidelines for ecological risk assessment of metals and radionuclides released to the environment from uranium mining and milling activities in Canada. Environ. Monit. Assess. 110, 71–85.
Trabalka, J.R., Gehrs, C.W., 1977. An observation on the toxicity of hexavalent chromium to Daphnia magna. Toxicol. Lett. 1, 131–134.
Underwood, E.J., 1971. Trace elements in human and animal nutrition, in: Molybdenum. Academic Press, New York, pp. 116–140.
UNSCEAR, 2008. Sources and Effects of Ionizing Radiation. Annex E. Effects of Ionizing Radiation on Non-human Biota., Report to the General Assembly with Scientific Annexes. United Nations Scientific Committee on Effects of Ionizing Radiation.
US EPA, 2021a. Indicators: Zooplankton [WWW Document]. National Aquatic Resource Surveys.
US EPA, 2021b. Indicators: Macrophytes [WWW Document]. National Aquatic Resource Surveys.
US EPA, 2021c. Indicators: Phytoplankton [WWW Document]. National Aquatic Resource Surveys.
US EPA, 2021d. 2021 Revision* to: Aquatic Life Ambient Water Quality Criterion for Selenium – Freshwater 2016 (No. EPA 822-R-21-006). United States Environmental Protection Agency.
US EPA, 2007a. Aquatic Life Ambient Freshwater Quality Criteria – Copper. United States Environmental Protection Agency.
US EPA, 2007b. Ecological Soil Screening Levels for Copper (Interim Final). United States Environmental Protection Agency.
US EPA, 2007c. Ecological Soil Screening Levels for Selenium– Interim Final. U.S. Environmental Protection Agency.
US EPA, 2007d. Ecological Soil Screening Levels for Zinc – Interim Final. U.S. Environmental Protection Agency.
US EPA, 2005a. Guidance for Developing Ecological Soil Screening Levels. OSWER Directive 9285.7-55 (Revised). United States Environmental Protection Agency.
US EPA, 2005b. Ecological Soil Screening Levels for Arsenic – Interim Final.
US EPA, 2005c. Ecological Soil Screening Levels for Cadmium – Interim Final. U.S. Environmental Protection Agency.
US EPA, 2005d. Ecological Soil Screening Levels for Chromium - Interim Final (No. OSWER Directive 9285.7-66). U.S. Environmental Protection Agency.
US EPA, 2005e. Ecological Soil Screening Levels for Cobalt– Interim Final (Interim Final).
US EPA, 2005f. Ecological Soil Screening Levels for Vanadium - Interim Final (No. OSWER Directive 9285.7-75). U.S. Environmental Protection Agency.
US EPA, 1998. Toxicological Review of Trivalent Chromium in Support of Summary Information on the Integrated Risk Information System (IRIS). Washington, DC.
US EPA, 1993. Wildlife Exposure Factors Handbook (No. EPA/600/R-93/187). Office of Health and Environmental Assessment, U.S. Environmental Protection Agency, Washington, D.C.

US EPA, 1985. Ambient Water Quality Criteria for Chromium - 1984 (No. EPA-440/5-84-029). Criteria and Standards Division, U.S. Environmental Protection Agency, Washington, D.C.

US EPA, 1980. Particle Size Distribution of Yellowcake Emissions at the United Nuclear-Churchrock Uranium Mill (No. ORP/LV-80-1). Office of Radiation Programs, U.S. Environmental Protection Agency, Las Vegas, NV.

USFS, 2021. About Lichens [WWW Document]. United States Forest Service.

USGS, 2006. Cadmium Risks to Freshwater Life: Derivation and Validation of Low-Effect Criteria Values using Laboratory and Field Studies. Scientific Investigations Report 2006-5245. U.S. Geological Survey, Department of the Interior.

Vives i Batlle, J., Balonov, M., Beaugelin-Seiller, K., Beresford, N.A., Brown, J., Cheng, J.-J., Copplestone, D., Doi, M., Filistovic, V., Golikov, V., Horyna, J., Hosseini, A., Howard, B.J., Jones, S.R., Kamboj, S., Kryshev, A., Nedvecaite, T., Olyslaegers, G., Prohl, G., Ulanovsky, A., Vives Lynch, S., Yankovic, T., Yu, C., 2007. Inter-comparison of absorbed dose rates for non-human biota 349–373.

Vives i Batlle, J., Beaugelin-Seiller, K., Beresford, N.A., Copplestone, D., 2011. The estimation of absorbed dose rates for non-human biota: an extended intercomparison. Radiation Environ. Biophys. 50, 231–251.

Vocke, R.W., Sears, K.L., O'Toole, J.J., Wildman, R.B., 1980. Growth responses of selected freshwater algae to trace elements and scrubber ash slurry generated by coal-fired power plants. Water. Res. 14, 141–150.

Vohra, P., Kratzer, F.H., 1968. Zinc, copper and manganese toxicities in turkey poults and their alleviation by EDTA. Poult. Sci. 47, 699.

VST, 2004. Final Report on the Toxicity Investigation of Uranium to Aquatic Organisms. Vizon SciTech Inc., for the Canadian Nuclear Safety Commission.

WHO, 2017. Guidelines for drinking-water quality. World Health Organization.

WHO, 2011. Evaluation of certain food additives and contaminants: seventy-third [73rd] report of the Joint FAO/WHO Expert Committee on Food Additives (No. No. 960), WHO Technical Report Series. World Health Organization, Food and Agriculture Organization of the United Nations & Joint FAO/WHO Expert Committee on Food Additives.

WHO, 2006. WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide Global update 2005, Summary of risk assessment.

Wiemeyer, S.N., Hoffman, D.J., 1996. Reproduction in eastern screech-owls fed selenium. Journal of Wildlife Management 60, 332–341.

Wood, C.M., Port, P., 2000. Intracellular pH regulation and buffer capacity in CO2/HCO3-buffered media in cultured epithelial cells from rainbow trout gills. J. Comp. Physiol. B. 170, 175–184.

WSA, 2017. Saskatchewan Water Quality Objective for the Protection of Aquatic Life – Molybdenum. Fact Sheet. (No. WSA 514). Saskatchewan Water Security Agency.

Wu, M.M., Kuo, T.L., Hwang, Y.H., Chen, C.J., 1989. Dose–response relation between arsenic concentration in well water and mortality from cancers and vascular diseases. American Journal of Epidemiology 130, 1123–1132.

YNLRO, 2022. An Exploration of Recorded Athabasca Denesųłiné Traditional Knowledge, Land Use and Occupancy Information in the Vicinity of Denison Mines Wheeler River Project. Ya'thi Néné Lands and Resources Office.

Zarafonetis, J.H., Hampton, R.E., 1974. Some effects of small concentrations of chromium on growth and photosynthesis in algae. Mich. Acad. 6, 417–421.

Appendix A Wheeler River Project IMPACT Model

WHEELER RIVER PROJECT - IMPACT MODEL

MODELLING REPORT

REPORT PREPARED FOR:

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1 October 2024

WHEELER RIVER PROJECT - IMPACT MODEL

MODELLING REPORT

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

BAF	bioaccumulation factor
CNSC	Canadian Nuclear Safety Commission
COPC	constituent of potential concern
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CSA	Canadian Standards Association
DCF	dose coefficient
dw	dry weight
ERA	environmental risk assessment
fw	fresh weight
HQ	hazard quotient
IMPACT	Integrated Model for the Probabilistic Assessment of Contaminant Transport
TF	transfer factor
USEPA	United States Environmental Protection Agency

Units of Measure

%	percent
µGy/h	micrograys per hour
Bq/kg	becquerels per kilogram
Bq/L	becquerels per litre
Bq/m^2	becquerels per square metre
Bq/m^3	becquerels per cubic metre
cm/h	centimetres per hour
d	day
h	hour
ha	hectare
kg	kilogram
kg/L	kilograms per litre
$kg/m^2/s$	kilograms per square metre per second
kg/yr	kilograms per year
km	kilometre
km^2	square kilometre
L	litre
L/d	litres per day
L/kg	litres per kilogram
$L/m^2/s$	litres per square metre per second
L/m^3	litres per cubic metre
L/s	litres per second
m	metre
m/s	metres per second

m^2	square metre
m^3	cubic metre
m^3/d	cubic metres per day
m^3/kg	cubic metres per kilogram
m^3/yr	cubic metres per year
mg	milligram
mg/kg	milligrams per kilogram
mg/kg/d	milligrams per kilogram per day
mg/L	milligrams per litre
mg/m^3	milligrams per cubic metre
mg/s	milligrams per second
mSv/yr	millisieverts per year
s	second
Sv/Bq	sieverts per becquerel
Sv/yr	sieverts per year
yr	year

1.0 Introduction

1.1 Overview of the IMPACT Model

The environmental transport and pathways model, IMPACT (Integrated Model for the Probabilistic Assessment of Contaminant Transport), is used to evaluate the transport and effects of constituents of potential concern (COPCs) on the local environment and receptors, including humans and non-human biota. The model represents a convenient platform and powerful tool to complete systematic evaluations of the risks to ecological and human receptors associated with releases of constituents to water and air from proposed or existing anthropogenic (i.e., human) activities. The scope of this appendix is to provide further detail on the modelling approach followed to calculate dose and risk to ecological and human receptors, as reported in the main body of the Wheeler River Environmental Risk Assessment (ERA).

IMPACT is a modelling tool, the current version of which was created, and is maintained and supported, by Ecometrix Incorporated (Ecometrix). The IMPACT model was originally developed by BEAK Consultants Ltd. in 1993 as part of a research initiative partially funded by the Atomic Energy Control Board (now the Canadian Nuclear Safety Commission, CNSC). Since the initial development, IMPACT has been continuously updated to improve the interface, to integrate various operating systems, and most importantly, to embody an up-to-date understanding of the fate, transport, and toxicity of metals, radionuclides, and other constituents released to the environment.

IMPACT updates have been funded by the CANDU Owners Group to ensure that it is continually aligned with the Canadian Standards Association (CSA) relevant standards. The CSA standard N288.1 presents analytical equations and parameters for radiological pathways analysis, developed with the participation of experts from the nuclear industry, government agencies and consultants, including the CNSC and Ecometrix. The CSA standard N288.6-22 provides guidance for environmental risk assessment at nuclear facilities, and references N288.1 for radiological risk assessment.

The IMPACT 5.6.0 is a dynamic version of the model and was tailored to align with the guidance in CSA standards N288.6-22 (CSA Group, 2022) and N288.1-20 (CSA Group, 2020). It contains differential equations for COPC transport, allowing for non-steady-state conditions, whereas N288.1 contains the corresponding steady-state equations.

The IMPACT model is a customizable tool that allows the user to assess the transport and fate of COPCs through a user-specified environment. The model is used to estimate concentrations of COPCs in a range of environmental media, based on releases and environmental features. The IMPACT model enables the quantification of potential doses and hazard quotients (HQs) for aquatic and terrestrial ecological receptors, as well as humans. The graphical user interface features make it possible to create or modify scenarios quickly and without the need to change the programming code. Thus, users can construct complex models to predict potential environmental effects in a wide variety of natural environments without the need for programming skills or the use of multiple, complex model interfaces.

The IMPACT model has been applied to ecological and human health risk assessments at several proposed and operating uranium mines and mills including Cigar Lake Mine (Cameco, 2004), Key Lake Mine (Ecometrix, 2005, 2012, 2013a) and Millennium Mine (Ecometrix, 2013b, c). This model has also been used extensively by other nuclear facilities for ecological and human health risk assessments, to support preparation of derived release limits and for annual public dose calculations. The extensive environmental database developed for northern Saskatchewan since the 1970s to present day has gone through numerous updates as a larger available database of environmental data became available over time. This has helped develop more statistically rigorous relationships for COPC transfer among various environmental compartments. Substantial effort was made during this assessment to review parameters in the model and compare to the existing baseline dataset for the Wheeler River Project, which is further discussed in Section 3.0, Development of Model Parameters.

1.2 Objective of this Document

The objective of this document is to present the structure and functioning of the IMPACT model as implemented for the Wheeler River Project (the Project). The Project is a proposed uranium mine and processing plant in northern Saskatchewan, Canada. It is located in a relatively undisturbed area of the boreal forest about 4 km off of Highway 914 and approximately 35 km north-northeast of the Key Lake uranium operation. Denison is proposing to apply an innovative approach to uranium mining called In-Situ Recovery (ISR), which eliminates the need for large open pits, shafts, and underground mine workings. The Project site and surrounding local and regional study areas are shown in Figure 1-1.

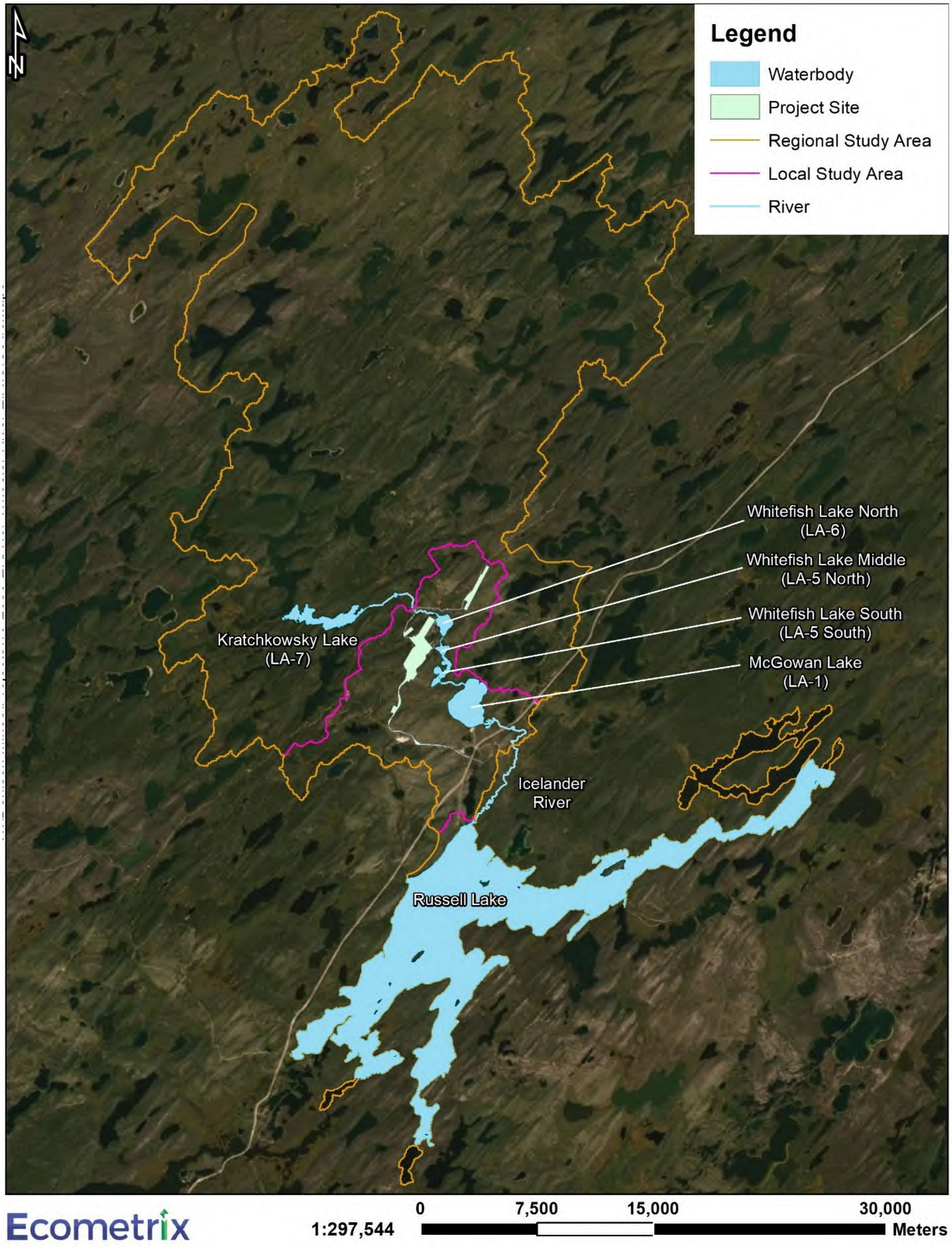


Figure 1-1: Wheeler River Project Site and Study Areas

This document discusses the inputs and assumptions used in the IMPACT model, including receptor characteristics, exposure pathways, and the derivation and identification of site-specific information.

1.3 Structure of this Document

The document contains the following sections and content:

Section 2: Describes the model structure for ecological and human receptor assessment, specific assumptions made for the Project, and the generic equations used to calculate the transfer of constituents between environmental media and the receptors.

Section 3: Presents the development of project-specific input parameters and describes the approach used for calibration and validation based on regional monitoring data.

2.0 The IMPACT Model

The IMPACT model simulates the transport of constituents from sources through various environmental media such as air, water, soil, and sediment, to receptors. The model estimates the resulting concentration of constituents in environmental media, potential uptake (i.e., absorption) by aquatic and terrestrial vegetation and animals, and potential intake (i.e., ingestion) by and dose to animals and humans.

Environmental pathways are the transport, transformation, and transfer mechanisms by which COPCs travel from sources to receptors. A pathway exists when there is a point at which COPC uptake or external exposure by an ecological or human receptor may occur, following COPC transport from the source through environmental media. If a complete transport pathway does not exist between the source of a COPC and an ecological or human receptor, then no exposure is expected to occur.

The links within a pathway represent different processes of COPC transfer, which depend on the receptors and environmental conditions. These processes can include intake, transfer, and accumulation of constituents.

IMPACT is consistent with the calculations outlined in CSA N288.1-20 and CSA N288.6-22. As such the default model parameters are consistent with these publications. All environmental parameters including bioaccumulation factors, transfer factors and other constants can be adjusted to site or regional data as these are available. In general, it is preferable to use regional values and this approach was followed in this assessment, where regional values were available. Values for water-sediment transfer as well as aquatic animals and plants were based on regional datasets which have been developed using extensive environmental data collected over many years (Ecometrix 2005, 2012, 2013). These values will be identified as regional data. For the remaining factors, literature values were selected. In this selection process the CSA standards were preferred to other available literature.

This IMPACT model was set up to be representative of the environment it models and the transfer processes between environmental components. Where deemed applicable, field measurements were used either as inputs or as a validation of modelled values. Some model parameters were selected based on regional monitoring data and previous model calibrations to regional data for northern Saskatchewan. Model predicted COPC concentrations for the Wheeler River baseline condition were compared to measured Wheeler River baseline data to ensure that model predictions were not underestimating as compared to measurements. This is discussed in detail in Section 3.0, Development of Model Parameters.

2.1 The IMPACT Model Structure

The basic units of assessment in IMPACT are "polygons". IMPACT supports two types of polygons, aquatic and terrestrial, which represent aquatic and terrestrial environments respectively. Ecological and human receptors inhabit polygons. Polygons represent zones of surface water or land that have similar physical, chemical, biological, and/or hydrological characteristics. Individual polygons are given specific attributes, such as topography for land polygons and water depth and flow for water polygons, which can be based on site-specific information. Each polygon is given a specific spatial extent that is defined by a centroid point (with X and Y coordinates) and a surface area. Polygons can be connected by water or air pathways. A number of receptors may reside within each polygon and may have exposure connections to other polygons.

The transfer of constituents between environmental media, receptors, and polygons is conceptualized by links (i.e., arrows indicating direction of transfer). The links represent different transfer processes depending on the context. For example, a link between two waterbodies may represent flow of water, and a link between water and sediment may represent sedimentation. Each transfer process is represented by a differential equation.

Transfer of constituents is modelled iteratively with a constant user-selected time step. IMPACT uses the Euler Method to numerically solve the set of ordinary differential equations at each time step. The modelling time step for this Project was selected to optimize computing time and produce a convergent solution in a dynamic system. The modelling simulation time step chosen was 0.0025 years. Results were monitored at intervals of 0.083 years (monthly) during the Project phases and 2 years for the scenario of future centuries.

2.2 Water Polygons

Lakes and streams are defined within IMPACT as water polygons, which are distinct from land polygons. Water polygons can be inhabited by aquatic receptors and provide exposure pathways for terrestrial and human receptors.

The IMPACT model includes flow and mass balance in lakes and streams. Constituents enter the aquatic environment from a source and travel through various waterbodies. Atmospheric deposition to Whitefish Lake is considered negligible relative to direct input from effluent. This is consistent with the COG DRL guidance (COG, 2019) which shows that the transfer of constituents from the atmosphere to large bodies of water (including lakes and rivers) is negligible if emissions to water approximate those to air.

A sample calculation for uranium is provided below to illustrate that for the Project the atmospheric input of uranium to Whitefish Lake (LA-5) is very small relative to the direct input to water via effluent.

The transfer from air source to air (P_{01}) is estimated by dividing the air concentration (X_1) by the atmospheric release rate ($X_{0(a)}$), as shown below.

$P_{01}=X_1/X_{0(a)}$

X_1	Air Concentration (LA-5) U	3.45E-05	mg/m^3	EIS Appendix 6
$X_{0(a)}$	Atmospheric Release Rate	6.83E+01	mg/s	EIS Appendix 6
P_{01}	Transfer source to air	5.05E-07	s/m^3	calculated

The transfer from water source to water (P_{02}) is estimated by dividing the water concentration (X_2) by the effluent release rate ($X_{0(w)}$).

$P_{02}=X_2/X_{0(w)}$

X_2	Water Concentration (LA-5) U	5.74E-04	mg/L	From IMPACT Model
$X_{0(w)}$	Effluent Release Rate (U)	5.78E-01	mg/s	U Effluent Concentration x Effluent Flowrate
P_{02}	Transfer source to water	9.93E-04	s/L	calculated

The transfer from air to water (P_{12}) is estimated below.

$P_{12} = V_g (A/V)10^{-3}/(\lambda_s+\lambda_w)$

V_g	Atmospheric deposition velocity	0.003	m/s	N288.1
Area	LA-5	96940	m^2	site-specific (Appendix A)
Volume	LA-5	106634	m	site-specific (Appendix A) (Area*Depth)

$\lambda_s = DR \cdot \rho \cdot K_d \cdot (A/V)$

DR	Sediment deposition rate	6.34E-08	mm/s	Assumption (2mm/yr)
P	sediment dry bulk density	0.11	kg/L	N288.1
K_d	partition coefficient	20000	L/kg	N288.1
λ_s	sedimentation loss rate constant	1.27E-07	s^{-1}	calculated

$\lambda_w = U \cdot CA/V = Q/V$

Q	Inflow into LA-5	1.379	m^3/s	site-specific (Appendix A)
V	Volume of LA-5	106634	m^3	Area*Depth
λ_w	loss via water flow rate constant	1.29E-05	s^{-1}	calculated
P_{12}	Transfer from air to water	2.09E-01	m^3/L	calculated

Water concentration from air = $X_{0(a)}*P_{01}*P_{12}$	7.20E-06	mg/L
Water concentration from effluent = $X_{0(w)}*P_{02}$	5.74E-04	mg/L
Percent contribution to Water from Air	1%	

As constituents travel through a series of connected waterbodies such as lakes, concentrations in water can decrease as a result of mixing with natural inflows from the surrounding watershed and interactions with lake sediment. The sediment-water exchange of constituents is estimated using chemical-specific partitioning coefficients. The water and sediment pathways involve the exchange of constituents between surface water and sediment through the following processes:

- sorption and desorption between dissolved and particulate forms in water and sediment;
- settling of particulates from water to sediment;
- diffusive exchange between sediment porewater and the water column; and
- loss to deeper sediments through accumulation and burial.

The model estimates concentrations in water and sediment using the advection dispersion equation (detailed below), which is essentially a mass conservation equation. The partial differential equations are solved iteratively. The model estimates change in concentrations in water and sediment through each downstream waterbody, over time.

Aquatic receptors reside in water polygons. Terrestrial receptors (e.g., moose, humans) reside in land polygons and can be linked to aquatic receptors from water polygons.

The IMPACT model included the following distinct water polygons: LA-7 South (Kratchkowsky Lake – reference lake), LA-6 (Whitefish Lake North), LA-5 North (Whitefish Lake Middle), LA-5 South (Whitefish Lake South), LA-1 (McGowan Lake), Russell Lake (exposed area). The lakes were connected by creeks which were considered as a flow-through channel, in the same way as the Icelander River connecting LA-1 and Russell Lake. This is discussed in more detail in Section 3.1.1.

2.2.1 Ecological Receptors Residing in Water Polygons

Aquatic plants and animals are assigned to water polygons. The aquatic ecological receptors that were considered in this iteration of the IMPACT model include aquatic macrophytes (i.e., plants), phytoplankton, zooplankton, benthic invertebrates, and fish.

Macrophytes

Aquatic macrophytes are primary producers that occupy the lowest level in the food chain and are exposed to constituents in surface water. Macrophytes can potentially uptake metals in their roots and shoots and are modelled accordingly. Macrophytes provide a pathway for the introduction of bioavailable constituents and their compounds into the food chain through direct consumption by terrestrial herbivores (e.g., moose [*Alces alces*] and woodland caribou [*Rangifer tarandus caribou*]).

Phytoplankton

Phytoplankton are primary producers that occupy the lowest level in the food chain and are assessed for exposure to constituents in surface water.

Zooplankton

Zooplankton are primary consumers that occupy the second lowest level in the food chain and are assessed for exposure to constituents in surface water.

Benthic Invertebrates

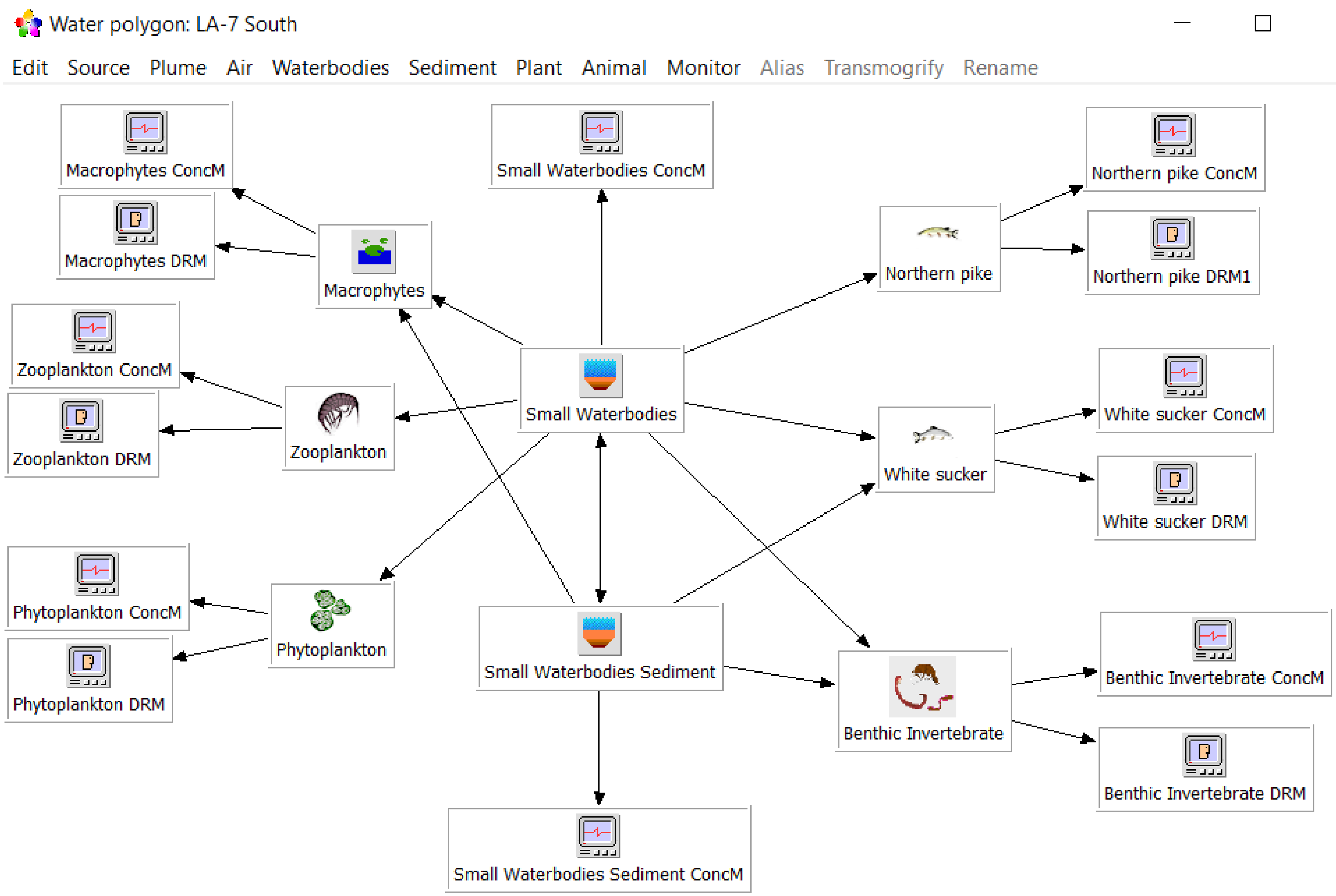
Benthic invertebrates are primary consumers. These organisms are important food sources for aquatic and semi-aquatic animals. In the IMPACT model, benthic invertebrates are assumed to be exposed to COPCs in the aquatic environment directly through contact with water and sediment.

Fish

Fish were collected from waterbodies within the vicinity of the Project local and regional study areas to provide data on baseline COPC concentrations in muscle and bone tissues in large-bodied fish (Ecometrix, 2020a). Fish species observed and sampled included northern pike (*Esox lucius*) and white sucker (*Catostomus commersonii*). Northern pike was selected for IMPACT modelling purposes to represent a piscivorous (i.e., fish-eating) top carnivore. White sucker was selected for IMPACT modelling to represent a bottom-feeding fish. Northern pike and white sucker represent different trophic levels. Although there may be other fish species that are not included explicitly in the model, northern pike and white sucker are assumed to be representative of other similar species. Since baseline data are available for these species, model predictions can be validated against measured data (see Section 3.6.2).

2.2.2 Aquatic Pathways

Aquatic pathways include the transfer of COPCs between water, sediment, aquatic animals, and aquatic plants. Environmental media (i.e., water and sediment) and aquatic ecological receptors (i.e., macrophytes, phytoplankton, zooplankton, benthic invertebrates, and fish) are connected by arrows in the IMPACT model (Figure 2-1). The arrows represent equations listed below the figure. Model outputs include concentrations in environmental media and receptors, and dose and risk values for aquatic ecological receptors.



DRM = Dose-Risk Monitor; ConcM = Concentration Monitor.

Figure 2-1: Representation of Transfer between Aquatic Media in the IMPACT Model

The equations for concentrations in water and sediment are partial differential equations that are solved numerically within IMPACT. Each of these equations is characterized by a series of parameters that describe the physical and biochemical environment of each lake and stream represented by the model. These parameters can be divided into general categories to represent the following components and processes:

- physical environment;
- natural background conditions;
- project-related constituent loadings; and
- biochemical exchange processes.

There are four basic equations that describe the concentrations in the aquatic environment for water and sediment.

Water column concentration (C_{wc}):

$$\frac{dC_{wc}}{dt} = \frac{W_w + Q_{in} \cdot C_{in} + Q_{gw} \cdot C_{gw}}{V_w} + \lambda_{parent} \cdot C_{parent} - \frac{k_s}{z_w}\left[(1 - f_w) \cdot C_{wc} - C_{pw}\right] - C_{wc} \cdot \left[\lambda_T + \frac{g_w \cdot f_w}{z_w} + \frac{Q_{out} + (1 - f_w) \cdot Q_{gw \leftrightarrow out}}{V_w}\right]$$

Sediment layer concentration (C_s):

$$\frac{dC_s}{dt} = \frac{g_w \cdot f_w \cdot C_{wc}}{z_s} + \lambda_{parent} \cdot C_{parent} + \frac{k_s}{z_s}\left[(1 - f_w) \cdot C_{wc} - C_{pw}\right] + \frac{Q_{gw} \cdot C_{gw}}{V_s} - C_s \cdot \left[\lambda_T + \frac{g_b}{z_s} + \frac{(1 - f_s) \cdot Q_{gw \leftrightarrow out}}{\varepsilon_s \cdot V_s}\right]$$

The fraction of a constituent that is particulate in the water column (f_w) defined as:

$$f_w = \frac{K_d \cdot \frac{\rho_s}{\varepsilon_s}}{1 + K_d \cdot \frac{\rho_s}{\varepsilon_s}}$$

The sediment-water transport coefficient (k_s) defined as:

$$k_s = \frac{D^*}{z_i}$$

The burial rate of sediments (g_b) defined as:

$$g_b = \frac{g_w \cdot SS}{\rho_s}$$

Aquatic animal concentrations (C_{aa}) are calculated as:

$$C_{aa} = C_{wc} \cdot BAF_{aa} \cdot \alpha \cdot (1 - OF_s) + C_{pw} \cdot BAF_{aa} \cdot \alpha \cdot OF_s$$

Aquatic plant concentrations (C_{ap}) are calculated as:

$$C_{ap} = C_{wc} \cdot BAF_{ap}$$

where:

α	=	food web multiplier(s) (unitless)
BAF_{aa}	=	bioaccumulation factor for aquatic animal L/kg)
BAF_{ap}	=	bioaccumulation factor for aquatic plants L/kg)
C_{in}	=	concentration of constituent entering water column (mg/L, Bq/L)
C_{gw}	=	concentration of constituent in seepage (input) groundwater (mg/L, Bq/L)
C_{parent}	=	concentration of parent constituent (mg/L, Bq/L)
C_{pw}	=	concentration in the surficial sediment pore water (mg/L, Bq/L)
C_s	=	concentration of constituent in surficial sediments (mg/kg, Bq/kg)
C_{wc}	=	concentration of constituent in water column (mg/L, Bq/L)
D^*	=	sediment-water column diffusion coefficient (m^2/s)
ε_s	=	porosity of surficial sediment (unitless)
f_s	=	fraction of a constituent that is particulate in the sediment layer (unitless)
f_w	=	fraction of a constituent that is particulate in the water column (unitless)
g_b	=	burial rate of sediments (m/s)
g_w	=	settling rate of particulates in water column (m/s)
K_d	=	water-to-sediment partitioning coefficient (L/kg)
k_s	=	sediment-water transport coefficient (m/s)
λ_{parent}	=	first-order decay constant for parent constituent (1/s)
λ_T	=	total first-order decay constant for constituent (1/s), which is the sum of the universal decay constant and the media-specific decay constant
OF_S	=	sediment occupancy factor (unitless)
Q_{in}	=	inflow rate from upstream surface water (L/s)
Q_{gw}	=	inflow rate from groundwater (L/s)
Q_{out}	=	net outflow rate to downstream surface water (L/s)
$Q_{gw \leftrightarrow out}$	=	outflow rate to groundwater (L/s)
ρ_s	=	bulk density of surficial sediment (kg dw/L)
SS	=	suspended solids concentration (mg/L)
V_s	=	volume of surficial sediment layer (L)
V_w	=	volume of surface waterbody (L)
W_w	=	total effluent emission rate from all sub-sources (mg/s, Bq/s)
z_i	=	sediment-water column diffusion interface thickness (mm)
z_s	=	thickness of sediment layer (m)
z_w	=	mean lake depth (m)

Many parameters representing the physical environment were derived from baseline hydrology studies (Ecometrix, 2020b) including waterbody surface areas and volumes. Information from published literature and from experience with similar environments was used to quantify physical parameters that are conceptual or that were not observed directly (e.g., sediment interface thickness). A summary of these parameters used as inputs for the above transport equations is presented in Table 2-1. It should be noted here that the underlying assumption for water-sediment transport in IMPACT is that minimal suspended solids will be introduced through the effluent.

Table 2-1: Water-Sediment Transport Modelling Parameters

Model Parameter		Value	Unit
Mixing depth (thickness of sediment layer)	z_s	0.03	m
Dry bulk density	ρ_s	0.11	kg dw/L
Water content (porosity)	ε_s	0.96	unitless
Diffusion coefficient	D*	3.16×10^{-10}	m^2/s
Interface thickness	z_i	0.01	m
Settling rate	g_w	2	mm/yr
Suspended solids	SS	2	mg/L

dw = dry weight.
Note: Values calibrated based on regional data.

The natural background conditions represent the quality of water and sediment within the watershed prior to mining. Where possible, field data were used to quantify natural background conditions (Section 3.2.1, Background Water Quality and Section, 3.3.1, Background Sediment Quality). Monitoring data indicated that concentrations of some constituents in water were below analytical detection limits. Concentrations in the sediments from lakes were generally measurable. Water-sediment partitioning coefficients were selected based on the available data (Section 3.3.2, Water to Sediment Partitioning Coefficients).

The source loads of constituents from natural and Project-related sources represent the boundary conditions of the model. Natural sources are represented by the chemical influx from natural groundwater discharge, overland runoff, and stream inflows from the surrounding landscape. These natural loadings were estimated from natural background water quality and inflow rates for site-specific conditions.

2.2.3 Radiological Dose to Aquatic Ecological Receptors

Radiological dose to an aquatic receptor is the radiation energy absorbed due to radiation emissions from radionuclides present in the environment (water or sediment) or in the tissues of the organism. Through comparison with dose benchmarks, the risk to the organism can be quantified. This model characterizes dose resulting from both background and project exposure.

The total dose (D_{total}) to an aquatic ecological receptor from each constituent is:

$$D_{total} = D_{int} + D_{ext}$$

The internal dose of COPCs to an aquatic ecological receptor due to incorporated radioactivity (D_{int}) is:

$$D_{int} \quad = \quad C_t \cdot DCF_{int}$$

The external dose to an aquatic ecological receptor from radioactivity in water and sediment (D_{ext}) is:

$$D_{ext} \quad = \quad [C_w \cdot (OF_w + 0.5OF_{ws} + 0.5OF_{ss}) + C_s \cdot (OF_s + 0.5OF_{ss})] \cdot DCF_{ext}$$

where:

C_t	=	whole body tissue concentration from water (becquerels per kilogram fresh weight (Bq/kg fw))
C_w	=	water concentration (becquerels per litre (Bq/L))
C_s	=	sediment concentration (Bq/kg fw)
D_{int}	=	internal radiation dose (micrograys per hour (µGy/h))
D_{ext}	=	external radiation dose (µGy/h)
DCF_{int}	=	dose coefficient for radionuclide in tissue ([µGy/h])/[Bq/kg fw])
DCF_{ext}	=	external dose coefficient for water ([µGy/h]/[Bq/kg fw sediment] or [µGy/h]/[Bq/L water])
OF_s	=	fraction of time spent immersed in sediment (unitless). Assumption based on characteristics of the organism; see Table 2-5
OF_{ss}	=	fraction of time spent on the sediment surface (unitless). Assumption based on characteristics of the organism; see Table 2-5
OF_w	=	fraction of time spent immersed in the water column (unitless). Assumption based on characteristics of the organism; see Table 2-5
OF_{ws}	=	fraction of time spent on the water surface (unitless). Assumption based on characteristics of the organism; see Table 2-5

2.2.4 Non-radiological Risk to Aquatic Receptors

Risk to aquatic receptors from exposure to non-radionuclide COPCs is expressed as a Hazard Quotient (HQ). For aquatic receptors, it is characterized through comparison of the exposure concentration with a reference toxicity concentration. This model calculates the risk from both background and project exposure. The HQ for aquatic ecological receptors due to exposure to COPCs in water is estimated as:

$$HQ \quad = \quad \frac{1}{RC_{wc}} \cdot [C_{wc} \cdot (1 - OF_s) + C_{pw} \cdot OF_s]$$

where:

C_{pw}	=	concentration of constituent in the surficial sediment pore water (mg/L)
C_{wc}	=	concentration of constituent in water column (mg/L)

OF_s = sediment occupancy factor (unitless). Assumption based on characteristics of the organism; see Table 2-5

RC_{wc} = reference toxic concentration – water column (mg/L)

2.3 Land Polygons

Terrestrial receptors are modelled as residing in land polygons. Land polygons provide exposure pathways for terrestrial and human receptors. Land polygons are populated by one or more terrestrial receptors that are expected to occupy the habitat represented by the prevailing vegetation community and physical characteristics of the surrounding environment.

IMPACT models both terrestrial and aquatic dietary components for terrestrial receptors. Terrestrial pathways include the transfer of constituents between air, soil, water, plants, and animals.

2.3.1 Terrestrial Ecological Receptors

Terrestrial receptors are divided into ecological receptors and human receptors. Ecological receptors typically are selected to include representative species of terrestrial plants, small and large mammals, invertebrates, birds, and riparian animals. Human receptors can be modelled to represent the habits of population groups and ages that are expected to reside in the area of interest (Section 2.4, Exposure of Human Receptors).

Terrestrial ecological receptors are assigned to a land polygon. The terrestrial ecological receptors that were selected include primary producers (plants) and consumers (invertebrates and animals). Primary consumers (herbivores) and secondary consumers (omnivores and carnivores) were selected from among mammals and birds that are known to be present in the vicinity of the Project and are known to be of value to Indigenous groups and local communities. Documented rationale for receptor selection is provided in the Wheeler River ERA Report. The terrestrial ecological receptors considered in the IMPACT model include terrestrial plants, terrestrial invertebrates, terrestrial and riparian mammals, and terrestrial and riparian birds.

Terrestrial Vegetation

Terrestrial vegetation types are dietary components for terrestrial animals and humans. They are represented by browse (shrubs and grasses), lichen (*Cladonia* spp., *Cladina* spp.), blueberry (*Vaccinium mytilloides*), and Labrador tea (*Rhododendron groenlandicum)*. Plants are exposed to constituents in soil through contact with soil and contaminant uptake from soil via bioaccumulation. Lichen is exposed to constituents depositing from air. Berries and Labrador tea represent plants used in the Traditional Foods diet (i.e., diet made up of plants and animals fished, hunted, or gathered from the land).

Terrestrial Invertebrates

Terrestrial invertebrates are considered to be primary consumers. They are represented by earthworms, which live in soil and are therefore exposed to constituents in soil layers through direct contact. Earthworms acquire nutrition through organic matter in soil and decomposing remains of other animals. Terrestrial invertebrates are part of the diet for the American robin (*Turdus migratorius*).

Terrestrial and Riparian Mammals

Mammalian herbivores are represented by woodland caribou, snowshoe hare (*Lepus americanus*), moose, and southern red-backed vole (*Myodes gapperi*). Herbivores convert vegetable matter to animal protein, and in turn are consumed by omnivores and carnivores. Snowshoe hare and southern red-backed vole are small mammals that consume berries and browse. These species are important prey for larger terrestrial predators such as Canada lynx (*Lynx canadensis*). The southern red-backed vole is very abundant in the vicinity of the Project based on the local terrestrial environment wildlife and vegetation baseline inventory (Omnia, 2019). Woodland caribou and moose are large ungulates with distinct home ranges and linkages to aquatic environments during the summer period. The primary food sources for woodland caribou are lichen in the winter and terrestrial vegetation (browse) and aquatic vegetation (macrophytes) in the summer. Moose consumes terrestrial and aquatic vegetation. Moose is part of the Traditional Foods diet and is assumed to be representative for other ungulate species such as white-tailed deer (*Odocoileus virginianus*).

Black bear (*Ursus americanus*) is a terrestrial omnivore that is opportunistic and relies on readily available and easily accessed foods. Black bears consume berries and fish, and therefore have a dietary link to the aquatic environment.

Muskrat (*Ondatra zibethicus*) is riparian mammal that is exposed to constituents in both aquatic and terrestrial environments. The muskrat's diet is fully aquatic, and muskrats are assumed to consume a combination of aquatic plants and benthic invertebrates.

Mink (*Neovison vison*) and Canada lynx are terrestrial predators representing the top level of the food chain. The mink's diet has linkages to both land and water polygons through the consumption of fish, benthic invertebrates, riparian mammals, and birds.

Terrestrial and Riparian Birds

Canada goose (*Branta canadensis*) is terrestrial herbivore. It is part of the traditional food diet and is assumed to be representative for other birds with similar dietary characteristics.

Olive-Sided Flycatcher (*Contopus cooperi*) is an aerial insectivore which has a varied diet but feeds primarily on terrestrial and benthic invertebrates. The olive-sided flycatcher is a Species of Special Concern under the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and is threatened under the *Species at Risk Act (SARA)*. It can be considered representative for other small birds and at-risk species, such as barn swallow and common nighthawk.

American robin (*Turdus migratorius*) is a terrestrial omnivore and can be representative of other insectivores and ground-feeding birds which were commonly found within the Wheeler River project area (Omnia, 2019), such as ruby-crowned kinglet, dark-eyed junco, hermit thrush, and yellow-rumped warbler. The American robin feeds on fruit and soil invertebrates.

Bald eagle (*Haliaeetus leucocephalus*) is a terrestrial carnivore, which was observed in the study area and is representative for other raptors. Bald eagles consume fish and other riparian birds.

Mallard (*Anas platyrhynchos*), lesser scaup (*Aythya affinis*) and common loon (*Gavia immer*) are migratory water birds that are common to northern Saskatchewan. These riparian birds have a primarily aquatic diet; the mallard and lesser scaup consume macrophytes and benthic invertebrates, and the common loon consumes fish and benthic invertebrates.

2.3.2 Home Ranges and Residency Factors

Home range is defined as the geographic area encompassed by an animal's activities, excluding migration, over a specific time (USEPA 1993). The home range size is used to determine the portion of time that an individual animal is expected to be exposed to COPCs through contact with environmental media. Small mammals such as muskrat and vole have small home ranges that are represented by small polygons with similar vegetation communities.

The residency factor represents the fraction of time an animal is expected to be exposed to a location and the proportion of the animal's intake (i.e., food, water) that is taken from each location. Animals are given a residency factor of one if they receive 100% of their exposures from one polygon location. The IMPACT model looked at three polygon locations where potential exposures to Project emissions could occur (LA-5 (Whitefish Lake), LA-1 (McGowan Lake), Russell Lake) and one reference location that is unexposed (upstream) to Project emissions (Reference Lake represented by LA-7 South). Each polygon location includes both water and land polygons.

Animals with large home ranges (i.e., greater than 10 km^2), such as the woodland caribou, black bear and bald eagle, interact with several different exposed polygon locations for feeding and water intake. All other receptors have relatively small home ranges (i.e., less than 10 km^2) and were assumed to reside in the same polygon year-round. The estimated home ranges of selected mammalian receptors with potentially larger home ranges are presented in Table 2-2. The woodland caribou and black bear have home ranges of approximately 80 km^2 and the bald eagle has a home range of approximately 314 km^2. Therefore, these animals have the potential to be present at more than one polygon location to obtain their food. Home ranges are generally conservatively selected based on the expected home range during sensitive life stages.

Animals that are migratory are unlikely to have 100% residency at one polygon location for the entire year. However, because toxicity reference values that are used to establish potential risk are typically based on sensitive life stages such as reproduction, a 100% residency can be conservatively assumed for a specific life stage to capture the risk from exposure for the life stage of interest. For instance, mallards are not present in the vicinity of the Project for over half the year due to migration but have a small home range during the nesting and rearing of their young. Therefore, it was conservatively assumed that the mallard has a 100% residency factor at one polygon location where the young are hatched and reared.

Similarly, moose can move to different geographical locations between seasons, but generally remain within small seasonal home ranges of 5 km^2 to 10 km^2 during the summer and winter. Mink remains within small seasonal home ranges of 0.06 km^2 to 16.3 km^2. For modelling purposes, these animals (with local home ranges or migratory patterns) are associated with one polygon location (100% residency).

Table 2-2: Estimated Home Ranges of Selected Terrestrial Ecological Receptors

Ecological Receptor	Home Range (km^2)			Comment	Reference
	Expected	Minimum	Maximum		
Woodland Caribou	80[a]	67[b]	267[c]	Female home ranges from GPS tracking data in the Saskatchewan Boreal Shield. The expected home range used for assessment is based on an average female range during the most sensitive life stage of the woodland caribou (i.e., calving/post-calving).	McLoughlin et al, 2016.
Moose	10	5	10	Moose are essentially solitary and have one or several distinct home ranges to which they are strongly attached. Movements between seasonal home ranges may be extensive but home ranges are generally small. The same home ranges are generally returned to year after year.	Wilson and Ruff 1999; Franzmann 1981
Black Bear	80	40	130	Female home ranges from GPS tracking data in the Saskatchewan Boreal Shield.	McLoughlin et al, 2019.
Mink	7.7	0.06	16.3	Expected value based on a study in southern Manitoba	Arnold and Fritzell 1987, FCSAP 2012
Bald Eagle	314	7	452	Eagles tend to nest closer to suitable fishing habitat, forage from the nest, and avoid areas of human disturbance.	Livingston et al . 1990 as cited in US FWS 2002

Notes:
[a] Represents the mean range size pooled over the two study years for calving/post-calving stage.
[b] Represents the mean range size for autumn/rut.
[c] Represents the mean range size for early winter.

Residency factors for receptors with large home ranges (i.e., woodland caribou, black bear, and bald eagle) were estimated based on the relative sizes of waterbodies (surface areas) that are located within an area consistent with the receptor's expected home range size. The objective is to determine the time spent at exposure locations and reference locations.

The woodland caribou or black bear receptor at LA-5 (Table 2-3) was assumed to spend time at LA-5, LA-1, and Russell Lake (i.e., exposed locations). The woodland caribou or black bear receptor at either location is likely to overlap with the others due to the size of their expected home range of 80 km^2 and therefore exposures to these locations were assessed together as one location at LA-5. It was also assumed that the woodland caribou or black bear spends a proportion of time at unexposed locations within its home range (i.e., lakes upstream of future water discharge points). One lake northeast of LA-5 and other unnamed lakes near LA-5 were included as an unexposed location for the woodland caribou and black bear for their residency factor calculation. As a result, the LA-5 woodland caribou or black bear receptor was assumed to spend 6% of its time at LA-5 (59 ha), 13% of its time at LA-1 (149 ha), 46% of its time at Russell Lake (512 ha) and 35% of its time at unexposed locations (392 ha).

Due to its large home range of 314 km^2, the bald eagle located near LA-5 was also assumed to spend only a portion of its time at exposed locations. The exposed locations for determining residency factors include LA-5, LA-1, and Russell Lake (exposed area). The unexposed locations for determining residency factors include LA-7 South, Russell Lake (unexposed area), and other unnamed lakes near LA-5. The sum of the surface areas of these water bodies was used to determine the proportion of time the bald eagle near LA-5 spends at the reference (unexposed) locations, adding up to 5,153 ha. Therefore, the bald eagle located near LA-5 was assumed to spend 1% of its time at LA-5, 2.5% of its time at LA-1, 8.7% of its time at Russell Lake (exposed area) and 87.8% of its time at unexposed locations.

Due to the relatively small seasonal home ranges of moose and mink (Table 2-2), they were assumed to have 100% residency at each home polygon (i.e., residency factor of 1).

Table 2-3 presents the residency factors that were applied in the model for each terrestrial ecological receptor. The exposed lakes are shown on Figure 1-1.

Table 2-3: Residency Factors for Terrestrial Ecological Receptors with Potentially Larger Home Ranges

Ecological Receptors	Home Polygon	Waterbody Surface Area (ha)	Total Waterbody Surface Area (ha)	Residency Factor	Water and Feed Source Polygon
Woodland Caribou	LA-7 South	323	323	1	LA-7 South
	LA-5	59	1111	0.06	LA-5
		149		0.13	LA-1
		512		0.46	Russell Lake
		392		0.35	Unexposed Locations
Moose	LA-7 South	-	-	1	LA-7 South
	LA-5	-	-	1	LA-5
	LA-1	-	-	1	LA-1

Ecological Receptors	Home Polygon	Waterbody Surface Area (ha)	Total Waterbody Surface Area (ha)	Residency Factor	Water and Feed Source Polygon
	Russell Lake	-	-	1	Russell Lake
Black Bear	LA-7 South	323	323	1	LA-7 South
	LA-5	59	1111	0.06	LA-5
		149		0.13	LA-1
		512		0.46	Russell Lake
		392		0.35	Unexposed Locations
Mink	LA-7 South	-	-	1	LA-7 South
	LA-5			1	LA-5
	LA-1	-	-	1	LA-1
	Russell Lake	-	-	1	Russell Lake
Bald Eagle	LA-7 South	323	323	1	LA-7 South
	LA-5	59	5872	0.010	LA-5
		149		0.025	LA-1
		512		0.087	Russell Lake
		5153		0.878	Unexposed Locations

2.3.3 Exposure Assumptions for Terrestrial Ecological Receptors

2.3.3.1 Body Weight and Intake Rates

The body weight and intake rates are required for the calculation of exposure to birds and mammals (Table 2-4). Body weights and intake rates were obtained, in order of preference, from CSA N288.1-20, the US Environmental Protection Agency (USEPA) *Wildlife Exposure Factors Handbook* (USEPA 1993), and the Federal Contaminated Sites Action Plan *Module 3: Standardization of Wildlife Receptor Characteristics* (FCSAP 2012). For species not represented in the above sources, additional sources as identified in Table 2-4 were consulted to identify representative body weights, and then feed intake rates were calculated using allometric equations from the USEPA (1993).

Water intake and inhalation rates were determined using allometric equations from the USEPA (1993) for birds and mammals. The incidental ingestion of soil and/or sediment was estimated from feed intake. Incidental ingestion varied from 2% to 10.4% of food intake as dry weight, depending on the biota (Beyer et al. 1994). However, no incidental soil or sediment ingestion was assumed for the common loon, which feeds from the water column.

Table 2-4: Bird and Mammal Body Weights and Intake Rates

Receptor	Body Weight		Total Feed Intake				Dietary Components	Feed Type Fraction		Feed Intake Rate		Dry Weight Fraction [g]	IMPACT Intake Group	Feed Intake by Group		Intake of Soil [m]	Intake of Sediment [m]	Intake of Soil & Sediment [j]	Basis of the Soil and Sediment Intake Value	Total Soil/ Sediment Intake [k]	Water Intake [l]	Inhalation Rate	
	kg	Source	kg dw/d	Source	kg fw/d	Source		fw	dw	kg dw/d	kg fw/d	unitless		kg dw/d	kg fw/d	%	%	%		kg dw/d	L/d	m³/d	source
Woodland Caribou	180.0	e	3.817	l	11.327	-	Browse	0.50	0.30	1.133	5.664	0.20	Terrestrial Plants	2.968	7.929	5.3	1.5	6.8	Bison	0.260	10.602	34.774	l
							Lichen	0.20	0.48	1.835	2.265	0.81											
							Macrophytes	0.30	0.22	0.850	3.398	0.25	Aquatic Plants	0.850	3.398								
Snowshoe Hare	1.8	c	0.110	c	0.475	-	Browse	0.90	0.78	0.086	0.428	0.20	Terrestrial Plants	0.110	0.475	3.7	0	3.7	Average of small mammals	0.004	0.168	0.900	c,l
							Berries (Blueberry)	0.10	0.22	0.024	0.048	0.52											
Moose	400.0	b	8.000	b	38.095	-	Browse	0.80	0.76	6.095	30.476	0.20	Terrestrial Plants	6.095	30.476	1.5	0.5	2.0	Moose	0.160	21.751	65.869	l
							Macrophytes	0.20	0.24	1.905	7.619	0.25	Aquatic Plants	1.905	7.619								
Southern Red-Backed Vole	0.03	a, i	0.004	-	0.012	a, i	Berries (Blueberry)	0.60	0.79	0.004	0.007	0.52	Terrestrial Plants	0.004	0.012	2.4	0	2.4	Meadow vole	0.0001	0.005	0.048	a
							Browse	0.40	0.21	0.001	0.005	0.20											
Black Bear	102.5	f	3.075	b	7.053	-	Berries (Blueberry)	0.70	0.83	2.546	4.937	0.52	Terrestrial Plants	2.546	4.937	2.9	0	2.9	Average of large mammals	0.090	6.387	22.162	l
							Fish (Northern Pike)	0.30	0.17	0.529	2.116	0.25	Aquatic Animals	0.529	2.116								
Canada Lynx	14.0	n	0.601	l	2.038	-	Showshoe hare	0.80	0.81	0.489	1.630	0.30	Terrestrial Animals	0.601	2.038	2.8	0	2.8	Red fox	0.017	1.065	4.508	l
							Small Mammals (represented by Vole)	0.15	0.14	0.082	0.306	0.27											
							Terrestrial Birds (Goose)	0.05	0.05	0.031	0.102	0.30											
Muskrat	1.2	a	0.088	-	0.352	a	Macrophytes	0.80	0.80	0.070	0.282	0.25	Aquatic Plants	0.070	0.282	0	3.3	3.3	Mallard	0.003	0.114	0.590	a
							Benthic Invertebrates	0.20	0.20	0.018	0.070	0.25	Aquatic Animals	0.018	0.070								
Mink	1.0	a	0.045	-	0.161	a	Fish (Northern Pike)	0.30	0.27	0.012	0.048	0.25	Aquatic Animals	0.018	0.072	2.6	0.4	3.1	Average of mallard and Lynx	0.001	0.101	0.440	a
							Benthic Invertebrates	0.15	0.14	0.006	0.024	0.25											
							Small Mammals (Muskrat)	0.45	0.49	0.022	0.072	0.30	Terrestrial Animals	0.026	0.088								
							Birds (Mallard)	0.10	0.11	0.005	0.016	0.30											
Canada Goose	3.7	c	0.023	-	0.115	a	Browse	1.00	1.00	0.023	0.115	0.20	Terrestrial Plants	0.023	0.115	8.2	0	8.2	Canada goose	0.002	0.142	0.082	c
Olive-Sided Flycatcher	0.03	d	0.008	-			Soil Invertebrates (Earthworms)	0.90	0.86	0.007	0.039	0.17	Terrestrial Plants	0.007	0.039	8.9	1.5	10.4	American woodcock	0.001	0.006	0.058	l
							Benthic Invertebrates	0.10	0.14	0.001	0.004	0.25	Aquatic Animals	0.001	0.004								
Bald Eagle	5.8	a		-	0.691	a	Fish (Northern Pike)	0.80	0.77	0.138	0.553	0.25	Aquatic Animals	0.138	0.553	9.3	0	9.3	Wild turkey	0.051	0.191	1.310	a
							Riparian birds (Mallard)	0.20	0.23	0.041	0.138	0.30	Terrestrial Animals	0.041	0.138								
American Robin	0.1	a			0.202	a, h	Fruit (Berries)	0.60	0.82	0.062	0.121	0.52	Terrestrial Plants	0.076	0.202	10.4	0	10.4	American woodcock	0.008	0.013	0.142	l
							Soil Invertebrates (Earthworms)	0.40	0.18	0.014	0.081	0.17											
Lesser Scaup	0.8	a	0.063	a			Benthic Invertebrates	0.90	0.90	0.056	0.226	0.25	Aquatic Animals	0.056	0.226	0	3.3	3.3	Mallard	0.002	0.051	0.350	a
							Macrophytes	0.10	0.10	0.006	0.025	0.25	Aquatic Plants	0.006	0.250								
Mallard	1.1	c	0.060	c	0.240	-	Macrophytes	0.25	0.25	0.015	0.060	0.25	Aquatic Plants	0.015	0.060	0	3.3	3.3	Mallard	0.002	0.064	0.020	c
							Benthic Invertebrates	0.75	0.75	0.045	0.180	0.25	Aquatic Animals	0.045	0.180								
Common Loon	5.3	b	0.159	b	0.636	-	Fish (Northern Pike)	0.90	0.90	0.143	0.572	0.25	Aquatic Animals	0.159	0.636	0	0	0	negligible	0	0.180	1.477	l
							Benthic Invertebrates	0.10	0.10	0.016	0.064	0.25											

Notes:

[a] USEPA (1993). Body weights, ingestion rates and inhalation rates of adults or all groups (adults and juveniles) are an average of the listed values. If only a range is given, the upper limit of the range is used. Values for the southern red-backed vole was based on the meadow vole

[b] FCSAP Ecological Risk Assessment Guidance, Module 3: Standardization of Wildlife Receptor Characteristics (March 2012)

[c] CSA Standard N288.1-20 (March 2020), Clause 7.7.4.2, and Table A.5d

[d] Environment Canada. 2015. Recovery Strategy for Olive-sided Flycatcher (*Contopus cooperi*) in Canada; average for adult male/female weight range of 31 to 34 g.

[e] COSEWIC Assessment and Update Status Report on the Woodland Caribou (2002). Body weight calculated as a mean of the male and female upper range.

[f] Hinterland Who's Who. 2007. Average of males and females from http://www.hww.ca/en/wildlife/mammals/black-bear.html

[g] Moisture/dry weight fraction values are based on Beresford *et al,* 2008 (soil invertebrate - assume earthworm); Omnia 2019 (blueberries, lichen and small mammal - assuming vole); and CSA Standard N288.1-20 (all other receptors). The blueberry value is based on the fruit only.

[h] The total feed intake for the American Robin was used in the absence of a species-specific value.

[i] The body weight and total feed intake for the Meadow Vole was used in the absence of a species-specific value.

[j] Beyer *et al* , 1994

[k] Intake of Soil & Sediment (kg dw/d) = Total Feed Intake (kg dw/d) x Intake of Soil & Sediment (%)/100.

[l] Calculated using allometric equations in USEPA (1993)

[m] The % intake of soil or sediment is calculated from the combined % intake of soil and sediment, weighted to the relative proportions of terrestrial vs. aquatic dietary components for each receptor, based on the following equations.
Intake of Soil (%) = Total Intake of Soil & Sediment (%) x Feed Type Fraction Terrestrial. Intake of Sediment (%) = Total Intake of Soil & Sediment (%) x Feed Type Fraction Aquatic.

[n] U.S.FWS (Fish and Wildlife Service), 2017. Species Status Assessment for the Canada Lynx (Lynxcanadensis), Contiguous United States Distinct Population Segment. Version 1.0 - Final, October 2017. Lakewood, Colorado.

fw = fresh weight; dw = dry weight

2.3.3.2 Occupancy Factors

An occupancy factor is defined as the fraction of time the receptor species spend in or on various media. The occupancy factors are based on the experience and judgment of the risk assessor and the known behaviour of the receptor. The occupancy factors used in the IMPACT model are presented in Table 2-5. The riparian biota spends half of its time on soil/sediment surface and the other half in water. However, the water immersion dose to riparian receptors, as for all terrestrial receptors, is considered minor, therefore, only the occupancy factors on soil/sediment surface (OF_{ss}) are applied in dose calculation.

Table 2-5: Receptor Occupancy Factors

Aquatic Biota	OF_a	OF_S	OF_{SS}	OF_W	Terrestrial and Riparian Biota	OF_a	OF_S	OF_{SS}
Macrophytes	-	-	0.1	0.9	Lichen	-	-	1
Phytoplankton	-	-	-	1	Blueberry	-	0.5	0.5
Zooplankton	-	-	-	1	Terrestrial Invertebrates	-	1	-
Benthic Invertebrates	-	1	-	-	Labrador Tea	-	0.5	0.5
White Sucker	-	-	0.5	0.5	Browse	-	0.5	0.5
Northern Pike	-	-	-	1	Woodland Caribou	1	-	1
					Snowshoe Hare	1	-	1
					Moose	1	-	1
					Southern Red-Backed Vole	1	-	1
					Black Bear	1	-	1
					Canada Lynx	1	-	1
					Olive-Sided Flycatcher	1	-	0
					American Robbin	1	-	1
					Canada Goose	1	-	1
					Bald Eagle	1	-	0
					Muskrat	1	-	0.5
					Mink	1	-	0.5
					Mallard	1	-	0.5
					Common Loon	1	-	0.5
					Lesser Scaup	1	-	0.5

Notes

OF_a = occupancy factor in contaminated air
OF_s = occupancy factor in soil/sediment
OF_{ss} = occupancy factor on soil/sediment surface
OF_w = occupancy factor in water
- = not applicable.

2.3.4 Terrestrial Pathways

Terrestrial pathways include the transfer of COPCs between air, soil, terrestrial plants, and terrestrial animals. The specific equations that consider the concentrations of COPCs in soil, terrestrial plants, and terrestrial animals along each of these pathways are listed below.

Concentration in soil (C_{soil}):

$$\frac{dC_{soil}}{dt} = \frac{C_{air} \cdot (V_g + W_r \cdot P_{pt}) \cdot D_f}{\rho_b \cdot z_{soil}} + \lambda_{parent} \cdot C_{parent} + \frac{C_{irr} \cdot Q_{irr}}{\rho_b \cdot z_{soil}} - C_{soil} \cdot \left[\lambda_T + \frac{L \cdot f_{soil}}{\rho_b \cdot z_{soil}} + \frac{v_i \cdot (1 - f_{soil})}{z_{soil} \cdot \varphi}\right]$$

where:

C_{soil}	=	concentration in soil (Bq/kg dw, mg/kg dw)
C_{air}	=	concentration in air (becquerels per cubic metre (Bq/m^3, mg/m^3)
C_{irr}	=	concentration of constituent in irrigation water (Bq/L, mg/L)
C_{parent}	=	concentration of parent constituent (Bq/kg, mg/kg)
D_f	=	deposition fraction for airborne constituents (unitless)
f_{soil}	=	fraction of constituent that is sorbed to solids in soil (unitless)
φ	=	volumetric water content (unitless)
λ_{parent}	=	first order decay constant for parent constituent (1/s)
λ_T	=	sum of the rate constants for all significant loss processes (1/s)
L	=	erosion loss rate in soil block (kg/m^2/s)
P_{pt}	=	precipitation rate (m/s)
Q_{irr}	=	irrigation rate (L/m^2/s)
ρ_b	=	bulk density of soil (kg/L)
v_i	=	infiltration rate (m/s)
V_g	=	atmospheric deposition velocity (m/s)
W_r	=	wet deposition washout ratio (unitless)
Z_{soil}	=	thickness of soil mixing layer (m)

Table 2-6: Modelling Parameters for the Soil Model

Model Parameter		Value	Unit
Mixing depth (thickness of soil layer)	Z_{soil}	0.2	m
Dry bulk density	ρ_b	1.5	kg dw/L
Water content (porosity)	φ	0.1	unitless
Infiltration rate	v_i	1.205E-8	m^3/m^2/s
Erosion rate	L	1.5E-8	kg dw/m^2/s
Precipitation rate	P_{pt}	800	mm/yr
Wet deposition washout ratio (metals)	W_r	5.5E+6	unitless
Dry Deposition velocity (metals)	V_g	0.0014	m/s

Note: All values for the soil model are the default parameters specified in CSA N288.1-20, assuming sandy soil based on the soil type described in the Wheeler River Project - Terrestrial Environment Wildlife and Vegetation Baseline Inventory report (Omnia, 2019).

Concentration in terrestrial plants (C_{tp}):

$$C_{tp} = C_{int} + C_{ext}$$

$$C_{int} = C_{soil} \cdot B_v + C_{air} \cdot T_f$$

$$\frac{dC_{ext}}{dt} = \frac{C_{air} \cdot (V_g + W_r \cdot P_{pt}) \cdot f_a}{Y} + \lambda_{parent} \cdot C_{parent} + \frac{C_{irr} \cdot Q_{irr} \cdot f_{irr}}{Y \cdot A} - C_{ext} \cdot [\lambda_T + \lambda_e]$$

where:

A	=	Area of polygon (m^2)
B_v	=	bioaccumulation factor for soil-to-plant transfer (dw unitless)
C_{tp}	=	concentration in terrestrial plants (Bq/kg fw, mg/kg dw)
C_{int}	=	internal concentration in plant from soil uptake (Bq/kg fw, mg/kg dw)
C_{ext}	=	external concentration in plant from dust and irrigation (Bq/kg fw, mg/kg fw)
C_{soil}	=	concentration in soil (Bq/kg dw, mg/kg dw)
C_{air}	=	concentration in air (Bq/m^3, mg/m^3]
C_{irr}	=	concentration of constituent in irrigation water (Bq/L, mg/L)
C_{parent}	=	concentration of parent constituent (Bq/kg)
f_{irr}	=	irrigation fraction retained on irrigation (unitless)
λ_{Parent}	=	first order decay constant for parent constituent (1/s)
λ_T	=	sum of the rate constants for all significant loss processes (1/s)
λ_e	=	effective removal decay constant (1/s)
P_{pt}	=	precipitation rate (m/s)
Q_{irr}	=	irrigation rate (L/m^2/s)
T_f	=	air-to-plant transfer factor (m^3/kg)
V_g	=	atmospheric deposition velocity (m/s)
W_r	=	wet deposition washout ratio (unitless)
Y	=	vegetation yield (kg dw/m^2)

Concentration in terrestrial animals (C_{ta}):

$$C_{ta} = C_{air} \cdot I_a \cdot F_{inh} + F_{ing} \cdot \begin{bmatrix} I_w \cdot \sum(C_{wc} \cdot k_w) + I_s \cdot \sum(C_s \cdot k_{sed}) + I_{soil} \cdot \sum(C_{soil} \cdot k_{soil}) + \\ I_{tp} \cdot \sum(C_{tp} \cdot k_{tp}) + I_{ta} \cdot \sum(C_{ta} \cdot k_{ta}) + \\ I_{ap} \cdot \sum(C_{ap} \cdot k_{ap}) + I_{aa} \cdot \sum(C_{aa} \cdot k_{aa}) \end{bmatrix}$$

Where:

C_{ta}	=	concentration in ingested terrestrial animals (Bq/kg fw, mg/kg fw)
C_{wc}	=	concentration in water column (Bq/L, mg/L)
C_s	=	concentration in surficial sediment (Bq/kg dw, mg/kg dw)
C_{soil}	=	concentration in soil (Bq/kg dw, mg/kg dw)
C_{tp}	=	concentration in ingested terrestrial plants (Bq/kg dw, mg/kg dw)
C_{ap}	=	concentration in ingested aquatic plants (Bq/kg fw, mg/kg fw)
C_{aa}	=	concentration in ingested aquatic animals (Bq/kg fw, mg/kg fw)
F_{inh}	=	inhalation transfer factor (d/kg fw)
F_{ing}	=	ingestion transfer factor (d/kg fw)
I_w	=	water ingestion rate (L/d)
I_a	=	inhalation rate (m^3/d)
I_s	=	sediment ingestion rate (kg dw/d)
I_{soil}	=	soil ingestion rate (kg dw/d)
I_{tp}	=	terrestrial plants ingestion rate (kg dw/d)
I_{ta}	=	terrestrial animals ingestion rate (kg fw/d)
I_{ap}	=	aquatic plants ingestion rate (kg fw/d)
I_{aa}	=	aquatic animals ingestion rate (kg fw/d)
k_w	=	fraction of water intake from contaminated sources (unitless)
k_{sed}	=	fraction of sediment intake from contaminated sources (unitless)
k_{soil}	=	fraction of soil intake from contaminated sources (unitless)
k_{ta}	=	fraction of terrestrial animal intake from contaminated sources (unitless)
k_{tp}	=	fraction of terrestrial plant intake from contaminated sources (unitless)
k_{aa}	=	fraction of aquatic animal intake from contaminated sources (unitless)
k_{ap}	=	fraction of aquatic plant intake from contaminated sources (unitless)

2.3.5 Radiological Dose to Terrestrial Ecological Receptors

Radiological dose to a terrestrial receptor is the radiation energy absorbed due to radiation emissions from radionuclides present in the environment (air or soil/sediment) or in the tissues of the organism. Through comparison with dose benchmarks, the risk to the organism can be quantified. This model characterizes dose and risk from both background and project exposure.

The total dose to terrestrial animals from each radionuclide is:

$$D_{total} = D_{int} + D_{ext}$$

The internal dose of COPCs to terrestrial animals due to internal radioactivity (D_{int}) is estimated using the equation shown below.

$$D_{int} = C_t \cdot DC_{int}$$

The external dose to terrestrial animals from radioactivity in sediment and soil (D_{ext}) is:

$$D_{ext} = D_{ext,s} + D_{ext,ss}$$

$$D_{ext,s} = C_{soil} \cdot DC_{ext,s} \cdot OF_s$$

$$D_{ext,ss} \quad = \quad C_{ss} \cdot DC_{ext,ss} \cdot OF_{ss}$$

The external dose from noble gases (naturally occurring gases with very low chemical reactivity [e.g., helium]) to terrestrial animals is calculated in IMPACT from outdoor air; however, there are no noble gases in the Wheeler River model applicable to ecological receptors, so the equation is not provided.

Where:

C_t	=	whole body tissue concentration (Bq/kg fw)
C_{soil}	=	soil concentration (Bq/kg dw)
C_{ss}	=	surface soil concentration (Bq/m^2)
D_{int}	=	internal radiation dose (µGy/h)
DC_{int}	=	dose coefficient for radionuclide in tissue ([µGy/h]/[Bq/kg fw])
$D_{ext,s}$	=	external radiation dose in soil (µGy/h)
$D_{ext,ss}$	=	external radiation dose on soil surface (µGy/h)
$DC_{ext,s}$	=	dose coefficient for radionuclide in soil ([µGy/h]/[Bq/kg dw])
$DC_{ext,ss}$	=	dose coefficient for radionuclide on soil surface([µGy/h]/[Bq/m^2])
OF_s	=	fraction of time spent immersed in soil (unitless)
OF_{ss}	=	fraction of time spent on the soil (unitless)

For animals with large home ranges (Section 2.3.2), the total dose is the combined exposure from several locations (Table 2-3), where the residency factors are used as weighting factors to calculate the total dose.

2.3.6 Non-radiological Risk to Terrestrial Ecological Receptors

The IMPACT model provides a means of evaluating the potential effects on environmental components by comparing the non-radiological exposures of receptors to recognized benchmarks, usually a concentration or dose-based toxicity reference values in the same units, for each COPC. This measure of potential risk is known as an HQ. This model calculates the risk from both background and project exposure.

The HQ for terrestrial animals due to ingestion of non-radiological constituents is estimated as:

$$\mathrm{HQ} \quad = \quad \frac{1}{\mathrm{RD} \cdot \mathrm{BM}} \cdot \begin{bmatrix} I_w \cdot \sum(C_{wc} \cdot k_w) + I_s \cdot \sum(C_s \cdot k_{sed}) + \\ I_{soil} \cdot \sum(C_{soil} \cdot k_{soil}) + I_{tp} \cdot \sum(C_{tp} \cdot k_{tp}) + I_{ta} \cdot \sum(C_{ta} \cdot k_{ta}) + \\ I_{ap} \cdot \sum(C_{ap} \cdot k_{ap}) + I_{aa} \cdot \sum(C_{aa} \cdot k_{aa}) \end{bmatrix}$$

Where:

BM	=	body mass (kg)
C_{ap}	=	concentration in ingested aquatic plants (mq/kg fw)

C_{aa}	=	concentration in ingested aquatic animals (mq/kg fw)
C_s	=	concentration in surficial sediment (mg/kg dw)
C_{soil}	=	concentration in soil (mg/kg dw)
C_{ta}	=	concentration in ingested terrestrial animals (mg/kg fw)
C_{tp}	=	concentration in ingested terrestrial plants (mq/kg dw)
C_{wc}	=	concentration in water column (mg/L)
I_{aa}	=	aquatic animals ingestion rate (kg fw/d)
I_{ap}	=	aquatic plants ingestion rate (kg fw/d)
I_s	=	sediment ingestion rate (kg dw/d)
I_{soil}	=	soil ingestion rate (kg dw/d)
I_{tp}	=	terrestrial plants ingestion rate (kg dw/d)
I_{ta}	=	terrestrial animals ingestion rate (kg fw/d)
I_w	=	water ingestion rate (L/d)
k_{aa}	=	fraction of aquatic animal intake from contaminated sources (unitless)
k_{ap}	=	fraction of aquatic plant intake from contaminated sources (unitless)
k_{sed}	=	fraction of sediment intake from contaminated sources (unitless)
k_{soil}	=	fraction of soil intake from contaminated sources (unitless)
k_{ta}	=	fraction of terrestrial animal intake from contaminated sources (unitless)
k_{tp}	=	fraction of terrestrial plant intake from contaminated sources (unitless)
k_w	=	fraction of water intake from contaminated sources (unitless)
RD	=	reference toxic dose (mg/kg/d)

2.4 Exposure of Human Receptors

2.4.1 Exposure Assumptions for Human Receptors

The human receptor groups selected for the human health risk assessment are based on the current understanding of how people use the area in the vicinity of the Project and their potential for exposure to Project-related media concentrations during one or more Project phases (i.e., Construction, Operation, Decommissioning and Post-decommissioning). The selected human receptor groups are a camp worker, seasonal resident, recreational fisher/hunter, fisher/trapper and future permanent resident (as shown on Figure 2-2), with rationale for receptor selection provided in the Wheeler River ERA report.
Adult and one-year-old receptors were used to assess potential risk to human health. The exposure factors for these two age groups are summarized in Table 2-7. The selection process and further characteristics of the human receptors are discussed in the ERA report.

The primary exposure routes for human health include ingestion (i.e., food, water, incidental amounts of soil and/or sediment), inhalation (i.e., vapours and/or particulates), dermal absorption (non-radiological), and external exposure to radiation (radiological). The potential exposure pathways are expected to be the same for all human receptors assessed.

Table 2-7: Summary of Receptor Characteristics for the Human Health Risk Assessment

Receptor Characteristic	Unit	Adult [(a)]	One-year-old [(b)]	Reference
Air inhalation (mean)	m^3/yr	5,950	1,830	CSA N288.1-20; Table 19
Water ingestion (mean)	L/yr	379.6	98.92	CSA N288.1-20; Table 21
Soil ingestion (mean) [(c)]	kg dw/d	4.00×10^{-06}	6.10×10^{-05}	CSA N288.1-20; Table 20
Sediment ingestion [(c)]	kg dw/d	4.00×10^{-06}	6.10×10^{-05}	CSA N288.1-20; Table 20
Exposed surface area - water (whole body)	m^2	2.19	0.72	CSA N288.1-20; Table 22
Total food ingestion [(d)]	kg fw/yr	706	410	CSA N288.1-20; Annex G

a) Adult applies to both male and female receptors.
b) The one-year-old is equivalent to the CSA N288.1-20 age class “infant”.
c) Incidental ingestion rate for soil/sediment is apportioned to soil and sediment according to time spent at beach.
d) The higher total food ingestion for the adult male (from CSA N288.1-20) is used to represent both male and female human receptors, which is a conservative assumption for females.
dw = dry weight; fw = fresh weight.

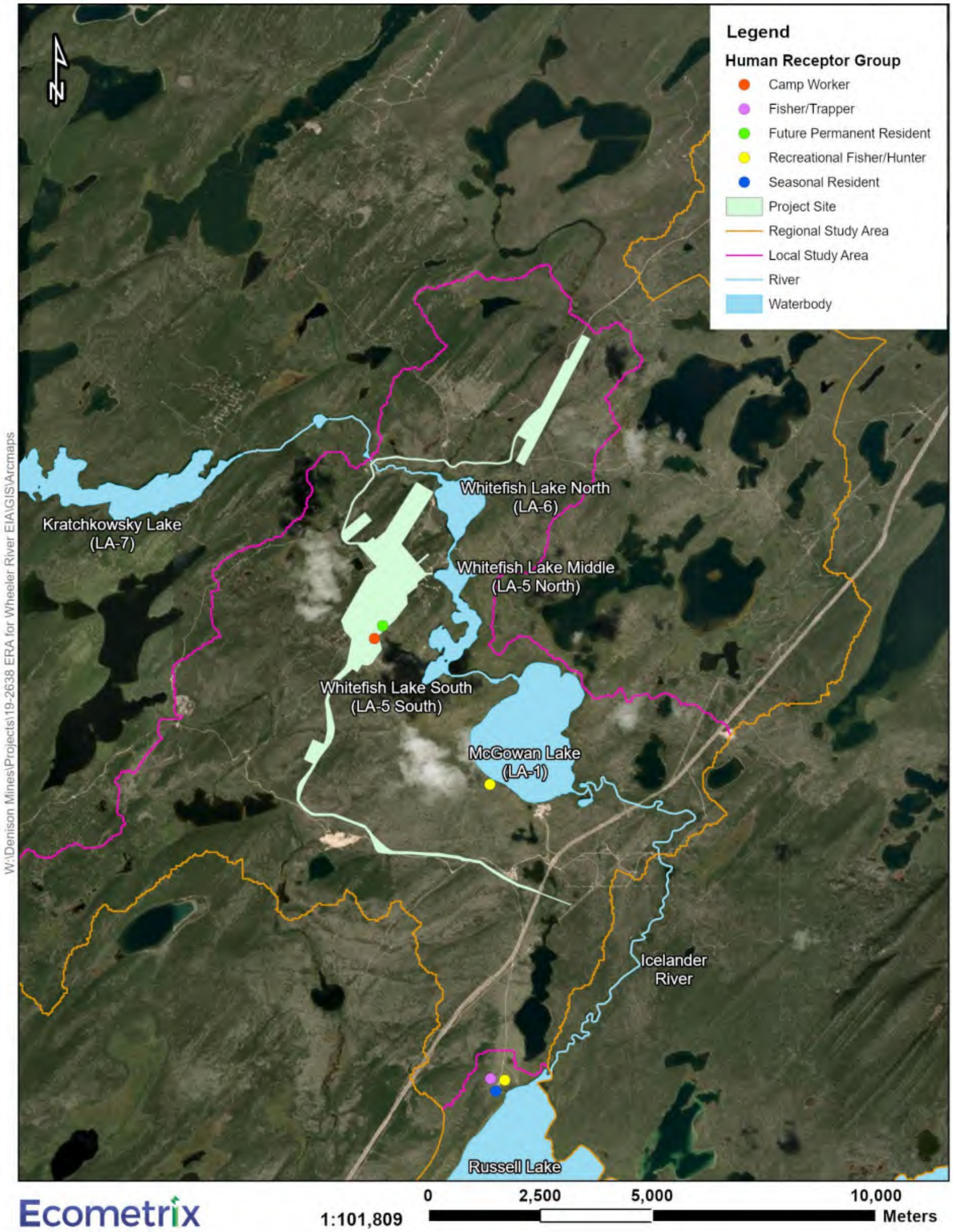


Figure 2-2: Human Receptor Locations for the Wheeler River Model

2.4.1.1 Dietary Assumptions

Each of the human health receptors described in Section 2.4.1, Exposure Assumptions for Human Receptors consumes locally sourced Traditional Foods to an extent that is consistent with either an average or a high consumer. Where possible, the total of Traditional Foods derived was obtained from pertinent Traditional Foods surveys and engagement with Indigenous Groups and local communities. Traditional Foods are those animals and plants that are fished, hunted, or gathered from the land and consumed as food (Health Canada 2018). The remainder of the total food diet is assumed to be from store-bought foods (i.e., store foods). Store foods include grain and other agricultural products of a typical diet that are not available locally.

The camp worker is assumed to work and reside at the Denison camp for half of the year and does not consume any Traditional Foods while at the site. During the other times of the year, the camp worker is assumed to be an average Traditional Foods consumer. The fisher/trapper are assumed to be high Traditional Foods consumers. The future permanent resident, the seasonal resident and the recreational fisher/hunter are assumed to be average Traditional Foods consumers.

<u>Adult Diet</u>

As stated in Table 2-7, the initial assumptions for ingestion rates and components of the total foods diet for the human health risk assessment were taken from CSA N288.1-20 Adult (Table G.9b – Central) total diet.

The human diet provided in CSA N288.1-20 was derived from the 2004 food basket survey results for an adult male. The CSA N288.1-20 human diet was selected over the Health Canada (2010a) human diet. Health Canada (2010a) references Richardson (1997), which used survey results from the late 1970s. The Richardson (1997) diet was also a combined adult male/female diet. The CSA N288.1-20 total adult diet is a smaller overall diet (706 kg/yr) than the Richardson diet (808 kg/yr) by about 100 kg/yr and is based on more recent data.

The total food diet is the sum of Traditional Foods and store foods. Its dietary components, expressed in kilograms per year (kg/yr) of food consumed, are shown in Table 2-8 for average consumers, and high consumers of Traditional Foods.

The store food intakes in each food category were estimated from the total diet intakes provided in CSA N288.1-20, minus the Traditional Foods intakes. If the Traditional Foods intakes were higher than the total intake for the same CSA N288.1-20 food category, the store food intake was set to zero, and then the values for other store food categories were reduced as needed to obtain total dietary intakes equal to those in CSA N288.1-20.

<u>One-Year-Old Diet</u>

Annual food consumption rates for the "one-year-old" were calculated using “adult-to-one-year-old” ratios from CSA N288.1-20 for each of the selected food categories. Annual ingestion rates for individual food items were combined into relevant food categories and the adult-to-one-year-old ratios were determined for each of these food categories.

Representative Ecological Receptors Used in the IMPACT Model

The concentrations of COPCs in Traditional Foods used in the exposure assessment were estimated using the IMPACT model and the modelled concentrations are shown in Appendix B of the Wheeler River ERA report. Based on the descriptions of the different human receptor groups and their Traditional Foods diets, representative ecological receptors were selected for the IMPACT model to represent each Traditional Foods group. The final selection of representative ecological receptors for the Traditional Foods diet is shown in Table 2-9. The local food intake fractions as implemented in IMPACT for the human diet are shown in Table 2-10.

Table 2-8: Annual Food Intakes (kg/yr) for Components of the Human Receptors' Diets

Food Components	Unit	Average Traditional Foods Consumer				High Traditional Foods Consumer			
		Adult [1]		One-year-old [2]		Adult [1]		One-year-old [2]	
Total Food Intake [3] (fresh weight)	**kg/yr**	**706.01**		**409.45**		**706.01**		**409.45**	
Country Meat and Fish	**kg/yr**	**52.82**		**9.34**		**366.88**		**63.50**	
Caribou	kg/yr		2.63		0.33		175.28		21.79
Moose	kg/yr		11.75		1.46		4.65		0.58
Moose (organs)	kg/yr		4.49		0.56				0
Small Mammals [4]	kg/yr		2.45		0.23		0.87		0.08
Mallard [5]	kg/yr		2.99		0.53		1.55		0.28
Canada Goose [6]	kg/yr		1.86		0.33		1.09		0.19
Fish [7]	kg/yr		26.65		5.89		183.44		40.58
Country Plants [8]	**kg/yr**	**19.82**		**10.83**		**0**		**0**	
Blueberries	kg/yr		19.64		10.79		0		0
Labrador Tea	kg/yr		0.18		0.04		0		0
Store Foods	**kg/yr**	**633.38**		**389.28**		**339.13**		**345.95**	

Notes:

[1] Food intake for human receptors that are average Traditional Foods consumers were developed from the results of a dietary survey of the English River First Nation (CanNorth 2017).

[2] CanNorth (2017) provides survey results for adults. Food intake for one-year-olds was proportioned from the adult receptor group using Central Adult - to Central 1-Year-Old derived from the N288.1-20 Human Diet (Table G.9b).

[3] The total food intake is from Table G.9b in CSA N288.1-20 (2020) which represents the central dietary intake based on reference energy intakes.

[4] While ERFN predominantly eat hare, modelling for small mammals is represented by muskrat to have a stronger link to the aquatic environment.

[5] Mallard was selected to represent all waterbirds in the country food diet.

[6] Canada goose was selected to represent upland birds in the country food diet.

[7] Assumed to include 50% predator fish (northern pike) and 50% forage fish (white sucker) based on ERFN dietary survey (CanNorth 2017).

[8] Blueberries include edible fruits and berries. Labrador Tea includes edible plants other than fruits and berries.

Table 2-9: Representative Ecological Receptors Used in the Traditional Foods Diet

Traditional Foods Category	Representative Ecological Receptor	Traditional Foods Diet Components	Rationale[(a)]
Fish			
Fish	Northern Pike	Lake Trout Northern Pike Walleye Yellow Perch	Predator species and forage species represent two ecological trophic levels. Both are present in most area lakes and surrounding surface water bodies. Spawning habitat of both has also been identified within the study area. Fish flesh and bone of both were analyzed for metal and radionuclides. Age determination has also been done. Both are important reginal traditional foods components. Recreational and commercial fishing documented at Russell Lake.
	White Sucker	Arctic Grayling Burbot Lake Whitefish Longnose Sucker White sucker	
Game Meat/Organs			
Large mammal	Woodland Caribou	Caribou meat	Large herbivore with linkages to the aquatic environment. Generally present in the vicinity of the Project according to baseline studies. Important regional traditional food items. Woodland Caribou has threatened status under COSEWIC and SARA for broader regional study area.
	Moose	Moose meat	
	Moose organs	Moose kidney Moose liver Caribou kidney	
Small mammal	Muskrat	Muskrat meat Rabbit meat	Small herbivore with linkages to the aquatic environment. Generally present in the vicinity of the Project according to baseline studies. Surrogate for other riparian herbivores such as the beaver. Important regional traditional food items. Harvested regionally for fur.
Birds			
Aquatic bird	Mallard	Mallard Common Loon	Omnivorous bird with linkages to the aquatic environment. Observed in the vicinity of the Project according to baseline studies. Important regional traditional food items.
Terrestrial bird	Canada Goose	Grouse Canada Goose	Ground feeding herbivore bird. Observed in the vicinity of the Project according to baseline studies. Important regional traditional food items.
Berries/Plants			
Berries	Blueberry	Blueberry	Observed in the study area. Fruit, leaves and stems collected and analyzed for metals and radionuclides. Important regional traditional food item.

Traditional Foods Category	Representative Ecological Receptor	Traditional Foods Diet Components	Rationale[a]
Plants	Labrador tea	Labrador Tea	Generally present in the vicinity of the Project according to baseline studies. Harvested regionally for medicinal use (tea).

a) The selection of representative ecological receptors to represent Traditional Foods diet components was informed by feedback received from local Indigenous Groups during engagement activities.

Table 2-10: Local Food Intake Fractions for Human Diet

		Camp Worker	Recreational Fisher/Hunter		Seasonal Resident				Fisher/ Trapper	Future Permanent Resident	
		(Adult)	(Adult)	(One-Year-Old)	(Adult)		(One-Year-Old)		(Adult)	(Adult)	(One-Year-Old)
Food Category	Food Type	Exposure %	Exposure %	Exposure %	Reference %	Exposure %	Reference %	Exposure %	Exposure %	Exposure %	Exposure %
Aquatic Animals	Northern Pike	50	50	50	35	15	35	15	50	50	50
	White Sucker	50	50	50	35	15	35	15	50	50	50
Terrestrial Animals	Store Foods	98.08	96.03	99.12	67.22	28.81	69.38	29.74	64.90	96.03	99.12
	Woodland Caribou	0.19	0.40	0.08	0.28	0.12	0.06	0.02	33.54	0.40	0.08
	Moose	0.86	1.78	0.37	1.25	0.53	0.26	0.11	0.89	1.78	0.37
	Moose Organs	0.33	0.68	0.14	0.48	0.20	0.10	0.04	-	0.68	0.14
	Muskrat	0.18	0.37	0.06	0.26	0.11	0.04	0.02	0.16	0.37	0.06
	Mallard	0.22	0.46	0.14	0.32	0.14	0.10	0.04	0.30	0.46	0.14
	Canada Goose	0.14	0.28	0.09	0.20	0.08	0.06	0.03	0.21	0.28	0.09
Terrestrial Plants	Labrador Tea	0.92	0.92	0.34	0.64	0.28	0.24	0.10	-	0.92	0.34
	Blueberry	99.08	99.08	99.66	69.36	29.72	69.76	29.90	-	99.08	99.66

Note:

- = value not available, or not applicable.

The concentrations of COPCs in store foods (Table 2-11) used in the exposure assessment are consistent with other recent human health risk assessments conducted for uranium mine and mill projects in Saskatchewan. The proportions of different food items in store foods for the Hatchet Lake Band (CanNorth 2000) were used to derive weighted average concentrations of constituents in the store food diet of human receptors based on Health Canada data (2000 to 2011) for non-radiological constituents (except for chromium, molybdenum and vanadium) in foods for all Canadian cities (Health Canada 2011) and United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR 2000) for radiological constituents. Chromium and vanadium concentrations in store food were calculated from Canadian Total Diet Study - Trace Elements 1993-2018 (Health Canada 2020). Molybdenum concentration was obtained from Health Canada data on trace elements in foods from the Total Diet Study (1993 to 1999) for all Canadian cities (Health Canada 2000).

Table 2-11: Concentrations of Constituents of Potential Concern in Store Foods

Constituents of Potential Concern	Concentration [a]
Non-radionuclides [b]	**mg/kg fw**
Arsenic	0.0066
Cadmium	0.0077
Chromium [c]	0.0416
Cobalt	0.0055
Copper	0.57
Molybdenum [d]	0.097
Selenium	0.063
Uranium	0.0014
Vanadium [c]	0.0133
Zinc	3.98
Radionuclides [e]	**Bq/kg fw**
Lead-210	0.039
Polonium-210	0.048
Radium-226	0.042
Thorium-230	0.0058
Uranium-234	0.0097
Uranium-238	0.0097

a) For the estimation of constituents of potential concern in store foods, proportions of food types in the store food diet were aligned with regional data from CanNorth (2000) for the Hatchet Lake First Nation.

b) Non-radionuclides in store foods were calculated from Canadian Total Diet Study on trace elements in foods (2000 to 2011) for all Canadian cities (Health Canada 2011).

c) Chromium and vanadium values were the average values calculated from Canadian Total Diet Study - Trace Elements 1993-2018 (Health Canada 2020). For those values below the limit of detection (LOD), half of their LOD values were used for calculating average concentrations.

d) Molybdenum value from Health Canada data on trace elements in foods from the Total Diet Study (1993 to 1999) for all Canadian cities (Health Canada 2000).

e) Calculated from UNSCEAR (2000).

Bq = becquerel; fw = fresh weight.

2.4.2 Exposure Duration and Frequency

The residency assumptions for human receptors used for the human health risk assessment are summarized in Table 2-12. This includes the fraction of time the receptor spends at a given location as well as the exposure frequency (which refers to the frequency at which the activity causing the exposure occurs). The exposure duration (which refers to the length of time the receptor engages in the activity causing the exposure) was either the duration of the Project phases (30 years) for non-carcinogens, or the lifetime of the receptor (80 years) for carcinogens except for the camp worker, where only the adult life stage would be relevant for carcinogens.

Table 2-12: Summary of Residency Assumptions for Human Health Receptor Groups

Human Health Receptor Group	Age Group(s)	Residence within Study Area	Project Phases	Fraction of Time at Residence/ Reference Location	Exposure Frequency at Residence/Refence Location (months/year)
Camp Worker (such as a cook)	Adult	Whitefish Lake (LA-5)	Construction Operation Decommissioning Post-decommissioning	0.5/0.5	6/6
Recreational Fisher/Hunter	Adult and one-year-old	McGowan Lake (LA-1) Russell Lake	Construction Operation Decommissioning Post-decommissioning Future centuries	0.3/0.7	4/8
Seasonal Resident	Adult and one-year-old	Russell Lake			
Fisher/Trapper	Adult	Russell Lake		0.5/0.5	6/6
Future Permanent Resident	Adult and one-year-old	Whitefish Lake (LA-5)	Future centuries	1	12

2.4.3 Radiological Dose

The dose to human receptors from all radioactive isotopes except radon-222 is estimated using the equations listed below.

Radiological dose due to ingestion (D_f):

$$D_f = DCF_f \Big[\cdot I_w \cdot \sum C_{wc} \cdot k_w \cdot rf \cdot + I_s \cdot \sum C_{soil} \cdot EF_{soil} + I_{sed} \cdot \sum C_s \cdot EF_s \cdot DF_s + I_{tp} \cdot \sum C_{tp} \cdot k_{tp} \cdot \rho_f + I_{ta} \cdot \sum C_{ta} \cdot k_{ta} \cdot \rho_f + I_{ap} \cdot \sum C_{ap} \cdot k_{ap} \cdot \rho_f + I_{aa} \cdot \sum C_{aa} \cdot k_{aa} \cdot \rho_f \Big]$$

Radiological dose due to external exposure to water (D_w):

$$D_w = C_{wc} \cdot [k_w \cdot OF_w + k_w^S \cdot rf \cdot OF_w^S + k_w^B \cdot rf \cdot D_c \cdot OF_w^B] \cdot DCF_w$$

Radiological dose due to external exposure to soil (D_g):

$$D_g = C_{soil} \cdot f_o \cdot f_r \cdot \left[f_u + (1 - f_u) \cdot S_g\right] \cdot DCF_g \cdot \rho_b \cdot z_{soil}$$

Radiological dose due to external exposure to shoreline sediment (D_s):

$$D_s = C_s \cdot OF_s \cdot W \cdot DF_s \cdot DCF_s$$

Radiological dose due to inhalation in air (D_i):

$$D_i = I_a \cdot OF_i \cdot C_a \cdot DCF_{inh}$$

Radiological dose due to immersion in air (D_a):

$$D_a = f_o \cdot [f_u + (1 - f_u) \cdot S_b] \cdot C_a \cdot DCF_a$$

Total dose (D_{total}) to a human receptor from all pathways of exposure:

$$D_{total} = D_f + D_w + D_g + D_s + D_i + D_a$$

where:

C_{aa}	=	aquatic animal concentration (Bq/kg fw)
C_{ap}	=	aquatic plant concentration (Bq/kg fw)
C_s	=	sediment concentration (Bq/kg dw)
C_{soil}	=	surficial soil concentration (Bq/kg dw)
C_{tp}	=	terrestrial plant concentration (Bq/kg dw)
C_{ta}	=	terrestrial animal concentration (Bq/kg fw)
C_{wc}	=	water column concentration (Bq/L)
D_a	=	dose due to external exposure in air (mSv/yr)
D_f	=	dose due to ingestion (millisieverts per year (mSv/yr)
D_g	=	dose due to external exposure to soil/sediment (mSv/yr)
D_i	=	dose due to inhalation (mSv/yr)
D_w	=	dose due to external exposure in water (mSv/yr)
D_{total}	=	total dose (mSv/yr)
DCF_a	=	dose coefficient for external exposure in air ([Sv/yr]/[Bq/m^3])
DCF_f	=	dose coefficient for ingestion (sieverts per becquerel [Sv/Bq])
DCF_g	=	dose coefficient for external exposure to soil ([Sv/yr]/[Bq/m^2])
DCF_{inh}	=	dose coefficient for inhalation (Sv/Bq)
DCF_s	=	dose coefficient for external exposure to sediment ([Sv/yr]/[Bq/kg])
DCF_w	=	dose coefficient for external exposure in water ([Sv/yr]/[Bq/L])
DF_s	=	dilution factor for shoreline deposits (unitless)
EF_{soil}	=	number of days per year in which soil ingestion occurs (d/yr)
EF_s	=	number of days per year in which sediment ingestion occurs (d/yr)
f_o	=	fraction of total time spent by the individual at the particular location (unitless)
f_r	=	dose reduction factor for non-uniformity of ground surface (unitless)

f_u	=	time spent outdoors at a particular location as a fraction of total time spent at that location (unitless)
I_a	=	inhalation rate (m^3/yr)
I_{aa}	=	aquatic animals' ingestion rate (kg fw/yr)
I_{ap}	=	aquatic plants ingestion rate (kg fw/yr)
I_s	=	sediment ingestion rate (kg dw/d)
I_{soil}	=	soil ingestion rate (kg dw/d)
I_{ta}	=	terrestrial animal ingestion rate (kg fw/yr)
I_{tp}	=	terrestrial plant ingestion rate (kg dw/yr)
I_w	=	water ingestion rate (L/yr)
k_a	=	fraction of air inhalation intake from contaminated source (unitless)
k_{aa}	=	fraction of aquatic animal intake from contaminated source (unitless)
k_{ap}	=	fraction of aquatic plant intake from contaminated source (unitless)
k_{ta}	=	fraction of terrestrial animal intake from contaminated source (unitless)
k_{tp}	=	fraction of terrestrial plant intake from contaminated source (unitless)
k_w	=	fraction of water intake from contaminated source (unitless)
k_w^B	=	fraction of bathing in contaminated water (unitless)
k_w^S	=	fraction of beach swimming in contaminated water (unitless)
OF_i	=	occupancy factor for inhalation (unitless)
OF_s	=	occupancy factor for sediment (unitless)
OF_w	=	occupancy factor for swimming in a surface water body (unitless)
OF_W^B	=	occupancy factor in bath water (unitless)
OF_W^S	=	occupancy factor in swimming water (unitless)
ρ_b	=	dry bulk density of the soil (kg dry soil per m^3)
ρ_f	=	adjustment factor for food processing (unitless)
rf	=	dose reduction factor for water treatment (unitless)
S_b	=	building shielding factor (unitless)
S_g	=	groundshine dose reduction factor for indoor shielding (unitless)
W	=	shore-width factor that describes the shoreline exposure geometry (unitless)
z_{soil}	=	soil mixing depth (m)

<u>Dose from Radon</u>

Consistent with recommendations in CSA N288.6-22 and Health Canada (2010b), the dose from radon in air is calculated according to the following equation:

$$Dose_{Rn} = \left[\frac{C_{Rn}}{3700\,\frac{Bq}{m^3}} \times F \times \frac{ET}{170h}\right] \times 4mSv$$

Radon typically dissipates quickly outdoors and is usually not a human health issue. However, dose from exposure to radon indoors should be quantified. The outdoor equilibrium fraction is needed to estimate the indoor equilibrium fraction. The equilibrium fraction for radon in outdoor air was estimated as a function of the travel time from the radon source using guidance from Health Canada and the USEPA according to the following equation (Health Canada 2010b; USEPA 1986):

$$F_{out} = 1.0 - 0.0479e^{-\frac{t}{4.39}} - 2.1963e^{-\frac{t}{38.6}} + 1.2442e^{-\frac{t}{28.4}}$$

The equilibrium fraction for radon in indoor air (F_{in}) was estimated as a function of the outdoor equilibrium fraction (F_{out}) using guidance from Health Canada (2010b) and the USEPA (1986) according to the following equation:

$$F_{in} = 0.35(1 + F_{out})$$

where:

C_{Rn}	=	concentration of radon in air (Bq/m^3)
$Dose_{Rn}$	=	incremental dose from radon (mSv/yr)
ET	=	exposure time (h/yr)
F	=	degree of equilibrium between radon and decay products (unitless)
F_{in}	=	indoor equilibrium fraction (unitless)
F_{out}	=	outdoors equilibrium fraction (unitless)
t	=	travel time from source to receptor (minutes) (distance from source to receptor divided by mean wind speed)

2.4.4 Non-radiological Dose

The human receptor exposure to non-radiological COPCs is estimated from the following equations:

Non-radiological intake due to inhalation (D_i):

$$D_i = \frac{C_{air} \cdot I_a \cdot k_a \cdot OF_i}{BM}$$

Non-radiological dose due to ingestion (D_f):

$$D_f = \frac{1}{BM \cdot C} \cdot \Big[I_w \cdot \sum(C_{wc} \cdot k_w \cdot rf) + I_s \cdot \sum\left(C_s \cdot EF_s \cdot DF_s \cdot RAF_{ing}\right) + I_{soil} \cdot \sum\left(C_{soil} \cdot EF_{soil} \cdot RAF_{ing}\right) + I_{tp} \cdot \sum\left(C_{tp} \cdot k_{tp} \cdot \rho_f\right) + I_{ta} \cdot \sum\left(C_{ta} \cdot k_{ta} \cdot \rho_f\right) + I_{ap} \cdot \sum\left(C_{ap} \cdot k_{ap} \cdot \rho_f\right) + I_{aa} \cdot \sum\left(C_{aa} \cdot k_{aa} \cdot \rho_f\right)\Big]$$

Non-radiological external exposure to water (dermal absorption) (D_w):

$$D_w = \frac{k_p \cdot SA_w}{BM} \cdot [C_w^S \cdot OF_w^S + C_w^B \cdot rf \cdot OF_w^B + C_w^P \cdot rf \cdot OF_w^P]$$

Non-radiological external exposure to soil and/or sediment (dermal absorption) ($D_{s,d}$):

$$D_{s,d} = \frac{[C_{soil} * (SA_{hands} * AF_{hands} + SA_{other} * AF_{other}) * RAF_{derm} * EF_{soil}]}{BM * C}$$

where:

AF_{hands}	=	soil adherence factor to hands (kg/m^2 d)
AF_{other}	=	soil adherence factor to skin other than hands (kg/m^2 d)
BM	=	body mass (kg)
C	=	conversion factor (365 days per year)
C_{aa}	=	aquatic animal concentration (mg/kg fw)
C_{air}	=	air concentration (mg/m^3)
C_{ap}	=	aquatic plant concentration (mg/kg fw)
C_s	=	sediment concentration (mg/kg dw)
C_{soil}	=	surficial soil concentration (mg/kg dw)
C_{tp}	=	terrestrial plant concentration (mg/kg dw)
C_{ta}	=	terrestrial animal concentration (mg/kg fw)
C_w^S	=	water concentration at the beach (mg/L)
C_w^B	=	water concentration in the bath (mg/L)
C_w^P	=	water concentration in the pool (mg/L)
C_{wc}	=	water column concentration (mg/L)
D_f	=	dose due to ingestion (mg/kg d)
D_i	=	dose due to inhalation (mg/kg d)
$D_{s,d}$	=	dose due to dermal contact with soil (mg/kg d)
EF_s	=	days per year exposed to sediment (d/yr)
EF_{soil}	=	days per year exposed to soil (d/yr)
I_a	=	inhalation rate (m^3/yr)
I_{aa}	=	aquatic animals' ingestion rate (kg fw/yr)
I_{ap}	=	aquatic plants ingestion rate (kg fw/yr)
I_s	=	sediment ingestion rate (kg dw/d)
I_{soil}	=	soil ingestion rate (kg dw/d)
I_{ta}	=	terrestrial animal ingestion rate (kg fw/yr)
I_{tp}	=	terrestrial plant ingestion rate (kg dw/yr)
I_w	=	water ingestion rate (L/yr)
k_a	=	fraction of air inhalation intake from contaminated source (unitless)
k_{aa}	=	fraction of aquatic animal intake from contaminated source (unitless)
k_{ap}	=	fraction of aquatic plant intake from contaminated source (unitless)
k_p	=	chemical specific permeability coefficient (cm/h)
k_{ta}	=	fraction of terrestrial animal intake from contaminated source (unitless)
k_{tp}	=	fraction of terrestrial plant intake from contaminated source (unitless)
OF_i	=	occupancy factor for inhalation (unitless)

OF_W^B	=	occupancy factor in bath water (unitless)
OF_W^P	=	occupancy factor in pool water (unitless)
OF_W^S	=	occupancy factor at the beach (unitless)
ρ_f	=	adjustment factor for food processing (unitless)
RAF_{derm}	=	relative absorption factor for soil dermal contact (unitless)
RAF_{ing}	=	relative absorption factor for ingestion (unitless)
rf	=	dose reduction factor for water treatment (unitless)
SA_w	=	surface area of exposed skin (m^2)
SA_{hands}	=	surface area of hands (m^2)
SA_{other}	=	surface area of exposed skin other than hands (m^2)

Potential non-cancer effects are evaluated using HQ values estimated as described in Section 2.3.6 for ecological receptors. Potential cancer risks from exposure to carcinogenic constituents are evaluated as incremental lifetime cancer risks.

3.0 Development of Model Parameters

3.1 Ambient Hydrology

A baseline sampling program is fundamental to the development and application of an ecological model for Environmental Assessment. In addition to data on environmental media, many other parameters are required to quantify the transport and fate of constituents in the environment. Many of those parameters are not typically measured and are therefore estimated in the modelling process.

3.1.1 Lake Morphometry

Waterbodies from Whitefish Lake to the Russell Lake inlet were modelled to assess the effects of the Project on the downstream environment. Kratchkowsky Lake and Whitefish Lake North were modelled as reference locations. The lakes were modelled based on characteristics consistent with measured values as presented in Table 3-1. All values are based on the baseline aquatic environment study report (Ecometrix, 2020a).

Table 3-1: Lake Morphometry for all Modelled Lakes in the IMPACT Model

Lake Modelled	Average Depth (m)	Area (km^2)	Average Outflow (L/s)	Retention Time (day)
Reference Kratchkowsky Lake (LA-7 South)	2.9	0.80	331.2	80.66
Whitefish Lake North (LA-6)	1.6	0.26	1379.3	3.53
Whitefish Lake Middle (LA-5 North)	1.1	0.10	1398.5	0.88
Whitefish Lake South (LA-5 South)	1.0	0.32	1414.3	2.65
McGowan Lake (LA-1)	5.5	1.49	1832.3	51.61
Russell Lake Inlet	3.0	0.75	2390.3	10.92

The stream model in IMPACT was used to model rivers and streams to connect McGowan Lake and Russell Lake. As such, the Icelander River acts as a flow-through channel, and no sediment interaction was modelled here. The three basins of Whitefish Lake were modelled as separate waterbodies: Whitefish Lake North, Whitefish Lake Middle and Whitefish Lake South. Part of Russell Lake was modelled, as a conservative representation of the exposure area on Russell Lake.

3.1.2 Surface Water Flows

Watersheds and yields were implemented consistent with the hydrological effect assessment report (NewFields, 2021). Average monthly flows are shown in Table 3-2, and Figure 3-1 shows the flow direction through the modelled environment as implemented in IMPACT. The outflow in IMPACT is calculated as the sum of the upstream flow entering a body of water and the local inflow, defined as any inflow from the contributing watershed and tributaries. The local inflow was calculated based on watershed yield and area. Based on this, inputs for the local inflows were calculated for input into the IMPACT model (Table 3-3).

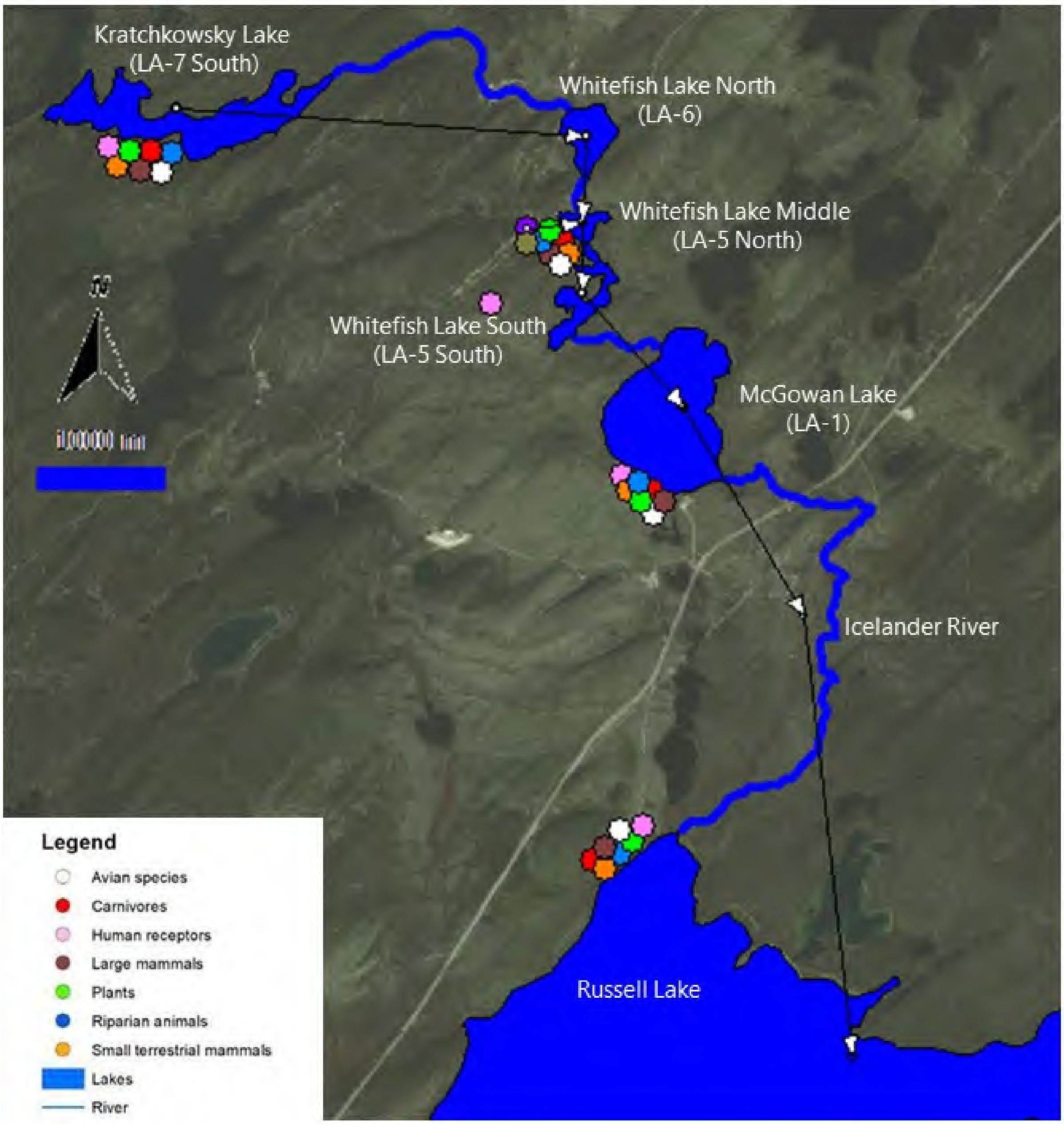


Figure 3-1: Waterbodies and Flow Direction as Implemented in the IMPACT Model

Table 3-2: Average Monthly Flows

Lake Name	Outflow (L/s)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Kratchkowsky Lake	276.8	264.7	254.9	292.9	444.4	443.8	380.9	337.1	326.7	340.6	323.7	288.1	331.2
Whitefish Lake North	1129.2	1075.4	1029.4	1198.7	1900.0	1900.2	1607.0	1405.0	1360.1	1425.1	1343.4	1178.0	1379.3
Whitefish Lake Middle	1138.7	1082.8	1035.1	1210.9	1939.4	1939.5	1634.9	1425.2	1378.5	1446.1	1361.2	1189.4	1398.5
Whitefish Lake South	1146.6	1088.9	1039.7	1221.0	1971.9	1972.0	1658.1	1441.9	1393.8	1463.4	1375.9	1198.8	1414.3
McGowan Lake	1571.7	1501.6	1458.0	1673.7	2371.9	2356.3	2077.7	1868.0	1800.0	1863.4	1803.5	1641.2	1832.3
Icelander River	1588.9	1517.9	1473.9	1692.0	2397.8	2382.0	2100.4	1888.4	1819.7	1883.7	1823.2	1659.1	1852.3
Russell Lake Inlet	2050.4	1958.9	1902.0	2183.4	3094.3	3073.9	2710.5	2436.9	2348.2	2430.9	2352.7	2141.0	2390.3

Table 3-3: Mean Monthly Local Inflows for All Waterbodies Modelled in IMPACT

Lake Name	Mean Monthly Local Inflow (L/s)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Kratchkowsky Lake	276.8	264.7	254.9	292.9	444.4	443.8	380.9	337.1	326.7	340.6	323.7	288.1	331.2
Whitefish Lake North	852.4	810.7	774.5	905.8	1455.6	1456.4	1226.1	1067.9	1033.4	1084.5	1019.7	889.9	1048.1
Whitefish Lake Middle	9.5	7.4	5.7	12.2	39.4	39.3	27.9	20.2	18.4	21.0	17.8	11.4	19.2
Whitefish Lake South	7.8	6.1	4.6	10.1	32.5	32.5	23.2	16.7	15.2	17.3	14.7	9.4	15.9
McGowan Lake	425.1	412.7	418.3	452.7	400.0	384.3	419.6	426.1	406.2	400.0	427.6	442.4	417.9
Icelander River	17.2	16.3	15.9	18.3	25.9	25.7	22.7	20.4	19.7	20.3	19.7	17.9	20.0
Russell Lake Inlet	461.5	441.0	428.1	491.4	696.5	691.9	610.1	548.5	528.5	547.2	529.5	481.9	538.0

3.2 Water Quality

3.2.1 Background Water Quality

To characterize regional background water quality, a database of baseline water and sediment quality data was compiled from baseline studies performed between 2011 and 2019 (Ecometrix, 2020a). The water and sediment quality data included in the calculation of the regional baseline were obtained from 32 water measurement stations and 35 sediment measurement stations along the five modelled lakes and nearby waterbodies from Kratchkowsky Lake to Russell Lake. The geometric mean of all data in a series of lakes from Kratchkowsky Lake to Russell Lake was selected as the baseline concentration for constituents that had measured data over the detection limit. In the case of constituents for which most or all measured values in water were under the detection limit, but sediment concentration measurements were over the detection limit, the baseline water concentration was calculated from the geometric mean of the sediment measurements using the partitioning coefficients (K_d) (Section 3.3.2). This was the case for cadmium, chromium, copper, selenium, uranium, and vanadium. The geomean is generally more representative of the central value of the data distribution; however, considering the data represents baseline conditions with many values below the detection limit, there is limited difference between the geomean and the arithmetic mean for the majority of constituents.

Lead-210 and its daughter polonium-210 were assumed to be in transient equilibrium. Activity concentrations of a parent and daughter nuclide in transient equilibrium are governed by the following relationship:

$$Q_B = \frac{\lambda_B}{\lambda_B - \lambda_A} \cdot Q_A$$

where:

Q_A	=	activity of the parent
Q_B	=	activity of the daughter
λ_A	=	half life of the parent
λ_B	=	half life of the daughter

Polonium-210 and lead-210 were balanced to remain in transient equilibrium. Sediment concentration of polonium-210 was calculated from the measured values of its water concentration using the distribution coefficient (K_d). The transient equilibrium assumption was used to calculate the sediment concentration of lead-210 from the polonium-210 sediment concentration, and the calculated lead-210 sediment concentration was used to model water concentration of lead-210 using the K_d.

The inflow concentrations for each waterbody were assigned slightly higher values than the background concentrations since sedimentation processes remove metals and radionuclides from the inflow. Inflow concentrations were calculated from the background concentration, the residence time within each respective waterbody, the sedimentation rate, and the COPC-specific partitioning coefficient. The slightly higher inflow values were used in the model to predict stable concentrations in water and sediment within the range of observed values of background conditions. Those concentrations are presented in Table 3-4.

Table 3-4: Calibrated Local Inflow Concentrations for each Water Polygon modelled in IMPACT

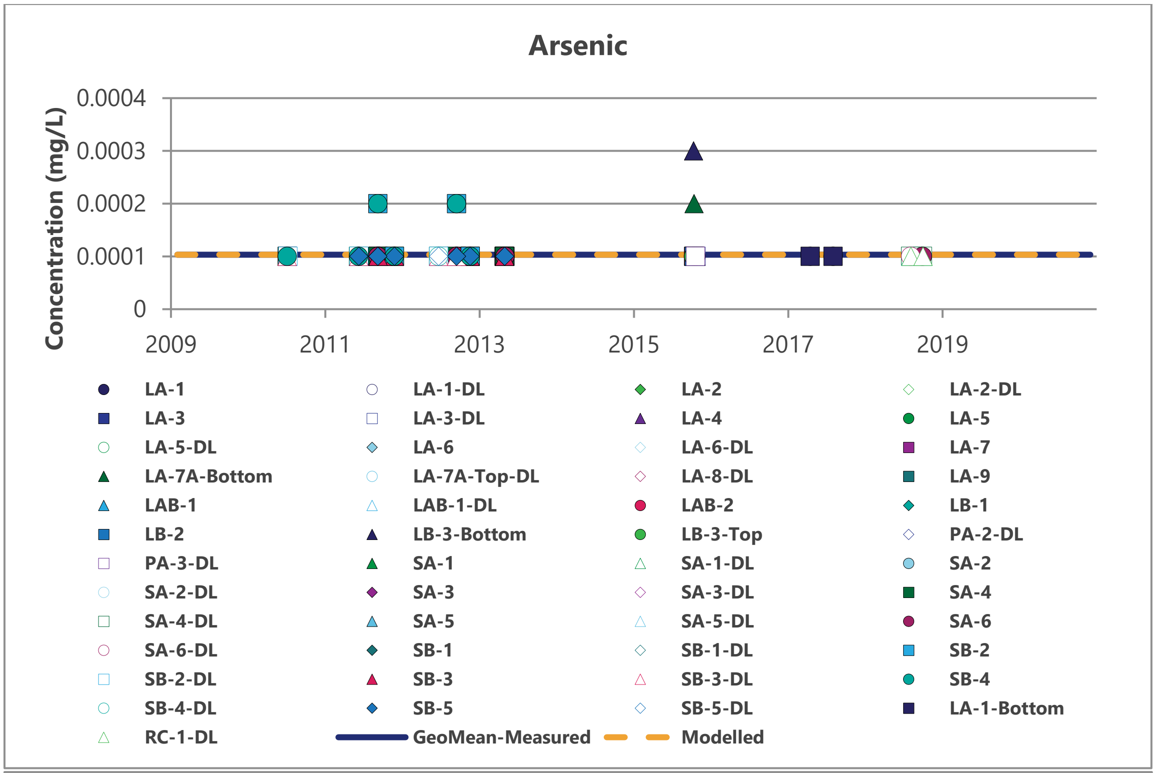
COPCs	Water Baseline	Kratchkowsky Lake	Whitefish Lake North	Whitefish Lake Middle	Whitefish Lake South	McGowan Lake	Icelander River	Russel Lake Inlet
Non-radionuclides	mg/L							
Arsenic	1.03E-04	2.70E-04	1.21E-04	4.54E-04	1.52E-03	3.50E-04	1.03E-04	2.00E-04
Cadmium	2.32E-05	2.90E-05	2.38E-05	3.54E-05	7.28E-05	3.18E-05	2.32E-05	2.66E-05
Chloride	3.22E-01	3.22E-01	3.22E-01	3.22E-01	3.22E-01	3.22E-01	3.22E-01	3.22E-01
Chromium	5.19E-04	6.19E-04	5.29E-04	7.30E-04	1.37E-03	6.68E-04	5.19E-04	5.77E-04
Cobalt	1.01E-04	1.05E-04	1.01E-04	1.10E-04	1.37E-04	1.07E-04	1.01E-04	1.03E-04
Copper	6.18E-04	6.49E-04	6.22E-04	6.84E-04	8.83E-04	6.64E-04	6.18E-04	6.36E-04
Molybdenum	1.07E-04	1.13E-04	1.07E-04	1.19E-04	1.55E-04	1.15E-04	1.07E-04	1.10E-04
Selenium	3.23E-05	4.32E-05	3.34E-05	5.51E-05	1.24E-04	4.83E-05	3.23E-05	3.86E-05
Sulphate	6.87E-01	6.87E-01	6.87E-01	6.87E-01	6.87E-01	6.87E-01	6.87E-01	6.87E-01
Uranium	3.01E-05	4.01E-05	3.11E-05	5.13E-05	1.16E-04	4.50E-05	3.01E-05	3.59E-05
Vanadium	1.46E-04	3.68E-04	1.69E-04	6.13E-04	2.03E-03	4.74E-04	1.46E-04	2.75E-04
Zinc	6.81E-04	8.52E-04	6.98E-04	1.04E-03	2.14E-03	9.34E-04	6.81E-04	7.80E-04
Radionuclides	Bq/L							
Lead-210 [a]	5.27E-03	1.60E-02	6.39E-03	2.78E-02	9.63E-02	2.12E-02	5.27E-03	1.15E-02
Polonium-210	5.36E-03	1.63E-02	6.50E-03	2.83E-02	9.80E-02	2.16E-02	5.36E-03	1.17E-02
Radium-226	5.57E-03	6.70E-03	5.69E-03	7.94E-03	1.51E-02	7.23E-03	5.57E-03	6.23E-03
Thorium-230	1.01E-02	1.05E-02	1.01E-02	1.09E-02	1.34E-02	1.07E-02	1.01E-02	1.03E-02
Uranium-234 [b]	3.71E-04	4.96E-04	3.84E-04	6.33E-04	1.43E-03	5.56E-04	3.71E-04	4.44E-04
Uranium-238 [b]	3.71E-04	4.96E-04	3.84E-04	6.33E-04	1.43E-03	5.56E-04	3.71E-04	4.44E-04

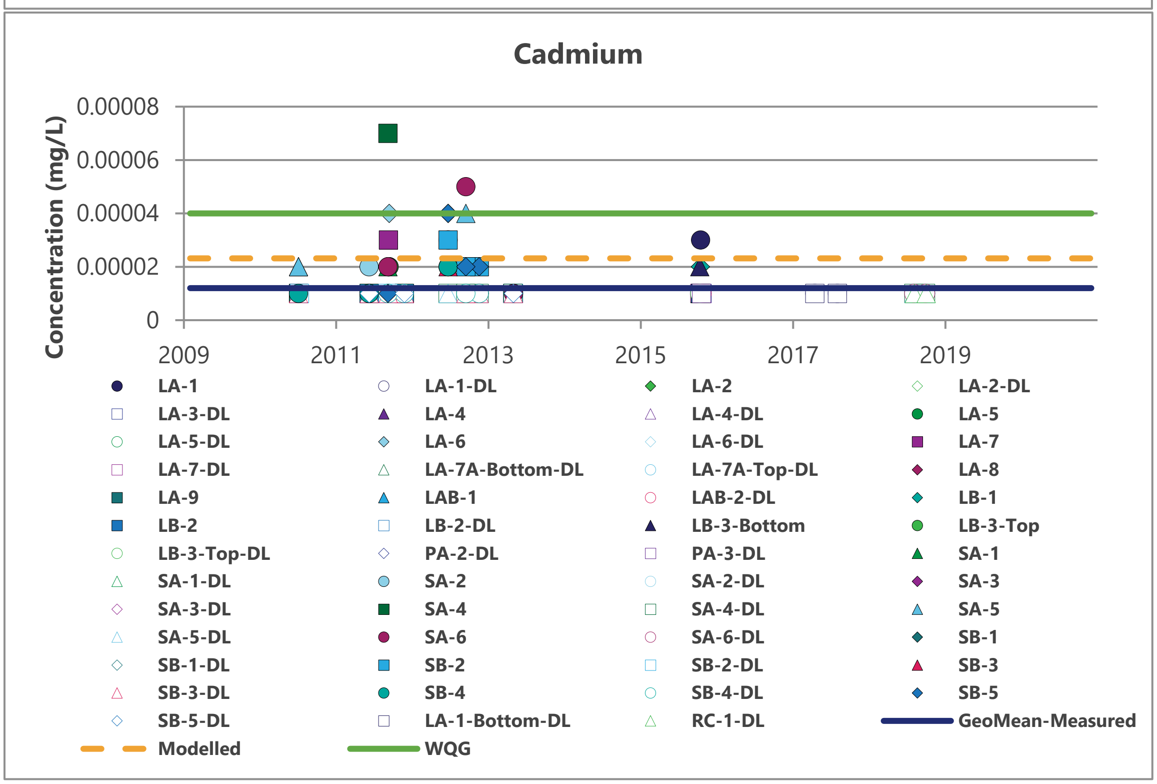
a. Calculated to be in transient equilibrium with polonium-210.

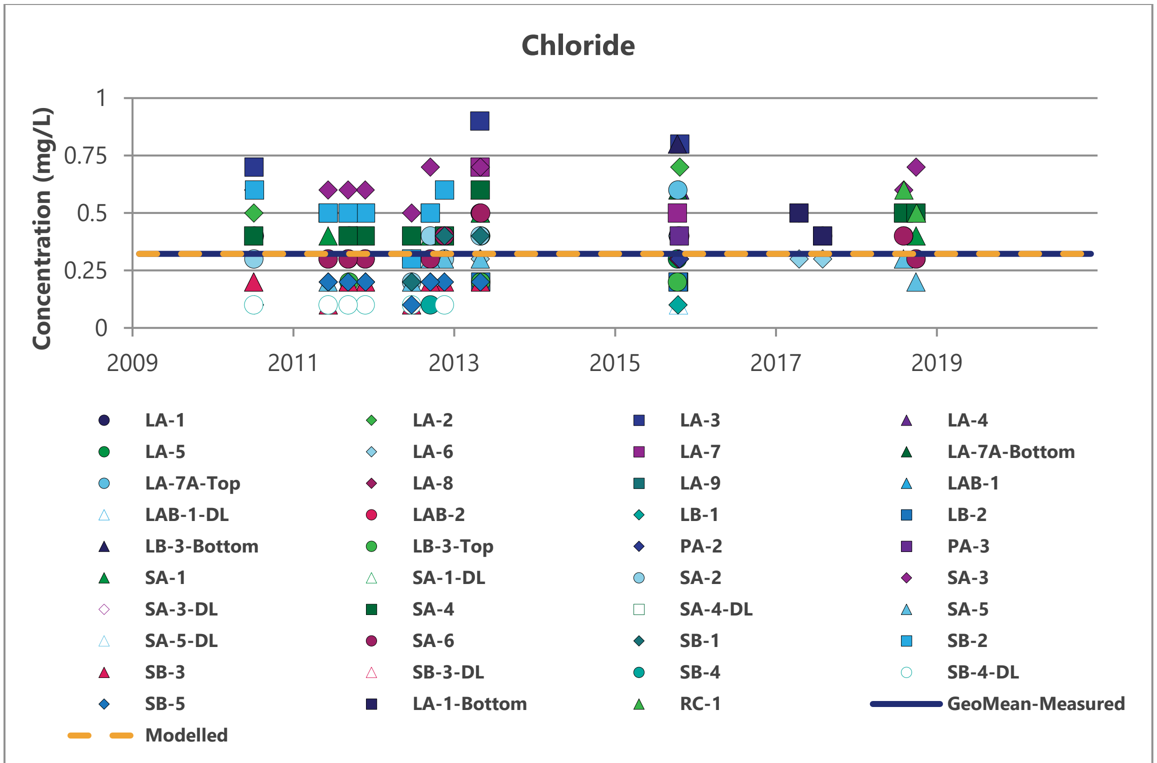
b. Estimated from uranium using the specific activity of 12,356 Bq/g and assuming secular equilibrium between uranium-238 and uranium-234 (**https://www.wise-uranium.org/rup.html**)

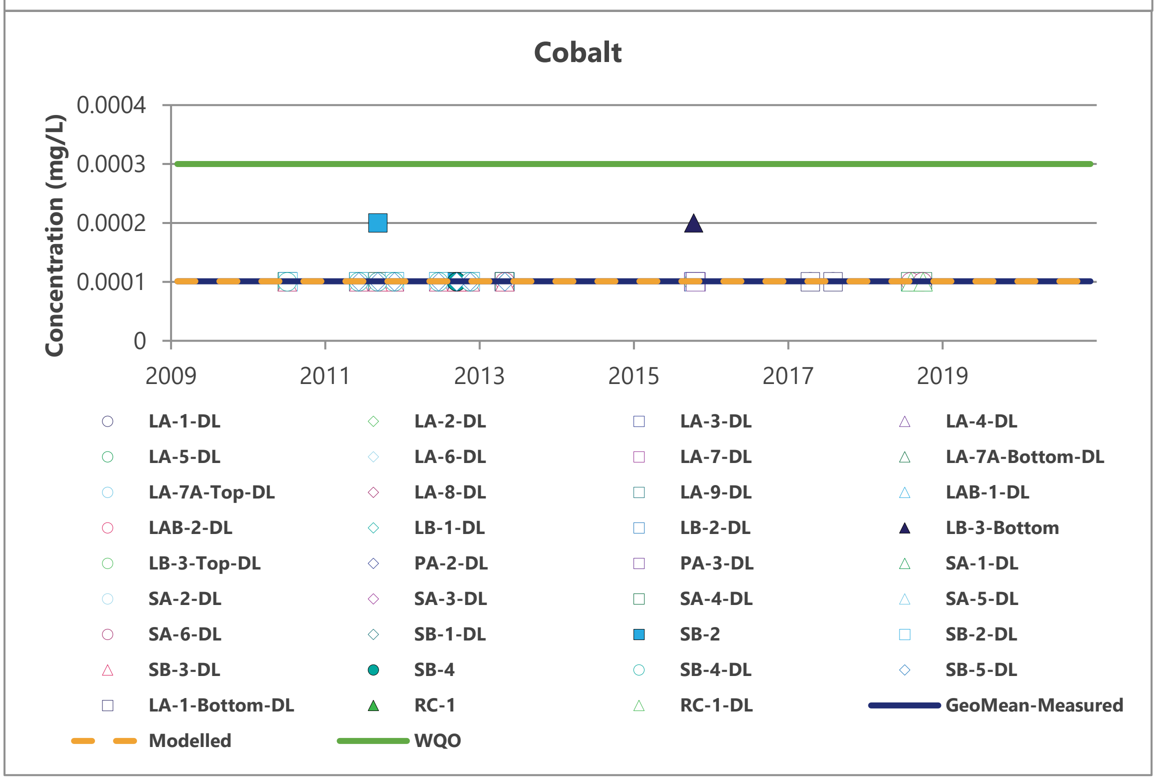
Modelled average water baseline concentrations of COPCs are presented in Table 3-4 and a comparison to measured values is shown in Figure 3-2. The purpose of these plots is to show trends over time for selected COPCs and the generally good agreement between the measured and modelled concentrations. A good agreement is considered as the modelled concentrations fall in the range of measured concentrations, which is the case for most of the COPCs with the exception for selenium, uranium and lead-210. Water concentrations for selenium, uranium and lead-210 are unlikely underestimated because more than 96% of the measured values (142 in total) are below their detection limit. Water concentration for copper is likely overestimated, since the modelled concentration is over the detection limit, with 98% of the measured values (139 out of 142) being under the detection limit for copper. This under (selenium, uranium and lead-210) or overestimation (cadmium, chromium, copper and vanadium) is a result of the method for derivation of water concentrations based on their measured sediment values

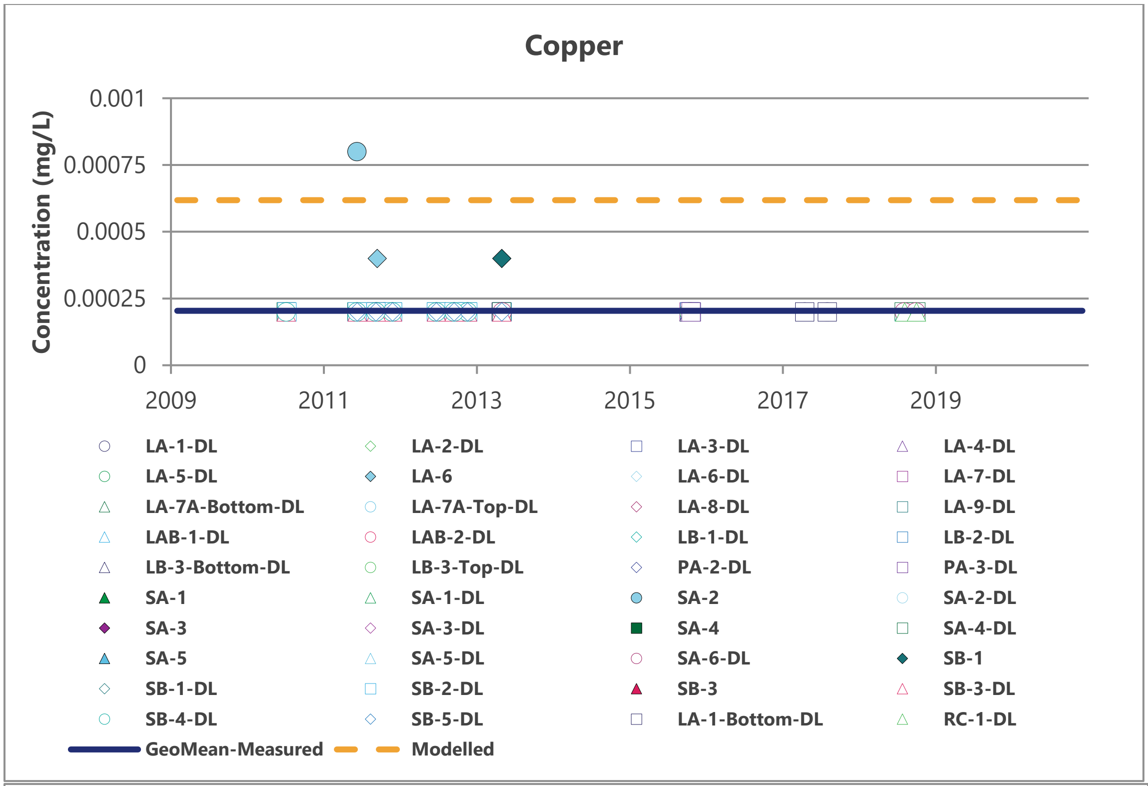
(Section 3.3, Sediment Quality). Unlike chloride and sulphate, metals and radionuclides are expected to interact with sediment. In the case of radionuclides, ingrowth and decay are other factors that may influence activities in the receiving environment.

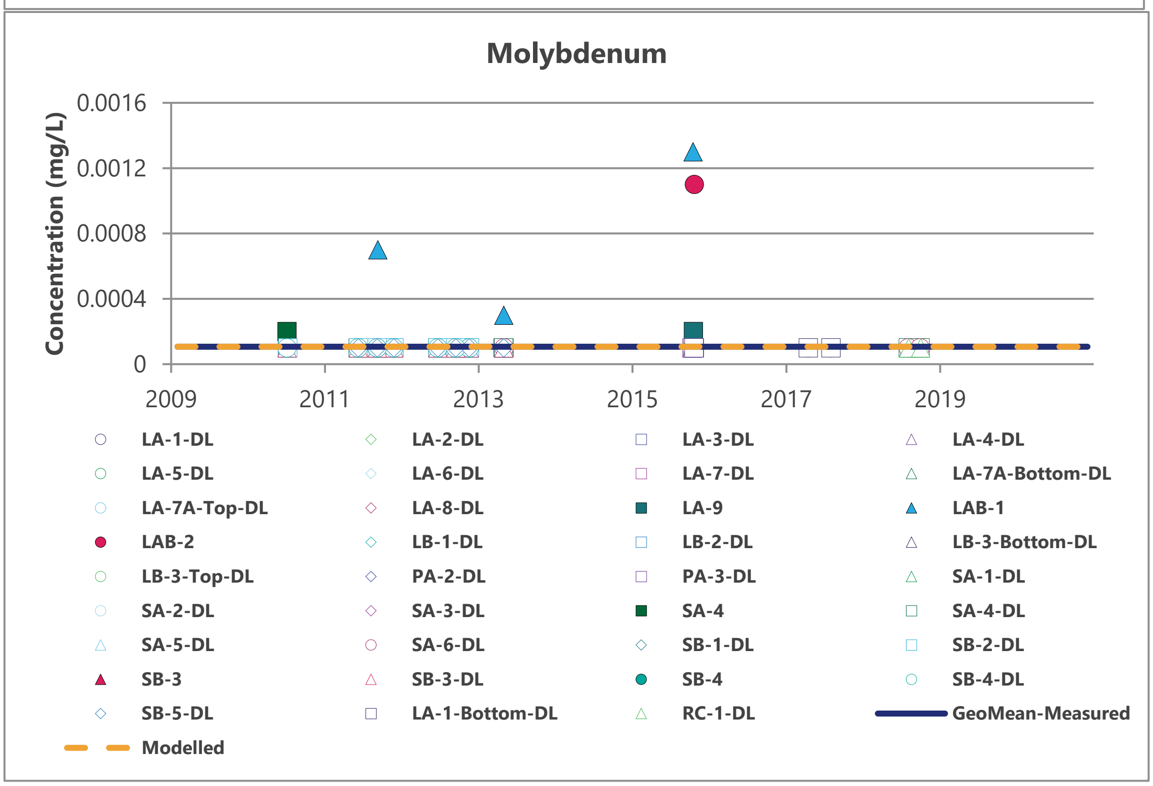


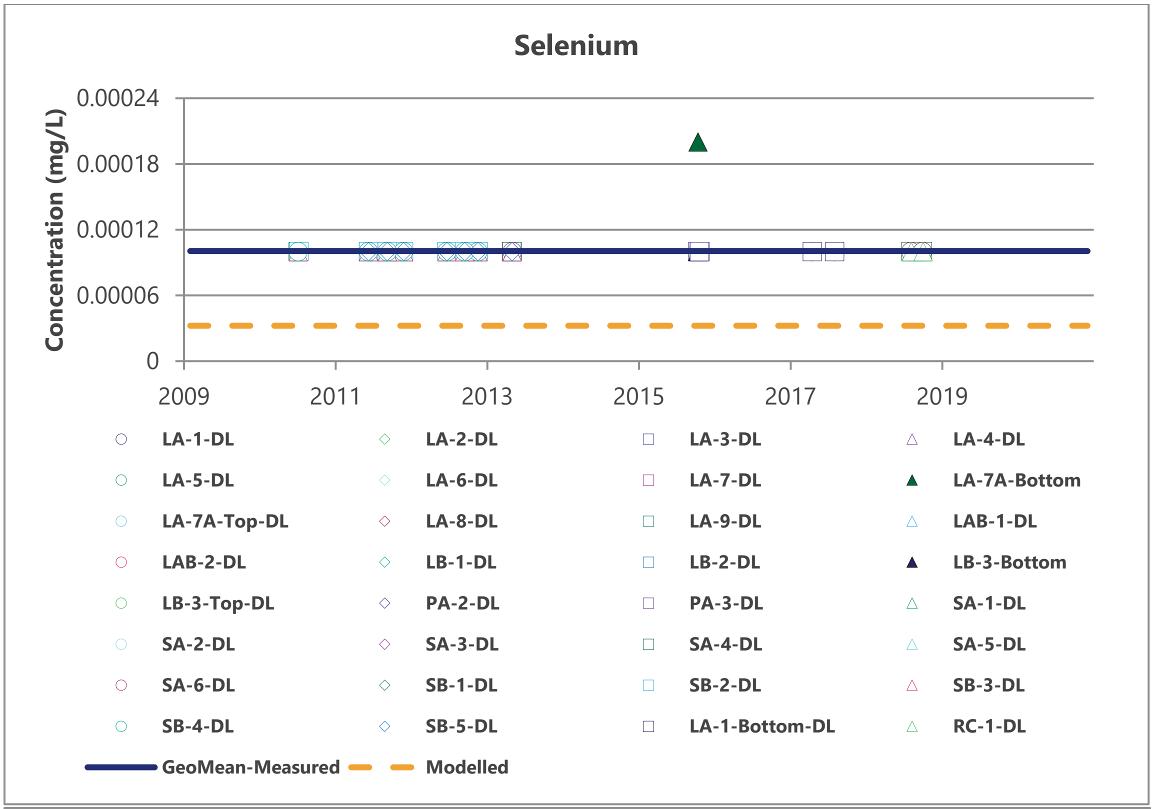


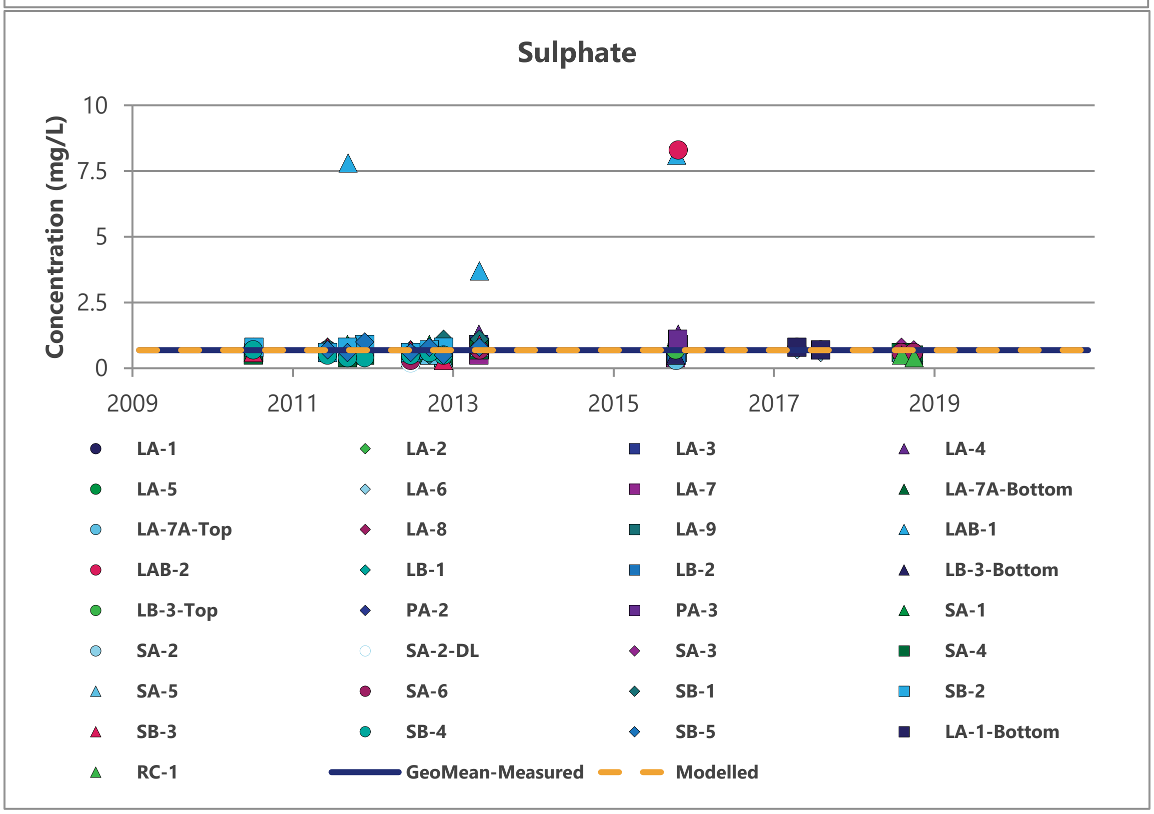

Chloride
Concentration (mg/L)
0
0.25
0.5
0.75
1
2009
2011
2013
2015
2017
2019
LA-1
LA-2
LA-3
LA-4
LA-5
LA-6
LA-7
LA-7A-Bottom
LA-7A-Top
LA-8
LA-9
LAB-1
LAB-1-DL
LAB-2
LB-1
LB-2
LB-3-Bottom
LB-3-Top
PA-2
PA-3
SA-1
SA-1-DL
SA-2
SA-3
SA-3-DL
SA-4
SA-4-DL
SA-5
SA-5-DL
SA-6
SB-1
SB-2
SB-3
SB-3-DL
SB-4
SB-4-DL
SB-5
LA-1-Bottom
RC-1
GeoMean-Measured
Modelled

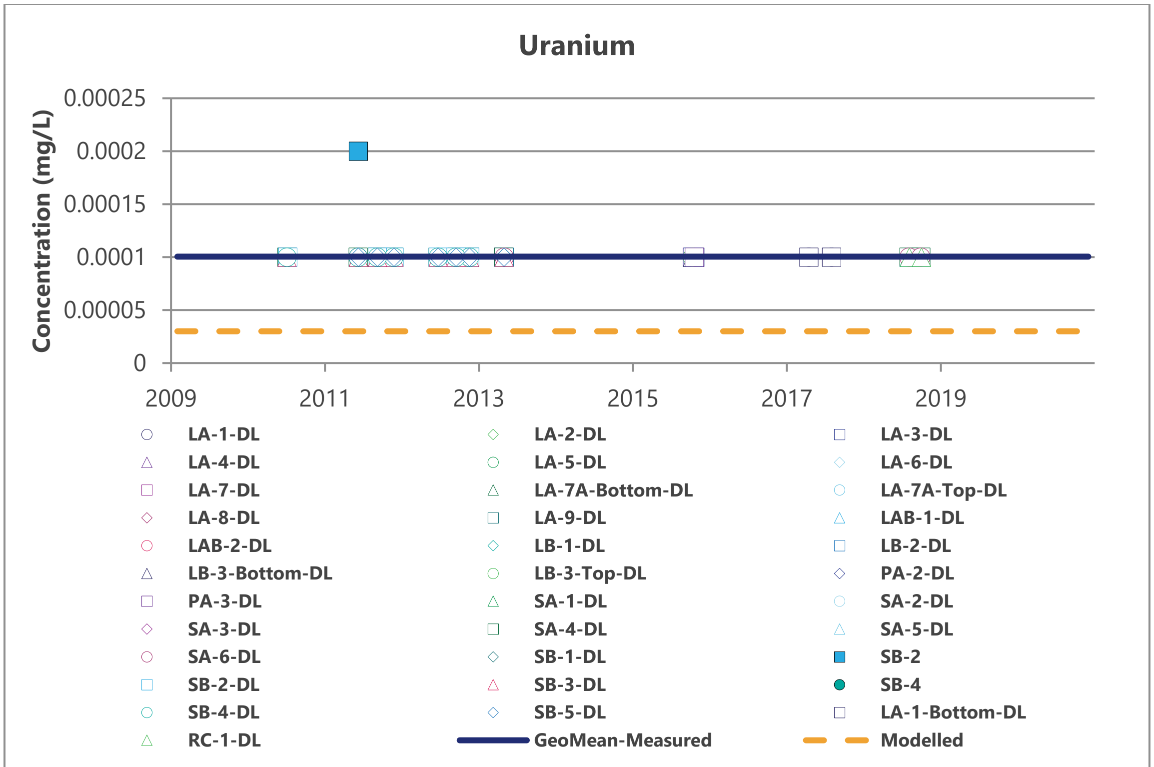

Cobalt
Concentration (mg/L)
0
0.0001
0.0002
0.0003
0.0004
2009
2011
2013
2015
2017
2019
LA-1-DL
LA-2-DL
LA-3-DL
LA-4-DL
LA-5-DL
LA-6-DL
LA-7-DL
LA-7A-Bottom-DL
LA-7A-Top-DL
LA-8-DL
LA-9-DL
LAB-1-DL
LAB-2-DL
LB-1-DL
LB-2-DL
LB-3-Bottom
LB-3-Top-DL
PA-2-DL
PA-3-DL
SA-1-DL
SA-2-DL
SA-3-DL
SA-4-DL
SA-5-DL
SA-6-DL
SB-1-DL
SB-2
SB-2-DL
SB-3-DL
SB-4
SB-4-DL
SB-5-DL
LA-1-Bottom-DL
RC-1
RC-1-DL
GeoMean-Measured
Modelled
WQO

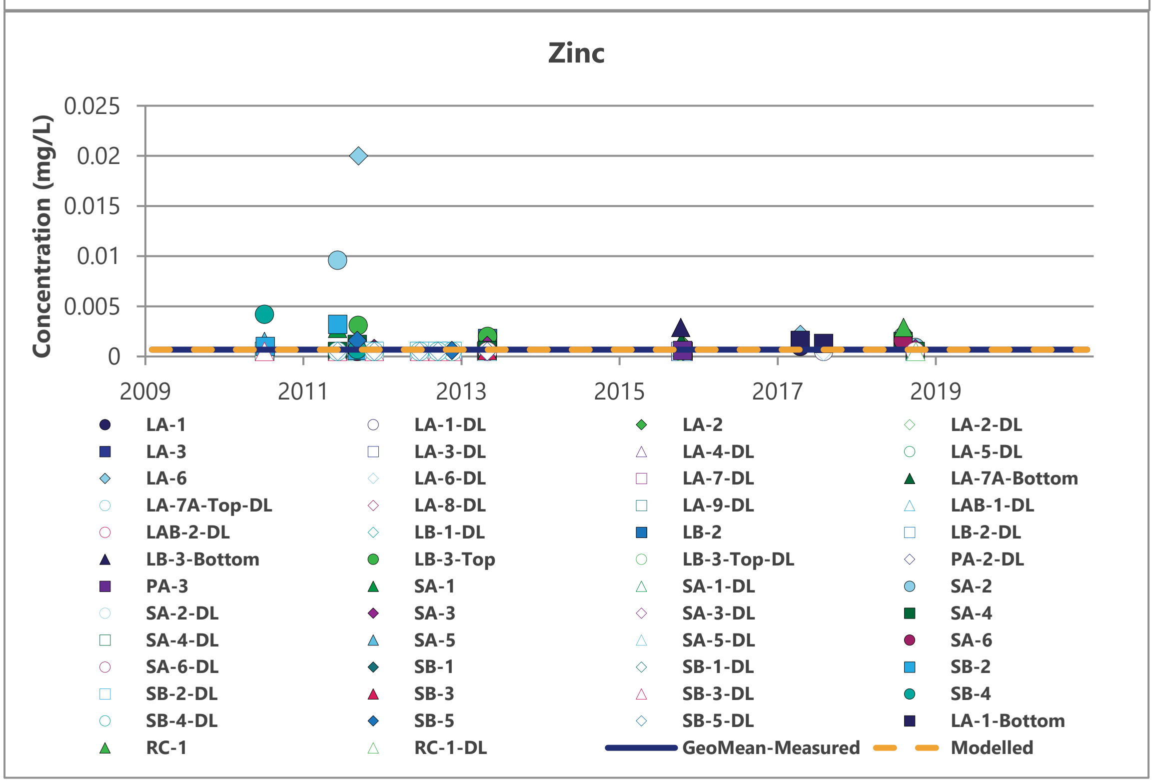

Copper
Concentration (mg/L)
0.001
0.00075
0.0005
0.00025
0
2009
2011
2013
2015
2017
2019
LA-1-DL
LA-2-DL
LA-3-DL
LA-4-DL
LA-5-DL
LA-6
LA-6-DL
LA-7-DL
LA-7A-Bottom-DL
LA-7A-Top-DL
LA-8-DL
LA-9-DL
LAB-1-DL
LAB-2-DL
LB-1-DL
LB-2-DL
LB-3-Bottom-DL
LB-3-Top-DL
PA-2-DL
PA-3-DL
SA-1
SA-1-DL
SA-2
SA-2-DL
SA-3
SA-3-DL
SA-4
SA-4-DL
SA-5
SA-5-DL
SA-6-DL
SB-1
SB-1-DL
SB-2-DL
SB-3
SB-3-DL
SB-4-DL
SB-5-DL
LA-1-Bottom-DL
RC-1-DL
GeoMean-Measured
Modelled

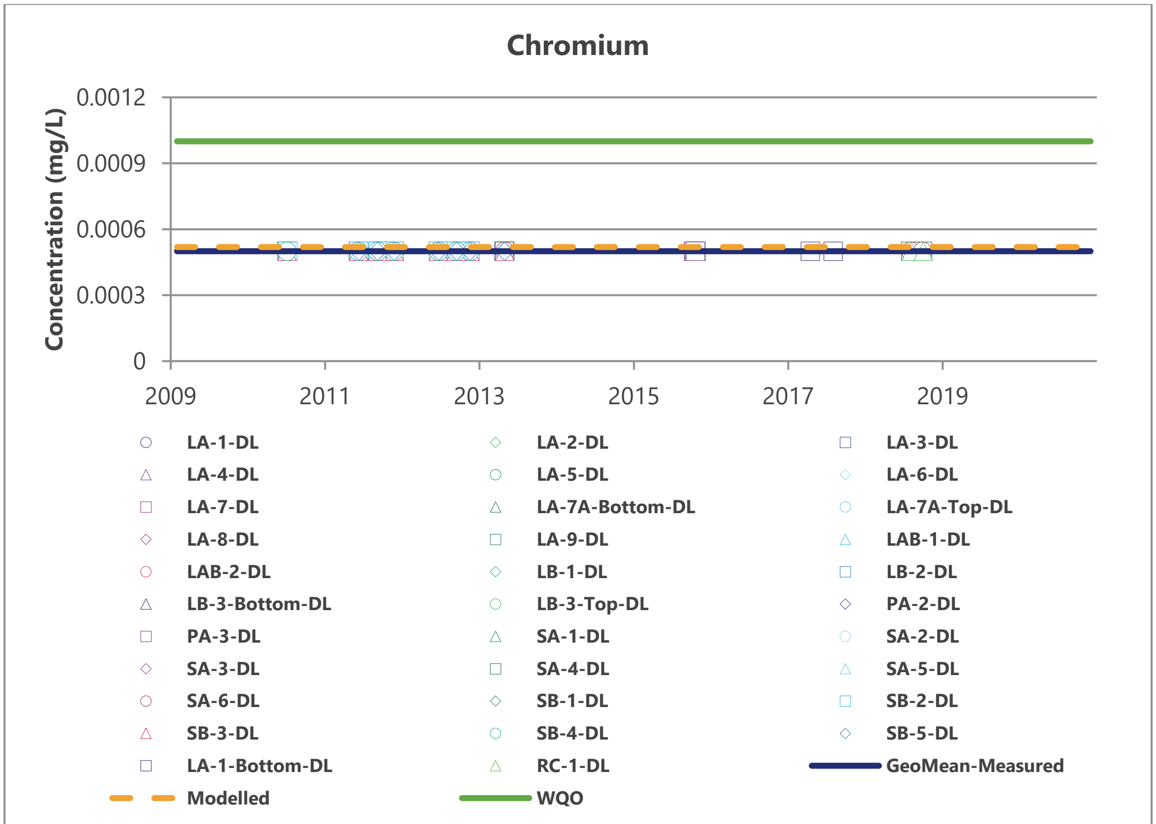

Molybdenum
Concentration (mg/L)
0.0016
0.0012
0.0008
0.0004
0
2009
2011
2013
2015
2017
2019
LA-1-DL
LA-2-DL
LA-3-DL
LA-4-DL
LA-5-DL
LA-6-DL
LA-7-DL
LA-7A-Bottom-DL
LA-7A-Top-DL
LA-8-DL
LA-9
LAB-1
LAB-2
LB-1-DL
LB-2-DL
LB-3-Bottom-DL
LB-3-Top-DL
PA-2-DL
PA-3-DL
SA-1-DL
SA-2-DL
SA-3-DL
SA-4
SA-4-DL
SA-5-DL
SA-6-DL
SB-1-DL
SB-2-DL
SB-3
SB-3-DL
SB-4
SB-4-DL
SB-5-DL
LA-1-Bottom-DL
RC-1-DL
GeoMean-Measured
Modelled

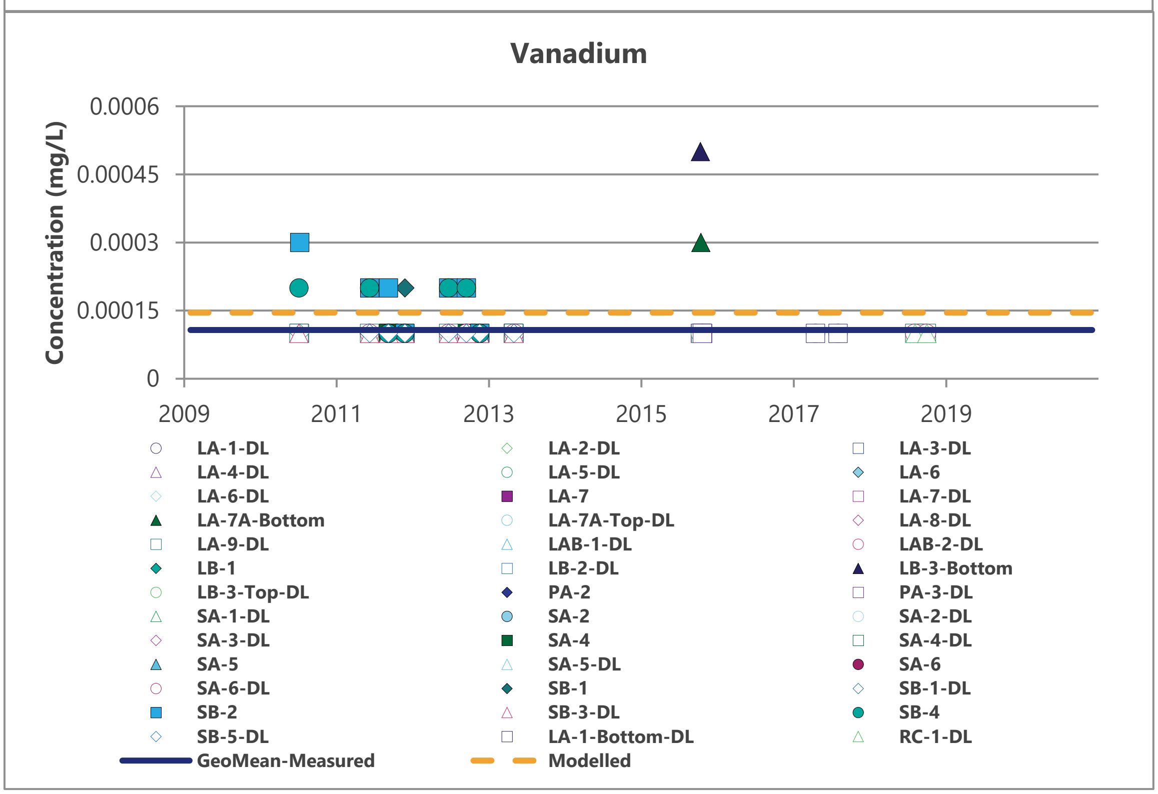

Selenium
Concentration (mg/L)
0.00024
0.00018
0.00012
0.00006
0
2009
2011
2013
2015
2017
2019
LA-1-DL
LA-2-DL
LA-3-DL
LA-4-DL
LA-5-DL
LA-6-DL
LA-7-DL
LA-7A-Bottom
LA-7A-Top-DL
LA-8-DL
LA-9-DL
LAB-1-DL
LAB-2-DL
LB-1-DL
LB-2-DL
LB-3-Bottom
LB-3-Top-DL
PA-2-DL
PA-3-DL
SA-1-DL
SA-2-DL
SA-3-DL
SA-4-DL
SA-5-DL
SA-6-DL
SB-1-DL
SB-2-DL
SB-3-DL
SB-4-DL
SB-5-DL
LA-1-Bottom-DL
RC-1-DL
GeoMean-Measured
Modelled

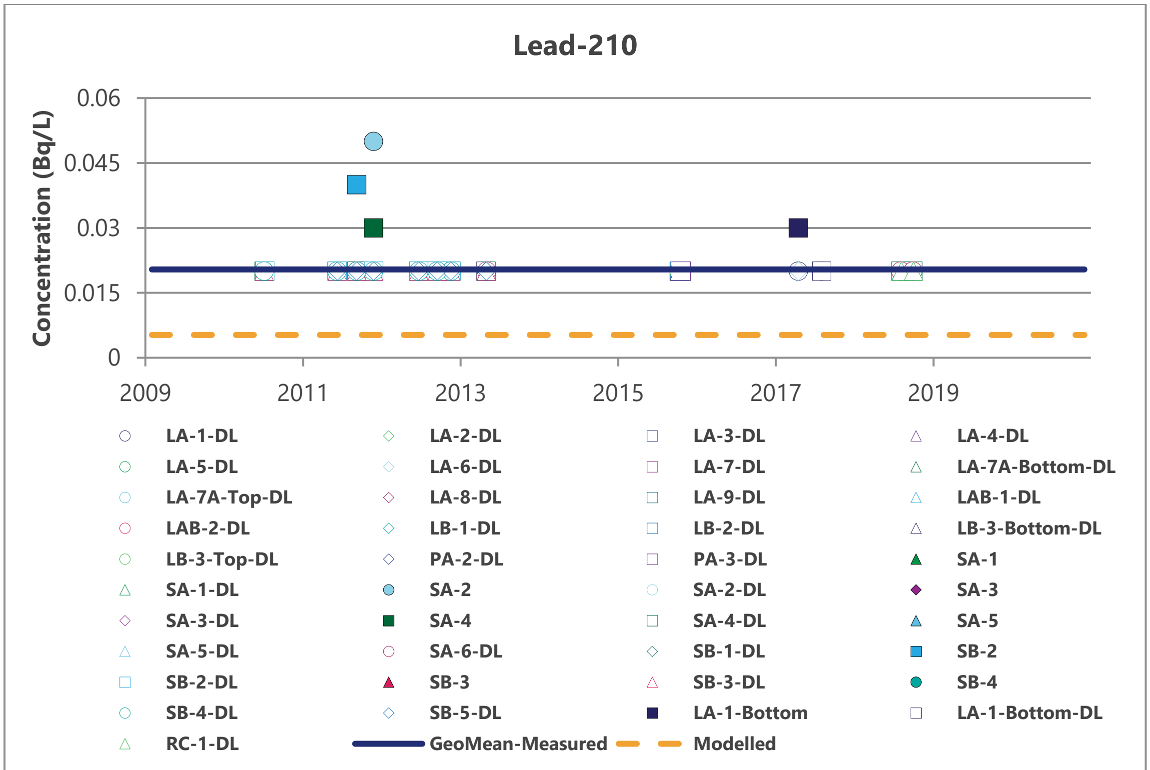

Sulphate
Concentration (mg/L)
10
7.5
5
2.5
0
2009
2011
2013
2015
2017
2019
LA-1
LA-2
LA-3
LA-4
LA-5
LA-6
LA-7
LA-7A-Bottom
LA-7A-Top
LA-8
LA-9
LAB-1
LAB-2
LB-1
LB-2
LB-3-Bottom
LB-3-Top
PA-2
PA-3
SA-1
SA-2
SA-2-DL
SA-3
SA-4
SA-5
SA-6
SB-1
SB-2
SB-3
SB-4
SB-5
LA-1-Bottom
RC-1
GeoMean-Measured
Modelled

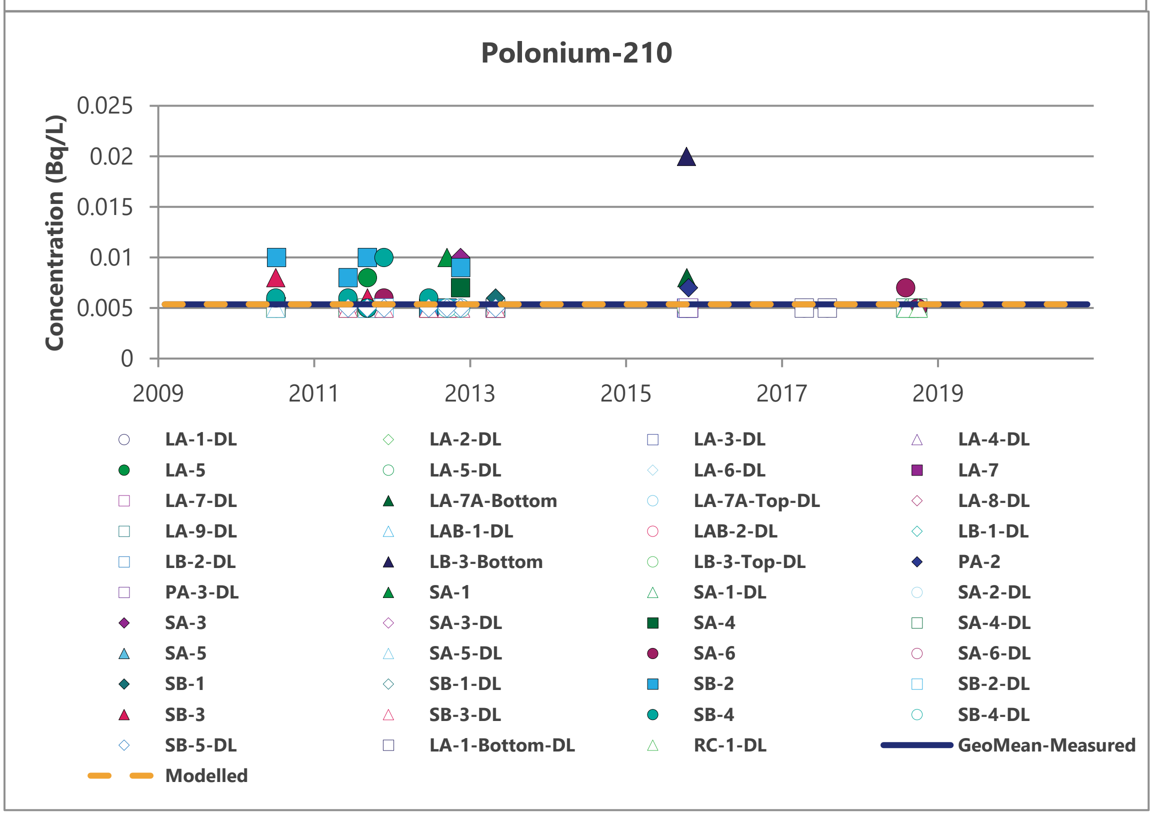

Uranium
Concentration (mg/L)
0.00025
0.0002
0.00015
0.0001
0.00005
0
2009
2011
2013
2015
2017
2019
LA-1-DL
LA-2-DL
LA-3-DL
LA-4-DL
LA-5-DL
LA-6-DL
LA-7-DL
LA-7A-Bottom-DL
LA-7A-Top-DL
LA-8-DL
LA-9-DL
LAB-1-DL
LAB-2-DL
LB-1-DL
LB-2-DL
LB-3-Bottom-DL
LB-3-Top-DL
PA-2-DL
PA-3-DL
SA-1-DL
SA-2-DL
SA-3-DL
SA-4-DL
SA-5-DL
SA-6-DL
SB-1-DL
SB-2
SB-2-DL
SB-3-DL
SB-4
SB-4-DL
SB-5-DL
LA-1-Bottom-DL
RC-1-DL
GeoMean-Measured
Modelled

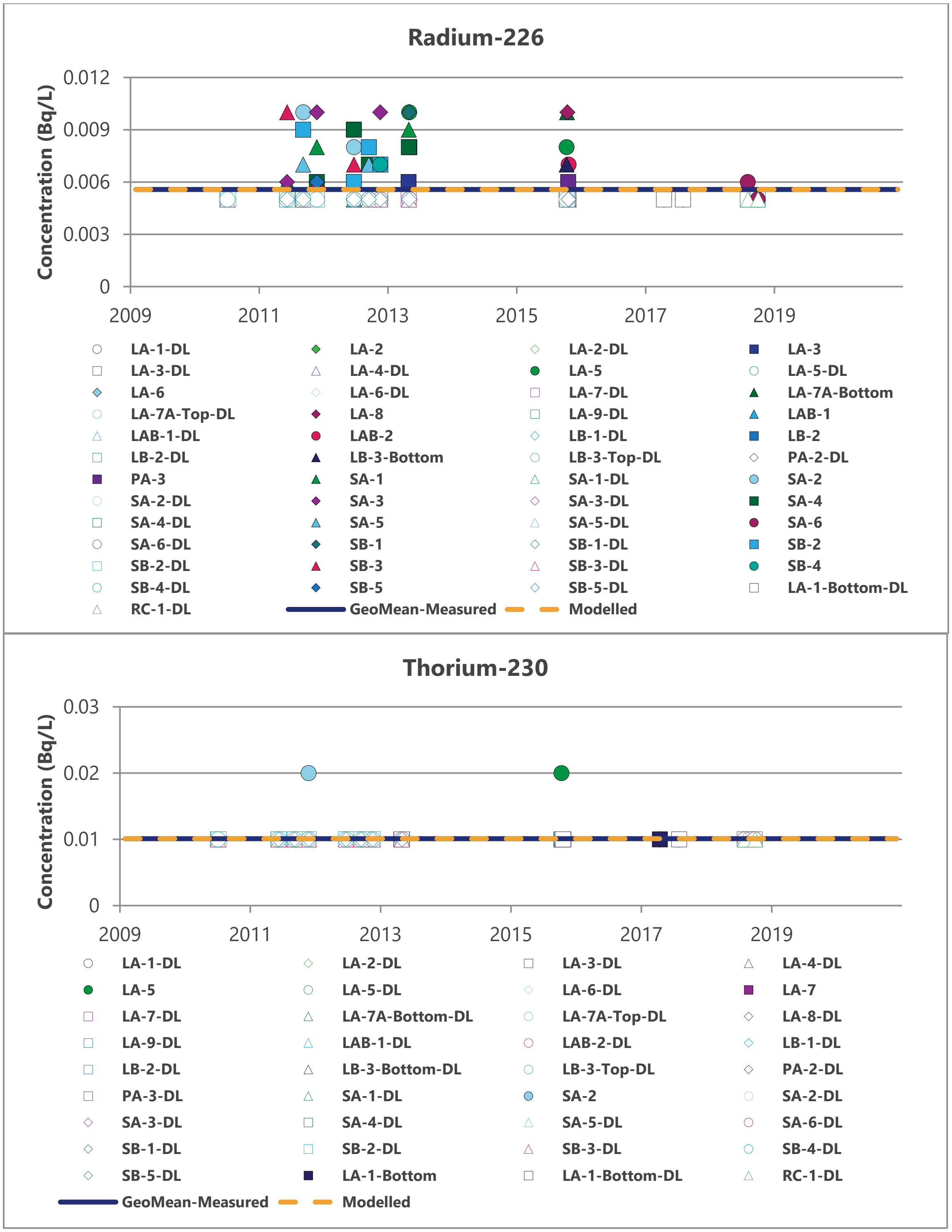

Zinc
Concentration (mg/L)
0.025
0.02
0.015
0.01
0.005
0
2009
2011
2013
2015
2017
2019
LA-1
LA-1-DL
LA-2
LA-2-DL
LA-3
LA-3-DL
LA-4-DL
LA-5-DL
LA-6
LA-6-DL
LA-7-DL
LA-7A-Bottom
LA-7A-Top-DL
LA-8-DL
LA-9-DL
LAB-1-DL
LAB-2-DL
LB-1-DL
LB-2
LB-2-DL
LB-3-Bottom
LB-3-Top
LB-3-Top-DL
PA-2-DL
PA-3
SA-1
SA-1-DL
SA-2
SA-2-DL
SA-3
SA-3-DL
SA-4
SA-4-DL
SA-5
SA-5-DL
SA-6
SA-6-DL
SB-1
SB-1-DL
SB-2
SB-2-DL
SB-3
SB-3-DL
SB-4
SB-4-DL
SB-5
SB-5-DL
LA-1-Bottom
RC-1
RC-1-DL
GeoMean-Measured
Modelled


Chromium
Concentration (mg/L)
0.0012
0.0009
0.0006
0.0003
0
2009
2011
2013
2015
2017
2019
LA-1-DL
LA-2-DL
LA-3-DL
LA-4-DL
LA-5-DL
LA-6-DL
LA-7-DL
LA-7A-Bottom-DL
LA-7A-Top-DL
LA-8-DL
LA-9-DL
LAB-1-DL
LAB-2-DL
LB-1-DL
LB-2-DL
LB-3-Bottom-DL
LB-3-Top-DL
PA-2-DL
PA-3-DL
SA-1-DL
SA-2-DL
SA-3-DL
SA-4-DL
SA-5-DL
SA-6-DL
SB-1-DL
SB-2-DL
SB-3-DL
SB-4-DL
SB-5-DL
LA-1-Bottom-DL
RC-1-DL
GeoMean-Measured
Modelled
WQO


Vanadium
Concentration (mg/L)
0.0006
0.00045
0.0003
0.00015
0
2009
2011
2013
2015
2017
2019
LA-1-DL
LA-2-DL
LA-3-DL
LA-4-DL
LA-5-DL
LA-6
LA-6-DL
LA-7
LA-7-DL
LA-7A-Bottom
LA-7A-Top-DL
LA-8-DL
LA-9-DL
LAB-1-DL
LAB-2-DL
LB-1
LB-2-DL
LB-3-Bottom
LB-3-Top-DL
PA-2
PA-3-DL
SA-1-DL
SA-2
SA-2-DL
SA-3-DL
SA-4
SA-4-DL
SA-5
SA-5-DL
SA-6
SA-6-DL
SB-1
SB-1-DL
SB-2
SB-3-DL
SB-4
SB-5-DL
LA-1-Bottom-DL
RC-1-DL
GeoMean-Measured
Modelled


Lead-210
Concentration (Bq/L)
0.06
0.045
0.03
0.015
0
2009
2011
2013
2015
2017
2019
LA-1-DL
LA-2-DL
LA-3-DL
LA-4-DL
LA-5-DL
LA-6-DL
LA-7-DL
LA-7A-Bottom-DL
LA-7A-Top-DL
LA-8-DL
LA-9-DL
LAB-1-DL
LAB-2-DL
LB-1-DL
LB-2-DL
LB-3-Bottom-DL
LB-3-Top-DL
PA-2-DL
PA-3-DL
SA-1
SA-1-DL
SA-2
SA-2-DL
SA-3
SA-3-DL
SA-4
SA-4-DL
SA-5
SA-5-DL
SA-6-DL
SB-1-DL
SB-2
SB-2-DL
SB-3
SB-3-DL
SB-4
SB-4-DL
SB-5-DL
LA-1-Bottom
LA-1-Bottom-DL
RC-1-DL
GeoMean-Measured
Modelled


Polonium-210
Concentration (Bq/L)
0.025
0.02
0.015
0.01
0.005
0
2009
2011
2013
2015
2017
2019
LA-1-DL
LA-2-DL
LA-3-DL
LA-4-DL
LA-5
LA-5-DL
LA-6-DL
LA-7
LA-7-DL
LA-7A-Bottom
LA-7A-Top-DL
LA-8-DL
LA-9-DL
LAB-1-DL
LAB-2-DL
LB-1-DL
LB-2-DL
LB-3-Bottom
LB-3-Top-DL
PA-2
PA-3-DL
SA-1
SA-1-DL
SA-2-DL
SA-3
SA-3-DL
SA-4
SA-4-DL
SA-5
SA-5-DL
SA-6
SA-6-DL
SB-1
SB-1-DL
SB-2
SB-2-DL
SB-3
SB-3-DL
SB-4
SB-4-DL
SB-5-DL
LA-1-Bottom-DL
RC-1-DL
GeoMean-Measured
Modelled



WQO = Water Quality Objective. The WQO is only shown in the figures for those COPCs whose measured/modelled concentrations are close to its WQO. Blank symbol indicates that the measurement was under the detection limit. The location of sampling stations is described in detail in baseline aquatic environment study report (Ecometrix, 2020a).

Figure 3-2: Modelled and Measured Baseline Concentrations in Water

3.3 Sediment Quality

3.3.1 Background Sediment Quality

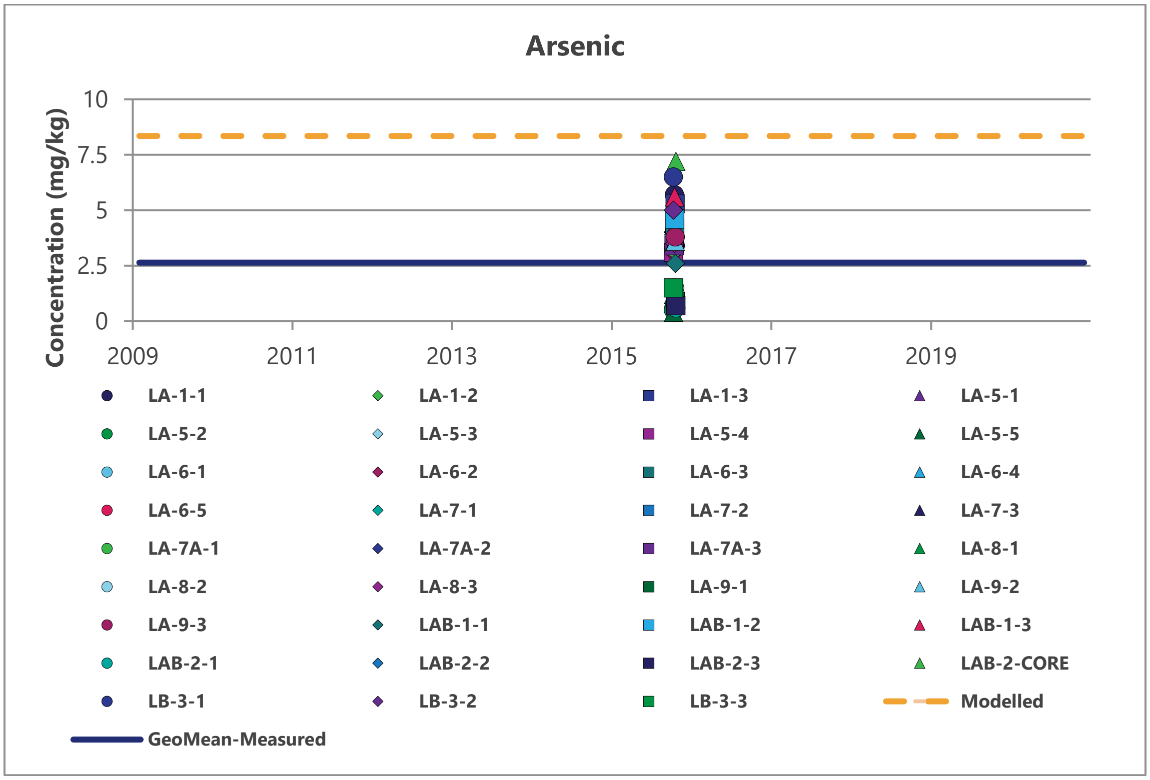
To characterize regional background sediment quality, a database of baseline water and sediment quality data was compiled from baseline studies performed between 2011 and 2019 (Ecometrix, 2020a). Concentrations in sediment were modelled based on concentrations in water using the partitioning coefficients (K_d) as discussed in Section 3.2.1.

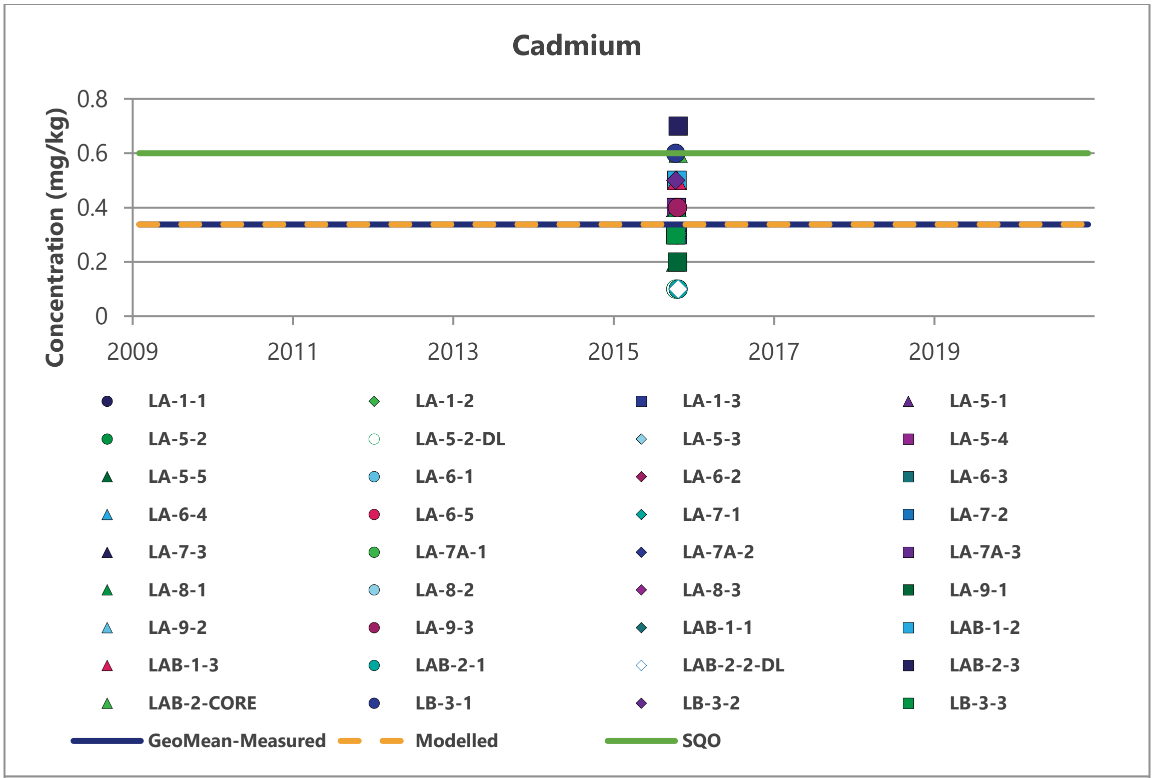
Average water and sediment baseline concentrations are presented in Table 3-5, and a comparison to measured values is shown in Figure 3-2 and Figure 3-3. These plots indicate generally good agreement between measured and modelled COPC concentrations in water and sediment. Metals and radionuclides are expected to interact with water and, in the case of radionuclides, ingrowth and decay are other factors that may influence activities in the receiving environment. As shown in Figure 3-3, the modelled concentration in sediment falls in the range of measured concentrations for most of the COPCs with the exception for arsenic and radium-226 which are likely overestimated (which is conservative). Poor agreement between modelled and measured concentration of arsenic and radium-226 are likely due to lack of measured data; only one sampling campaign was conducted for sediment. The modelled sediment concentrations can be refined in the future when more measured sediment data are available.

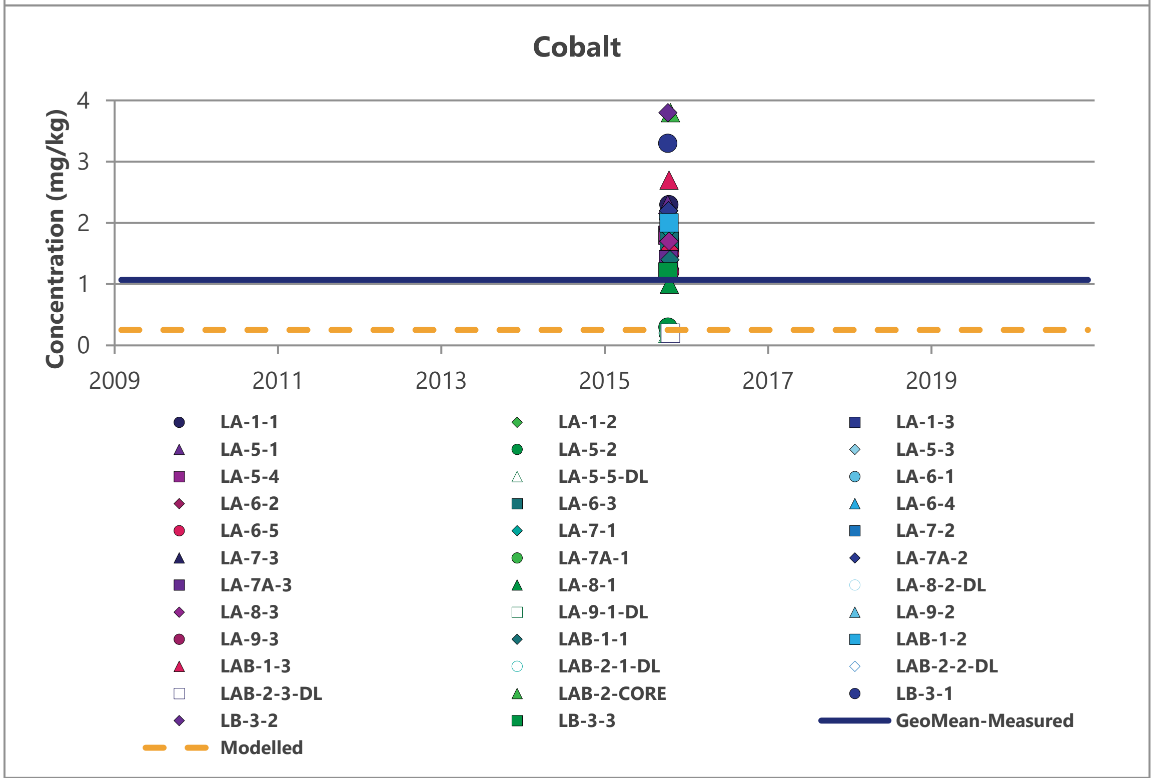
Table 3-5: Baseline Water and Sediment Concentrations Used in the IMPACT model

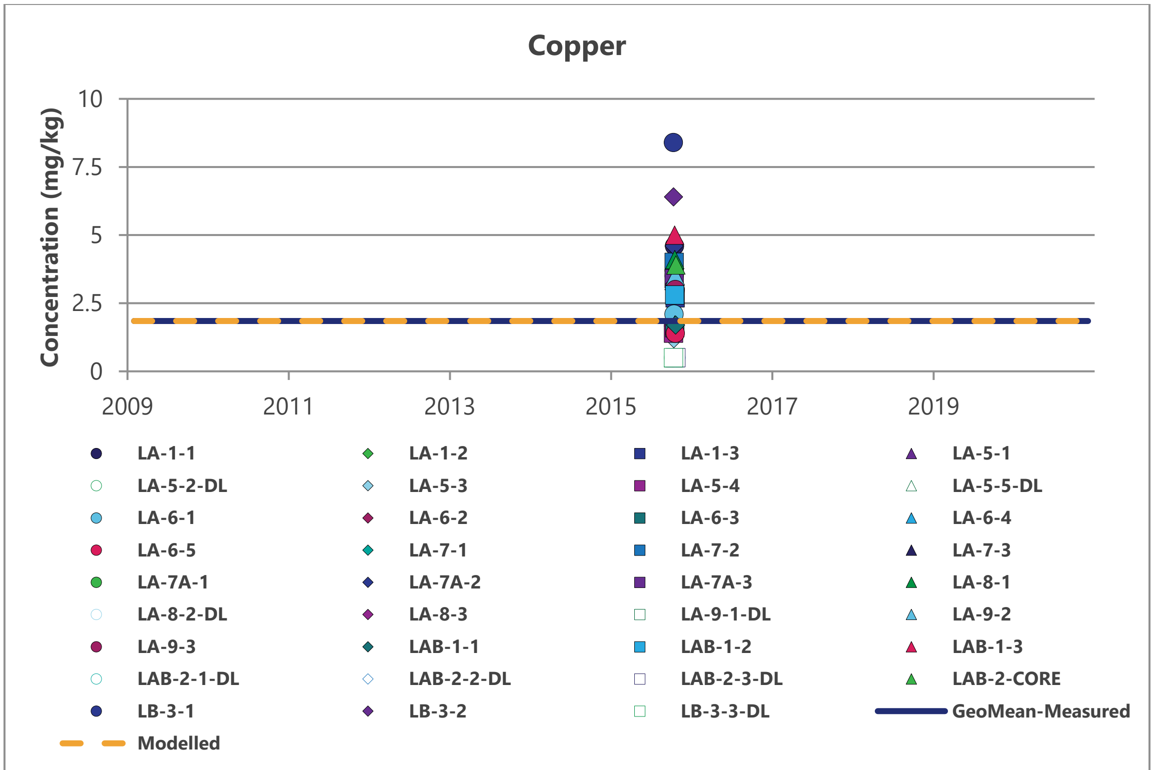
COPCs	Water Baseline Concentration	Sediment Baseline Concentration
Non-radionuclides	**mg/L**	**mg/kg dw**
Arsenic	**1.03E-04**	8.35E+00
Cadmium	2.32E-05	**3.38E-01**
Chloride	**3.22E-01**	-
Chromium	5.19E-04	**5.86E+00**
Cobalt	**1.01E-04**	2.52E-01
Copper	6.18E-04	**1.85E+00**
Molybdenum	**1.07E-04**	3.37E-01
Selenium	3.23E-05	**6.22E-01**
Sulphate	**6.87E-01**	-
Uranium	3.01E-05	**5.78E-01**
Vanadium	1.46E-04	**1.12E+01**
Zinc	**6.81E-04**	9.93E+00
Radionuclides	**Bq/L**	**Bq/kg dw**
Lead-210 [a]	5.27E-03	3.74E+02
Polonium-210	**5.36E-03**	3.80E+02
Radium-226	**5.57E-03**	6.51E+01
Thorium-230	**1.01E-02**	2.32E+01
Uranium-234 [b]	3.71E-04	7.14E+00
Uranium-238 [b]	3.71E-04	7.14E+00

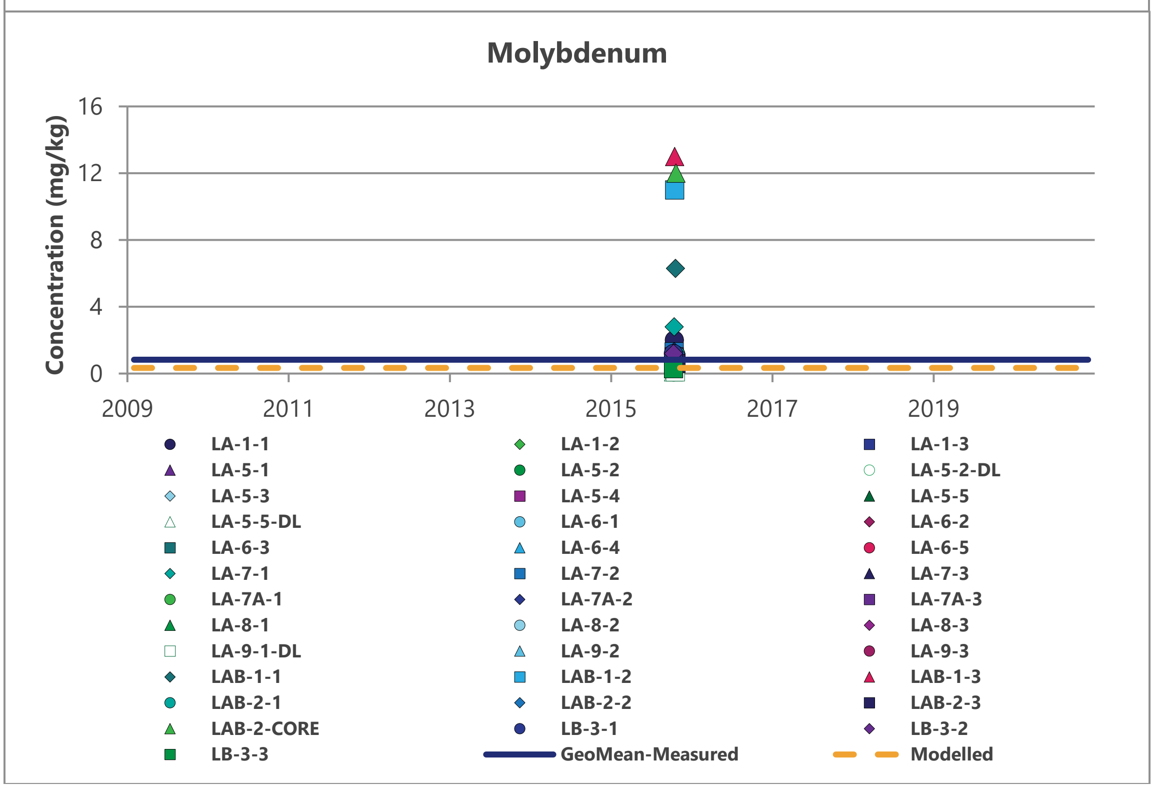
Dash (-) represents no value calculated as COPC does not partition to sediment.
Bold = measured values. Values that are not bolded indicate modelled values.
a. Calculated to be in transient equilibrium with polonium-210.
b. Estimated from uranium using the specific activity of 12,356 Bq/g and assuming secular equilibrium between uranium-238 and uranium-234 **(https://www.wise-uranium.org/rup.html).**
COPC = constituent of potential concern; dw = dry weight.

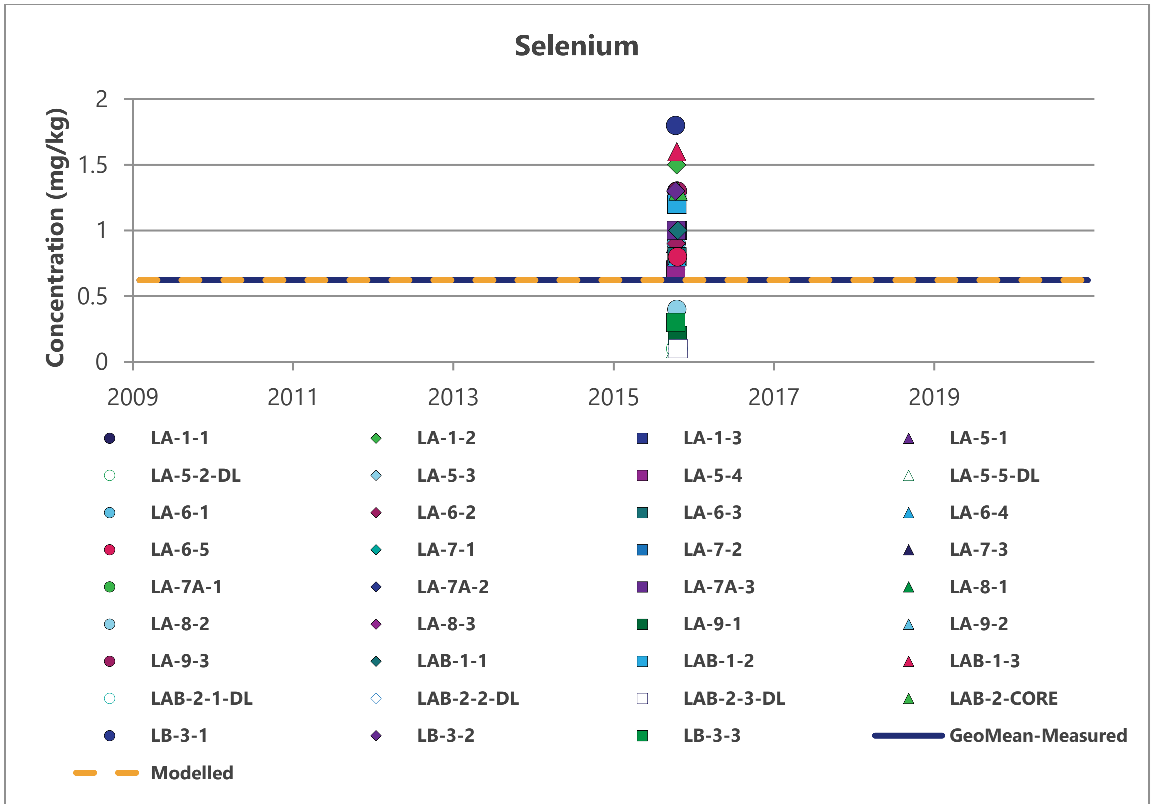


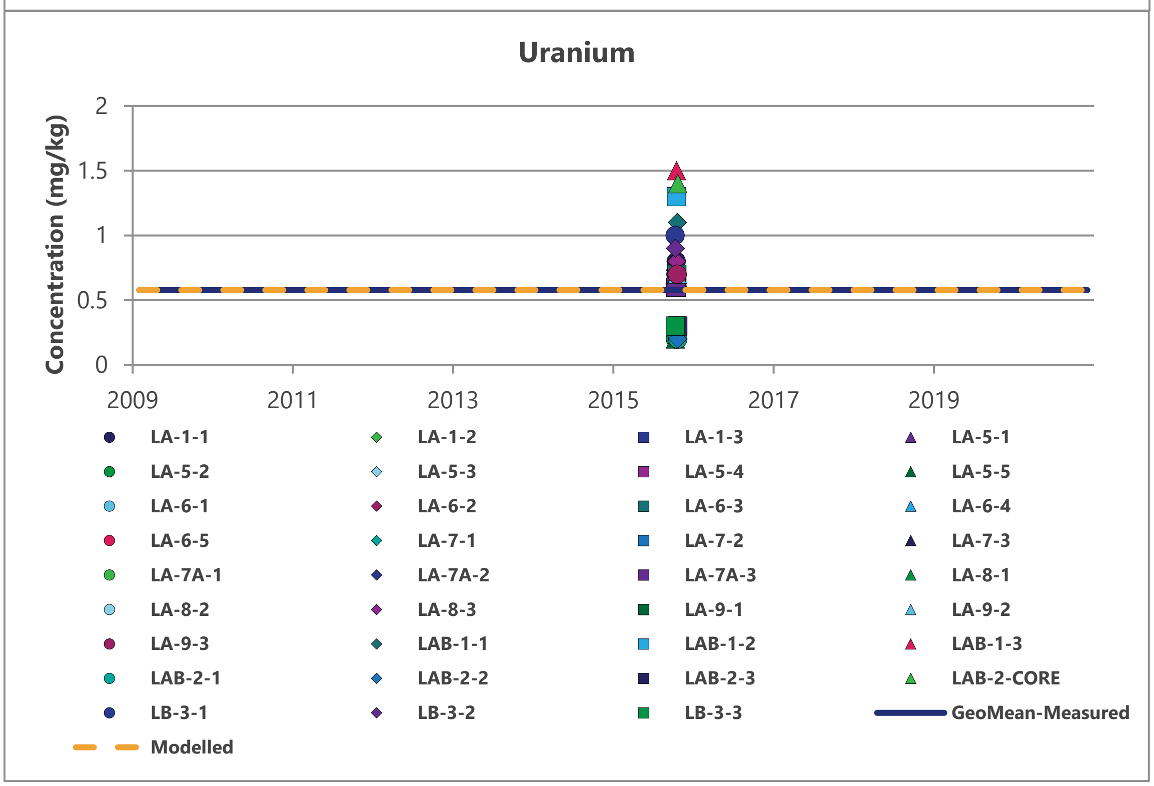

Cadmium
Concentration (mg/kg)
0
0.2
0.4
0.6
0.8
2009
2011
2013
2015
2017
2019
LA-1-1
LA-1-2
LA-1-3
LA-5-1
LA-5-2
LA-5-2-DL
LA-5-3
LA-5-4
LA-5-5
LA-6-1
LA-6-2
LA-6-3
LA-6-4
LA-6-5
LA-7-1
LA-7-2
LA-7-3
LA-7A-1
LA-7A-2
LA-7A-3
LA-8-1
LA-8-2
LA-8-3
LA-9-1
LA-9-2
LA-9-3
LAB-1-1
LAB-1-2
LAB-1-3
LAB-2-1
LAB-2-2-DL
LAB-2-3
LAB-2-CORE
LB-3-1
LB-3-2
LB-3-3
GeoMean-Measured
Modelled
SQO

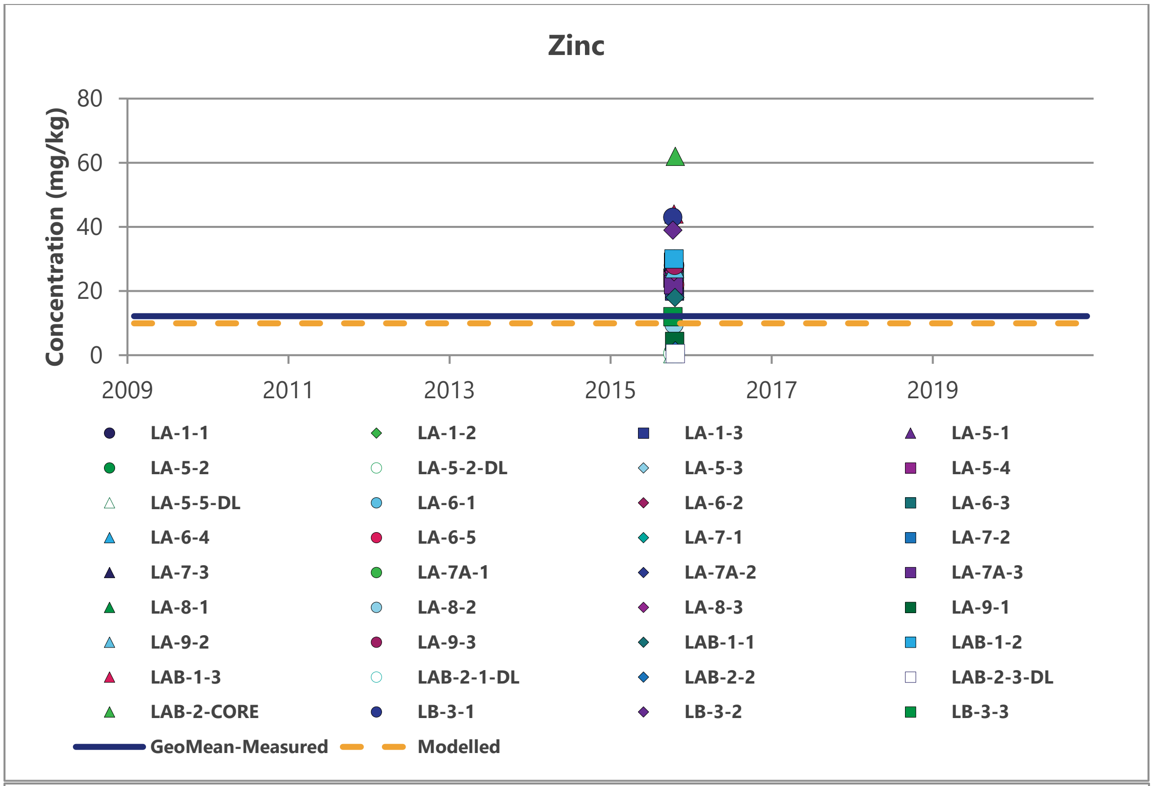

Cobalt
Concentration (mg/kg)
0
1
2
3
4
2009
2011
2013
2015
2017
2019
LA-1-1
LA-1-2
LA-1-3
LA-5-1
LA-5-2
LA-5-3
LA-5-4
LA-5-5-DL
LA-6-1
LA-6-2
LA-6-3
LA-6-4
LA-6-5
LA-7-1
LA-7-2
LA-7-3
LA-7A-1
LA-7A-2
LA-7A-3
LA-8-1
LA-8-2-DL
LA-8-3
LA-9-1-DL
LA-9-2
LA-9-3
LAB-1-1
LAB-1-2
LAB-1-3
LAB-2-1-DL
LAB-2-2-DL
LAB-2-3-DL
LAB-2-CORE
LB-3-1
LB-3-2
LB-3-3
GeoMean-Measured
Modelled

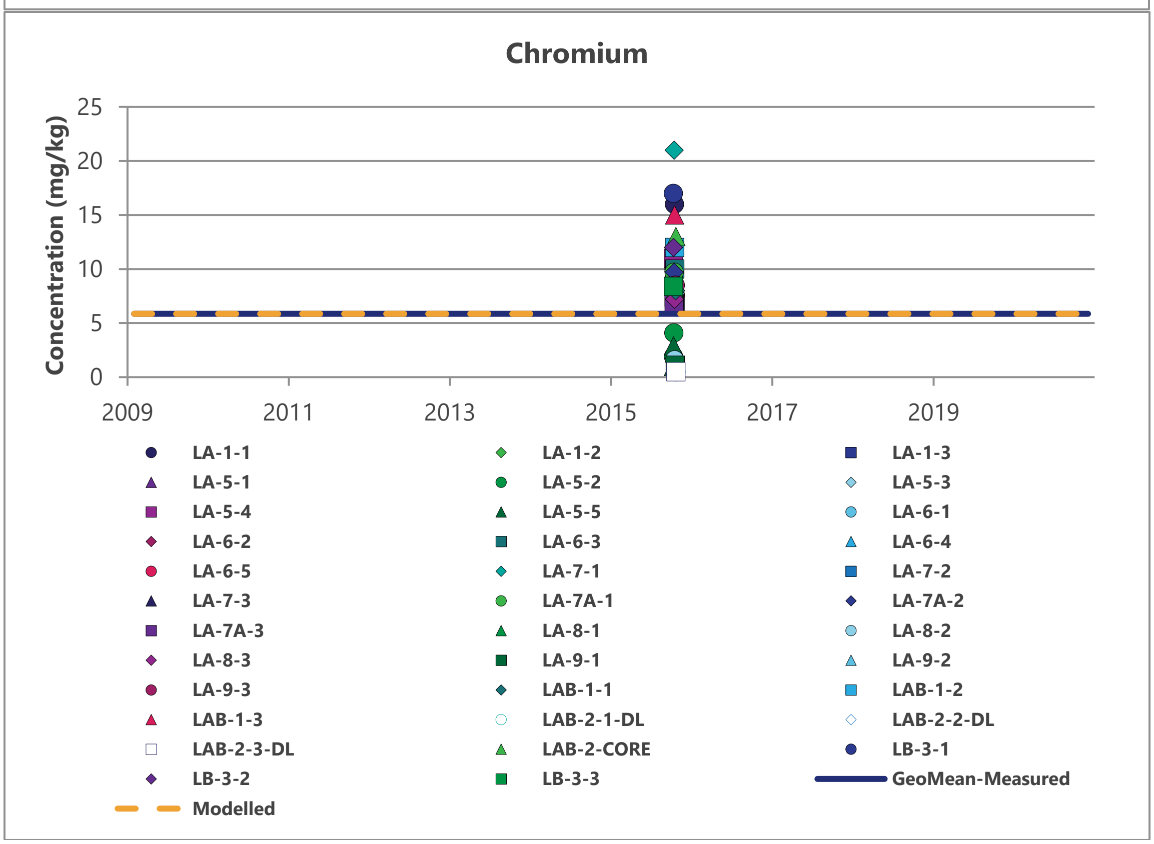

Copper
Concentration (mg/kg)
10
7.5
5
2.5
0
2009
2011
2013
2015
2017
2019
LA-1-1
LA-1-2
LA-1-3
LA-5-1
LA-5-2-DL
LA-5-3
LA-5-4
LA-5-5-DL
LA-6-1
LA-6-2
LA-6-3
LA-6-4
LA-6-5
LA-7-1
LA-7-2
LA-7-3
LA-7A-1
LA-7A-2
LA-7A-3
LA-8-1
LA-8-2-DL
LA-8-3
LA-9-1-DL
LA-9-2
LA-9-3
LAB-1-1
LAB-1-2
LAB-1-3
LAB-2-1-DL
LAB-2-2-DL
LAB-2-3-DL
LAB-2-CORE
LB-3-1
LB-3-2
LB-3-3-DL
GeoMean-Measured
Modelled

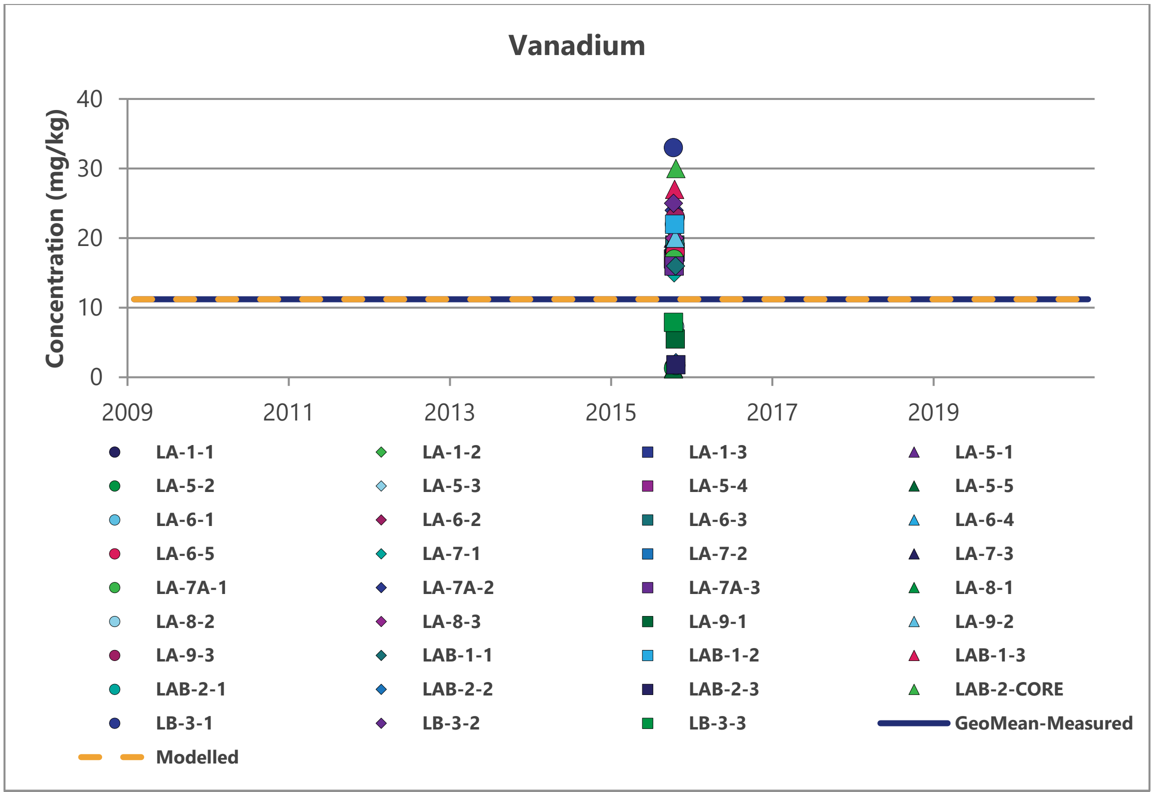

Molybdenum
Concentration (mg/kg)
16
12
8
4
0
2009
2011
2013
2015
2017
2019
LA-1-1
LA-1-2
LA-1-3
LA-5-1
LA-5-2
LA-5-2-DL
LA-5-3
LA-5-4
LA-5-5
LA-5-5-DL
LA-6-1
LA-6-2
LA-6-3
LA-6-4
LA-6-5
LA-7-1
LA-7-2
LA-7-3
LA-7A-1
LA-7A-2
LA-7A-3
LA-8-1
LA-8-2
LA-8-3
LA-9-1-DL
LA-9-2
LA-9-3
LAB-1-1
LAB-1-2
LAB-1-3
LAB-2-1
LAB-2-2
LAB-2-3
LAB-2-CORE
LB-3-1
LB-3-2
LB-3-3
GeoMean-Measured
Modelled

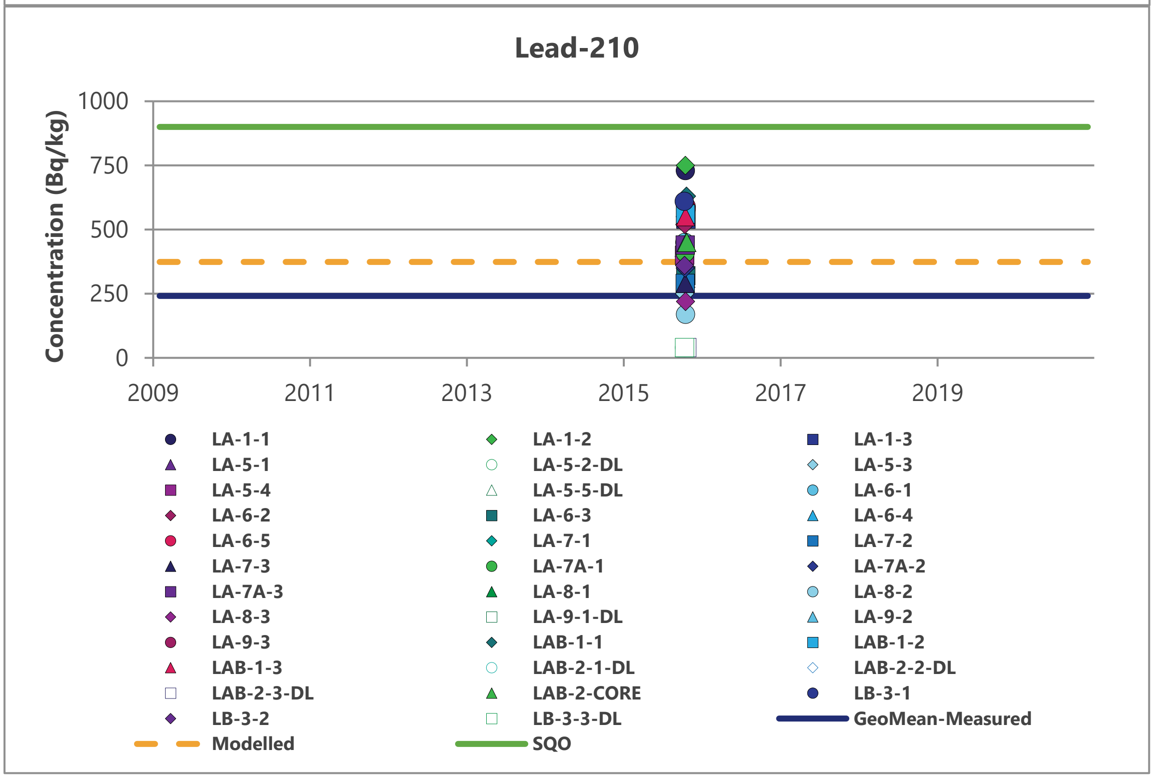

Selenium
Concentration (mg/kg)
0
0.5
1
1.5
2
2009
2011
2013
2015
2017
2019
LA-1-1
LA-1-2
LA-1-3
LA-5-1
LA-5-2-DL
LA-5-3
LA-5-4
LA-5-5-DL
LA-6-1
LA-6-2
LA-6-3
LA-6-4
LA-6-5
LA-7-1
LA-7-2
LA-7-3
LA-7A-1
LA-7A-2
LA-7A-3
LA-8-1
LA-8-2
LA-8-3
LA-9-1
LA-9-2
LA-9-3
LAB-1-1
LAB-1-2
LAB-1-3
LAB-2-1-DL
LAB-2-2-DL
LAB-2-3-DL
LAB-2-CORE
LB-3-1
LB-3-2
LB-3-3
GeoMean-Measured
Modelled

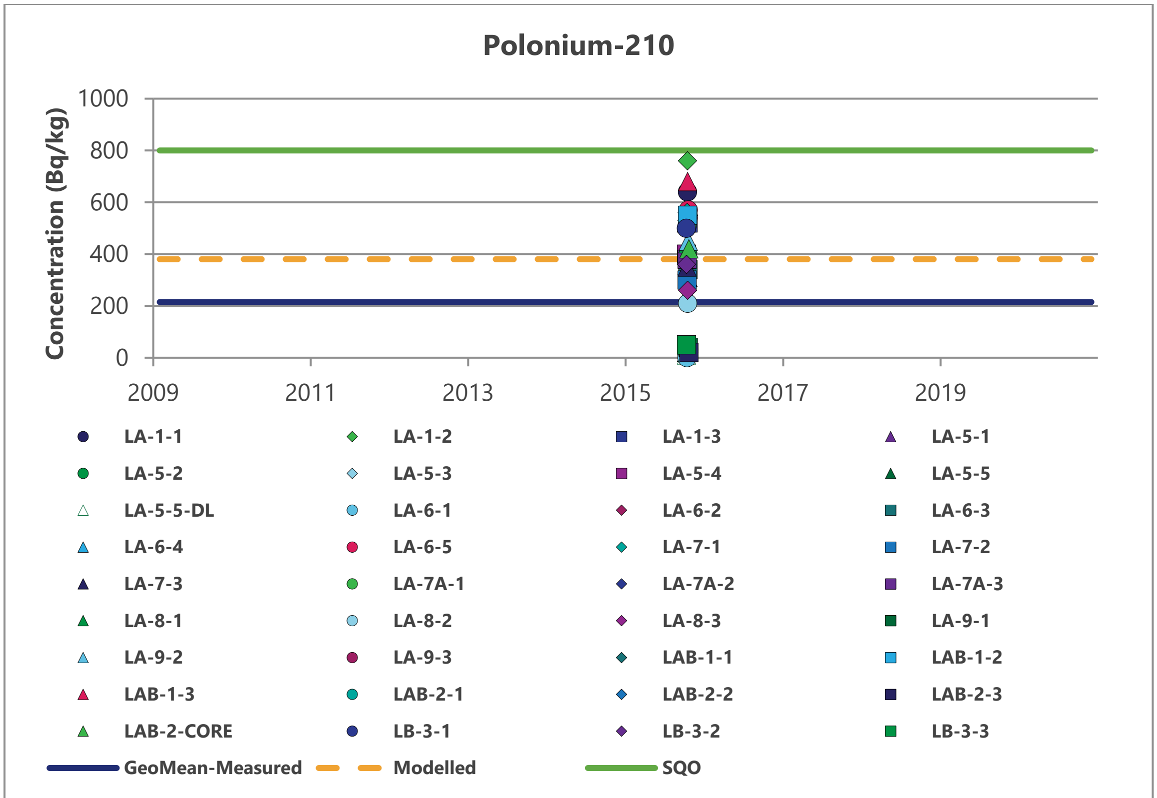

Uranium
Concentration (mg/kg)
0
0.5
1
1.5
2
2009
2011
2013
2015
2017
2019
LA-1-1
LA-1-2
LA-1-3
LA-5-1
LA-5-2
LA-5-3
LA-5-4
LA-5-5
LA-6-1
LA-6-2
LA-6-3
LA-6-4
LA-6-5
LA-7-1
LA-7-2
LA-7-3
LA-7A-1
LA-7A-2
LA-7A-3
LA-8-1
LA-8-2
LA-8-3
LA-9-1
LA-9-2
LA-9-3
LAB-1-1
LAB-1-2
LAB-1-3
LAB-2-1
LAB-2-2
LAB-2-3
LAB-2-CORE
LB-3-1
LB-3-2
LB-3-3
GeoMean-Measured
Modelled

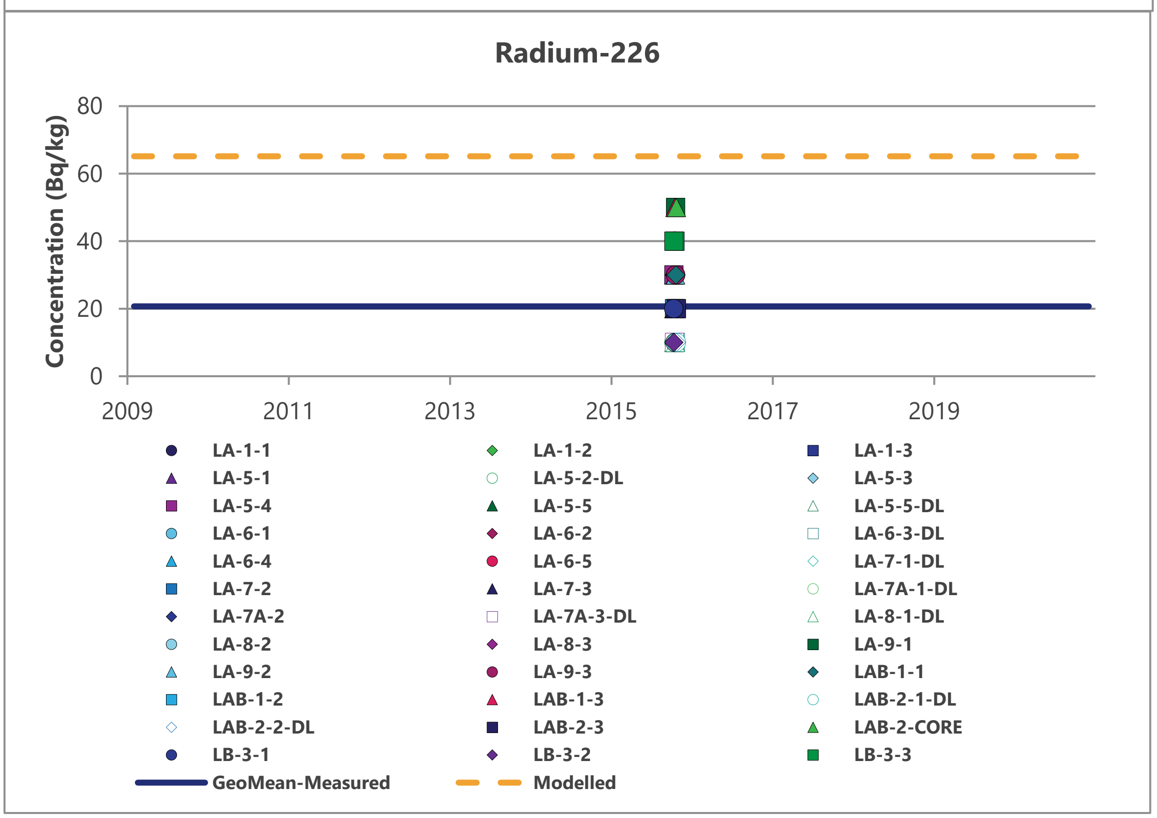

Zinc
Concentration (mg/kg)
0
20
40
60
80
2009
2011
2013
2015
2017
2019
LA-1-1
LA-1-2
LA-1-3
LA-5-1
LA-5-2
LA-5-2-DL
LA-5-3
LA-5-4
LA-5-5-DL
LA-6-1
LA-6-2
LA-6-3
LA-6-4
LA-6-5
LA-7-1
LA-7-2
LA-7-3
LA-7A-1
LA-7A-2
LA-7A-3
LA-8-1
LA-8-2
LA-8-3
LA-9-1
LA-9-2
LA-9-3
LAB-1-1
LAB-1-2
LAB-1-3
LAB-2-1-DL
LAB-2-2
LAB-2-3-DL
LAB-2-CORE
LB-3-1
LB-3-2
LB-3-3
GeoMean-Measured
Modelled

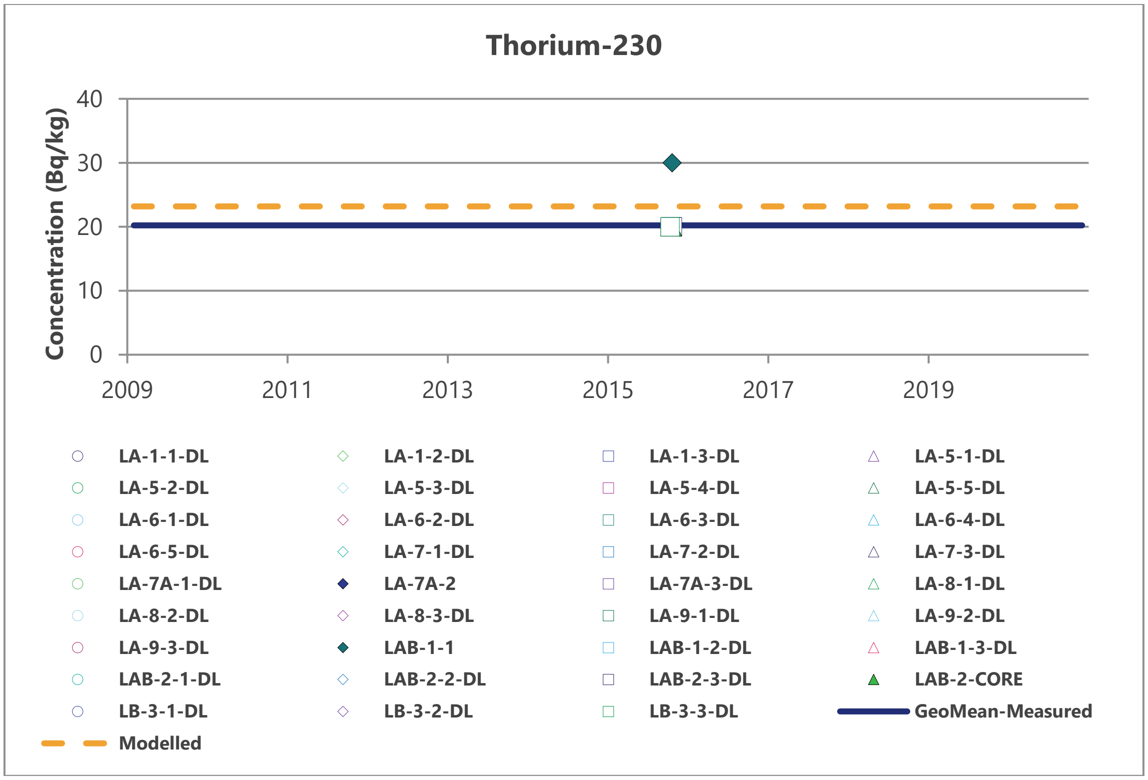

Chromium
Concentration (mg/kg)
0
5
10
15
20
25
2009
2011
2013
2015
2017
2019
LA-1-1
LA-1-2
LA-1-3
LA-5-1
LA-5-2
LA-5-3
LA-5-4
LA-5-5
LA-6-1
LA-6-2
LA-6-3
LA-6-4
LA-6-5
LA-7-1
LA-7-2
LA-7-3
LA-7A-1
LA-7A-2
LA-7A-3
LA-8-1
LA-8-2
LA-8-3
LA-9-1
LA-9-2
LA-9-3
LAB-1-1
LAB-1-2
LAB-1-3
LAB-2-1-DL
LAB-2-2-DL
LAB-2-3-DL
LAB-2-CORE
LB-3-1
LB-3-2
LB-3-3
GeoMean-Measured
Modelled


Vanadium
Concentration (mg/kg)
40
30
20
10
0
2009
2011
2013
2015
2017
2019
LA-1-1
LA-1-2
LA-1-3
LA-5-1
LA-5-2
LA-5-3
LA-5-4
LA-5-5
LA-6-1
LA-6-2
LA-6-3
LA-6-4
LA-6-5
LA-7-1
LA-7-2
LA-7-3
LA-7A-1
LA-7A-2
LA-7A-3
LA-8-1
LA-8-2
LA-8-3
LA-9-1
LA-9-2
LA-9-3
LAB-1-1
LAB-1-2
LAB-1-3
LAB-2-1
LAB-2-2
LAB-2-3
LAB-2-CORE
LB-3-1
LB-3-2
LB-3-3
GeoMean-Measured
Modelled


Lead-210
Concentration (Bq/kg)
1000
750
500
250
0
2009
2011
2013
2015
2017
2019
LA-1-1
LA-1-2
LA-1-3
LA-5-1
LA-5-2-DL
LA-5-3
LA-5-4
LA-5-5-DL
LA-6-1
LA-6-2
LA-6-3
LA-6-4
LA-6-5
LA-7-1
LA-7-2
LA-7-3
LA-7A-1
LA-7A-2
LA-7A-3
LA-8-1
LA-8-2
LA-8-3
LA-9-1-DL
LA-9-2
LA-9-3
LAB-1-1
LAB-1-2
LAB-1-3
LAB-2-1-DL
LAB-2-2-DL
LAB-2-3-DL
LAB-2-CORE
LB-3-1
LB-3-2
LB-3-3-DL
GeoMean-Measured
Modelled
SQO


Polonium-210
Concentration (Bq/kg)
1000
800
600
400
200
0
2009
2011
2013
2015
2017
2019
LA-1-1
LA-1-2
LA-1-3
LA-5-1
LA-5-2
LA-5-3
LA-5-4
LA-5-5
LA-5-5-DL
LA-6-1
LA-6-2
LA-6-3
LA-6-4
LA-6-5
LA-7-1
LA-7-2
LA-7-3
LA-7A-1
LA-7A-2
LA-7A-3
LA-8-1
LA-8-2
LA-8-3
LA-9-1
LA-9-2
LA-9-3
LAB-1-1
LAB-1-2
LAB-1-3
LAB-2-1
LAB-2-2
LAB-2-3
LAB-2-CORE
LB-3-1
LB-3-2
LB-3-3
GeoMean-Measured
Modelled
SQO


Radium-226
Concentration (Bq/kg)
80
60
40
20
0
2009
2011
2013
2015
2017
2019
LA-1-1
LA-1-2
LA-1-3
LA-5-1
LA-5-2-DL
LA-5-3
LA-5-4
LA-5-5
LA-5-5-DL
LA-6-1
LA-6-2
LA-6-3-DL
LA-6-4
LA-6-5
LA-7-1-DL
LA-7-2
LA-7-3
LA-7A-1-DL
LA-7A-2
LA-7A-3-DL
LA-8-1-DL
LA-8-2
LA-8-3
LA-9-1
LA-9-2
LA-9-3
LAB-1-1
LAB-1-2
LAB-1-3
LAB-2-1-DL
LAB-2-2-DL
LAB-2-3
LAB-2-CORE
LB-3-1
LB-3-2
LB-3-3
GeoMean-Measured
Modelled



SQO = Sediment Quality Objective, The SQO is only shown in the figures for those COPCs whose measured/modelled concentrations are close to its SQO. Blank symbol indicates that the measurement was under the detection limit. The location of sampling stations is described in detail in baseline aquatic environment study report (Ecometrix, 2020a).

Figure 3-3: Modelled and Measured Baseline Concentrations in Sediment

3.3.2 Water to Sediment Partitioning Coefficients

The water-to-sediment partitioning coefficients (K_d) are regional parameters governing the exchange between sediment and water in lakes. The K_d values are used to estimate the fraction of a constituent that is associated with the particulate fraction in the shallow sediment layer (f_s). The fraction of COPC in the solid phase is estimated using the following equation:

$$f_s = \frac{K_d \cdot \frac{\rho_s}{\varepsilon_s}}{1 + K_d \cdot \frac{\rho_s}{\varepsilon_s}}$$

where:

ε_s	=	porosity of surficial sediment (unitless)
K_d	=	distribution coefficient between water and sediment (L/kg)
ρ_s	=	bulk density of surficial sediment (kg/L)

The K_d values used in this model are presented in Table 3-6. They consist of regional published values that have been calibrated on similar sites in northern Saskatchewan and have been checked against Wheeler River measurement data as shown in Figure 3-2 and Figure 3-3.

Table 3-6: Distribution Coefficients (K_d) Used in the IMPACT Model

COPC	Distribution Coefficient L/kg (dw)
Arsenic	9.64E+04
Cadmium	1.50E+04
Chromium	1.16E+04
Cobalt	2.50E+03
Copper	3.00E+03
Molybdenum	3.17E+03
Selenium	2.00E+04
Uranium	2.00E+04
Vanadium	9.10E+04
Zinc	1.50E+04
Lead-210	1.20E+05
Polonium-210	1.20E+05
Radium-226	1.20E+04
Thorium-230	2.30E+03
Uranium-234	2.00E+04
Uranium-238	2.00E+04

COPC = constituent of potential concern; dw = dry weight.

3.4 Air Quality

Risk through air exposure pathways is considered during Construction, Operation, and Decommissioning. Table 3-7 presents the modelled air quality, based on Project emissions and baseline air quality during Construction, Operation, and Decommissioning at the locations of interest for human and ecological receptors. Air quality data was obtained from the Air Quality Impact Assessment report (IEC, 2024).

Table 3-7: Modelled Air Quality for Human and Ecological Receptors

Project Phase	Arsenic	Cadmium	Cobalt	Chromium	Copper	Molybdenum	Selenium	Uranium	Vanadium	Zinc	Radon-222	Uranium-234[a]	Uranium-238[a]
	mg/m^3	mg/m^3	mg/m^3	mg/m^3	mg/m^3	mg/m^3	mg/m^3	mg/m^3	mg/m^3	mg/m^3	Bq/m^3	Bq/m^3	Bq/m^3
	Air Baseline												
Baseline	7.00E-07	7.44E-08	7.07E-07	1.49E-07	6.30E-05	7.19E-07	1.54E-07	6.00E-07	1.43E-06	2.16E-04	0.00E+00	7.41E-06	7.41E-06
	Air Quality at Camp Location for Human Receptors												
Construction	7.05E-07	7.50E-08	7.10E-07	1.53E-07	6.31E-05	7.25E-07	1.55E-07	4.12E-06	1.44E-06	2.16E-04	2.15E+00	5.09E-05	5.09E-05
Operation	7.04E-07	7.58E-08	7.14E-07	1.68E-07	6.33E-05	7.24E-07	1.57E-07	1.77E-05	1.46E-06	2.16E-04	1.24E+01	2.19E-04	2.19E-04
Decommissioning	7.00E-07	7.44E-08	7.07E-07	1.49E-07	6.30E-05	7.19E-07	1.54E-07	7.70E-07	1.43E-06	2.16E-04	8.57E+00	9.51E-06	9.51E-06
	Air Quality at Whitefish Lake for Ecological Receptors												
Construction	7.01E-07	7.45E-08	7.07E-07	1.50E-07	6.30E-05	7.20E-07	1.54E-07	1.26E-06	1.43E-06	2.16E-04	1.98E+00	1.55E-05	1.55E-05
Operation	7.12E-07	7.75E-08	7.22E-07	1.93E-07	6.38E-05	7.34E-07	1.61E-07	3.45E-05	1.51E-06	2.16E-04	3.61E+01	4.26E-04	4.26E-04
Decommissioning	7.01E-07	7.45E-08	7.07E-07	1.51E-07	6.30E-05	7.21E-07	1.54E-07	1.47E-06	1.43E-06	2.16E-04	1.71E+01	1.82E-05	1.82E-05
	Air Quality at McGowan Lake for Human and Ecological Receptors												
Construction	7.00E-07	7.44E-08	7.07E-07	1.49E-07	6.30E-05	7.19E-07	1.54E-07	6.90E-07	1.43E-06	2.16E-04	2.60E-01	8.53E-06	8.53E-06
Operation	7.01E-07	7.47E-08	7.08E-07	1.54E-07	6.31E-05	7.20E-07	1.55E-07	5.05E-06	1.43E-06	2.16E-04	2.50E+00	6.23E-05	6.23E-05
Decommissioning	7.00E-07	7.44E-08	7.07E-07	1.49E-07	6.30E-05	7.19E-07	1.54E-07	6.39E-07	1.43E-06	2.16E-04	1.51E+00	7.90E-06	7.90E-06
	Air Quality at Russell Lake Inlet for Human and Ecological Receptors												
Construction	7.00E-07	7.44E-08	7.07E-07	1.49E-07	6.30E-05	7.19E-07	1.54E-07	6.19E-07	1.43E-06	2.16E-04	5.64E-02	7.65E-06	7.65E-06
Operation	7.00E-07	7.45E-08	7.07E-07	1.50E-07	6.30E-05	7.19E-07	1.54E-07	1.79E-06	1.43E-06	2.16E-04	5.92E-01	2.21E-05	2.21E-05
Decommissioning	7.00E-07	7.44E-08	7.07E-07	1.49E-07	6.30E-05	7.19E-07	1.54E-07	6.08E-07	1.43E-06	2.16E-04	3.71E-01	7.51E-06	7.51E-06

Note:

a) Uranium-234/238 concentration was calculated using a specific activity of 12.356 Bq/mg.

COPC = constituent of potential concern; Bq = becquerel.

3.5 Soil Quality

3.5.1 Background Soil Quality

Regional background soil chemistry was derived from baseline data collected from 10 sample sites in August 2017 (Omnia, 2020). The geometric mean of 10 soil sample results was used to characterize background concentrations of metals and radionuclides in soil. Table 3-8 presents the selected background soil concentrations used in the IMPACT model. Sandy soil was selected for the IMPACT model based on baseline studies identifying sandy and gravelly Podzols, Brunisols, and Luvisols occurring on till materials, while sand and sandy loam Brunisols have developed on glaciofluvial deposits.

Table 3-8: Soil Baseline Concentrations

COPC	Unit	Soil Baseline Concentration
Arsenic	mg/kg (dw)	6.16E-01
Cadmium	mg/kg (dw)	3.61E-01
Chromium	mg/kg (dw)	3.31E+00
Cobalt	mg/kg (dw)	2.65E-01
Copper	mg/kg (dw)	1.46E+00
Molybdenum	mg/kg (dw)	1.15E-01
Selenium	mg/kg (dw)	1.07E-01
Uranium	mg/kg (dw)	3.82E-01
Vanadium	mg/kg (dw)	4.81E+00
Zinc	mg/kg (dw)	5.31E+00
Lead-210	Bq/kg (dw)	7.29E+01
Polonium-210	Bq/kg (dw)	6.55E+01
Radium-226	Bq/kg (dw)	1.52E+01
Thorium-230	Bq/kg (dw)	2.00E+01
Uranium-234	Bq/kg (dw)	4.72E+00
Uranium-238	Bq/kg (dw)	4.72E+00

a) Uranium-234/238 concentration was calculated using a specific activity of 12.356 Bq/mg.
COPC = constituent of potential concern; Bq = becquerel; dw = dry weight.

3.5.2 Soil Quality during the Project

Soil quality during construction, operation, and decommissioning was estimated based on the modelled air quality at each location of interest for human and ecological receptors. IMPACT calculates COPC concentrations in soil in terms of concentration per kg of dry soil, following the soil model equations in CSA N288.1-20 (Section 2.3.4).

For wet deposition, the fraction of the time that precipitation falls when the wind blows from a specific sector was set conservatively to 0.36 for all wind directions (CSA Group, 2020).

Concentrations calculated based on deposition from air to soil during project phases were added to baseline concentrations to represent the total exposure concentrations in soil.

3.6 Transfer of Constituents to Aquatic Receptors

A fundamental premise of pathways analysis is that chemical uptake by receptors is related to the receptors' level of exposure. A linear relationship is usually assumed and is represented by a bioaccumulation factor (BAF). For aquatic receptors, the BAF is the concentration in the organism (e.g., C_{fish}) divided by the concentration in water (C_{water}). The BAF may be estimated from organism and water data by fitting a regression line that generally is assumed to pass through the origin, such as "$C_{fish} = Slope \cdot C_{water}$". The slope of the regression line is the BAF. It represents the equilibrium ratio of C_{fish} / C_{water}.

The IMPACT model uses the BAF model as a simplification of the more complex multi-media uptake process. While several media (e.g., water and food) may contribute to COPC uptake into the animal tissue, at steady state, all media concentrations will have a fixed ratio to the tissue concentration. Thus, the BAF based on water and tissue measurements will reflect all the multi-media contributions to uptake. If animals and their prey are in equilibrium with the COPC in the environment, their concentrations can be estimated using an overall BAF between the water and the organism (Thomann and Mueller 1987). If animals have not reached equilibrium because they have not spent enough time in the exposure situation, because they are migratory or the project effects are transient, the BAF provides a conservative estimate of tissue concentrations.

As a result of physiological control, intracellular storage, and different excretion mechanisms, biota have an ability to actively regulate the body burden of many metals, including selenium, and maintain homeostatic control over a range of exposures (Chapman et al. 1996; Hamilton and Mehrle 1986; Wood and Port 2000). These homeostatic controls can produce non-linear relationships between the steady-state tissue concentrations and the environmental exposure concentrations (Newman and Unger 2002). However, these complicating issues do not diminish the importance, or negate the practical application, of BAFs in the assessment of environmental risks associated with COPCs.

Because of non-linearity and other factors, BAF values cited in the literature vary over a considerable range. BAF values based on site-specific data are preferred. The values of BAFs based on background concentrations tend to be higher than those based on higher exposure concentrations in affected environments. In this model BAFs representative of regional conditions have been used. The predictions are compared to the measured baseline values in Section 3.6.2.

3.6.1 Aquatic Bioaccumulation Factors

Bioaccumulation factors relate the COPCs in the environmental media to the concentration in the receptor. Water-based BAFs were used to calculate COPC concentrations in aquatic and terrestrial plant, invertebrate, and fish tissues. These factors were generally obtained from CSA N288.1-20 and the International Atomic Energy Agency (IAEA 2010), and from publicly available regional data from other uranium mine sites in northern Saskatchewan. Table 3-9 shows all aquatic BAFs used in the model.

The water-based BAFs for aquatic organisms were based on measured ratios of COPC concentration in tissue vs. water, under multi-media equilibrium conditions.

$$\text{BAF (L/kg fresh weight)} = \frac{\text{Concentration in Tissue (mg/kg fresh weight)}}{\text{Concentration in Water (mg/L)}}$$

While expressed relative to water, BAFs represent all pathways of COPC uptake into the organism, because all pathways were operating under the environmental conditions of BAF measurement. These pathways include food ingestion, dermal absorption, and uptake across the gills.

Table 3-9: Aquatic Bioaccumulation Factors (L/kg fw)

COPC	BAF (L/kg fw)					
	Macrophytes	Phytoplankton	Benthic Invertebrate [a]	Northern Pike	White Sucker	Zooplankton
Arsenic	1.72E+02	1.72E+02	5.40E+02	3.00E+02	3.00E+02	5.40E+02
Cadmium	6.53E+01	6.53E+01	2.60E+02	3.00E+00	3.00E+00	2.60E+02
Chromium [b]	1.00E+01	1.00E+01	3.90E+02	5.50E+01	5.50E+01	3.90E+02
Cobalt	1.58E+02	1.58E+02	2.00E+02	1.20E+01	1.20E+01	2.00E+02
Copper	2.17E+02	2.17E+02	7.80E+03	5.00E+02	5.00E+02	7.80E+03
Molybdenum	6.80E+00	6.80E+00	1.62E+02	1.00E-01	1.00E-01	1.62E+02
Selenium	1.77E+02	1.77E+02	1.07E+03	9.49E+02	4.43E+03	1.07E+03
Uranium	5.04E+01	5.04E+01	1.00E+02	2.00E+01	2.00E+01	1.00E+02
Vanadium [c]	3.25E+02	3.25E+02	3.90E+02	9.70E+01	9.70E+01	3.90E+02
Zinc	5.62E+02	5.62E+02	4.30E+03	2.00E+03	2.00E+03	4.30E+03
Lead-210 [d]	1.90E+03	1.90E+03	2.30E+03	6.00E+01	6.00E+01	2.30E+03
Polonium-210	2.93E+02	2.93E+02	1.58E+04	1.50E+02	1.50E+02	1.58E+04
Radium-226	1.63E+02	1.63E+02	2.50E+02	1.20E+01	1.20E+01	2.50E+02
Thorium-230	2.32E+02	2.32E+02	5.00E+02	6.00E+00	6.00E+00	5.00E+02
Uranium-234	5.04E+01	5.04E+01	1.00E+02	2.00E+01	2.00E+01	1.00E+02
Uranium-238	5.04E+01	5.04E+01	1.00E+02	2.00E+01	2.00E+01	1.00E+02

COPC = constituent of potential concern; fw = fresh weight.

Regional data was used for aquatic BAFs, except for:

a. Thorium-230, Radium-226, Uranium and Cobalt BAFs for Benthic Invertebrates are from Thompson et al. (1972)

b. Chromium BAFs are from CSA N288.1-20.

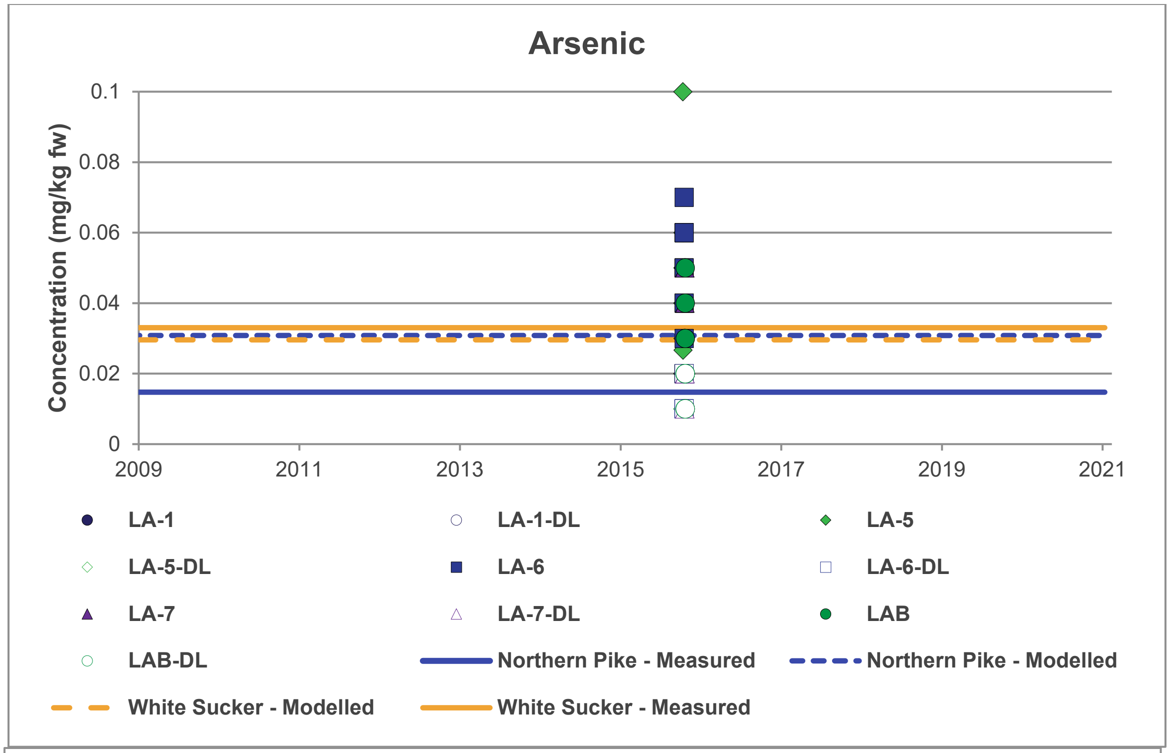
c. Vanadium BAFs are from IAEA TRS 472 (2010)

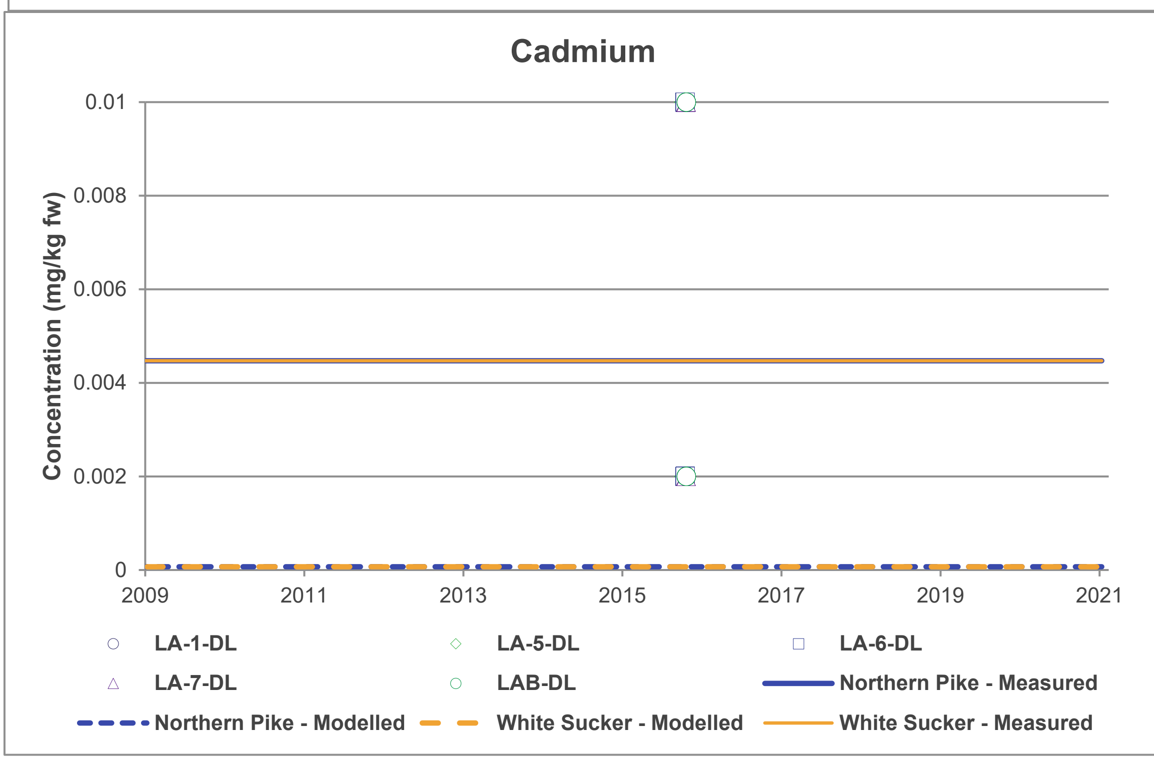
d. Lead-210 BAFs for macrophytes and phytoplankton are from IAEA TRS 472 (2010)

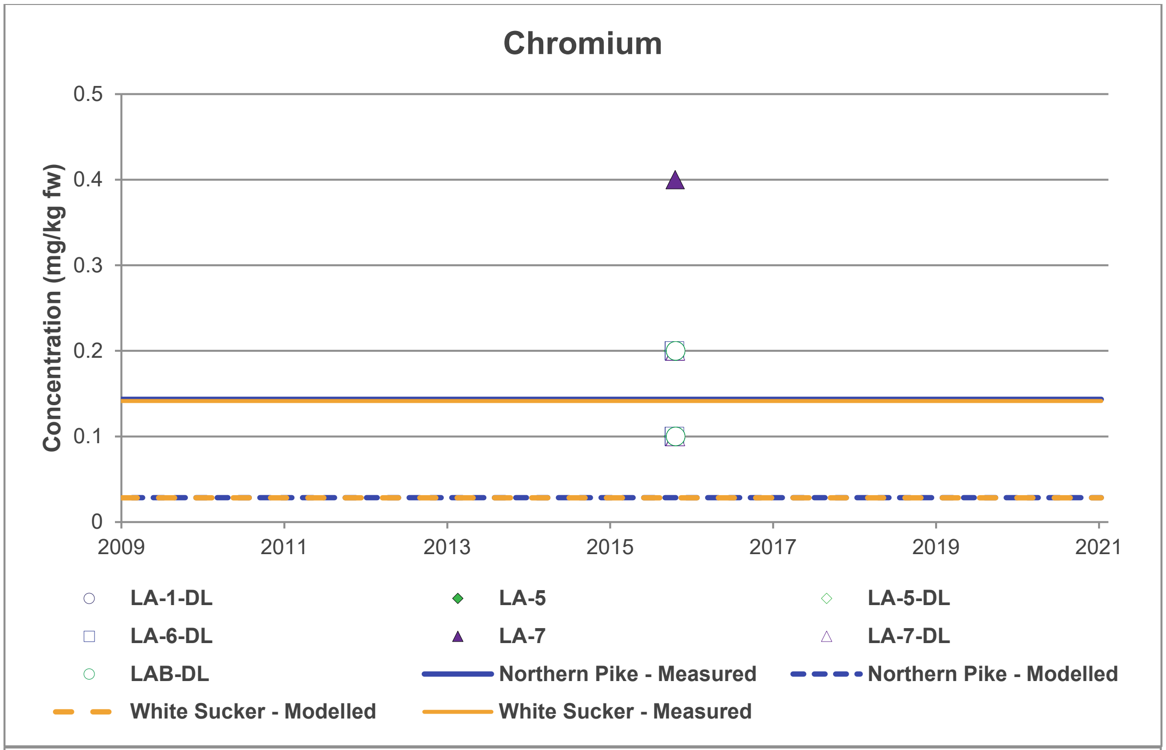
3.6.2 Model Validation

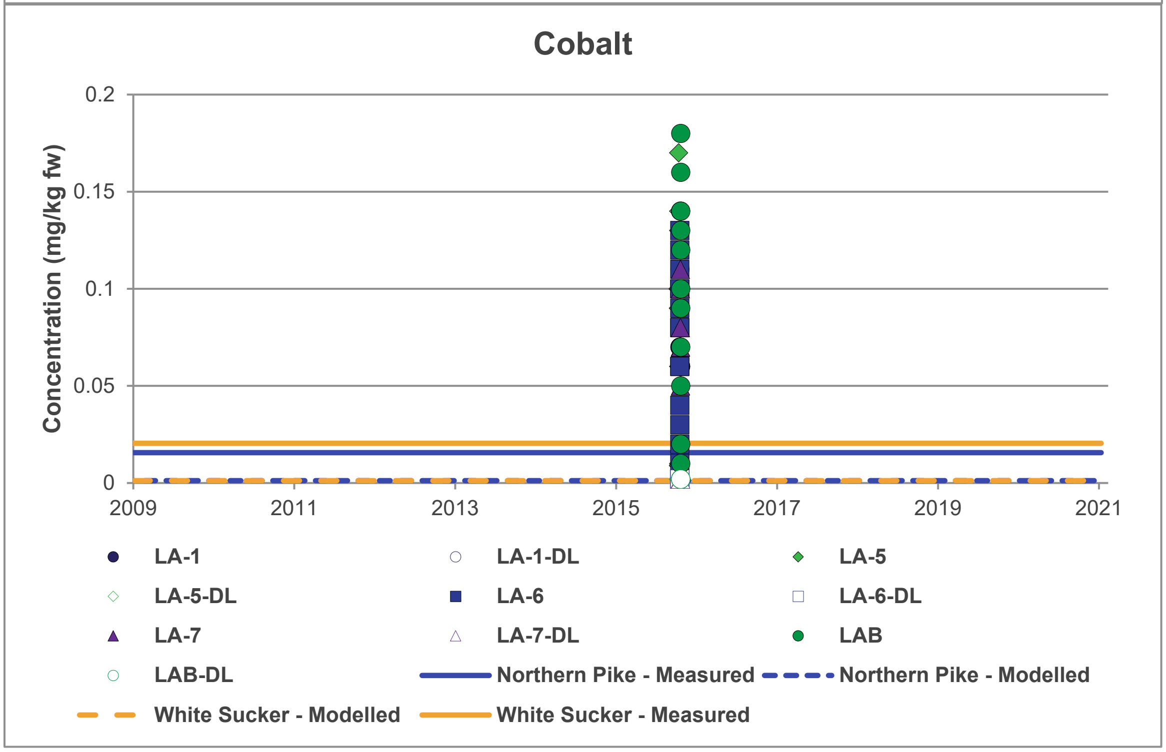
No measured data was available for other aquatic receptors except for northern pike and white sucker. Figure 3-4 presents the modelled and measured concentrations of COPCs in northern pike and white sucker from baseline sampling in 2016 and 2017 (Ecometrix, 2020a). Measured concentrations of radionuclides are mostly under the detection limit which agrees with the modelled concentrations.

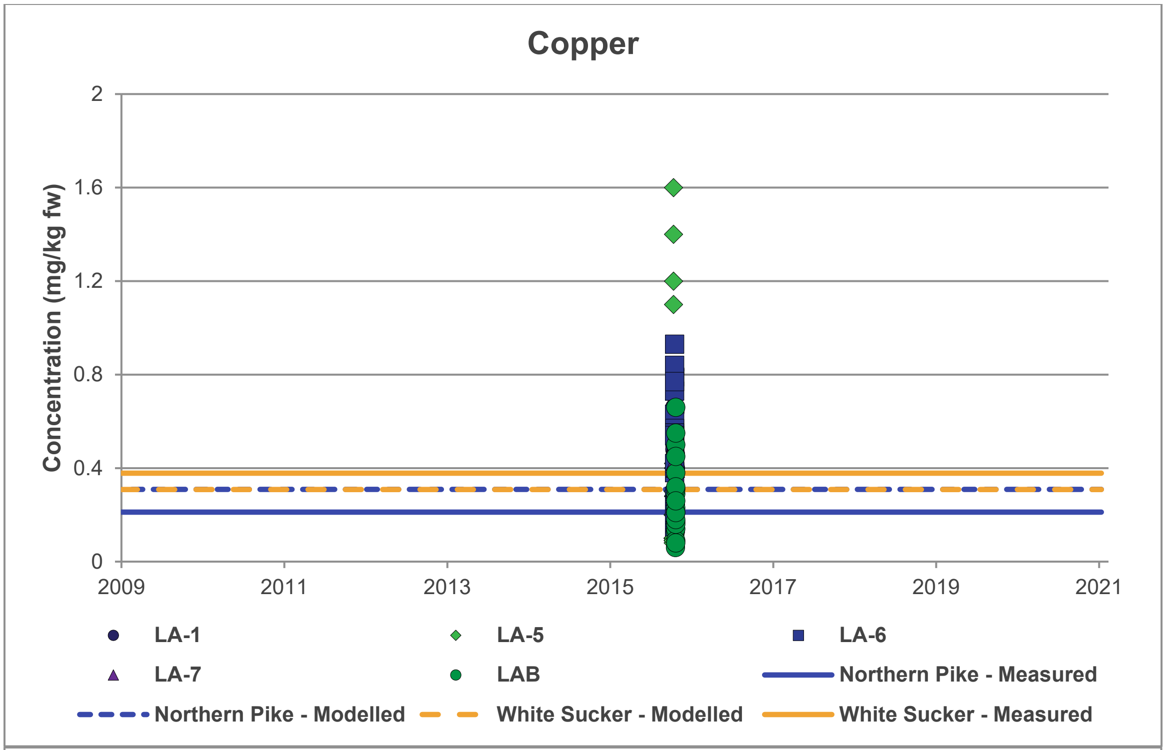
The modelled concentrations of the COPCs are generally in good agreement with the measured values. However, the data suggest that the model may be slightly underpredicting COPC concentrations in northern pike and white sucker, except for arsenic, copper, polonium-210 and selenium whose modelled concentrations are in good agreement with the measured ones. This is mainly due to data limitations: that only one sampling event was available and that measured values were often non-detectable. For instance, more than 90% of the measured concentrations for cadmium (100%), chromium (99%), molybdenum (95%), uranium (97%), vanadium (100%), lead-210 (96%), radium-226 (92%) and thorium-230 (97%) are below their detection limits, respectively. For non-detectable samples, the detection limit was used for calculation of averages in fish. The BAFs used are consistent with regionally calibrated values representing exposure conditions. The generally good agreement of the modelled results with the measured data validates the use of the selected BAFs and modelled processes. However, refinement of the BAFs for aquatic animals can be completed as new data become available during future phases of the Project.

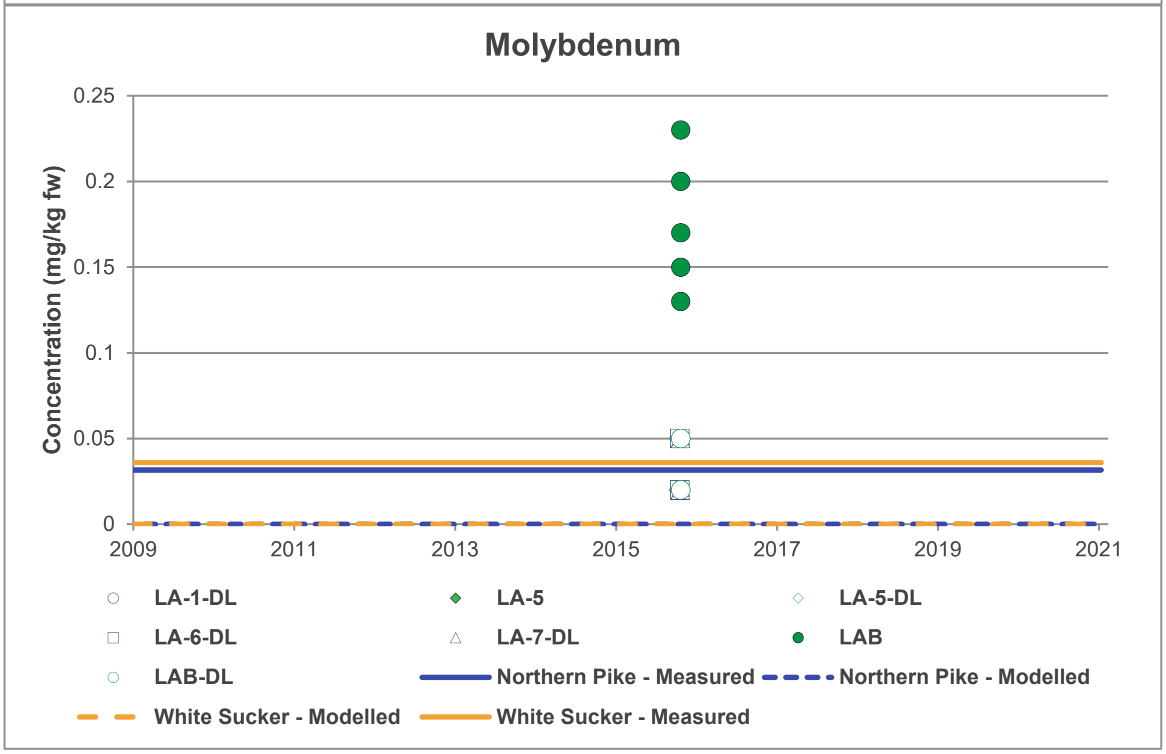

Arsenic
Concentration (mg/kg fw)
0.1
0.08
0.06
0.04
0.02
0
2009
2011
2013
2015
2017
2019
2021
LA-1
LA-1-DL
LA-5
LA-5-DL
LA-6
LA-6-DL
LA-7
LA-7-DL
LAB
LAB-DL
Northern Pike - Measured
Northern Pike - Modelled
White Sucker - Modelled
White Sucker - Measured

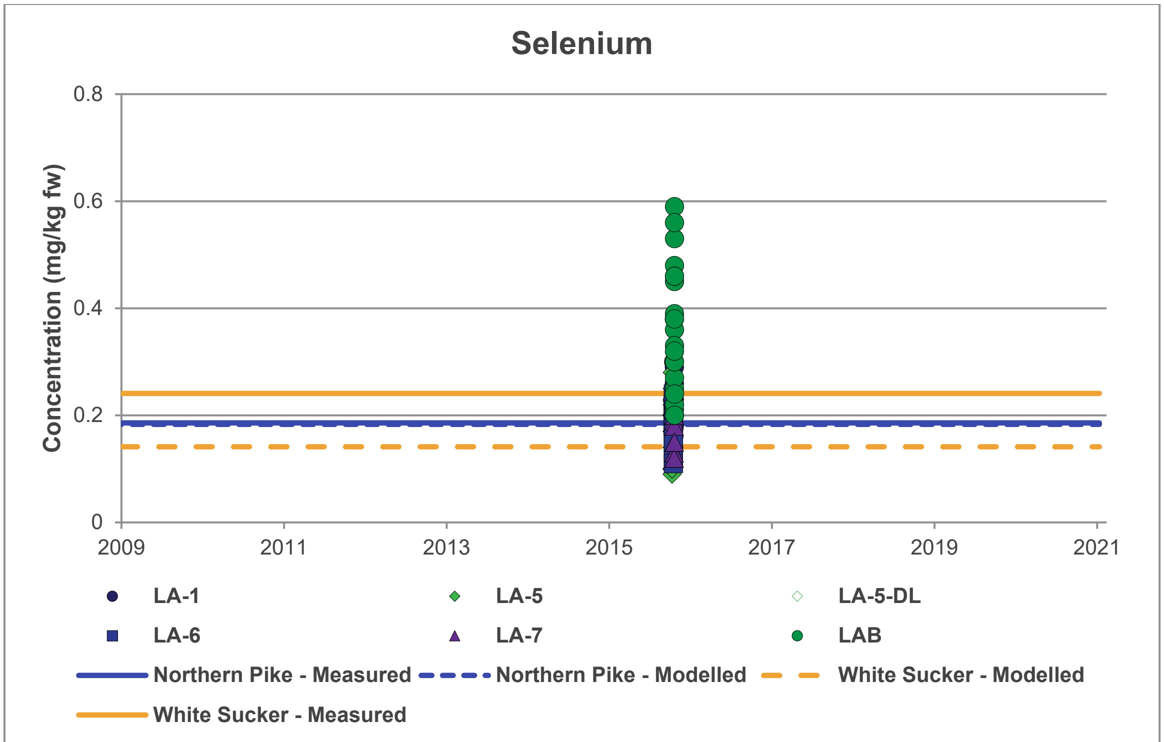

Cadmium
Concentration (mg/kg fw)
0.01
0.008
0.006
0.004
0.002
0
2009
2011
2013
2015
2017
2019
2021
LA-1-DL
LA-5-DL
LA-6-DL
LA-7-DL
LAB-DL
Northern Pike - Measured
Northern Pike - Modelled
White Sucker - Modelled
White Sucker - Measured

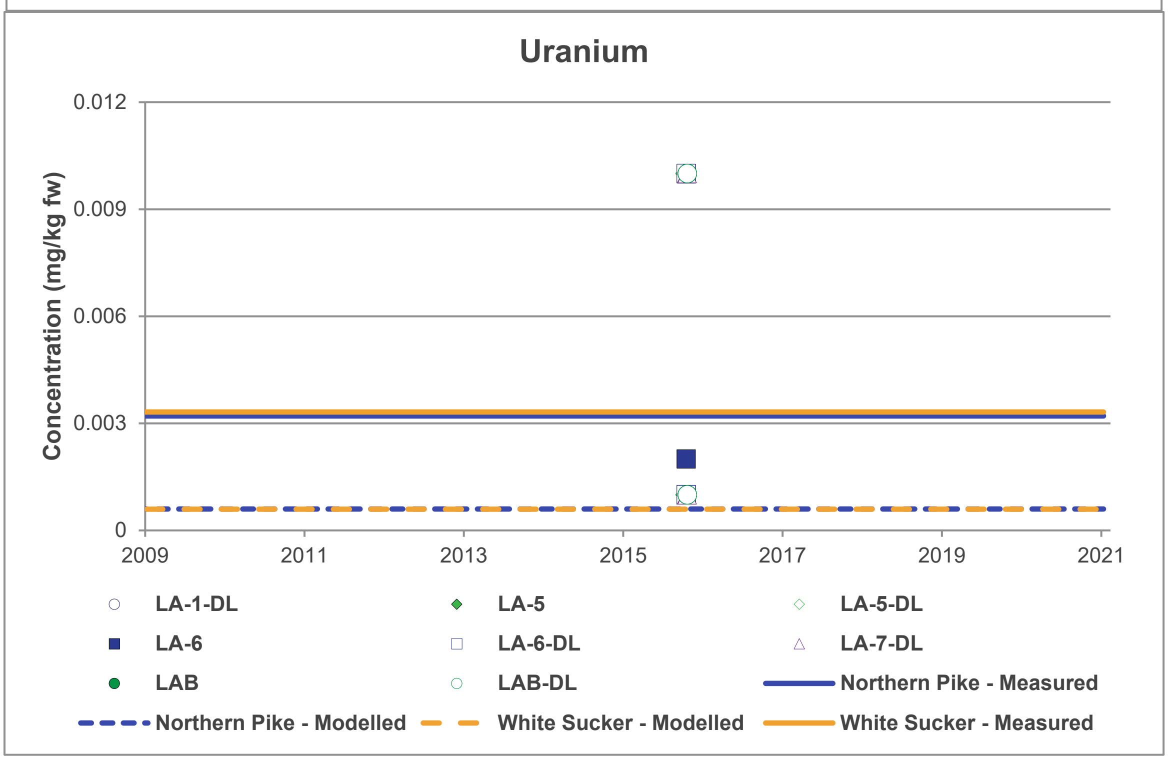

Chromium
Concentration (mg/kg fw)
0.5
0.4
0.3
0.2
0.1
0
2009
2011
2013
2015
2017
2019
2021
LA-1-DL
LA-5
LA-5-DL
LA-6-DL
LA-7
LA-7-DL
LAB-DL
Northern Pike - Measured
Northern Pike - Modelled
White Sucker - Modelled
White Sucker - Measured

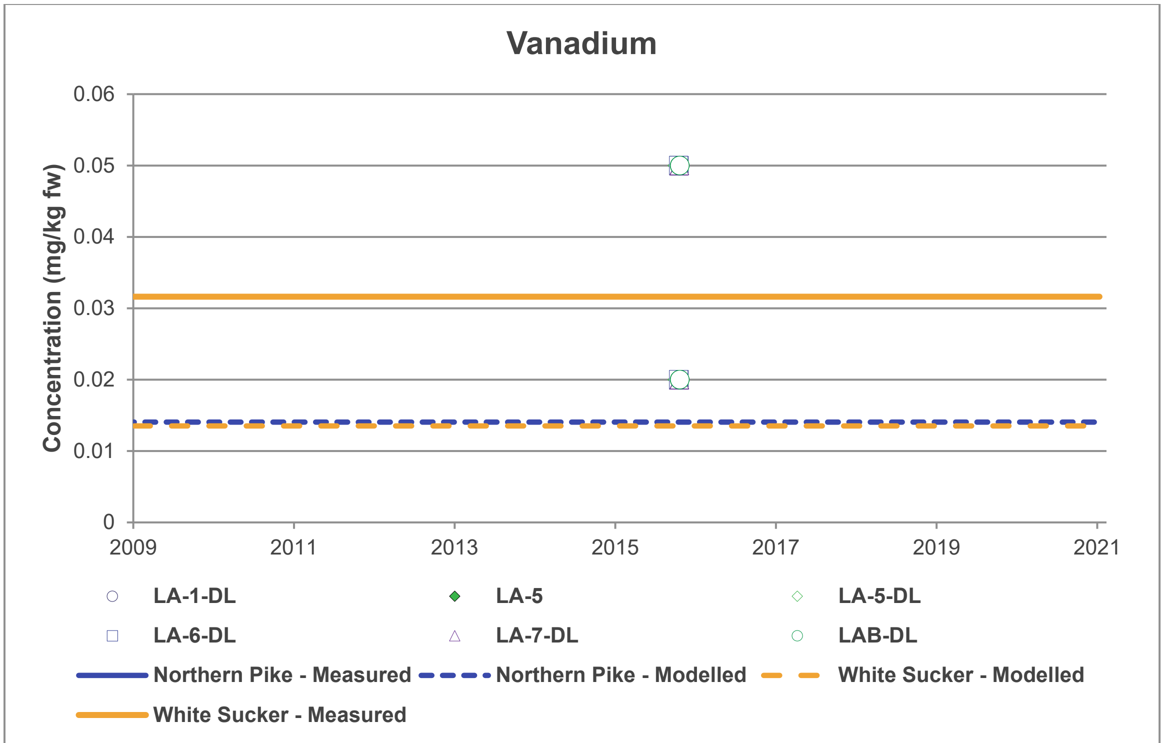

Cobalt
Concentration (mg/kg fw)
0.2
0.15
0.1
0.05
0
2009
2011
2013
2015
2017
2019
2021
LA-1
LA-1-DL
LA-5
LA-5-DL
LA-6
LA-6-DL
LA-7
LA-7-DL
LAB
LAB-DL
Northern Pike - Measured
Northern Pike - Modelled
White Sucker - Modelled
White Sucker - Measured

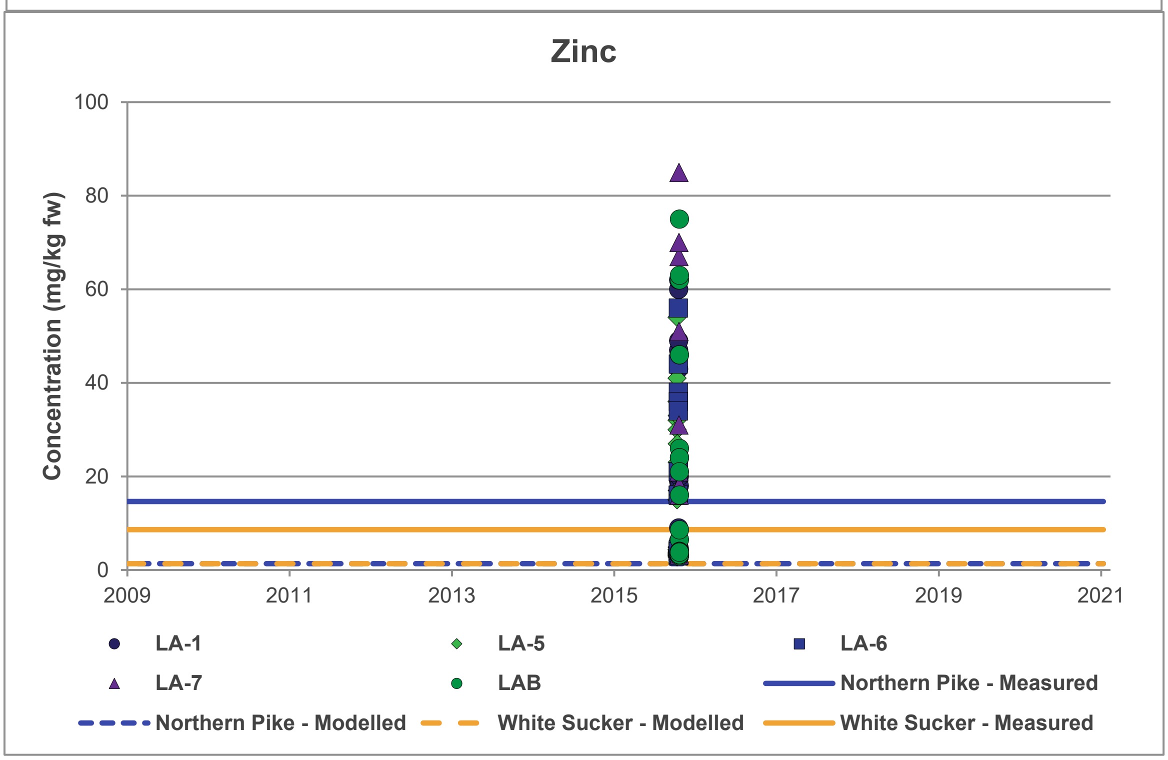

Copper
Concentration (mg/kg fw)
0
0.4
0.8
1.2
1.6
2
2009
2011
2013
2015
2017
2019
2021
LA-1
LA-5
LA-6
LA-7
LAB
Northern Pike - Measured
Northern Pike - Modelled
White Sucker - Modelled
White Sucker - Measured

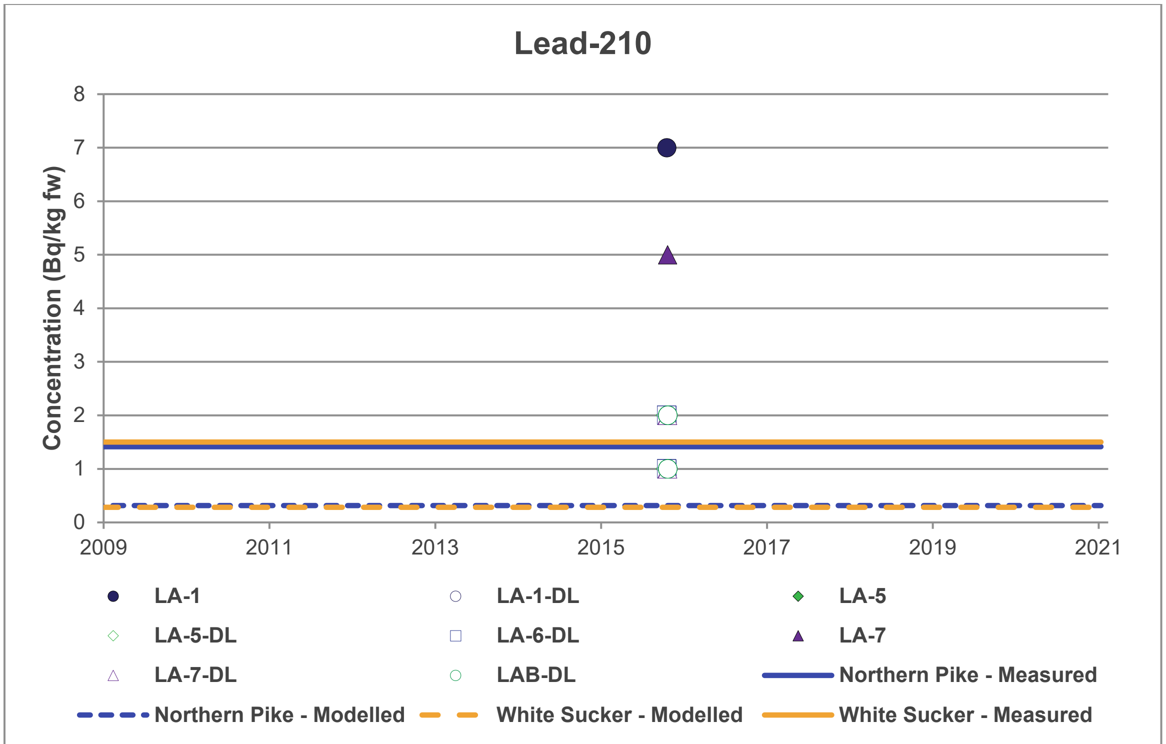

Molybdenum
Concentration (mg/kg fw)
0
0.05
0.1
0.15
0.2
0.25
2009
2011
2013
2015
2017
2019
2021
LA-1-DL
LA-5
LA-5-DL
LA-6-DL
LA-7-DL
LAB
LAB-DL
Northern Pike - Measured
Northern Pike - Modelled
White Sucker - Modelled
White Sucker - Measured

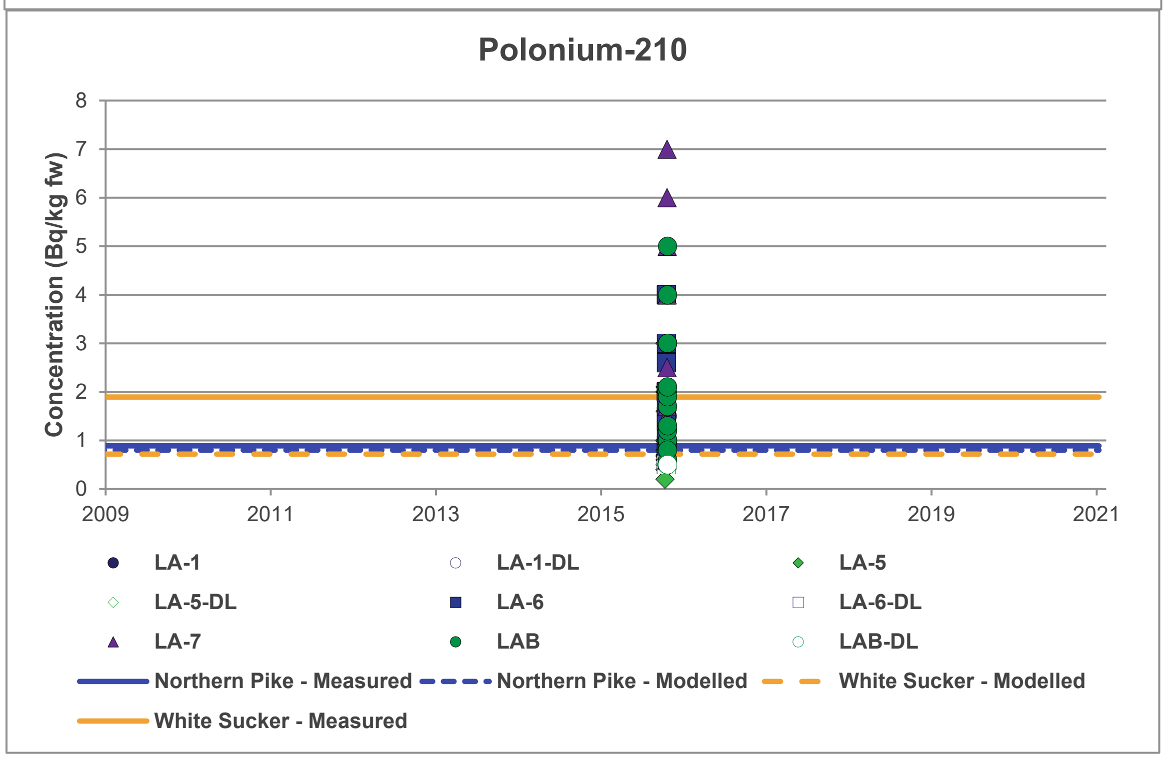

Selenium
Concentration (mg/kg fw)
0.8
0.6
0.4
0.2
0
2009
2011
2013
2015
2017
2019
2021
LA-1
LA-5
LA-5-DL
LA-6
LA-7
LAB
Northern Pike - Measured
Northern Pike - Modelled
White Sucker - Modelled
White Sucker - Measured

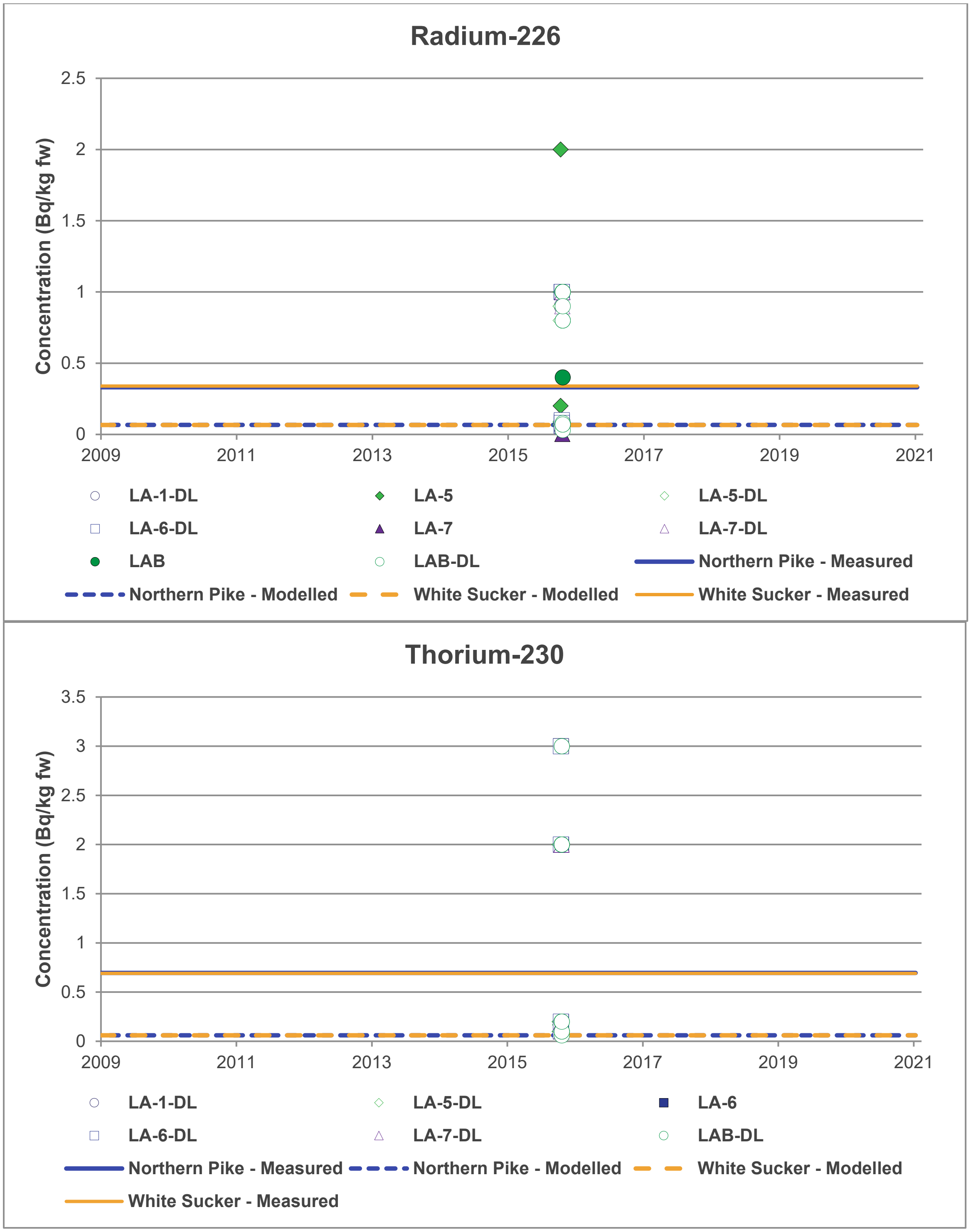

Uranium
Concentration (mg/kg fw)
0.012
0.009
0.006
0.003
0
2009
2011
2013
2015
2017
2019
2021
LA-1-DL
LA-5
LA-5-DL
LA-6
LA-6-DL
LA-7-DL
LAB
LAB-DL
Northern Pike - Measured
Northern Pike - Modelled
White Sucker - Modelled
White Sucker - Measured


Vanadium
Concentration (mg/kg fw)
0.06
0.05
0.04
0.03
0.02
0.01
0
2009
2011
2013
2015
2017
2019
2021
LA-1-DL
LA-5
LA-5-DL
LA-6-DL
LA-7-DL
LAB-DL
Northern Pike - Measured
Northern Pike - Modelled
White Sucker - Modelled
White Sucker - Measured


Zinc
Concentration (mg/kg fw)
100
80
60
40
20
0
2009
2011
2013
2015
2017
2019
2021
LA-1
LA-5
LA-6
LA-7
LAB
Northern Pike - Measured
Northern Pike - Modelled
White Sucker - Modelled
White Sucker - Measured


Lead-210
Concentration (Bq/kg fw)
0
1
2
3
4
5
6
7
8
2009
2011
2013
2015
2017
2019
2021
LA-1
LA-1-DL
LA-5
LA-5-DL
LA-6-DL
LA-7
LA-7-DL
LAB-DL
Northern Pike - Measured
Northern Pike - Modelled
White Sucker - Modelled
White Sucker - Measured


Polonium-210
Concentration (Bq/kg fw)
0
1
2
3
4
5
6
7
8
2009
2011
2013
2015
2017
2019
2021
LA-1
LA-1-DL
LA-5
LA-5-DL
LA-6
LA-6-DL
LA-7
LAB
LAB-DL
Northern Pike - Measured
Northern Pike - Modelled
White Sucker - Modelled
White Sucker - Measured



The measured lines indicate the geometric mean of the measured concentrations. fw: fresh weight. Blank symbol indicates that the measurement was under the detection limit. The location of sampling stations is described in detail in baseline aquatic environment study report (Ecometrix, 2020a).

Figure 3-4: Modelled and Measured Baseline Concentrations (fresh weight) of COPCs in Northern Pike and White Sucker

3.6.3 Dose Coefficients for Aquatic Receptors

Dose coefficients (DCFs) for all external and internal exposure routes considered are presented in Table 3-10 and Table 3-11, respectively. DCFs for internal and external exposure pathways are based on values published by the International Commission on Radiological Protection (ICRP) for aquatic plants and northern pike (ICRP 2008). For benthic invertebrates, zooplankton, and white sucker, DCFs were calculated with the ERICA Tool (Brown et al. 2008).

The DCF values from the ICRP (2008) and the ERICA Tool 1.3.1 (Brown et al. 2008) do not incorporate radiation quality factors for relative biological effectiveness for low beta and alpha components. The relative biological effectiveness is a radioecological weighting factor that represents the ratio of doses from different types of radiation needed to produce the same biological effect. Therefore, the "low beta" components of the DCFs were multiplied by 2, and the alpha components were multiplied by 10 (as per CSA N288.6-22), to represent their greater relative effectiveness.

Table 3-10: External Dose Coefficients for Aquatic Receptors

COPC	DCF External (µGy/hr)/(Bq/kg(fw sediment) or Bq/L(water))					
	Macrophytes [a]	Phytoplankton [a]	Benthic Invertebrate [b]	Northern Pike [c]	White Sucker [d]	Zooplankton [e]
Lead-210	3.38E-05	3.38E-05	1.10E-04	4.00E-06	3.80E-06	1.50E-04
Polonium-210	4.58E-09	4.58E-09	4.90E-09	4.17E-09	4.30E-09	4.90E-09
Radium-226	1.13E-03	1.13E-03	1.30E-03	9.17E-04	9.10E-04	1.40E-03
Thorium-230	4.58E-07	4.58E-07	9.00E-07	2.50E-07	2.40E-07	1.00E-06
Uranium-234	4.17E-07	4.17E-07	9.40E-07	1.63E-07	1.50E-07	1.00E-06
Uranium-238	3.17E-07	3.17E-07	7.20E-07	1.00E-07	9.50E-08	7.80E-07

a. DCFs are based on seaweed (ICRP 2008).
b. DCFs are the value for insect larvae from the ERICA Database (Brown et al. 2008).
c. DCFs are based on trout (ICRP 2008).
d. DCFs are the value for benthic fish from the ERICA Database (Brown et al. 2008).
e. DCFs are from the ERICA Database (Brown et al. 2008).
µGy = microgray; Bq = becquerel; fw = fresh weight.
COPC = constituent of potential concern; DCF = dose coefficient.

Table 3-11: Internal Dose Coefficients for Aquatic Receptors

COPC	DCF Internal (µGy/hr)/(Bq/kg fw)					
	Macrophytes [a]	Phytoplankton [a]	Benthic Invertebrate [b]	Northern Pike [c]	White Sucker [d]	Zooplankton [e]
Lead-210	2.17E-04	2.17E-04	1.40E-04	2.46E-04	2.50E-04	1.00E-04
Polonium-210	3.04E-02	3.04E-02	3.10E-03	3.04E-02	3.10E-03	3.10E-02
Radium-226	1.38E-01	1.38E-01	1.37E-01	1.39E-01	1.43E-01	1.37E-01
Thorium-230	2.71E-02	2.71E-02	2.70E-02	2.71E-02	2.70E-02	2.70E-02
Uranium-234	2.75E-02	2.75E-02	2.80E-02	2.75E-02	2.80E-02	2.80E-02
Uranium-238	2.42E-02	2.42E-02	2.40E-02	2.42E-02	2.40E-02	2.40E-02

a. DCFs are based on seaweed (ICRP 2008).
b. DCFs are the value for insect larvae from the ERICA Database (Brown et al. 2008).
c. DCFs are based on trout (ICRP 2008).
d. DCFs are the value for benthic fish from the ERICA Database (Brown et al. 2008).
e. DCFs are from the ERICA Database (Brown et al. 2008).
µGy = microgray; Bq = becquerel; fw = fresh weight.
COPC = constituent of potential concern; DCF = dose coefficient.

3.7 Transfer of Constituents to Terrestrial Receptors and Humans

The COPCs may be transferred from environmental media to terrestrial receptors through food, water, and air. Ingestion and inhalation transfer factors (TFs) are defined as the ratio between the COPC concentrations in the receptor and the COPC intake rates. The TF may be determined for specific organs or other body tissues (e.g., food to liver; food to eggs). Soil to terrestrial plant transfers may include deposition from air to plant, as well as soil-to-plant bioaccumulation, and are defined as the ratio between the concentration of a COPC in the plant and that in the soil, both in dry weight.

3.7.1 Soil-to-Plant Transfer

A plant may take up COPCs by dry and wet deposition of COPCs from air and raindrop splash onto the plant, as well as from uptake of COPCs from soil to the plant via the root system. In the case of most COPCs, transfer from deposition on soil and then uptake from soil into the plant is considered to be the dominant pathway. The terrestrial plants include blueberries, browse, Labrador tea, and lichen. The soil-to-plant pathway is not considered applicable to lichen; therefore, the soil-to-plant BAFs are zero for lichen. Lichens are considered to take up COPCs via wet and dry deposition directly from air only (IAEA, 2010). Uptake of COPCs by blueberries, browse, and Labrador tea is represented by soil-to-plant BAF values derived from regional data from northern Saskatchewan, as shown in Table 3-12. Uptake of COPCs by terrestrial invertebrates from soil is represented by the soil-to-invertebrate BAFs, as shown in Table 3-12.

Table 3-12: Bioaccumulation Factors for Terrestrial Plants and Invertebrates

Soil-to-Plant BAFs kg(dw soil)/kg(dw plant)		
COPC	**Terrestrial Plant [a]**	**Terrestrial Invertebrate [b]**
Arsenic	4.26E-01	2.24E-01
Cadmium	4.20E-02 (blueberries) 7.80E-01 (browse and Labrador tea)	1.24E+01
Chromium	8.20E-03	3.06E-01
Cobalt	5.80E-01	3.58E-02
Copper	6.64E+00	5.15E-01
Molybdenum	1.00E+00	1.54E+00
Selenium	1.00E+00	8.71E+00
Uranium	1.70E-01	5.20E-02

Soil-to-Plant BAFs kg(dw soil)/kg(dw plant)		
COPC	**Terrestrial Plant [a]**	**Terrestrial Invertebrate [b]**
Vanadium	1.90E-03	4.20E-02
Zinc	4.20E+00	3.20E+00
Lead-210	2.64E-01	1.68E-01
Polonium-210	3.86E-01	1.64E-01
Radium-226	6.00E-01	5.29E-01
Thorium-230	3.12E-02	5.20E-02
Uranium-234	1.70E-01	5.20E-02
Uranium-238	1.70E-01	5.20E-02

dw = dry weight; COPC = constituent of potential concern.

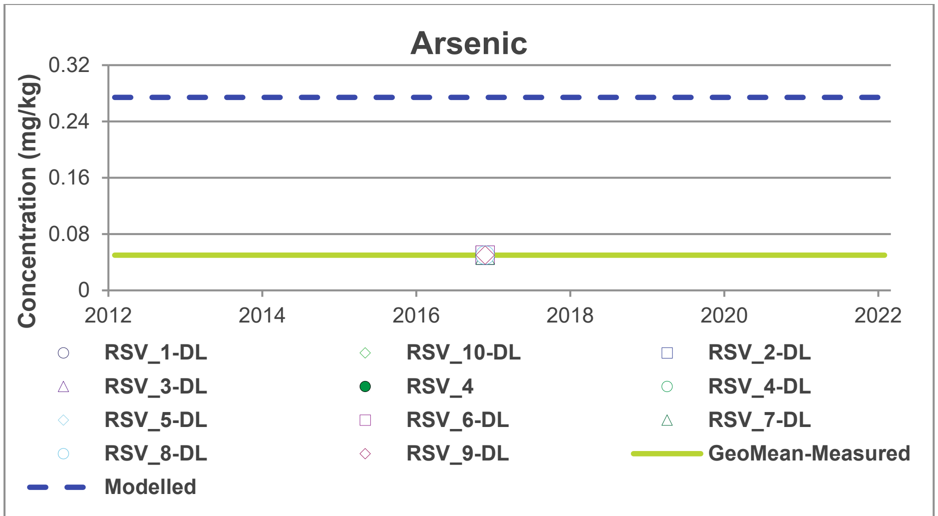
a. BAFs for terrestrial plants are compiled from regional data, except chromium from CSA N288.1-20 (Table G.3); cadmium and vanadium from Sheppard (2009); uranium, uranium-234/238 and zinc from IAEA (2010).

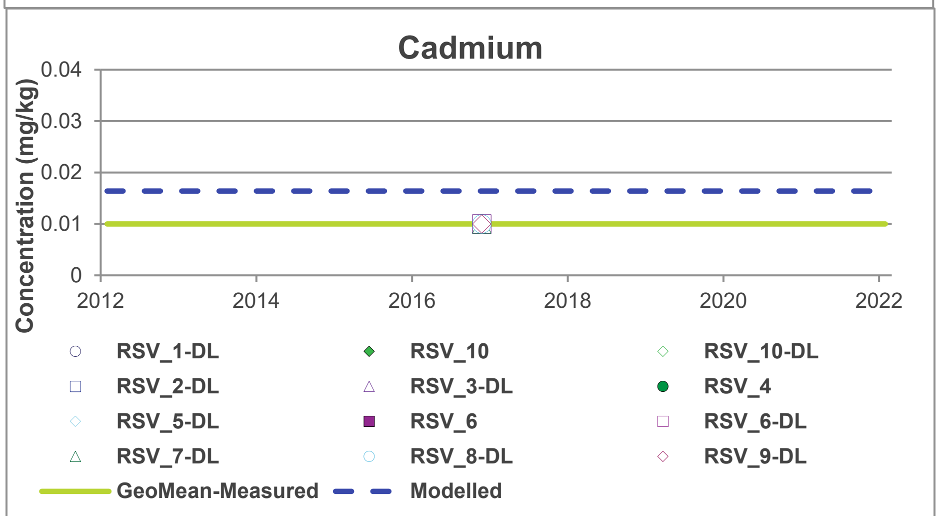
b. BAFs for terrestrial invertebrates are from Beresford et al. (2008), except molybdenum from Barnett et al. (2014), arsenic, chromium, copper, vanadium and zinc from Sample et al. (1998).

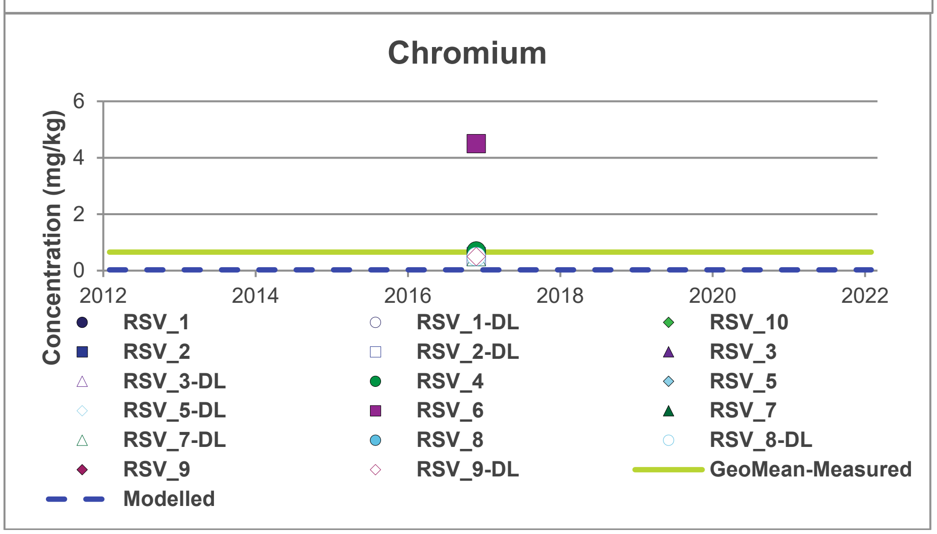
3.7.2 Model Validation

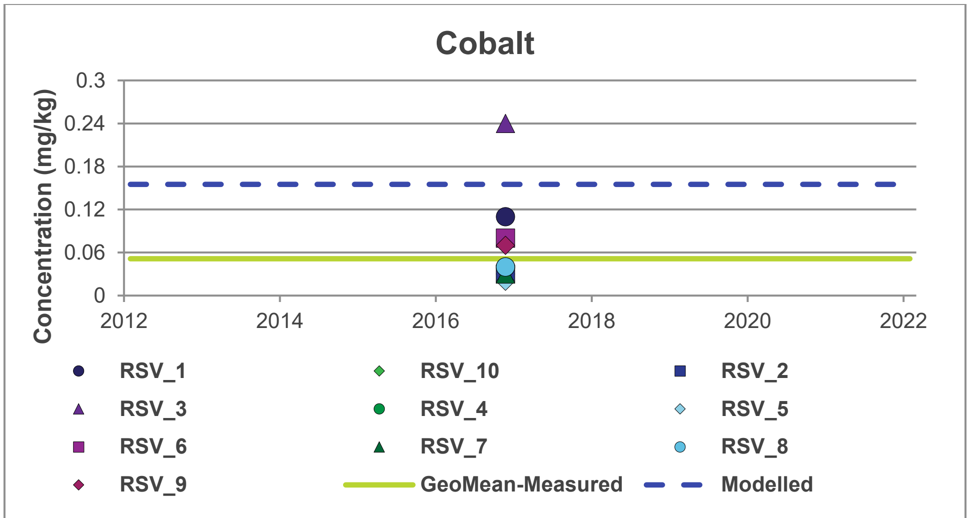
Figure 3-5 presents the predicted and observed concentrations of COPCs in blueberries obtained from 10 sample sites in August 2017 (Omnia, 2019).

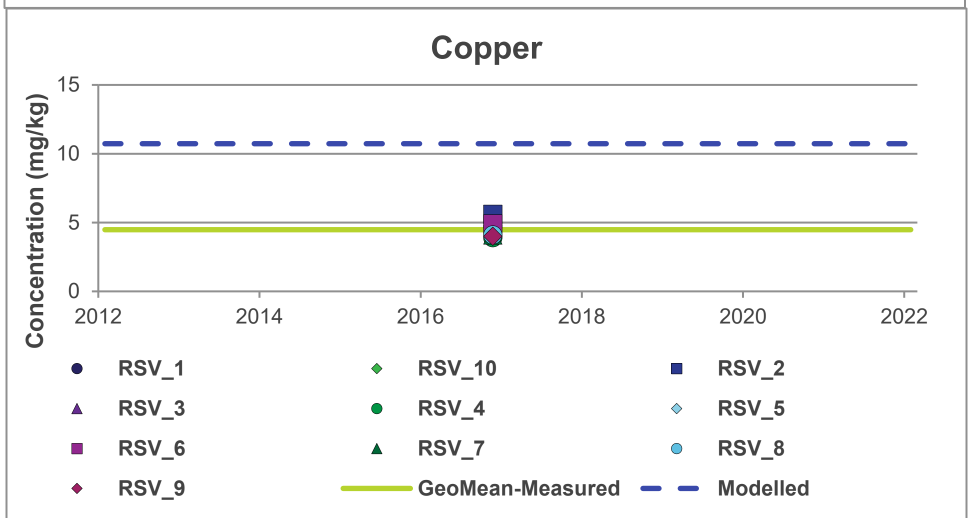
Based on available data from only one sampling event, modelled concentrations of cobalt, selenium, lead-210 and thorium-230 generally fall within the range of measured values, suggesting a good agreement of available data with the modelled values. For constituents for which the model predictions fall outside of the observed range, concentrations are conservatively overestimated for arsenic (which is non-detect in blueberry samples), cadmium, copper, molybdenum, uranium, zinc, polonium-210 and radium-226. Since the measured values are obtained from only 10 locations in one sampling event and more than 70% of the measured concentrations of chromium (7/10), and vanadium (9/10) are below the detection limit, it is reasonable that the modelled concentrations of these two COPCs are slightly lower than the measured geometric mean values.

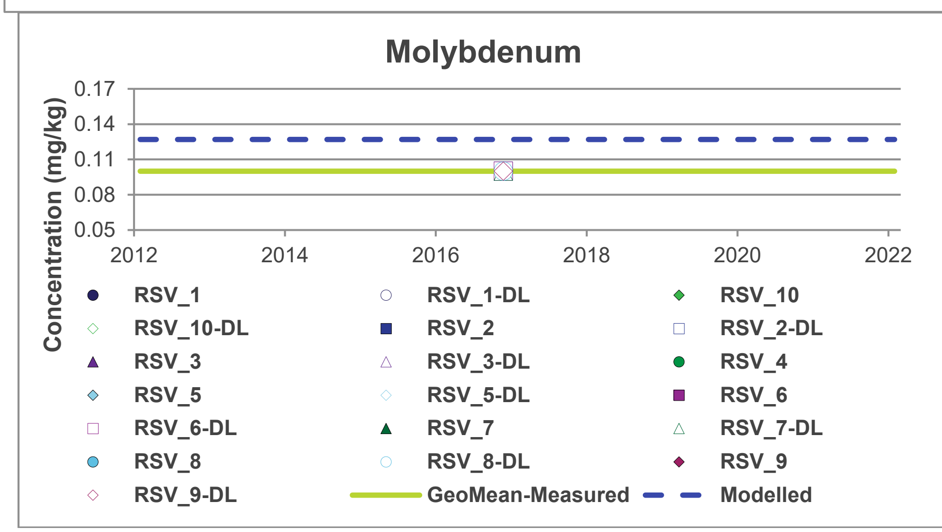

Arsenic
Concentration (mg/kg)
0.32
0.24
0.16
0.08
0
2012
2014
2016
2018
2020
2022
RSV_1-DL
RSV_10-DL
RSV_2-DL
RSV_3-DL
RSV_4
RSV_4-DL
RSV_5-DL
RSV_6-DL
RSV_7-DL
RSV_8-DL
RSV_9-DL
GeoMean-Measured
Modelled

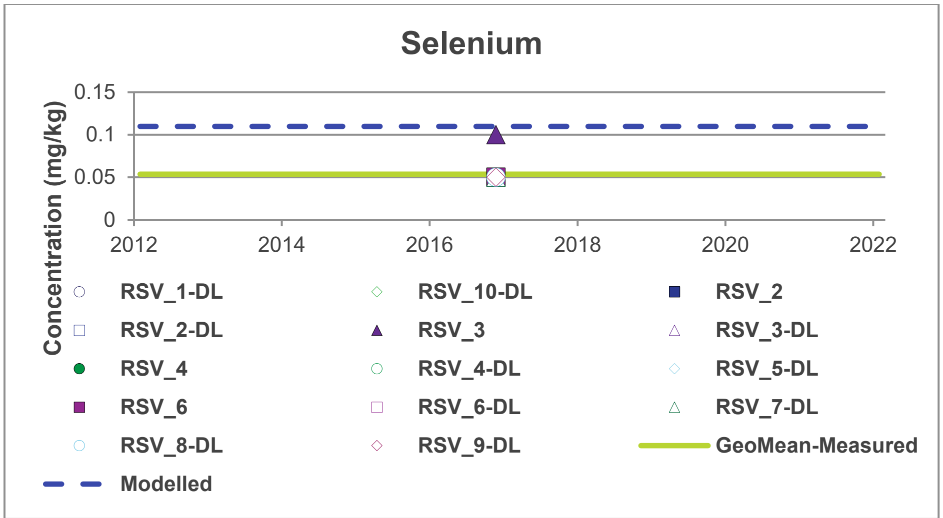

Cadmium
Concentration (mg/kg)
0.04
0.03
0.02
0.01
0
2012
2014
2016
2018
2020
2022
RSV_1-DL
RSV_10
RSV_10-DL
RSV_2-DL
RSV_3-DL
RSV_4
RSV_5-DL
RSV_6
RSV_6-DL
RSV_7-DL
RSV_8-DL
RSV_9-DL
GeoMean-Measured
Modelled

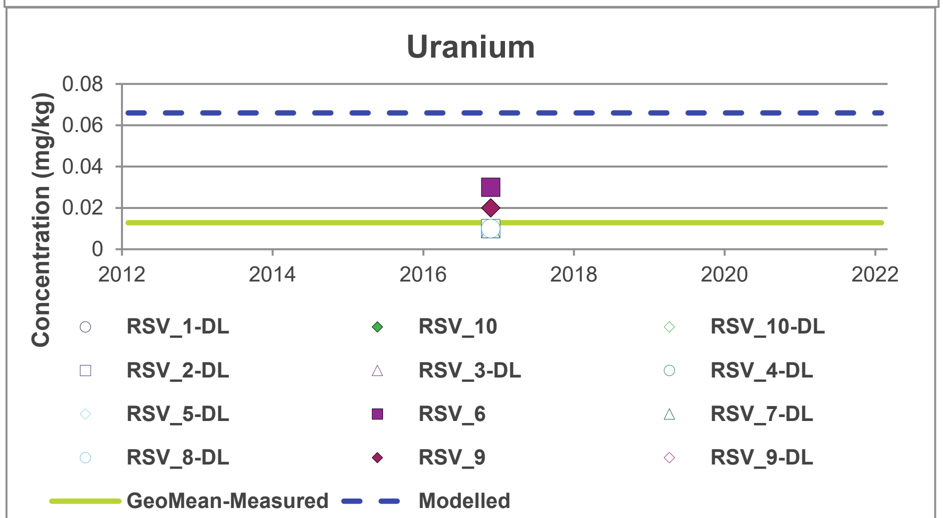

Chromium
Concentration (mg/kg)
6
4
2
0
2012
2014
2016
2018
2020
2022
RSV_1
RSV_1-DL
RSV_10
RSV_2
RSV_2-DL
RSV_3
RSV_3-DL
RSV_4
RSV_5
RSV_5-DL
RSV_6
RSV_7
RSV_7-DL
RSV_8
RSV_8-DL
RSV_9
RSV_9-DL
GeoMean-Measured
Modelled

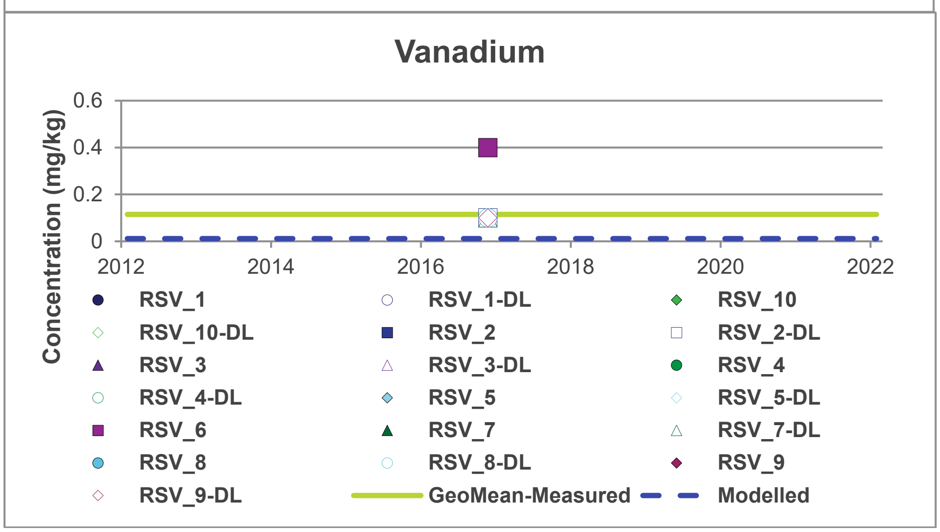

Cobalt
Concentration (mg/kg)
0.3
0.24
0.18
0.12
0.06
0
2012
2014
2016
2018
2020
2022
RSV_1
RSV_10
RSV_2
RSV_3
RSV_4
RSV_5
RSV_6
RSV_7
RSV_8
RSV_9
GeoMean-Measured
Modelled

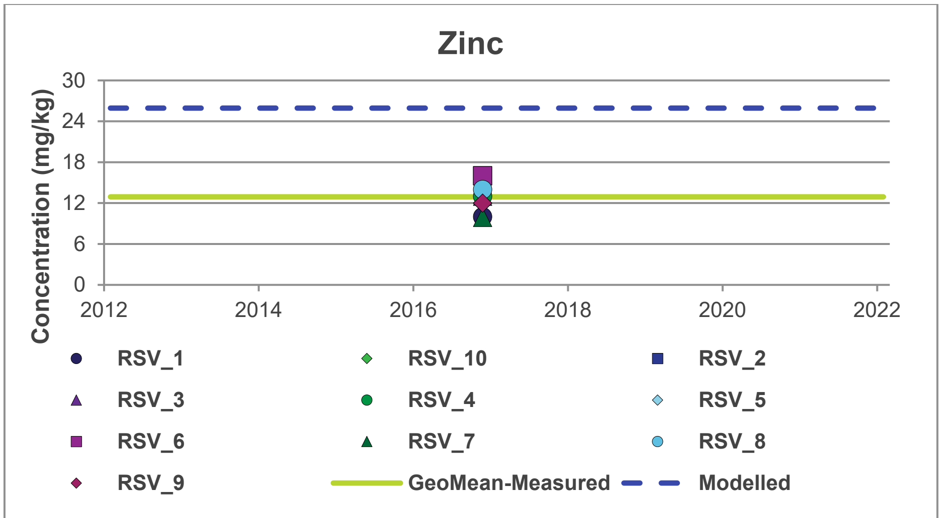

Copper
Concentration (mg/kg)
15
10
5
0
2012
2014
2016
2018
2020
2022
RSV_1
RSV_10
RSV_2
RSV_3
RSV_4
RSV_5
RSV_6
RSV_7
RSV_8
RSV_9
GeoMean-Measured
Modelled

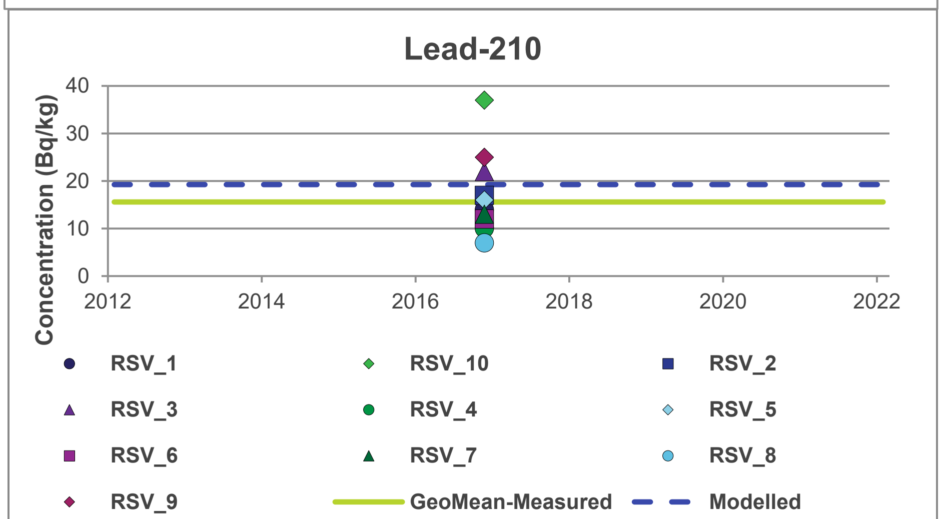

Molybdenum
Concentration (mg/kg)
0.17
0.14
0.11
0.08
0.05
2012
2014
2016
2018
2020
2022
RSV_1
RSV_1-DL
RSV_10
RSV_10-DL
RSV_2
RSV_2-DL
RSV_3
RSV_3-DL
RSV_4
RSV_5
RSV_5-DL
RSV_6
RSV_6-DL
RSV_7
RSV_7-DL
RSV_8
RSV_8-DL
RSV_9
RSV_9-DL
GeoMean-Measured
Modelled

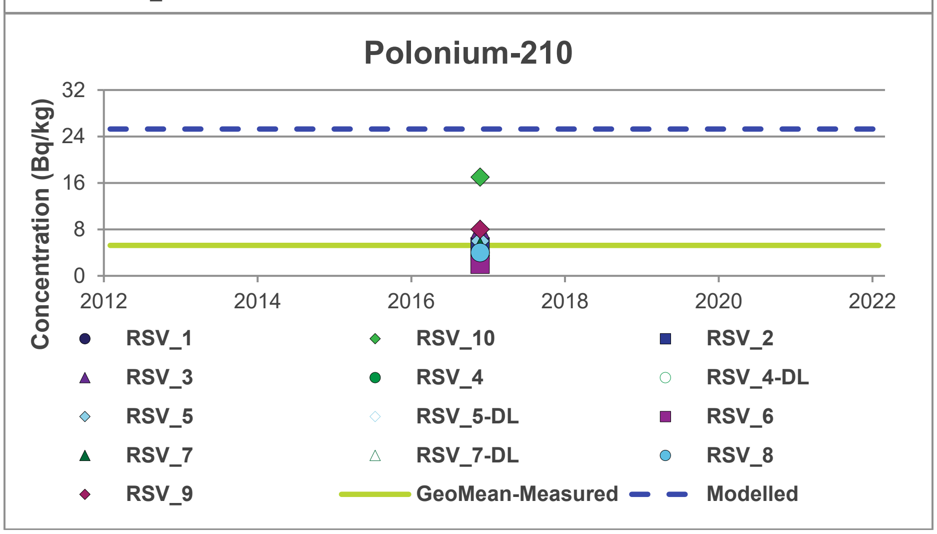

Selenium
Concentration (mg/kg)
0.15
0.1
0.05
0
2012
2014
2016
2018
2020
2022
RSV_1-DL
RSV_10-DL
RSV_2
RSV_2-DL
RSV_3
RSV_3-DL
RSV_4
RSV_4-DL
RSV_5-DL
RSV_6
RSV_6-DL
RSV_7-DL
RSV_8-DL
RSV_9-DL
GeoMean-Measured
Modelled

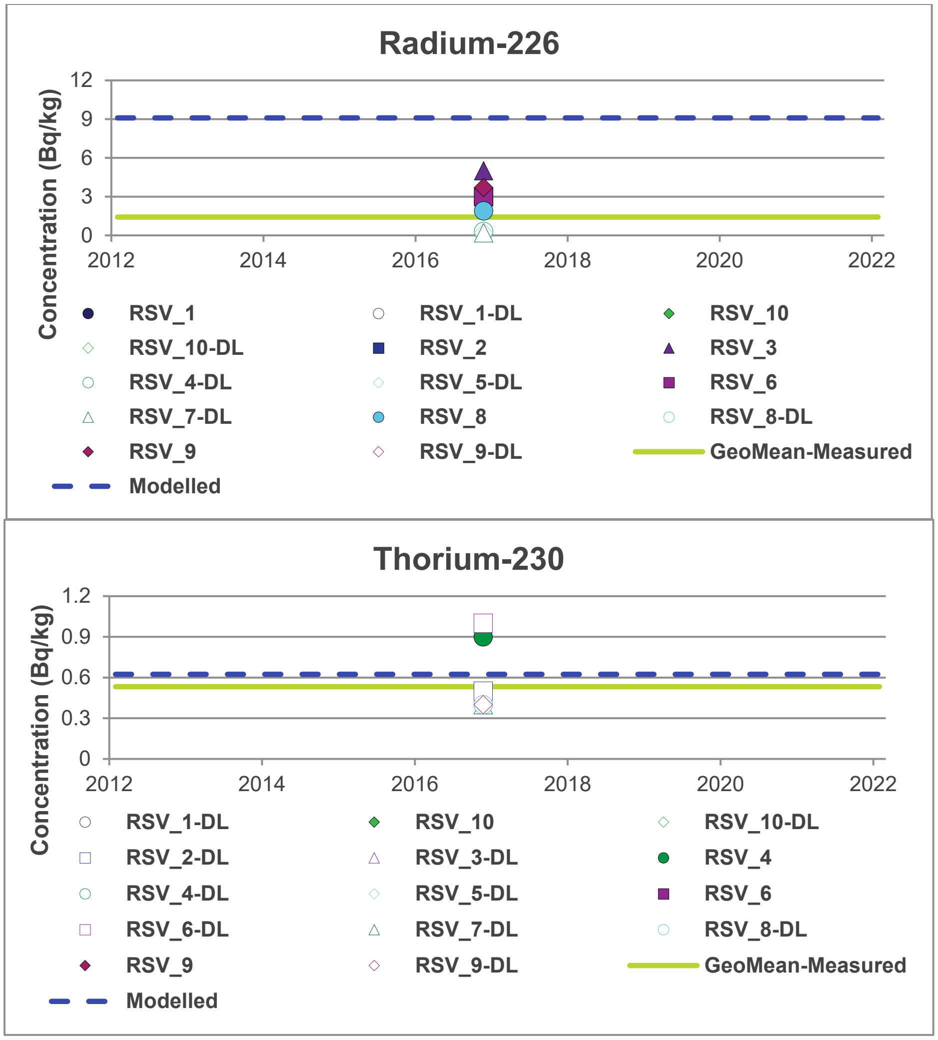

Uranium
Concentration (mg/kg)
0.08
0.06
0.04
0.02
0
2012
2014
2016
2018
2020
2022
RSV_1-DL
RSV_10
RSV_10-DL
RSV_2-DL
RSV_3-DL
RSV_4-DL
RSV_5-DL
RSV_6
RSV_7-DL
RSV_8-DL
RSV_9
RSV_9-DL
GeoMean-Measured
Modelled


Vanadium
Concentration (mg/kg)
0.6
0.4
0.2
0
2012
2014
2016
2018
2020
2022
RSV_1
RSV_1-DL
RSV_10
RSV_10-DL
RSV_2
RSV_2-DL
RSV_3
RSV_3-DL
RSV_4
RSV_4-DL
RSV_5
RSV_5-DL
RSV_6
RSV_7
RSV_7-DL
RSV_8
RSV_8-DL
RSV_9
RSV_9-DL
GeoMean-Measured
Modelled


Zinc
Concentration (mg/kg)
0
6
12
18
24
30
2012
2014
2016
2018
2020
2022
RSV_1
RSV_10
RSV_2
RSV_3
RSV_4
RSV_5
RSV_6
RSV_7
RSV_8
RSV_9
GeoMean-Measured
Modelled


Lead-210
Concentration (Bq/kg)
0
10
20
30
40
2012
2014
2016
2018
2020
2022
RSV_1
RSV_10
RSV_2
RSV_3
RSV_4
RSV_5
RSV_6
RSV_7
RSV_8
RSV_9
GeoMean-Measured
Modelled


Polonium-210
Concentration (Bq/kg)
0
8
16
24
32
2012
2014
2016
2018
2020
2022
RSV_1
RSV_10
RSV_2
RSV_3
RSV_4
RSV_4-DL
RSV_5
RSV_5-DL
RSV_6
RSV_7
RSV_7-DL
RSV_8
RSV_9
GeoMean-Measured
Modelled



Blank symbol indicates that the measurement was under the detection limit. The vegetation sampling plot locations are described in the terrestrial environment wildlife and vegetation baseline inventory report (Omnia, 2019).

Figure 3-5: Modelled and Measured Concentrations (dry weight) of COPCs in Blueberries

3.7.3 Dose Coefficients for Terrestrial Plants and Invertebrates

Dose coefficients for all external and internal exposure routes to terrestrial plants and invertebrates are presented in Table 3-13 and Table 3-14, respectively. Dose coefficients for internal and external exposure pathways are based on values published by the ICRP (ICRP 2008).

Table 3-13: External Dose Coefficients for Terrestrial Plants and Invertebrates

COPC	DCF external soil surface (µGy/hr)/(Bq/m²)				DCF external soil (µGy/hr)/(Bq/kg(dw soil))
	Blueberries [a]	Browse [b]	Labrador Tea [b]	Lichen [c]	Terrestrial Invertebrate [d]
Lead-210	7.50E-09	1.13E-06	1.13E-06	2.08E-09	5.83E-07
Polonium-210	1.96E-11	6.67E-11	6.67E-11	1.24E-11	4.58E-09
Radium-226	3.88E-06	1.33E-05	1.33E-05	2.47E-06	9.17E-04
Thorium-230	2.67E-09	3.04E-07	3.04E-07	5.14E-10	2.08E-07
Uranium-234	3.38E-09	3.67E-07	3.67E-07	5.12E-10	1.75E-07
Uranium-238	2.63E-09	3.04E-07	3.04E-07	3.57E-10	1.25E-07

a. DCFs are based on pine tree (ICRP 2008).

b. DCFs are based on grass (ICRP 2008).

c. DCFs are from the ERICA Database (Brown et al. 2008).

d. DCFs are from ICRP (2008).

µGy = microgray; Bq = becquerel; fw = fresh weight.

COPC = constituent of potential concern; DCF = dose coefficient.

Table 3-14: Internal Dose Coefficients for Terrestrial Plants and Invertebrates

COPC	DCF internal (µGy/hr)/(Bq/kg(fw plant))				
	Blueberries [a]	Browse [b]	Labrador Tea [b]	Lichen [c]	Terrestrial Invertebrate [d]
Lead-210	2.50E-04	2.25E-04	2.25E-04	1.82E-04	2.25E-04
Polonium-210	3.04E-02	3.04E-02	3.04E-02	3.06E-02	3.04E-02
Radium-226	1.41E-01	1.38E-01	1.38E-01	1.38E-01	1.38E-01
Thorium-230	2.71E-02	2.71E-02	2.71E-02	2.70E-02	2.71E-02
Uranium-234	2.75E-02	2.75E-02	2.75E-02	2.75E-02	2.75E-02
Uranium-238	2.42E-02	2.42E-02	2.42E-02	2.42E-02	2.42E-02

a. DCFs are based on pine tree (ICRP 2008).

b. DCFs are based on grass (ICRP 2008).

c. DCFs are from the ERICA Database (Brown et al. 2008).

d. DCFs are from ICRP (2008).

µGy = microgray; Bq = becquerel; fw = fresh weight.

COPC = constituent of potential concern; DCF = dose coefficient.

3.7.4 Ingestion Transfer Factors for Terrestrial Receptors

Ingestion transfer factors (TFs) are COPC- and biota-specific. Ingestion TFs from forage to tissue for agricultural livestock are available in CSA N288.1-20. An allometric equation (i.e., transfer proportional to a -3/4 power of body weight) (CSA N288.6-22) was applied to TFs available for beef and poultry from CSA N288.1-20, the IAEA (2010), or the National Council on Radiation Protection and Measurements (NCRP 1996) to estimate the TFs for the mammal and bird receptors, respectively. The derived ingestion TFs are presented in Table 3-15 and Table 3-16.

3.7.5 Inhalation Transfer Factors for Terrestrial Receptors

Inhalation TFs were calculated from the ingestion TF, by adjusting the ingestion TF by a COPC-specific inhalation/ingestion ratio (II) from CSA N288.1-20. The derived inhalation TFs are presented in Table 3-17.

Table 3-15: Ingestion Transfer Factors for Mammals (d/kg fw)

COPC	Beef Transfer Factor	Ref	Black Bear	Canada Lynx	Mink	Moose	Muskrat	Snowshoe Hare	Southern Red-Backed Vole	Woodland Caribou	Beef Organs Transfer Factor (a, d)	Moose Organs
Non-radionuclides												
Arsenic	2.00E-02	(a)	7.53E-02	3.35E-01	2.39E+00	2.71E-02	2.15E+00	1.56E+00	3.14E+01	4.93E-02	1.70E-01	2.30E-01
Cadmium	5.80E-03	(b)	2.18E-02	9.72E-02	6.93E-01	7.86E-03	6.23E-01	4.52E-01	9.11E+00	1.43E-02	2.00E-03	2.71E-03
Chromium	1.10E-02	(a)	4.14E-02	1.84E-01	1.31E+00	1.49E-02	1.18E+00	8.58E-01	1.73E+01	2.71E-02	5.00E-03	6.78E-03
Cobalt	4.30E-04	(a)	1.62E-03	7.20E-03	5.14E-02	5.83E-04	4.62E-02	3.35E-02	6.75E-01	1.06E-03	1.00E-01	1.36E-01
Copper	1.00E-02	(c)	3.76E-02	1.68E-01	1.19E+00	1.36E-02	1.07E+00	7.80E-01	1.57E+01	2.47E-02	4.00E-01	5.42E-01
Molybdenum	1.00E-03	(a)	3.76E-03	1.68E-02	1.19E-01	1.36E-03	1.07E-01	7.80E-02	1.57E+00	2.47E-03	1.00E-01	1.36E-01
Selenium	1.00E-01	(a)	3.76E-01	1.68E+00	1.19E+01	1.36E-01	1.07E+01	7.80E+00	1.57E+02	2.47E-01	1.00E-01	1.36E-01
Uranium	3.90E-04	(a)	1.47E-03	6.53E-03	4.66E-02	5.29E-04	4.19E-02	3.04E-02	6.13E-01	9.62E-04	6.90E-04	9.35E-04
Vanadium	1.00E-02	(c)	3.76E-02	1.68E-01	1.19E+00	1.36E-02	1.07E+00	7.80E-01	1.57E+01	2.47E-02	1.00E-05	1.36E-05
Zinc	1.60E-01	(a)	6.02E-01	2.68E+00	1.91E+01	2.17E-01	1.72E+01	1.25E+01	2.51E+02	3.95E-01	2.00E-03	2.71E-03
Radionuclides												
Lead-210	7.00E-04	(b)	2.63E-03	1.17E-02	8.36E-02	9.49E-04	7.52E-02	5.46E-02	1.10E+00	1.73E-03	2.20E-02	2.98E-02
Polonium-210	5.00E-03	(c)	1.88E-02	8.38E-02	5.97E-01	6.78E-03	5.37E-01	3.90E-01	7.85E+00	1.23E-02	5.00E-05	6.78E-05
Radium-226	1.70E-03	(a)	6.40E-03	2.85E-02	2.03E-01	2.30E-03	1.83E-01	1.33E-01	2.67E+00	4.19E-03	9.50E-04	1.29E-03
Thorium-230	2.30E-04	(a)	8.66E-04	3.85E-03	2.75E-02	3.12E-04	2.47E-02	1.79E-02	3.61E-01	5.67E-04	6.30E-02	8.54E-02
Uranium-234	3.90E-04	(a)	1.47E-03	6.53E-03	4.66E-02	5.29E-04	4.19E-02	3.04E-02	6.13E-01	9.62E-04	6.90E-04	9.35E-04
Uranium-238	3.90E-04	(a)	1.47E-03	6.53E-03	4.66E-02	5.29E-04	4.19E-02	3.04E-02	6.13E-01	9.62E-04	6.90E-04	9.35E-04

Notes:

Transfer factors in this table were calculated using the following allometric equation: TF (d/kg fw) = $aBW^{-0.75}$, where BW = body weight, TF = transfer factor, d/kg fw = days per kilogram fresh weight, "a" is a constant calculated using published transfer factor and body weight values for beef or beef organs as per CSA N288.1 (CSA Group 2020), and applied to calculate species-specific transfer factors.

a. TFs from N288.1 Table G3.

b. TFs from IAEA Technical Reports Series No. 472, (IAEA 2010).

c. TFs from NCRP No. 123, (NCRP 1996).

d. For elements that are not listed in N288.1 Table G.3, a surrogate element was used for organs as follows (surrogate in parentheses): Cd (Zn); Cu (Ag); Pb (Sn); Po (Te); V (Nb).

Table 3-16: Ingestion Transfer Factors for Birds (d/kg fw)

COPC	Poultry Transfer Factor	American Robin	Bald Eagle	Canada Goose	Common Loon	Lesser Scaup	Mallard	Olive-Sided Flycatcher
Non-radionuclides								
Arsenic [a]	1.20E+00	1.11E+01	5.43E-01	7.56E-01	5.78E-01	2.34E+00	1.84E+00	2.64E+01
Cadmium [b]	1.70E+00	1.57E+01	7.69E-01	1.07E+00	8.18E-01	3.32E+00	2.61E+00	3.74E+01
Chromium [a]	9.20E-01	8.51E+00	4.16E-01	5.80E-01	4.43E-01	1.80E+00	1.41E+00	2.02E+01
Cobalt [a]	9.70E-01	8.97E+00	4.39E-01	6.11E-01	4.67E-01	1.89E+00	1.49E+00	2.13E+01
Copper [c]	6.20E-01	5.74E+00	2.80E-01	3.91E-01	2.99E-01	1.21E+00	9.51E-01	1.36E+01
Molybdenum [a]	1.80E-01	1.67E+00	8.14E-02	1.13E-01	8.67E-02	3.51E-01	2.76E-01	3.95E+00
Selenium [a]	9.70E+00	8.97E+01	4.39E+00	6.11E+00	4.67E+00	1.89E+01	1.49E+01	2.13E+02
Uranium [a]	7.50E-01	6.94E+00	3.39E-01	4.73E-01	3.61E-01	1.46E+00	1.15E+00	1.65E+01
Vanadium [c]	6.20E-01	5.74E+00	2.80E-01	3.91E-01	2.99E-01	1.21E+00	9.51E-01	1.36E+01
Zinc [a]	4.70E-01	4.35E+00	2.13E-01	2.96E-01	2.26E-01	9.17E-01	7.21E-01	1.03E+01
Radionuclides								
Lead-210 [c]	5.00E-02	4.63E-01	2.26E-02	3.15E-02	2.41E-02	9.76E-02	7.67E-02	1.10E+00
Polonium-210 [b]	2.40E+00	2.22E+01	1.09E+00	1.51E+00	1.16E+00	4.68E+00	3.68E+00	5.27E+01
Radium-226 [a]	3.00E-02	2.78E-01	1.36E-02	1.89E-02	1.44E-02	5.86E-02	4.60E-02	6.59E-01
Thorium-230 [a]	1.00E-02	9.25E-02	4.52E-03	6.30E-03	4.81E-03	1.95E-02	1.53E-02	2.20E-01
Uranium-234 [a]	7.50E-01	6.94E+00	3.39E-01	4.73E-01	3.61E-01	1.46E+00	1.15E+00	1.65E+01
Uranium-238 [a]	7.50E-01	6.94E+00	3.39E-01	4.73E-01	3.61E-01	1.46E+00	1.15E+00	1.65E+01

Notes

Transfer factors in this table were calculated using the following allometric equation: TF (d/kg FW) = $aBW^{-0.75}$, where "a" was calculated using published TF and BW values for poultry, and applied to calculate species-specific TFs.

a. TFs from N288.1 Table G.3.

b. TFs from IAEA Technical Reports Series No. 472, (IAEA 2010).

c. TF was calculated based on the beef TF published in NCRP No. 123 (NCRP 1996), adjusted to poultry using a ratio of 62, as per the CANDU Owners Group DRL Guidance (Hart 2019).

Table 3-17: Inhalation Transfer Factors for Mammals and Birds (d/kg fw)

COPC	Inhalation/ Ingestion Ratio (II) a,b	Black Bear	Canada Lynx	Mink	Moose	Muskrat	Snowshoe Hare	Southern Red-Backed Vole	Woodland Caribou	American Robin	Bald Eagle	Canada Goose	Common Loon	Lesser Scaup	Mallard	Olive-Sided Flycatcher
Non-radionuclides																
Arsenic	0.75	5.64E-02	2.51E-01	1.79E+00	2.03E-02	1.61E+00	1.17E+00	2.36E+01	3.70E-02	8.33E+00	4.07E-01	5.67E-01	4.33E-01	1.76E+00	1.38E+00	1.98E+01
Cadmium	0.75	1.64E-02	7.29E-02	5.20E-01	5.90E-03	4.68E-01	3.39E-01	6.83E+00	1.07E-02	1.18E+01	5.77E-01	8.04E-01	6.14E-01	2.49E+00	1.96E+00	2.80E+01
Chromium	4.95	2.05E-01	9.12E-01	6.51E+00	7.38E-02	5.85E+00	4.25E+00	8.55E+01	1.34E-01	4.21E+01	2.06E+00	2.87E+00	2.19E+00	8.89E+00	6.99E+00	1.00E+02
Cobalt	1.71	2.77E-03	1.23E-02	8.79E-02	9.97E-04	7.90E-02	5.74E-02	1.15E+00	1.81E-03	1.53E+01	7.50E-01	1.05E+00	7.99E-01	3.24E+00	2.55E+00	3.64E+01
Copper	2.91	1.10E-01	4.87E-01	3.48E+00	3.94E-02	3.13E+00	2.27E+00	4.57E+01	7.18E-02	1.67E+01	8.16E-01	1.14E+00	8.69E-01	3.52E+00	2.77E+00	3.96E+01
Molybdenum	0.63	2.37E-03	1.06E-02	7.53E-02	8.54E-04	6.77E-02	4.91E-02	9.90E-01	1.55E-03	1.05E+00	5.13E-02	7.15E-02	5.46E-02	2.21E-01	1.74E-01	2.49E+00
Selenium	0.75	2.82E-01	1.26E+00	8.96E+00	1.02E-01	8.06E+00	5.85E+00	1.18E+02	1.85E-01	6.73E+01	3.29E+00	4.59E+00	3.50E+00	1.42E+01	1.12E+01	1.60E+02
Uranium	6.51	9.55E-03	4.25E-02	3.03E-01	3.44E-03	2.73E-01	1.98E-01	3.99E+00	6.26E-03	4.52E+01	2.21E+00	3.08E+00	2.35E+00	9.53E+00	7.49E+00	1.07E+02
Vanadium	12.51	4.71E-01	2.10E+00	1.49E+01	1.70E-01	1.34E+01	9.76E+00	1.97E+02	3.09E-01	7.17E+01	3.51E+00	4.89E+00	3.73E+00	1.51E+01	1.19E+01	1.70E+02
Zinc	0.75	4.52E-01	2.01E+00	1.43E+01	1.63E-01	1.29E+01	9.36E+00	1.88E+02	2.96E-01	3.26E+00	1.59E-01	2.22E-01	1.70E-01	6.88E-01	5.41E-01	7.74E+00
Radionuclides																
Lead-210	24.2	6.38E-02	2.84E-01	2.02E+00	2.30E-02	1.82E+00	1.32E+00	2.66E+01	4.18E-02	1.12E+01	5.47E-01	7.63E-01	5.83E-01	2.36E+00	1.86E+00	2.66E+01
Polonium-210	0.91	1.71E-02	7.62E-02	5.44E-01	6.17E-03	4.89E-01	3.55E-01	7.15E+00	1.12E-02	2.02E+01	9.88E-01	1.38E+00	1.05E+00	4.26E+00	3.35E+00	4.80E+01
Radium-226	1.11	7.10E-03	3.16E-02	2.25E-01	2.56E-03	2.03E-01	1.47E-01	2.96E+00	4.66E-03	3.08E-01	1.51E-02	2.10E-02	1.60E-02	6.50E-02	5.11E-02	7.32E-01
Thorium-230	101	8.74E-02	3.89E-01	2.78E+00	3.15E-02	2.50E+00	1.81E+00	3.65E+01	5.73E-02	9.34E+00	4.57E-01	6.37E-01	4.86E-01	1.97E+00	1.55E+00	2.22E+01
Uranium-234	6.51	9.55E-03	4.25E-02	3.03E-01	3.44E-03	2.73E-01	1.98E-01	3.99E+00	6.26E-03	4.52E+01	2.21E+00	3.08E+00	2.35E+00	9.53E+00	7.49E+00	1.07E+02
Uranium-238	6.51	9.55E-03	4.25E-02	3.03E-01	3.44E-03	2.73E-01	1.98E-01	3.99E+00	6.26E-03	4.52E+01	2.21E+00	3.08E+00	2.35E+00	9.53E+00	7.49E+00	1.07E+02

Notes

a. N288.1 Table G.8

b. For elements that are not listed in Table G.8, a surrogate element was used as follows (surrogate in parentheses): Cd (Zn); Cu (Ag); Po (Te), V (Nb).

3.7.6 Dose Coefficients for Terrestrial Animals, Birds, and Humans

Dose coefficients for all internal and external exposure routes to terrestrial animals and birds are presented in Table 3-18 and Table 3-19, respectively. The DCFs for terrestrial animals and birds follow the approach of the ICRP (2008). Progeny with half lives shorter than 10 days are included in each DCF.

Table 3-18: Internal Dose coefficients for Terrestrial Animals and Birds

COPC	DCF internal (µGy/hr)/(Bq/kg(fw animal))							
	Black Bear [a]	Canada Lynx [b]	Mink [b]	Moose [a]	Muskrat [b]	Snowshoe Hare [b]	Southern Red-backed Vole [b]	Woodland Caribou [a]
Lead-210	2.5E-04	2.4E-04	2.4E-04	2.5E-04	2.4E-04	2.4E-04	2.4E-04	2.5E-04
Polonium-210	3.0E-02	3.0E-02	3.0E-02	3.0E-02	3.0E-02	3.0E-02	3.0E-02	3.0E-02
Radium-226	1.4E-01	1.4E-01	1.4E-01	1.4E-01	1.4E-01	1.4E-01	1.4E-01	1.4E-01
Thorium-230	2.7E-02	2.7E-02	2.7E-02	2.7E-02	2.7E-02	2.7E-02	2.7E-02	2.7E-02
Uranium-234	2.8E-02	2.8E-02	2.8E-02	2.8E-02	2.8E-02	2.8E-02	2.8E-02	2.8E-02
Uranium-238	2.4E-02	2.4E-02	2.4E-02	2.4E-02	2.4E-02	2.4E-02	2.4E-02	2.4E-02
COPC	**American Robin [c]**	**Bald Eagle [c]**	**Canada Goose [c]**	**Common Loon [c]**	**Lesser Scaup [c]**	**Mallard [c]**	**Olive-Sided Flycatcher [c]**	
Lead-210	2.5E-04	2.5E-04	2.5E-04	2.5E-04	2.5E-04	2.5E-04	2.5E-04	
Polonium-210	3.0E-02	3.0E-02	3.0E-02	3.0E-02	3.0E-02	3.0E-02	3.0E-02	
Radium-226	1.4E-01	1.4E-01	1.4E-01	1.4E-01	1.4E-01	1.4E-01	1.4E-01	
Thorium-230	2.7E-02	2.7E-02	2.7E-02	2.7E-02	2.7E-02	2.7E-02	2.7E-02	
Uranium-234	2.8E-02	2.8E-02	2.8E-02	2.8E-02	2.8E-02	2.8E-02	2.8E-02	
Uranium-238	2.4E-02	2.4E-02	2.4E-02	2.4E-02	2.4E-02	2.4E-02	2.4E-02	

a. DCFs are based on deer (ICRP 2008).
b. DCFs are based on rat (ICRP 2008).
c. DCFs are based on duck (ICRP 2008).
COPC = constituent of potential concern; DCF = dose coefficient.

Table 3-19: External Dose Coefficients for Terrestrial Animals and Birds

COPC	DCF external (µGy/hr)/(Bq/m^2)							
	Black Bear [a]	Canada Lynx [b]	Mink [b]	Moose [a]	Muskrat [b]	Snowshoe Hare [b]	Southern Red-backed Vole [b]	Woodland Caribou [a]
Lead-210	2.3E-09	6.3E-09	6.3E-09	2.3E-09	6.3E-09	6.3E-09	6.3E-09	2.3E-09
Polonium-210	1.4E-11	2.8E-11	2.8E-11	1.4E-11	2.8E-11	2.8E-11	2.8E-11	1.4E-11
Radium-226	2.8E-06	5.4E-06	5.4E-06	2.8E-06	5.4E-06	5.4E-06	5.4E-06	2.8E-06
Thorium-230	5.4E-10	1.3E-09	1.3E-09	5.4E-10	1.3E-09	1.3E-09	1.3E-09	5.4E-10
Uranium-234	2.8E-10	7.5E-10	7.5E-10	2.8E-10	7.5E-10	7.5E-10	7.5E-10	2.8E-10
Uranium-238	1.5E-10	4.1E-10	4.1E-10	1.5E-10	4.1E-10	4.1E-10	4.1E-10	1.5E-10

COPC	American Robin [c]	Bald Eagle [c]	Canada Goose [c]	Common Loon [c]	Lesser Scaup [c]	Mallard [c]	Olive-Sided Flycatcher [c]	
Lead-210	5.8E-09	5.8E-09	5.8E-09	5.8E-09	5.8E-09	5.8E-09	5.8E-09	
Polonium-210	2.6E-11	2.6E-11	2.6E-11	2.6E-11	2.6E-11	2.6E-11	2.6E-11	
Radium-226	5.0E-06	5.0E-06	5.0E-06	5.0E-06	5.0E-06	5.0E-06	5.0E-06	
Thorium-230	1.3E-09	1.3E-09	1.3E-09	1.3E-09	1.3E-09	1.3E-09	1.3E-09	
Uranium-234	7.1E-10	7.1E-10	7.1E-10	7.1E-10	7.1E-10	7.1E-10	7.1E-10	
Uranium-238	3.9E-10	3.9E-10	3.9E-10	3.9E-10	3.9E-10	3.9E-10	3.9E-10	

a. DCFs are based on deer (ICRP 2008).
b. DCFs are based on rat (ICRP 2008).
c. DCFs are based on duck (ICRP 2008).
COPC = constituent of potential concern; DCF = dose coefficient.

Dose coefficients for all internal and external exposure routes for humans are presented in Table 3-20. The DCFs for ingestion and inhalation by human receptors were taken from CSA N288.1-20 and are progeny inclusive.

The external DCFs used in this IMPACT model update were derived based on the methodology described in CSA N288.1-20. Uranium-238 progeny associated with each of the radionuclides, as required, were included in the external DCFs as follows:

- uranium-238 with its progeny thorium-234 and protactinium-234m;
- uranium-234 was modelled explicitly and no progeny were included in the external DCF;
- thorium-230 was modelled explicitly and no progeny were included in the external DCF;
- radium-226 with its progeny radon-222 (except for air immersion), polonium-218, lead-214, bismuth-214, and polonium-214;
- lead-210 with its progeny bismuth-210; and
- radon-222 (air immersion only) with its progeny polonium-218, lead-214, and bismuth-214.

The achievement of transient or secular equilibrium by ingrowth of progeny takes time. Therefore, the available time for ingrowth in each exposure medium must be considered in deciding whether it is reasonable to assume equilibrium. The timeframes for ingrowth of the progeny assumed for each of the external pathways were two hours for air immersion, one day for water immersion, and 40 years for exposure to soils and sediment. Details for the calculation of the external DCFs are described in CSA N288.1-20.

Table 3-20: Human Dose Coefficients for Internal and External Exposure

COPC	Ingestion DCF	Inhalation DCF	External Soil DCF	External Water Immersion DCF	External Sediment DCF	External Air Immersion DCF
	(Sv/Bq)	(Sv/Bq)	(Sv/yr)/ (Bq/m^2)	(Sv/yr)/ (Bq/L)	(Sv/yr)/ (Bq/kg)	(Sv/yr)/ (Bq/m^3)
Adult						
Lead-210	6.9E-07	1.1E-06	1.2E-09	4.5E-09	1.8E-09	1.4E-09
Polonium-210	1.2E-06	3.3E-06	2.6E-13	2.7E-11	7.4E-12	1.2E-11
Radium-226	2.8E-07	3.5E-06	5.3E-08	9.2E-07	1.5E-06	9.0E-09
Thorium-230	2.1E-07	1.4E-05	2.4E-11	1.1E-09	2.3E-10	4.7E-10
Uranium-234	4.9E-08	3.5E-06	1.9E-11	4.4E-10	7.8E-11	1.9E-10
Uranium-238	4.5E-08	2.9E-06	3.7E-09	2.5E-09	2.2E-08	7.9E-11
1-year old						
Lead-210	3.6E-06	3.7E-06	1.5E-09	4.8E-09	2.3E-09	1.8E-09
Polonium-210	8.8E-06	1.1E-05	3.3E-13	3.5E-11	9.6E-12	1.6E-11
Radium-226	9.6E-07	1.1E-05	6.9E-08	1.2E-06	2.0E-06	1.2E-08
Thorium-230	4.1E-07	3.5E-05	2.6E-11	1.4E-09	3.0E-10	6.1E-10
Uranium-234	1.3E-07	1.1E-05	2.4E-11	5.7E-10	1.0E-10	2.5E-10
Uranium-238	1.2E-07	9.4E-06	4.8E-09	3.3E-09	2.8E-08	1.0E-10

COPC = constituent of potential concern; DCF = dose coefficient; Sv/yr = sieverts per year; Bq = becquerel.

4.0 References

Arnold TW, Fritzell EK. 1987. Food habits of prairie mink during the waterfowl breeding season. Canadian Journal of Zoology. 65, 2322–2324.

Barnett, C.L., Beresford, N.A., Walker, L.A. et al. Transfer parameters for ICRP reference animals and plants collected from a forest ecosystem. Radiat Environ Biophys 53, 125–149 (2014).

Beresford NA, Barnett CL, Howard BJ, Scott WA, Brown JE, Copplestone D. 2008. Derivation of transfer parameters for use within the ERICA Tool and the default concentration ratios for terrestrial biota. Journal of Environmental Radioactivity. 99 1393-1407.

Beyer WN, Connor E, Gerould S. 1994. Estimates of Soil Ingestion by Wildlife. Journal of Wildlife Management 58.

Brown JE, Alfonso B, Avila R, Beresford NA, Copplestone D, Prohl G, Ulanovsky A. 2008. The ERICA Tool. Journal of Environmental Radioactivity. 99 1393-1407 99, 1371–1383. September.

Cameco, 2004. Cigar Lake Project: Construction, Operation, and Decommissioning Environmental Assessment Study Report

CANDU Owners Group (COG), 2019. Derived Release Limits Guidance. COG-06-3090R4-I.

CanNorth (Canada North Environmental Services), 2000. Hatchet Lake Dietary Survey. Report Prepared for: Atomic Energy Control Board, Ottawa ON. March 2000

CanNorth (Canada North Environmental Services), 2017. English River First Nation Country Foods Study. Report Prepared for: English River First Nation, Patuanak, Saskatchewan. September 2017

Chapman PM, Allen HE, Z'Graggen MN. 1996. Evaluation of bioaccumulation factors in regulating metals. Environmental Science and Technology. 30, 448A-452A.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada.). 2002. COSEWIC assessment and update status report on the woodland caribou *Rangifer tarandus* caribou in Canada.

CSA Group (Canadian Standards Association Group). 2022. CSA N288.6-22: Environmental Risk Assessments at Nuclear Facilities and Uranium Mines and Mills.

CSA Group. 2020. CSA N288.1-20: Guidelines for Calculating Derived Release Limits for Radioactive Material in Airborne or Liquid Effluents for Normal Operation of Nuclear Facilities.

Ecometrix (Ecometrix Incorporated), 2005. Key Lake Project: Environmental Risk Assessment 2005. Report Prepared for Cameco Corporation.

Ecometrix (Ecometrix Incorporated), 2012. Key Lake IMPACT model 2011 Update. Report prepared for Cameco Corporation.

Ecometrix (Ecometrix Incorporated), 2013a. Key Lake Extension Project - Ecological and Human Health Risk Assessment. Report prepared for Cameco Corporation. In: Cameco. 2013. Key Lake Extension Project Environmental Impact Statement, Annex VII.

Ecometrix (Ecometrix Incorporated), 2013b. Millennium Project - Ecological and Human Health Risk Assessment. Report prepared for Cameco Corporation. In: Cameco. 2013. Millennium Project Environmental Impact Statement, Annex J.

Ecometrix (Ecometrix Incorporated), 2013c. Millennium IMPACT Model 2012. Report prepared for Cameco Corporation. In: Cameco. 2013. Millennium Project Environmental Impact Statement, Annex K.

Ecometrix (Ecometrix Incorporated), 2013d. McArthur River – IMPACT Model 2013 Update. Report prepared for Cameco Corporation. December 2013.

Ecometrix (Ecometrix Incorporated), 2020a. Wheeler River Project: Baseline Aquatic Environment Study. Report prepared for Denison Mines Corporation.

Ecometrix (Ecometrix Incorporated), 2020b. Wheeler River Project: Baseline Hydrology Summary Report. Report prepared for Denison Mines Corporation.

Environment Canada, 2015. Recovery Strategy for Olive-sided Flycatcher (*Contopus cooperi*) in Canada [Proposed]. *Species at Risk Act* Recovery Strategy Series. Environment Canada, Ottawa. vi + 51 pp.

FCSAP (Federal Contaminated Sites Action Plan), 2012. Ecological Risk Assessment Guidance, Module 3: Standardization of Wildlife Receptor Characteristics. Prepared for: Environment Canada (Government of Canada), Vancouver, BC. March.

Franzmann AW. 1981. *Alces alces*. Mammalian Species. 154:1–7. May.

Hamilton SJ, Mehrle PM. 1986. Metallothionein in fish: review of its importance in assessing stress from metal contaminants. Transactions of the American Fisheries Society 115, 596–609.

Hart D. 2019. Derived Release Limits. Report No. COG-06-3090-R4-I.

Health Canada, 2000. Food and Nutrition. Dietary Intakes of Contaminants and other Chemicals for Different Age-sex Groups of Canadians (1993 to 1999).

Health Canada, 2010a. Federal Contaminated Site Risk Assessment in Canada, Part I: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA), Version 2.0. Contaminated Sites Program. September.

Health Canada, 2010b. Federal Contaminated Site Risk Assessment in Canada. Part VI: Guidance on Human Health Detailed Quantitative Radiological Risk Assessment (DQRARAD). September.

Health Canada, 2011. Food and Nutrition. Dietary Intakes of Contaminants and other Chemicals for Different Age-sex Groups of Canadians (2000 to 2011).

Health Canada, 2018. Guidance for Evaluating Human Health Impacts in Environmental Assessment: Country Foods. Report No. H129- 54/5-2018. May.

Health Canada, 2020. Canadian Total Diet Study - Trace Elements 1993-2018. Available at **https://open.canada.ca/data/en/dataset/83934503-cfae-4773-b258-e336896c2c53**

Hinterland Who's Who, 2007. Profile on the Black Bear. Available at **http://www.hww.ca/en/wildlife/mammals/black-bear.html**

IAEA (International Atomic Energy Agency), 2010. Handbook of Parameter Values for the Prediction of Radionuclide Transfer in Terrestrial and Freshwater Environments. Technical Report Series No. 472.

IEC (Independent Environmental Consultants), 2024. Atmospheric Environment: Air Quality Impact Assessment, Denison Mines Corp. – Wheeler River Project. Report prepared for Denison Mines Corporation. January.

ICRP (International Commission on Radiological Protection), 2008. Environmental Protection - the Concept and Use of Reference Animals and Plants. ICRP Publication 108.

Livingston, S.A., C.S. Todd, W.B. Krohn and R.B. Owen, Jr. 1990. Habitat models for nesting bald eagles in Maine. J. Wildl. Manage. 54(4):644-653.

McLoughlin PD, Stewart K, Superbie C, Perry T, Tomchuk P, Greuel R, Singh K, Truchon-Savard A, Henkelman J, Johnstone JF (Department of Biology, University of Saskatchewan). 2016. Population dynamics and critical habitat of woodland caribou in the Saskatchewan Boreal Shield. Interim Project Report, 2013-2016.

McLoughlin PD, Superbie CM, Stewart K, Tomchuk P, Neufeld B, Barks D, Perry T, Greuel R, Regan C, Truchon-Savard A, Hart S, Henkelman J, Johnstone JF (Department of Biology, University of Saskatchewan). 2019. Population and habitat ecology of boreal caribou and their predators in the Saskatchewan Boreal Shield. Final Report.

NCRP (National Council on Radiation Protection and Measurements). 1996. Screening Models for Releases of Radionuclides to Atmosphere, Surface Water, and Ground - Vol. I and Vol. II. Report No. 123.

NewFields (NewFields Canada Mining & Environment), 2021. Hydrological Effects Assessment Report for Denison Mines Wheeler River Project. Report prepared for Ecometrix Incorporated. July 2021.

Newman MC, Unger MA. 2002. Fundamentals of Ecotoxicology, 2nd ed. CRC/Lewis Press, Boca Raton, FL.

Omnia (Omnia Ecological Services), 2020. Denison Mines Corporation Wheeler River Project - Terrestrial Environment Wildlife and Vegetation Baseline Inventory.

Richardson GM. 1997. Compendium of Canadian Human Exposure Factors for Risk Assessment. O'Connor Associates.

Sample BE, Beauchamp JJ, Efroymson RA, Suter GW, Ashwood TL. 1998. Development and Validation of Bioaccumulation Models for Earthworms. Report No. ES/ER/TM-220.

Sheppard, S.C., Long, J. and Sanipelli, B. 2009. Field measurements of the transfer factors for iodine and other trace elements. NWMO TR-2009-35

Species at Risk Act. SC. 2002, c 29. Last amended 12 August 2021. Available at: **https://laws-lois.justice.gc.ca/eng/acts/s-15.3/**

Thomann RV, Mueller JA. 1987. Principles of Surface Water Quality Modeling and Control. Harper & Row, Publishers, New York.

Thompson, S.E., C.A. Burton, D.J. Quinn and Y.C. Ng. 1972. Concentration factors of chemical elements in edible aquatic organisms. Lawrence Livermore Laboratory, University of California. Rep. UCRL-50564 Rev. 1.

UNSCEAR (United Nations Scientific Committee on the Effects of Atomic Radiation). 2000. Volume 1, Annex B: Exposures from Natural Radiation Sources and Effects of Ionizing Radiation, Report to the General Assembly with Scientific Annexes.

US EPA (United States Environmental Protection Agency). 1986. Standard for Radon-222 Emissions from Licensed Uranium Mill Tailings. Report No. EPA 520/1-86-009.

US EPA. 1993. Wildlife Exposure Factors Handbook. Report No. EPA/600/R-93/187.

US EPA. 2007. Attachment 4-1 Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs) Exposure Factors and Bioaccumulation Models for Derivation of Wildlife Eco-SSLsd

U.S. FWS (Fish and Wildlife Service), 2002. **https://www.fws.gov/r5gomp/gom/habitatstudy/metadata/bald_eagle_model.htm**

U.S. FWS (Fish and Wildlife Service), 2017. Species Status Assessment for the Canada Lynx (Lynx canadensis), Contiguous United States Distinct Population Segment. Version 1.0 - Final, October 2017.

Wilson D, Ruff S. 1999. The Smithsonian Book of North American Mammals. Smithsonian Institution Press, Washington.

Wood CM, Port P. 2000. Intracellular pH regulation and buffer capacity in CO_2/HCO_3-buffered media in cultured epithelial cells from rainbow trout gills. Journal of Comparative Physiology. 170, 175–184.

Appendix B Model Results in Support of the ERA

Table B.1: Maximum Concentration of Non-radionuclides in Environmental Media during Project Phases

Environmental Media	Location	Maximum Concentration of Non-radionuclides during Project Phases											
		Arsenic	Cadmium	Chloride	Cobalt	Chromium	Copper	Molybdenum	Sulphate	Selenium	Uranium	Vanadium	Zinc
Water (mg/L)	Kratchkowsky Lake	1.19E-04	2.38E-05	3.22E-01	1.01E-04	5.30E-04	6.22E-04	1.07E-04	6.87E-01	3.35E-05	3.12E-05	1.67E-04	7.00E-04
	Whitefish Lake North	1.10E-04	2.34E-05	3.22E-01	1.01E-04	5.24E-04	6.20E-04	1.07E-04	6.87E-01	3.28E-05	3.05E-05	1.55E-04	6.89E-04
	Whitefish Lake Middle	1.46E-04	3.97E-05	6.14E+00	1.29E-04	7.46E-04	8.22E-04	2.43E-02	3.87E+01	4.33E-04	5.74E-04	6.70E-04	1.06E-03
	Whitefish Lake South	1.49E-04	3.86E-05	6.11E+00	1.28E-04	7.30E-04	8.17E-04	2.40E-02	3.85E+01	4.12E-04	5.47E-04	5.64E-04	1.03E-03
	McGowan Lake	1.26E-04	3.28E-05	4.20E+00	1.19E-04	6.54E-04	7.50E-04	1.58E-02	2.60E+01	2.59E-04	3.38E-04	3.28E-04	9.01E-04
	Icelander River	1.26E-04	3.26E-05	4.16E+00	1.19E-04	6.52E-04	7.49E-04	1.56E-02	2.57E+01	2.56E-04	3.34E-04	3.26E-04	8.99E-04
	Russell Lake Inlet	1.22E-04	3.01E-05	3.26E+00	1.14E-04	6.17E-04	7.17E-04	1.18E-02	1.99E+01	1.95E-04	2.52E-04	2.69E-04	8.40E-04
Sediment (mg/kg dw)	Kratchkowsky Lake	8.35E+00	3.38E-01	-	2.52E-01	5.86E+00	1.85E+00	3.37E-01	-	6.22E-01	5.78E-01	1.12E+01	9.93E+00
	Whitefish Lake North	8.35E+00	3.38E-01	-	2.52E-01	5.86E+00	1.85E+00	3.37E-01	-	6.22E-01	5.78E-01	1.12E+01	9.93E+00
	Whitefish Lake Middle	1.10E+01	4.97E-01	-	3.05E-01	7.59E+00	2.31E+00	5.72E+01	-	5.48E+00	7.18E+00	3.72E+01	1.36E+01
	Whitefish Lake South	1.05E+01	4.90E-01	-	3.04E-01	7.53E+00	2.30E+00	5.62E+01	-	5.26E+00	6.87E+00	3.33E+01	1.35E+01
	McGowan Lake	9.47E+00	4.43E-01	-	2.90E-01	7.03E+00	2.18E+00	4.11E+01	-	3.71E+00	4.78E+00	2.22E+01	1.24E+01
	Russell Lake Inlet	9.04E+00	4.15E-01	-	2.81E-01	6.73E+00	2.10E+00	3.13E+01	-	2.88E+00	3.64E+00	1.82E+01	1.17E+01
Air (mg/m^3)	Kratchkowsky Lake	7.00E-07	7.44E-08	-	7.07E-07	1.49E-07	6.30E-05	7.19E-07	-	1.54E-07	6.00E-07	1.43E-06	2.16E-04
	Whitefish Lake South	7.05E-07	7.58E-08	-	7.14E-07	1.68E-07	6.33E-05	7.25E-07	-	1.57E-07	1.77E-05	1.46E-06	2.16E-04
	Whitefish Lake Middle	7.12E-07	7.75E-08	-	7.22E-07	1.93E-07	6.38E-05	7.34E-07	-	1.61E-07	3.45E-05	1.51E-06	2.16E-04
	McGowan Lake	7.01E-07	7.47E-08	-	7.08E-07	1.54E-07	6.31E-05	7.20E-07	-	1.55E-07	5.05E-06	1.43E-06	2.16E-04
	Russell Lake Inlet	7.00E-07	7.45E-08	-	7.07E-07	1.50E-07	6.30E-05	7.19E-07	-	1.54E-07	1.79E-06	1.43E-06	2.16E-04
Soil (mg/kg dw)	Kratchkowsky Lake	6.16E-01	3.61E-01	-	2.65E-01	3.31E+00	1.46E+00	1.15E-01	-	1.07E-01	3.82E-01	4.81E+00	5.31E+00
	Whitefish Lake South	6.16E-01	3.61E-01	-	2.66E-01	3.31E+00	1.48E+00	1.15E-01	-	1.07E-01	1.68E+00	4.82E+00	5.32E+00
	Whitefish Lake Middle	6.16E-01	3.61E-01	-	2.67E-01	3.31E+00	1.51E+00	1.15E-01	-	1.08E-01	2.89E+00	4.82E+00	5.33E+00
	McGowan Lake	6.16E-01	3.61E-01	-	2.65E-01	3.31E+00	1.46E+00	1.15E-01	-	1.07E-01	7.12E-01	4.81E+00	5.31E+00
	Russell Lake Inlet	6.16E-01	3.61E-01	-	2.65E-01	3.31E+00	1.46E+00	1.15E-01	-	1.07E-01	4.70E-01	4.81E+00	5.31E+00

Table B.2: Maximum Concentration of Non-radionuclides in Environmental Media during Future Centuries

Environmental Media	Location	Maximum Concentration of Non-radionuclides during Future Centuries											
		Arsenic	Cadmium	Chloride	Cobalt	Chromium	Copper	Molybdenum	Sulphate	Selenium	Uranium	Vanadium	Zinc
Water (mg/L)	Kratchkowsky Lake	1.03E-04	2.32E-05	3.22E-01	1.01E-04	5.19E-04	6.18E-04	1.07E-04	6.87E-01	3.23E-05	3.01E-05	1.46E-04	6.81E-04
	Whitefish Lake North	1.03E-04	2.32E-05	3.22E-01	1.01E-04	5.19E-04	6.18E-04	1.07E-04	6.87E-01	3.23E-05	3.01E-05	1.46E-04	6.81E-04
	Whitefish Lake Middle	1.07E-04	2.33E-05	4.15E-01	1.06E-04	5.26E-04	6.26E-04	1.16E-04	7.21E-01	4.30E-05	3.68E-05	1.47E-04	7.40E-04
	Whitefish Lake South	1.07E-04	2.33E-05	4.14E-01	1.06E-04	5.26E-04	6.26E-04	1.16E-04	7.20E-01	4.26E-05	3.65E-05	1.47E-04	7.37E-04
	McGowan Lake	1.05E-04	2.33E-05	3.93E-01	1.05E-04	5.24E-04	6.24E-04	1.14E-04	7.13E-01	3.94E-05	3.45E-05	1.46E-04	7.21E-04
	Icelander River	1.05E-04	2.33E-05	3.92E-01	1.05E-04	5.24E-04	6.24E-04	1.14E-04	7.13E-01	3.94E-05	3.45E-05	1.46E-04	7.21E-04
	Russell Lake Inlet	1.04E-04	2.32E-05	3.76E-01	1.04E-04	5.23E-04	6.23E-04	1.12E-04	7.07E-01	3.76E-05	3.33E-05	1.46E-04	7.11E-04
Sediment (mg/kg dw)	Kratchkowsky Lake	8.35E+00	3.38E-01	-	2.52E-01	5.86E+00	1.85E+00	3.37E-01	-	6.22E-01	5.78E-01	1.12E+01	9.93E+00
	Whitefish Lake North	8.35E+00	3.38E-01	-	2.52E-01	5.86E+00	1.85E+00	3.37E-01	-	6.22E-01	5.78E-01	1.12E+01	9.93E+00
	Whitefish Lake Middle	8.66E+00	3.40E-01	-	2.65E-01	5.94E+00	1.87E+00	3.68E-01	-	8.28E-01	7.07E-01	1.13E+01	1.08E+01
	Whitefish Lake South	8.62E+00	3.40E-01	-	2.65E-01	5.93E+00	1.87E+00	3.67E-01	-	8.19E-01	7.02E-01	1.13E+01	1.08E+01
	McGowan Lake	8.48E+00	3.39E-01	-	2.62E-01	5.91E+00	1.87E+00	3.60E-01	-	7.59E-01	6.64E-01	1.13E+01	1.05E+01
	Russell Lake Inlet	8.43E+00	3.39E-01	-	2.59E-01	5.90E+00	1.86E+00	3.55E-01	-	7.22E-01	6.41E-01	1.12E+01	1.04E+01
Air (mg/m^3)	Kratchkowsky Lake	7.00E-07	7.44E-08	-	7.07E-07	1.49E-07	6.30E-05	7.19E-07	-	1.54E-07	6.00E-07	1.43E-06	2.16E-04
	Whitefish Lake South	7.00E-07	7.44E-08	-	7.07E-07	1.49E-07	6.30E-05	7.19E-07	-	1.54E-07	6.00E-07	1.43E-06	2.16E-04
	Whitefish Lake Middle	7.00E-07	7.44E-08	-	7.07E-07	1.49E-07	6.30E-05	7.19E-07	-	1.54E-07	6.00E-07	1.43E-06	2.16E-04
	McGowan Lake	7.00E-07	7.44E-08	-	7.07E-07	1.49E-07	6.30E-05	7.19E-07	-	1.54E-07	6.00E-07	1.43E-06	2.16E-04
	Russell Lake Inlet	7.00E-07	7.44E-08	-	7.07E-07	1.49E-07	6.30E-05	7.19E-07	-	1.54E-07	6.00E-07	1.43E-06	2.16E-04
Soil (mg/kg dw)	Kratchkowsky Lake	6.16E-01	3.61E-01	-	2.65E-01	3.31E+00	1.46E+00	1.15E-01	-	1.07E-01	3.82E-01	4.81E+00	5.31E+00
	Whitefish Lake South	6.16E-01	3.61E-01	-	2.66E-01	3.31E+00	1.46E+00	1.15E-01	-	1.07E-01	4.55E-01	4.81E+00	5.31E+00
	Whitefish Lake Middle	6.16E-01	3.61E-01	-	2.66E-01	3.31E+00	1.46E+00	1.15E-01	-	1.07E-01	5.25E-01	4.81E+00	5.31E+00
	McGowan Lake	6.16E-01	3.61E-01	-	2.65E-01	3.31E+00	1.46E+00	1.15E-01	-	1.07E-01	4.01E-01	4.81E+00	5.31E+00
	Russell Lake Inlet	6.16E-01	3.61E-01	-	2.65E-01	3.31E+00	1.46E+00	1.15E-01	-	1.07E-01	3.87E-01	4.81E+00	5.31E+00

Table B.3: Maximum Concentration of Radionuclides in Environmental Media during Project Phases

Environmental Media	Location	Maximum Concentration of Radionuclides during Project Phases						
		Uranium-238	Uranium-234	Thorium-230	Radium-226	Radon-222	Lead-210	Polonium-210
Water (Bq/L)	Kratchkowsky Lake	3.85E-04	3.85E-04	1.01E-02	5.70E-03	-	6.22E-03	6.33E-03
	Whitefish Lake North	3.77E-04	3.77E-04	1.01E-02	5.63E-03	-	5.68E-03	5.78E-03
	Whitefish Lake Middle	7.05E-03	7.05E-03	1.87E-02	6.87E-03	-	8.36E-03	6.71E-03
	Whitefish Lake South	6.72E-03	6.72E-03	1.85E-02	6.73E-03	-	8.25E-03	7.22E-03
	McGowan Lake	4.15E-03	4.15E-03	1.57E-02	6.33E-03	-	6.68E-03	6.23E-03
	Icelander River	4.11E-03	4.11E-03	1.56E-02	6.32E-03	-	6.66E-03	6.20E-03
	Russell Lake Inlet	3.09E-03	3.09E-03	1.43E-02	6.14E-03	-	6.41E-03	6.16E-03
Sediment (Bq/kg dw)	Kratchkowsky Lake	7.14E+00	7.14E+00	2.32E+01	6.51E+01	-	3.74E+02	3.80E+02
	Whitefish Lake North	7.14E+00	7.14E+00	2.32E+01	6.51E+01	-	3.74E+02	3.80E+02
	Whitefish Lake Middle	8.82E+01	8.82E+01	3.83E+01	7.57E+01	-	5.57E+02	5.58E+02
	Whitefish Lake South	8.44E+01	8.44E+01	3.80E+01	7.52E+01	-	5.19E+02	5.22E+02
	McGowan Lake	5.87E+01	5.87E+01	3.41E+01	7.23E+01	-	4.42E+02	4.47E+02
	Russell Lake Inlet	4.48E+01	4.48E+01	3.15E+01	7.04E+01	-	4.14E+02	4.20E+02
Air (Bq/m^3)	Kratchkowsky Lake	7.41E-06	7.41E-06	-	-	0.00E+00	-	-
	Whitefish Lake South	2.19E-04	2.19E-04	-	-	1.24E+01	-	-
	Whitefish Lake Middle	4.26E-04	4.26E-04	-	-	3.61E+01	-	-
	McGowan Lake	6.23E-05	6.23E-05	-	-	2.50E+00	-	-
	Russell Lake Inlet	2.21E-05	2.21E-05	-	-	5.92E-01	-	-
Soil (Bq/kg dw)	Kratchkowsky Lake	4.72E+00	4.72E+00	2.00E+01	1.52E+01	-	7.29E+01	6.55E+01
	Whitefish Lake South	2.08E+01	2.08E+01	2.00E+01	1.52E+01	-	7.29E+01	6.55E+01
	Whitefish Lake Middle	3.57E+01	3.57E+01	2.00E+01	1.52E+01	-	7.29E+01	6.55E+01
	McGowan Lake	8.79E+00	8.79E+00	2.00E+01	1.52E+01	-	7.29E+01	6.55E+01
	Russell Lake Inlet	5.81E+00	5.81E+00	2.00E+01	1.52E+01	-	7.29E+01	6.55E+01

Table B.4: Maximum Concentration of Radionuclides in Environmental Media during Future Centuries

Environmental Media	Location	Maximum Concentration of Radionuclides during Future Centuries					
		Uranium-238	Uranium-234	Thorium-230	Radium-226	Lead-210	Polonium-210
Water (Bq/L)	Kratchkowsky Lake	3.71E-04	3.71E-04	1.01E-02	5.57E-03	5.27E-03	5.36E-03
	Whitefish Lake North	3.71E-04	3.71E-04	1.01E-02	5.57E-03	5.27E-03	5.36E-03
	Whitefish Lake Middle	4.54E-04	4.54E-04	1.04E-02	6.39E-03	6.05E-03	6.15E-03
	Whitefish Lake South	4.51E-04	4.51E-04	1.04E-02	6.37E-03	5.92E-03	6.02E-03
	McGowan Lake	4.26E-04	4.26E-04	1.03E-02	6.15E-03	5.57E-03	5.66E-03
	Icelander River	4.26E-04	4.26E-04	1.03E-02	6.14E-03	5.56E-03	5.64E-03
	Russell Lake Inlet	4.12E-04	4.12E-04	1.03E-02	6.00E-03	5.45E-03	5.53E-03
Sediment (Bq/kg dw)	Kratchkowsky Lake	7.14E+00	7.14E+00	2.32E+01	6.51E+01	3.74E+02	3.80E+02
	Whitefish Lake North	7.14E+00	7.14E+00	2.32E+01	6.51E+01	3.74E+02	3.80E+02
	Whitefish Lake Middle	8.74E+00	8.74E+00	2.38E+01	7.47E+01	4.29E+02	4.36E+02
	Whitefish Lake South	8.67E+00	8.67E+00	2.38E+01	7.44E+01	4.19E+02	4.27E+02
	McGowan Lake	8.20E+00	8.20E+00	2.36E+01	7.18E+01	3.95E+02	4.01E+02
	Russell Lake Inlet	7.92E+00	7.92E+00	2.35E+01	7.01E+01	3.86E+02	3.93E+02
Air (Bq/m^3)	Kratchkowsky Lake	7.41E-06	7.41E-06	-	-	-	-
	Whitefish Lake South	7.41E-06	7.41E-06	-	-	-	-
	Whitefish Lake Middle	7.41E-06	7.41E-06	-	-	-	-
	McGowan Lake	7.41E-06	7.41E-06	-	-	-	-
	Russell Lake Inlet	7.41E-06	7.41E-06	-	-	-	-
Soil (Bq/kg dw)	Kratchkowsky Lake	4.72E+00	4.72E+00	2.00E+01	1.52E+01	7.29E+01	6.55E+01
	Whitefish Lake South	5.63E+00	5.63E+00	2.00E+01	1.52E+01	7.29E+01	6.55E+01
	Whitefish Lake Middle	6.48E+00	6.48E+00	2.00E+01	1.52E+01	7.29E+01	6.55E+01
	McGowan Lake	4.95E+00	4.95E+00	2.00E+01	1.52E+01	7.29E+01	6.55E+01
	Russell Lake Inlet	4.78E+00	4.78E+00	2.00E+01	1.52E+01	7.29E+01	6.55E+01

Table B.5: Maximum Concentration of Non-radionuclides for Ecological Receptors during Project Phases

Biota		Location	Maximum Concentration of Non-radionuclides during Project Phases (mg/kg fw)									
			Arsenic	Cadmium	Cobalt	Chromium	Copper	Molybdenum	Selenium	Uranium	Vanadium	Zinc
Aquatic Plants	Macrophytes	Reference (Kratchkowsky Lake)	2.05E-02	1.56E-03	1.60E-02	5.30E-03	1.35E-01	7.31E-04	5.95E-03	1.57E-03	5.43E-02	3.93E-01
		Whitefish Lake North	1.89E-02	1.53E-03	1.60E-02	5.24E-03	1.34E-01	7.28E-04	5.82E-03	1.54E-03	5.03E-02	3.87E-01
		Whitefish Lake Middle	2.52E-02	2.59E-03	2.03E-02	7.46E-03	1.78E-01	1.65E-01	7.68E-02	2.89E-02	2.18E-01	5.97E-01
		Whitefish Lake South	2.56E-02	2.52E-03	2.02E-02	7.30E-03	1.77E-01	1.63E-01	7.32E-02	2.76E-02	1.83E-01	5.81E-01
		McGowan Lake	2.17E-02	2.14E-03	1.88E-02	6.54E-03	1.63E-01	1.07E-01	4.59E-02	1.70E-02	1.07E-01	5.06E-01
		Russell Lake Inlet	2.10E-02	1.97E-03	1.81E-02	6.17E-03	1.56E-01	8.06E-02	3.47E-02	1.27E-02	8.73E-02	4.72E-01
	Phytoplankton	Reference (Kratchkowsky Lake)	2.05E-02	1.56E-03	1.60E-02	5.30E-03	1.35E-01	7.31E-04	5.95E-03	1.57E-03	5.43E-02	3.93E-01
		Whitefish Lake North	1.89E-02	1.53E-03	1.60E-02	5.24E-03	1.34E-01	7.28E-04	5.82E-03	1.54E-03	5.03E-02	3.87E-01
		Whitefish Lake Middle	2.52E-02	2.59E-03	2.03E-02	7.46E-03	1.78E-01	1.65E-01	7.68E-02	2.89E-02	2.18E-01	5.97E-01
		Whitefish Lake South	2.56E-02	2.52E-03	2.02E-02	7.30E-03	1.77E-01	1.63E-01	7.32E-02	2.76E-02	1.83E-01	5.81E-01
		McGowan Lake	2.17E-02	2.14E-03	1.88E-02	6.54E-03	1.63E-01	1.07E-01	4.59E-02	1.70E-02	1.07E-01	5.06E-01
		Russell Lake Inlet	2.10E-02	1.97E-03	1.81E-02	6.17E-03	1.56E-01	8.06E-02	3.47E-02	1.27E-02	8.73E-02	4.72E-01
Aquatic Animals	Benthic Invertebrate	Reference (Kratchkowsky Lake)	4.68E-02	5.84E-03	2.01E-02	1.98E-01	4.79E+00	1.72E-02	3.32E-02	2.89E-03	4.80E-02	2.84E+00
		Whitefish Lake North	4.67E-02	5.84E-03	2.01E-02	1.98E-01	4.79E+00	1.72E-02	3.32E-02	2.89E-03	4.80E-02	2.84E+00
		Whitefish Lake Middle	6.18E-02	8.59E-03	2.43E-02	2.56E-01	5.99E+00	2.91E+00	2.93E-01	3.59E-02	1.59E-01	3.90E+00
		Whitefish Lake South	5.91E-02	8.48E-03	2.42E-02	2.54E-01	5.96E+00	2.86E+00	2.81E-01	3.43E-02	1.43E-01	3.85E+00
		McGowan Lake	5.31E-02	7.66E-03	2.31E-02	2.37E-01	5.65E+00	2.10E+00	1.99E-01	2.39E-02	9.51E-02	3.54E+00
		Russell Lake Inlet	5.06E-02	7.18E-03	2.24E-02	2.27E-01	5.44E+00	1.59E+00	1.54E-01	1.82E-02	7.79E-02	3.35E+00
	Northern pike	Reference (Kratchkowsky Lake)	3.58E-02	7.15E-05	1.22E-03	2.92E-02	3.11E-01	1.07E-05	1.89E-01	6.24E-04	1.62E-02	1.40E+00
		Whitefish Lake North	3.30E-02	7.03E-05	1.21E-03	2.88E-02	3.10E-01	1.07E-05	1.86E-01	6.11E-04	1.50E-02	1.38E+00
		Whitefish Lake Middle	4.39E-02	1.19E-04	1.54E-03	4.10E-02	4.11E-01	2.43E-03	1.57E+00	1.15E-02	6.50E-02	2.13E+00
		Whitefish Lake South	4.47E-02	1.16E-04	1.54E-03	4.01E-02	4.08E-01	2.40E-03	1.51E+00	1.09E-02	5.47E-02	2.07E+00
		McGowan Lake	3.78E-02	9.83E-05	1.43E-03	3.60E-02	3.75E-01	1.58E-03	1.02E+00	6.76E-03	3.18E-02	1.80E+00
		Russell Lake Inlet	3.66E-02	9.04E-05	1.37E-03	3.40E-02	3.58E-01	1.18E-03	8.12E-01	5.03E-03	2.61E-02	1.68E+00
	White sucker	Reference (Kratchkowsky Lake)	3.33E-02	7.04E-05	1.21E-03	2.88E-02	3.10E-01	1.07E-05	1.46E-01	6.12E-04	1.51E-02	1.38E+00
		Whitefish Lake North	3.12E-02	6.96E-05	1.21E-03	2.86E-02	3.09E-01	1.07E-05	1.43E-01	6.02E-04	1.42E-02	1.36E+00
		Whitefish Lake Middle	4.15E-02	1.14E-04	1.52E-03	3.98E-02	4.04E-01	2.27E-03	1.74E+00	1.04E-02	5.86E-02	2.05E+00
		Whitefish Lake South	4.17E-02	1.11E-04	1.51E-03	3.90E-02	4.02E-01	2.24E-03	1.66E+00	9.91E-03	4.99E-02	2.00E+00
		McGowan Lake	3.57E-02	9.57E-05	1.42E-03	3.53E-02	3.72E-01	1.50E-03	1.06E+00	6.25E-03	2.97E-02	1.76E+00
		Russell Lake Inlet	3.45E-02	8.84E-05	1.37E-03	3.35E-02	3.56E-01	1.13E-03	8.06E-01	4.68E-03	2.44E-02	1.65E+00
	Zooplankton	Reference (Kratchkowsky Lake)	6.44E-02	6.19E-03	2.03E-02	2.07E-01	4.85E+00	1.74E-02	3.59E-02	3.12E-03	6.52E-02	3.01E+00
		Whitefish Lake North	5.94E-02	6.09E-03	2.02E-02	2.04E-01	4.83E+00	1.74E-02	3.51E-02	3.05E-03	6.03E-02	2.96E+00
		Whitefish Lake Middle	7.91E-02	1.03E-02	2.57E-02	2.91E-01	6.41E+00	3.94E+00	4.63E-01	5.74E-02	2.61E-01	4.57E+00
		Whitefish Lake South	8.04E-02	1.00E-02	2.56E-02	2.85E-01	6.37E+00	3.88E+00	4.41E-01	5.47E-02	2.20E-01	4.44E+00
		McGowan Lake	6.81E-02	8.52E-03	2.38E-02	2.55E-01	5.85E+00	2.55E+00	2.77E-01	3.38E-02	1.28E-01	3.87E+00
		Russell Lake Inlet	6.59E-02	7.83E-03	2.29E-02	2.41E-01	5.59E+00	1.92E+00	2.09E-01	2.52E-02	1.05E-01	3.61E+00
	Blueberries	Reference (Kratchkowsky Lake)	1.43E-01	8.53E-03	8.06E-02	1.42E-02	5.58E+00	6.60E-02	5.71E-02	3.43E-02	6.00E-03	1.35E+01
		Whitefish Lake	1.43E-01	8.56E-03	8.10E-02	1.43E-02	5.78E+00	6.64E-02	5.74E-02	2.85E-01	6.08E-03	1.35E+01
		McGowan Lake	1.43E-01	8.53E-03	8.07E-02	1.42E-02	5.60E+00	6.60E-02	5.71E-02	6.72E-02	6.01E-03	1.35E+01
		Russell Lake Inlet	1.43E-01	8.53E-03	8.06E-02	1.42E-02	5.58E+00	6.60E-02	5.71E-02	4.31E-02	6.00E-03	1.35E+01

Biota		Location	Maximum Concentration of Non-radionuclides during Project Phases (mg/kg fw)									
			Arsenic	Cadmium	Cobalt	Chromium	Copper	Molybdenum	Selenium	Uranium	Vanadium	Zinc
Terrestrial Plants	Browse	Reference (Kratchkowsky Lake)	7.16E-02	5.83E-02	5.00E-02	9.48E-03	3.65E+00	4.26E-02	2.56E-02	2.93E-02	4.07E-02	1.03E+01
		Whitefish Lake	7.19E-02	5.84E-02	5.06E-02	1.07E-02	3.75E+00	4.31E-02	2.59E-02	1.04E+00	4.29E-02	1.04E+01
		McGowan Lake	7.16E-02	5.83E-02	5.01E-02	9.62E-03	3.66E+00	4.26E-02	2.57E-02	1.62E-01	4.09E-02	1.04E+01
		Russell Lake Inlet	7.16E-02	5.83E-02	5.01E-02	9.52E-03	3.65E+00	4.26E-02	2.56E-02	6.47E-02	4.08E-02	1.04E+01
	Labrador Tea	Reference (Kratchkowsky Lake)	2.34E-01	7.56E-02	2.14E-01	4.41E-02	1.83E+01	2.10E-01	6.14E-02	1.69E-01	3.72E-01	6.05E+01
		Whitefish Lake	2.37E-01	7.64E-02	2.18E-01	5.55E-02	1.86E+01	2.14E-01	6.33E-02	9.05E+00	3.93E-01	6.06E+01
		McGowan Lake	2.34E-01	7.57E-02	2.15E-01	4.54E-02	1.83E+01	2.10E-01	6.16E-02	1.33E+00	3.74E-01	6.05E+01
		Russell Lake Inlet	2.34E-01	7.56E-02	2.14E-01	4.44E-02	1.83E+01	2.10E-01	6.15E-02	4.80E-01	3.73E-01	6.05E+01
	Lichen	Reference (Kratchkowsky Lake)	1.09E-01	6.75E-02	1.14E-01	1.49E+00	1.30E+00	8.10E-02	9.14E-02	8.89E-02	6.56E-01	1.28E+01
		Whitefish Lake	1.27E-01	7.22E-02	1.37E-01	1.55E+00	2.43E+00	1.03E-01	1.02E-01	5.05E+01	7.76E-01	1.32E+01
		McGowan Lake	1.10E-01	6.80E-02	1.17E-01	1.49E+00	1.42E+00	8.22E-02	9.26E-02	6.71E+00	6.69E-01	1.28E+01
		Russell Lake Inlet	1.09E-01	6.77E-02	1.15E-01	1.49E+00	1.33E+00	8.12E-02	9.17E-02	1.86E+00	6.60E-01	1.28E+01
	Terrestrial Invertebrate	Reference (Kratchkowsky Lake)	4.25E-02	7.59E-01	2.09E-02	1.76E-01	1.85E+00	4.97E-02	1.63E-01	1.97E-02	7.32E-02	8.78E+00
		Whitefish Lake	4.29E-02	7.60E-01	2.13E-02	1.78E-01	1.87E+00	5.02E-02	1.64E-01	9.66E-01	7.55E-02	8.80E+00
		McGowan Lake	4.26E-02	7.59E-01	2.09E-02	1.76E-01	1.85E+00	4.97E-02	1.63E-01	1.44E-01	7.35E-02	8.78E+00
		Russell Lake Inlet	4.25E-02	7.59E-01	2.09E-02	1.76E-01	1.85E+00	4.97E-02	1.63E-01	5.29E-02	7.33E-02	8.78E+00
	Black Bear	Reference (Kratchkowsky Lake)	6.26E-02	1.63E-03	6.84E-04	1.79E-02	1.06E+00	1.26E-03	2.60E-01	3.00E-04	1.87E-02	4.19E+01
		Whitefish Lake	6.27E-02	1.63E-03	6.84E-04	1.82E-02	1.06E+00	1.48E-03	6.37E-01	5.10E-04	1.94E-02	4.22E+01
	Lynx	Reference (Kratchkowsky Lake)	7.55E-02	3.40E-03	5.69E-05	1.68E-02	7.93E-01	1.29E-04	6.74E-01	5.33E-05	2.40E-02	5.35E+02
		Whitefish Lake	7.57E-02	3.41E-03	5.75E-05	1.71E-02	8.16E-01	5.69E-04	6.81E-01	5.95E-04	2.44E-02	5.37E+02
		McGowan Lake	7.55E-02	3.40E-03	5.71E-05	1.69E-02	7.95E-01	4.14E-04	6.75E-01	1.26E-04	2.40E-02	5.35E+02
		Russell Lake Inlet	7.55E-02	3.40E-03	5.70E-05	1.69E-02	7.94E-01	3.42E-04	6.75E-01	7.35E-05	2.40E-02	5.35E+02
	Mink	Reference (Kratchkowsky Lake)	2.55E-02	5.45E-04	5.43E-05	1.83E-02	1.78E-01	7.82E-05	1.75E-01	3.34E-05	1.69E-02	6.18E+00
		Whitefish Lake	3.25E-02	6.64E-04	6.27E-05	2.24E-02	2.23E-01	1.06E-02	1.54E+00	3.13E-04	4.15E-02	9.00E+00
		McGowan Lake	2.82E-02	6.22E-04	6.02E-05	2.10E-02	2.10E-01	7.58E-03	1.00E+00	1.41E-04	2.66E-02	7.83E+00
		Russell Lake Inlet	2.71E-02	6.01E-04	5.88E-05	2.03E-02	2.02E-01	5.76E-03	7.86E-01	1.04E-04	2.30E-02	7.35E+00
	Moose	Reference (Kratchkowsky Lake)	7.41E-02	1.45E-02	9.87E-04	1.44E-02	1.53E+00	1.81E-03	1.17E-01	5.16E-04	3.64E-02	6.93E+01
		Whitefish Lake	7.79E-02	1.47E-02	1.02E-03	1.61E-02	1.57E+00	7.15E-03	2.17E-01	1.72E-02	6.68E-02	6.98E+01
		McGowan Lake	7.55E-02	1.46E-02	1.00E-03	1.53E-02	1.53E+00	5.46E-03	1.75E-01	2.81E-03	4.74E-02	6.96E+01
		Russell Lake Inlet	7.49E-02	1.46E-02	9.97E-04	1.50E-02	1.53E+00	4.57E-03	1.59E-01	1.19E-03	4.34E-02	6.95E+01
	Moose Organs	Reference (Kratchkowsky Lake)	6.30E-01	5.01E-03	2.29E-01	6.56E-03	6.11E+01	1.81E-01	1.17E-01	9.13E-04	3.62E-05	8.67E-01
		McGowan Lake	6.42E-01	5.03E-03	2.33E-01	6.94E-03	6.14E+01	5.46E-01	1.75E-01	4.96E-03	4.73E-05	8.70E-01
		Russell Lake Inlet	6.37E-01	5.03E-03	2.32E-01	6.84E-03	6.12E+01	4.57E-01	1.59E-01	2.10E-03	4.32E-05	8.69E-01
	Muskrat	Reference (Kratchkowsky Lake)	6.44E-02	8.86E-04	2.43E-04	2.19E-02	4.69E-02	1.29E-04	3.74E-02	8.91E-05	5.12E-02	2.41E+00
		Whitefish Lake	8.40E-02	1.35E-03	3.06E-04	2.85E-02	6.15E-02	2.31E-02	4.03E-01	1.21E-03	1.80E-01	3.58E+00
		McGowan Lake	7.21E-02	1.18E-03	2.84E-04	2.63E-02	5.63E-02	1.62E-02	2.54E-01	7.77E-04	1.01E-01	3.07E+00
		Russell Lake Inlet	6.91E-02	1.10E-03	2.74E-04	2.51E-02	5.39E-02	1.23E-02	1.94E-01	5.90E-04	8.25E-02	2.88E+00

Biota		Location	Maximum Concentration of Non-radionuclides during Project Phases (mg/kg fw)									
			Arsenic	Cadmium	Cobalt	Chromium	Copper	Molybdenum	Selenium	Uranium	Vanadium	Zinc
Terrestrial Animals	Snowshoe Hare	Reference (Kratchkowsky Lake)	6.22E-02	1.21E-02	8.82E-04	1.58E-02	1.43E+00	1.70E-03	1.10E-01	4.79E-04	2.92E-02	6.34E+01
		Whitefish Lake	6.24E-02	1.22E-02	8.91E-04	1.63E-02	1.47E+00	2.04E-03	1.12E-01	1.43E-02	3.00E-02	6.36E+01
		McGowan Lake	6.22E-02	1.21E-02	8.83E-04	1.58E-02	1.43E+00	1.91E-03	1.10E-01	2.29E-03	2.93E-02	6.34E+01
		Russell Lake Inlet	6.22E-02	1.21E-02	8.82E-04	1.58E-02	1.43E+00	1.86E-03	1.10E-01	9.63E-04	2.92E-02	6.34E+01
	Southern Red-Backed Vole	Reference (Kratchkowsky Lake)	3.68E-01	2.69E-02	4.74E-03	2.80E-02	7.71E+00	9.11E-03	7.15E-01	2.05E-03	4.01E-02	3.14E+02
		Whitefish Lake	3.69E-01	2.69E-02	4.77E-03	2.89E-02	7.96E+00	9.35E-03	7.20E-01	3.69E-02	4.16E-02	3.15E+02
		McGowan Lake	3.68E-01	2.69E-02	4.74E-03	2.81E-02	7.74E+00	9.22E-03	7.16E-01	6.63E-03	4.03E-02	3.14E+02
		Russell Lake Inlet	3.68E-01	2.69E-02	4.74E-03	2.80E-02	7.72E+00	9.19E-03	7.16E-01	3.27E-03	4.01E-02	3.14E+02
	WoodLand Caribou	Reference (Kratchkowsky Lake)	6.56E-02	8.32E-03	7.07E-04	1.21E-01	6.06E-01	1.16E-03	1.06E-01	4.66E-04	8.70E-02	3.58E+01
		Whitefish Lake	6.74E-02	8.39E-03	7.19E-04	1.22E-01	6.14E-01	5.17E-03	1.50E-01	1.14E-02	9.81E-02	3.60E+01
	Canada Goose	Reference (Kratchkowsky Lake)	7.12E-03	7.93E-03	3.84E-03	4.32E-03	1.65E-01	5.82E-04	1.93E-02	1.94E-03	5.42E-03	3.56E-01
		Whitefish Lake	7.14E-03	7.94E-03	3.87E-03	4.36E-03	1.69E-01	5.87E-04	1.95E-02	5.90E-02	5.51E-03	3.56E-01
		McGowan Lake	7.13E-03	7.93E-03	3.84E-03	4.34E-03	1.66E-01	8.35E-04	1.95E-02	9.45E-03	5.44E-03	3.56E-01
		Russell Lake Inlet	7.12E-03	7.93E-03	3.84E-03	4.33E-03	1.65E-01	7.71E-04	1.94E-02	3.96E-03	5.42E-03	3.56E-01
	Eagle	Reference (Kratchkowsky Lake)	3.16E-02	1.48E-02	6.75E-03	8.14E-02	1.01E-01	4.95E-04	5.52E-01	6.88E-03	7.31E-02	2.34E-01
		Whitefish Lake	3.17E-02	1.48E-02	6.76E-03	8.16E-02	1.03E-01	6.78E-04	7.75E-01	7.77E-03	7.34E-02	2.39E-01
	Flycatcher	Reference (Kratchkowsky Lake)	6.25E-02	1.18E+00	2.40E-02	2.09E-01	1.31E+00	8.68E-03	1.47E+00	1.80E-02	8.95E-02	3.89E+00
		Whitefish Lake	6.43E-02	1.18E+00	2.47E-02	2.15E-01	1.39E+00	5.45E-02	1.70E+00	6.91E-01	9.61E-02	3.94E+00
		McGowan Lake	6.32E-02	1.18E+00	2.43E-02	2.13E-01	1.36E+00	4.19E-02	1.61E+00	1.07E-01	9.21E-02	3.92E+00
		Russell Lake Inlet	6.29E-02	1.18E+00	2.42E-02	2.12E-01	1.35E+00	3.39E-02	1.58E+00	4.24E-02	9.11E-02	3.91E+00
	Loon	Reference (Kratchkowsky Lake)	1.36E-02	3.41E-04	9.31E-04	1.30E-02	1.44E-01	9.70E-05	5.16E-01	1.99E-04	3.71E-03	2.22E-01
		Whitefish Lake	1.68E-02	5.08E-04	1.15E-03	1.77E-02	1.84E-01	1.65E-02	4.28E+00	3.25E-03	1.42E-02	3.31E-01
		McGowan Lake	1.45E-02	4.48E-04	1.08E-03	1.58E-02	1.71E-01	1.19E-02	2.80E+00	1.96E-03	7.27E-03	2.84E-01
		Russell Lake Inlet	1.40E-02	4.20E-04	1.04E-03	1.50E-02	1.65E-01	9.01E-03	2.22E+00	1.47E-03	5.96E-03	2.66E-01
	Mallard	Reference (Kratchkowsky Lake)	4.84E-02	4.75E-03	7.57E-03	6.72E-02	8.31E-01	1.05E-03	1.13E-01	2.04E-03	3.26E-02	4.00E-01
		Whitefish Lake	6.39E-02	7.02E-03	9.24E-03	8.71E-02	1.04E+00	1.79E-01	1.01E+00	2.58E-02	1.10E-01	5.50E-01
		McGowan Lake	5.48E-02	6.24E-03	8.74E-03	8.07E-02	9.81E-01	1.29E-01	6.80E-01	1.70E-02	6.46E-02	4.99E-01
		Russell Lake Inlet	5.23E-02	5.85E-03	8.46E-03	7.72E-02	9.45E-01	9.79E-02	5.26E-01	1.30E-02	5.27E-02	4.72E-01
	Robin	Reference (Kratchkowsky Lake)	2.82E-01	1.02E+00	1.21E-01	3.58E-01	4.75E+00	2.13E-02	1.87E+00	6.05E-02	2.56E-01	1.03E+01
		Whitefish Lake	2.82E-01	1.02E+00	1.21E-01	3.59E-01	4.90E+00	2.15E-02	1.88E+00	9.34E-01	2.58E-01	1.03E+01
		McGowan Lake	2.82E-01	1.02E+00	1.21E-01	3.58E-01	4.77E+00	2.17E-02	1.87E+00	1.75E-01	2.56E-01	1.03E+01
		Russell Lake Inlet	2.82E-01	1.02E+00	1.21E-01	3.58E-01	4.76E+00	2.16E-02	1.87E+00	9.11E-02	2.56E-01	1.03E+01
	Scaup	Reference (Kratchkowsky Lake)	7.77E-02	8.03E-03	1.72E-02	1.05E-01	1.35E+00	1.68E-03	1.95E-01	3.31E-03	5.80E-02	6.98E-01
		Whitefish Lake	1.02E-01	1.20E-02	2.12E-02	1.36E-01	1.70E+00	2.88E-01	1.82E+00	4.43E-02	2.03E-01	9.69E-01
		McGowan Lake	8.73E-02	1.06E-02	1.99E-02	1.26E-01	1.60E+00	2.06E-01	1.20E+00	2.86E-02	1.14E-01	8.72E-01
		Russell Lake Inlet	8.35E-02	9.89E-03	1.93E-02	1.21E-01	1.54E+00	1.57E-01	9.30E-01	2.17E-02	9.36E-02	8.25E-01

Table B.6: Maximum Concentration of Non-radionuclides in Ecological Receptors during Future Centuries

Biota		Location	Maximum Concentration of Non-radionuclides during Future Centuries (mg/kg fw)									
			Arsenic	Cadmium	Cobalt	Chromium	Copper	Molybdenum	Selenium	Uranium	Vanadium	Zinc
Aquatic Plants	Macrophytes	Reference (Kratchkowsky Lake)	1.78E-02	1.51E-03	1.60E-02	5.19E-03	1.34E-01	7.27E-04	5.73E-03	1.51E-03	4.73E-02	3.82E-01
		Whitefish Lake North	1.78E-02	1.51E-03	1.60E-02	5.19E-03	1.34E-01	7.27E-04	5.73E-03	1.51E-03	4.73E-02	3.82E-01
		Whitefish Lake Middle	1.84E-02	1.52E-03	1.68E-02	5.26E-03	1.36E-01	7.92E-04	7.64E-03	1.85E-03	4.77E-02	4.16E-01
		Whitefish Lake South	1.83E-02	1.52E-03	1.68E-02	5.26E-03	1.36E-01	7.91E-04	7.56E-03	1.84E-03	4.77E-02	4.14E-01
		McGowan Lake	1.81E-02	1.52E-03	1.66E-02	5.24E-03	1.35E-01	7.76E-04	7.00E-03	1.74E-03	4.75E-02	4.05E-01
		Russell Lake Inlet	1.79E-02	1.52E-03	1.64E-02	5.23E-03	1.35E-01	7.64E-04	6.66E-03	1.68E-03	4.74E-02	3.99E-01
	Phytoplankton	Reference (Kratchkowsky Lake)	1.78E-02	1.51E-03	1.60E-02	5.19E-03	1.34E-01	7.27E-04	5.73E-03	1.51E-03	4.73E-02	3.82E-01
		Whitefish Lake North	1.78E-02	1.51E-03	1.60E-02	5.19E-03	1.34E-01	7.27E-04	5.73E-03	1.51E-03	4.73E-02	3.82E-01
		Whitefish Lake Middle	1.84E-02	1.52E-03	1.68E-02	5.26E-03	1.36E-01	7.92E-04	7.64E-03	1.85E-03	4.77E-02	4.16E-01
		Whitefish Lake South	1.83E-02	1.52E-03	1.68E-02	5.26E-03	1.36E-01	7.91E-04	7.56E-03	1.84E-03	4.77E-02	4.14E-01
		McGowan Lake	1.81E-02	1.52E-03	1.66E-02	5.24E-03	1.35E-01	7.76E-04	7.00E-03	1.74E-03	4.75E-02	4.05E-01
		Russell Lake Inlet	1.79E-02	1.52E-03	1.64E-02	5.23E-03	1.35E-01	7.64E-04	6.66E-03	1.68E-03	4.74E-02	3.99E-01
Aquatic Animals	Benthic Invertebrate	Reference (Kratchkowsky Lake)	4.67E-02	5.84E-03	2.01E-02	1.98E-01	4.79E+00	1.72E-02	3.32E-02	2.89E-03	4.80E-02	2.84E+00
		Whitefish Lake North	4.67E-02	5.84E-03	2.01E-02	1.98E-01	4.79E+00	1.72E-02	3.32E-02	2.89E-03	4.80E-02	2.84E+00
		Whitefish Lake Middle	4.85E-02	5.88E-03	2.11E-02	2.00E-01	4.85E+00	1.87E-02	4.43E-02	3.53E-03	4.85E-02	3.09E+00
		Whitefish Lake South	4.83E-02	5.88E-03	2.11E-02	2.00E-01	4.85E+00	1.87E-02	4.38E-02	3.51E-03	4.84E-02	3.08E+00
		McGowan Lake	4.75E-02	5.87E-03	2.09E-02	2.00E-01	4.84E+00	1.83E-02	4.06E-02	3.32E-03	4.82E-02	3.01E+00
		Russell Lake Inlet	4.72E-02	5.86E-03	2.07E-02	1.99E-01	4.82E+00	1.81E-02	3.86E-02	3.20E-03	4.82E-02	2.97E+00
	Northern pike	Reference (Kratchkowsky Lake)	3.10E-02	6.95E-05	1.21E-03	2.85E-02	3.09E-01	1.07E-05	1.83E-01	6.01E-04	1.41E-02	1.36E+00
		Whitefish Lake North	3.10E-02	6.95E-05	1.21E-03	2.85E-02	3.09E-01	1.07E-05	1.83E-01	6.01E-04	1.41E-02	1.36E+00
		Whitefish Lake Middle	3.22E-02	6.99E-05	1.28E-03	2.89E-02	3.13E-01	1.16E-05	2.33E-01	7.35E-04	1.43E-02	1.48E+00
		Whitefish Lake South	3.20E-02	6.99E-05	1.28E-03	2.89E-02	3.13E-01	1.16E-05	2.31E-01	7.30E-04	1.42E-02	1.47E+00
		McGowan Lake	3.15E-02	6.98E-05	1.26E-03	2.88E-02	3.12E-01	1.14E-05	2.16E-01	6.90E-04	1.42E-02	1.44E+00
		Russell Lake Inlet	3.13E-02	6.97E-05	1.25E-03	2.87E-02	3.11E-01	1.12E-05	2.08E-01	6.67E-04	1.42E-02	1.42E+00
	White sucker	Reference (Kratchkowsky Lake)	2.97E-02	6.90E-05	1.21E-03	2.84E-02	3.09E-01	1.07E-05	1.42E-01	5.95E-04	1.36E-02	1.35E+00
		Whitefish Lake North	2.97E-02	6.90E-05	1.21E-03	2.84E-02	3.09E-01	1.07E-05	1.42E-01	5.95E-04	1.36E-02	1.35E+00
		Whitefish Lake Middle	3.09E-02	6.94E-05	1.27E-03	2.87E-02	3.13E-01	1.16E-05	1.89E-01	7.28E-04	1.37E-02	1.47E+00
		Whitefish Lake South	3.07E-02	6.94E-05	1.27E-03	2.87E-02	3.13E-01	1.16E-05	1.87E-01	7.23E-04	1.37E-02	1.46E+00
		McGowan Lake	3.02E-02	6.92E-05	1.26E-03	2.86E-02	3.12E-01	1.14E-05	1.73E-01	6.84E-04	1.36E-02	1.43E+00
		Russell Lake Inlet	3.00E-02	6.92E-05	1.25E-03	2.86E-02	3.11E-01	1.12E-05	1.65E-01	6.60E-04	1.36E-02	1.41E+00
	Zooplankton	Reference (Kratchkowsky Lake)	5.58E-02	6.02E-03	2.02E-02	2.02E-01	4.82E+00	1.73E-02	3.46E-02	3.01E-03	5.68E-02	2.93E+00
		Whitefish Lake North	5.58E-02	6.02E-03	2.02E-02	2.02E-01	4.82E+00	1.73E-02	3.46E-02	3.01E-03	5.68E-02	2.93E+00
		Whitefish Lake Middle	5.79E-02	6.06E-03	2.13E-02	2.05E-01	4.89E+00	1.89E-02	4.61E-02	3.68E-03	5.73E-02	3.18E+00
		Whitefish Lake South	5.76E-02	6.06E-03	2.13E-02	2.05E-01	4.89E+00	1.88E-02	4.56E-02	3.65E-03	5.72E-02	3.17E+00
		McGowan Lake	5.67E-02	6.05E-03	2.10E-02	2.04E-01	4.87E+00	1.85E-02	4.22E-02	3.45E-03	5.70E-02	3.10E+00
		Russell Lake Inlet	5.63E-02	6.04E-03	2.08E-02	2.04E-01	4.86E+00	1.82E-02	4.02E-02	3.33E-03	5.69E-02	3.06E+00
	Blueberries	Reference (Kratchkowsky Lake)	1.43E-01	8.53E-03	8.06E-02	1.42E-02	5.58E+00	6.60E-02	5.71E-02	3.43E-02	6.00E-03	1.35E+01
		Whitefish Lake	1.43E-01	8.53E-03	8.08E-02	1.42E-02	5.59E+00	6.60E-02	5.71E-02	4.69E-02	6.00E-03	1.35E+01
		McGowan Lake	1.43E-01	8.53E-03	8.07E-02	1.42E-02	5.58E+00	6.60E-02	5.71E-02	3.59E-02	6.00E-03	1.35E+01
		Russell Lake Inlet	1.43E-01	8.53E-03	8.06E-02	1.42E-02	5.58E+00	6.60E-02	5.71E-02	3.47E-02	6.00E-03	1.35E+01

Biota		Location	Maximum Concentration of Non-radionuclides during Future Centuries (mg/kg fw)									
			Arsenic	Cadmium	Cobalt	Chromium	Copper	Molybdenum	Selenium	Uranium	Vanadium	Zinc
Terrestrial Plants	Browse	Reference (Kratchkowsky Lake)	7.16E-02	5.83E-02	5.00E-02	9.48E-03	3.65E+00	4.26E-02	2.56E-02	2.93E-02	4.07E-02	1.03E+01
		Whitefish Lake	7.16E-02	5.83E-02	5.01E-02	9.48E-03	3.65E+00	4.26E-02	2.56E-02	3.42E-02	4.07E-02	1.04E+01
		McGowan Lake	7.16E-02	5.83E-02	5.01E-02	9.48E-03	3.65E+00	4.26E-02	2.56E-02	3.00E-02	4.07E-02	1.03E+01
		Russell Lake Inlet	7.16E-02	5.83E-02	5.00E-02	9.48E-03	3.65E+00	4.26E-02	2.56E-02	2.95E-02	4.07E-02	1.03E+01
	Labrador Tea	Reference (Kratchkowsky Lake)	2.34E-01	7.56E-02	2.14E-01	4.41E-02	1.83E+01	2.10E-01	6.14E-02	1.69E-01	3.72E-01	6.05E+01
		Whitefish Lake	2.34E-01	7.56E-02	2.14E-01	4.41E-02	1.83E+01	2.10E-01	6.14E-02	1.74E-01	3.72E-01	6.05E+01
		McGowan Lake	2.34E-01	7.56E-02	2.14E-01	4.41E-02	1.83E+01	2.10E-01	6.14E-02	1.69E-01	3.72E-01	6.05E+01
		Russell Lake Inlet	2.34E-01	7.56E-02	2.14E-01	4.41E-02	1.83E+01	2.10E-01	6.14E-02	1.69E-01	3.72E-01	6.05E+01
	Lichen	Reference (Kratchkowsky Lake)	1.09E-01	6.75E-02	1.14E-01	1.49E+00	1.30E+00	8.10E-02	9.14E-02	8.89E-02	6.56E-01	1.28E+01
		Whitefish Lake	1.09E-01	6.75E-02	1.14E-01	1.49E+00	1.30E+00	8.10E-02	9.14E-02	8.89E-02	6.56E-01	1.28E+01
		McGowan Lake	1.09E-01	6.75E-02	1.14E-01	1.49E+00	1.30E+00	8.10E-02	9.14E-02	8.89E-02	6.56E-01	1.28E+01
		Russell Lake Inlet	1.09E-01	6.75E-02	1.14E-01	1.49E+00	1.30E+00	8.10E-02	9.14E-02	8.89E-02	6.56E-01	1.28E+01
	Terrestrial Invertebrate	Reference (Kratchkowsky Lake)	4.25E-02	7.59E-01	2.09E-02	1.76E-01	1.85E+00	4.97E-02	1.63E-01	1.97E-02	7.32E-02	8.78E+00
		Whitefish Lake	4.25E-02	7.59E-01	2.09E-02	1.76E-01	1.85E+00	4.97E-02	1.63E-01	2.10E-02	7.32E-02	8.78E+00
		McGowan Lake	4.25E-02	7.59E-01	2.09E-02	1.76E-01	1.85E+00	4.97E-02	1.63E-01	1.99E-02	7.32E-02	8.78E+00
		Russell Lake Inlet	4.25E-02	7.59E-01	2.09E-02	1.76E-01	1.85E+00	4.97E-02	1.63E-01	1.98E-02	7.32E-02	8.78E+00
	Black Bear	Reference (Kratchkowsky Lake)	6.18E-02	1.63E-03	6.84E-04	1.79E-02	1.06E+00	1.26E-03	2.55E-01	3.00E-04	1.86E-02	4.19E+01
		Whitefish Lake	6.18E-02	1.63E-03	6.84E-04	1.79E-02	1.06E+00	1.26E-03	2.70E-01	3.10E-04	1.86E-02	4.19E+01
	Lynx	Reference (Kratchkowsky Lake)	7.55E-02	3.40E-03	5.69E-05	1.68E-02	7.93E-01	1.29E-04	6.74E-01	5.33E-05	2.39E-02	5.35E+02
		Whitefish Lake	7.55E-02	3.40E-03	5.71E-05	1.68E-02	7.94E-01	1.29E-04	6.74E-01	7.16E-05	2.40E-02	5.35E+02
		McGowan Lake	7.55E-02	3.40E-03	5.70E-05	1.68E-02	7.93E-01	1.29E-04	6.74E-01	5.56E-05	2.39E-02	5.35E+02
		Russell Lake Inlet	7.55E-02	3.40E-03	5.70E-05	1.68E-02	7.93E-01	1.29E-04	6.74E-01	5.39E-05	2.39E-02	5.35E+02
	Mink	Reference (Kratchkowsky Lake)	2.47E-02	5.44E-04	5.43E-05	1.83E-02	1.78E-01	7.82E-05	1.71E-01	3.34E-05	1.66E-02	6.08E+00
		Whitefish Lake	2.55E-02	5.46E-04	5.64E-05	1.85E-02	1.80E-01	8.38E-05	2.21E-01	4.20E-05	1.67E-02	6.59E+00
		McGowan Lake	2.50E-02	5.45E-04	5.58E-05	1.84E-02	1.79E-01	8.24E-05	2.04E-01	3.57E-05	1.66E-02	6.43E+00
		Russell Lake Inlet	2.49E-02	5.45E-04	5.55E-05	1.84E-02	1.79E-01	8.14E-05	1.95E-01	3.48E-05	1.66E-02	6.34E+00
	Moose	Reference (Kratchkowsky Lake)	7.35E-02	1.45E-02	9.86E-04	1.44E-02	1.53E+00	1.81E-03	1.17E-01	5.16E-04	3.56E-02	6.93E+01
		Whitefish Lake	7.40E-02	1.45E-02	9.91E-04	1.45E-02	1.53E+00	1.81E-03	1.20E-01	6.03E-04	3.57E-02	6.94E+01
		McGowan Lake	7.37E-02	1.45E-02	9.89E-04	1.44E-02	1.53E+00	1.81E-03	1.19E-01	5.28E-04	3.57E-02	6.94E+01
		Russell Lake Inlet	7.37E-02	1.45E-02	9.89E-04	1.44E-02	1.53E+00	1.81E-03	1.18E-01	5.20E-04	3.57E-02	6.93E+01
	Moose Organs	Reference (Kratchkowsky Lake)	6.25E-01	5.01E-03	2.29E-01	6.55E-03	6.11E+01	1.81E-01	1.17E-01	9.13E-04	3.55E-05	8.67E-01
		McGowan Lake	6.27E-01	5.01E-03	2.30E-01	6.57E-03	6.11E+01	1.81E-01	1.19E-01	9.35E-04	3.55E-05	8.67E-01
		Russell Lake Inlet	6.26E-01	5.01E-03	2.30E-01	6.56E-03	6.11E+01	1.81E-01	1.18E-01	9.20E-04	3.55E-05	8.67E-01
	Muskrat	Reference (Kratchkowsky Lake)	6.28E-02	8.78E-04	2.42E-04	2.19E-02	4.66E-02	1.28E-04	3.68E-02	8.84E-05	4.91E-02	2.35E+00
		Whitefish Lake	6.52E-02	8.84E-04	2.55E-04	2.21E-02	4.72E-02	1.40E-04	4.90E-02	1.08E-04	4.95E-02	2.56E+00
		McGowan Lake	6.39E-02	8.82E-04	2.52E-04	2.20E-02	4.71E-02	1.37E-04	4.49E-02	1.02E-04	4.93E-02	2.49E+00
		Russell Lake Inlet	6.35E-02	8.81E-04	2.50E-04	2.20E-02	4.70E-02	1.35E-04	4.28E-02	9.80E-05	4.92E-02	2.46E+00

Biota		Location	Maximum Concentration of Non-radionuclides during Future Centuries (mg/kg fw)									
			Arsenic	Cadmium	Cobalt	Chromium	Copper	Molybdenum	Selenium	Uranium	Vanadium	Zinc
Terrestrial Animals	Snowshoe Hare	Reference (Kratchkowsky Lake)	6.22E-02	1.21E-02	8.82E-04	1.58E-02	1.43E+00	1.70E-03	1.10E-01	4.79E-04	2.92E-02	6.34E+01
		Whitefish Lake	6.22E-02	1.21E-02	8.83E-04	1.58E-02	1.43E+00	1.70E-03	1.10E-01	5.78E-04	2.92E-02	6.34E+01
		McGowan Lake	6.22E-02	1.21E-02	8.82E-04	1.58E-02	1.43E+00	1.70E-03	1.10E-01	4.92E-04	2.92E-02	6.34E+01
		Russell Lake Inlet	6.22E-02	1.21E-02	8.82E-04	1.58E-02	1.43E+00	1.70E-03	1.10E-01	4.82E-04	2.92E-02	6.34E+01
	Southern Red-Backed Vole	Reference (Kratchkowsky Lake)	3.68E-01	2.69E-02	4.74E-03	2.80E-02	7.71E+00	9.11E-03	7.15E-01	2.05E-03	4.01E-02	3.14E+02
		Whitefish Lake	3.68E-01	2.69E-02	4.74E-03	2.80E-02	7.72E+00	9.11E-03	7.15E-01	2.65E-03	4.01E-02	3.14E+02
		McGowan Lake	3.68E-01	2.69E-02	4.74E-03	2.80E-02	7.72E+00	9.11E-03	7.15E-01	2.13E-03	4.01E-02	3.14E+02
		Russell Lake Inlet	3.68E-01	2.69E-02	4.74E-03	2.80E-02	7.71E+00	9.11E-03	7.15E-01	2.07E-03	4.01E-02	3.14E+02
	WoodLand Caribou	Reference (Kratchkowsky Lake)	6.51E-02	8.32E-03	7.06E-04	1.21E-01	6.06E-01	1.16E-03	1.06E-01	4.66E-04	8.65E-02	3.58E+01
		Whitefish Lake	6.54E-02	8.32E-03	7.08E-04	1.21E-01	6.06E-01	1.17E-03	1.08E-01	4.72E-04	8.65E-02	3.58E+01
	Canada Goose	Reference (Kratchkowsky Lake)	7.12E-03	7.93E-03	3.84E-03	4.32E-03	1.65E-01	5.82E-04	1.93E-02	1.94E-03	5.41E-03	3.56E-01
		Whitefish Lake	7.11E-03	7.92E-03	3.83E-03	4.28E-03	1.65E-01	5.80E-04	1.93E-02	2.33E-03	5.41E-03	3.56E-01
		McGowan Lake	7.12E-03	7.93E-03	3.84E-03	4.32E-03	1.65E-01	5.82E-04	1.93E-02	1.99E-03	5.41E-03	3.56E-01
		Russell Lake Inlet	7.12E-03	7.93E-03	3.84E-03	4.32E-03	1.65E-01	5.82E-04	1.93E-02	1.95E-03	5.41E-03	3.56E-01
	Eagle	Reference (Kratchkowsky Lake)	3.01E-02	1.48E-02	6.74E-03	8.12E-02	1.01E-01	4.95E-04	5.38E-01	6.87E-03	7.27E-02	2.30E-01
		Whitefish Lake	3.01E-02	1.48E-02	6.75E-03	8.12E-02	1.01E-01	4.95E-04	5.47E-01	6.92E-03	7.27E-02	2.31E-01
	Flycatcher	Kratchkowsky Lake	6.25E-02	1.18E+00	2.40E-02	2.09E-01	1.31E+00	8.68E-03	1.47E+00	1.80E-02	8.95E-02	3.89E+00
		Whitefish Lake	6.27E-02	1.18E+00	2.41E-02	2.10E-01	1.31E+00	8.71E-03	1.48E+00	2.05E-02	8.95E-02	3.90E+00
		McGowan Lake	6.26E-02	1.18E+00	2.41E-02	2.10E-01	1.31E+00	8.70E-03	1.48E+00	1.83E-02	8.95E-02	3.90E+00
		Russell Lake Inlet	6.26E-02	1.18E+00	2.41E-02	2.10E-01	1.31E+00	8.70E-03	1.48E+00	1.81E-02	8.95E-02	3.90E+00
	Loon	Reference (Kratchkowsky Lake)	1.20E-02	3.40E-04	9.29E-04	1.29E-02	1.44E-01	9.69E-05	5.00E-01	1.95E-04	3.35E-03	2.17E-01
		Whitefish Lake	1.24E-02	3.42E-04	9.79E-04	1.30E-02	1.46E-01	1.06E-04	6.35E-01	2.38E-04	3.38E-03	2.36E-01
		McGowan Lake	1.22E-02	3.42E-04	9.66E-04	1.30E-02	1.45E-01	1.03E-04	5.90E-01	2.23E-04	3.36E-03	2.30E-01
		Russell Lake Inlet	1.21E-02	3.41E-04	9.58E-04	1.29E-02	1.45E-01	1.02E-04	5.67E-01	2.16E-04	3.35E-03	2.27E-01
	Mallard	Reference (Kratchkowsky Lake)	4.82E-02	4.75E-03	7.56E-03	6.72E-02	8.31E-01	1.05E-03	1.13E-01	2.04E-03	3.23E-02	4.00E-01
		Whitefish Lake	5.00E-02	4.78E-03	7.96E-03	6.81E-02	8.42E-01	1.15E-03	1.50E-01	2.49E-03	3.25E-02	4.34E-01
		McGowan Lake	4.90E-02	4.77E-03	7.86E-03	6.78E-02	8.39E-01	1.13E-03	1.38E-01	2.34E-03	3.24E-02	4.23E-01
		Russell Lake Inlet	4.87E-02	4.76E-03	7.79E-03	6.77E-02	8.37E-01	1.11E-03	1.31E-01	2.26E-03	3.23E-02	4.17E-01
	Robin	Reference (Kratchkowsky Lake)	2.82E-01	1.02E+00	1.21E-01	3.58E-01	4.75E+00	2.13E-02	1.87E+00	6.05E-02	2.56E-01	1.03E+01
		Whitefish Lake	2.82E-01	1.02E+00	1.21E-01	3.58E-01	4.76E+00	2.13E-02	1.87E+00	7.95E-02	2.56E-01	1.03E+01
		McGowan Lake	2.82E-01	1.02E+00	1.21E-01	3.58E-01	4.75E+00	2.13E-02	1.87E+00	6.30E-02	2.56E-01	1.03E+01
		Russell Lake Inlet	2.82E-01	1.02E+00	1.21E-01	3.58E-01	4.75E+00	2.13E-02	1.87E+00	6.12E-02	2.56E-01	1.03E+01
	Scaup	Reference (Kratchkowsky Lake)	7.62E-02	8.00E-03	1.71E-02	1.05E-01	1.35E+00	1.68E-03	1.94E-01	3.29E-03	5.59E-02	6.96E-01
		Whitefish Lake	7.91E-02	8.04E-03	1.81E-02	1.06E-01	1.37E+00	1.83E-03	2.58E-01	4.03E-03	5.65E-02	7.56E-01
		McGowan Lake	7.74E-02	8.03E-03	1.78E-02	1.06E-01	1.37E+00	1.79E-03	2.37E-01	3.78E-03	5.62E-02	7.37E-01
		Russell Lake Inlet	7.70E-02	8.02E-03	1.77E-02	1.06E-01	1.37E+00	1.76E-03	2.26E-01	3.65E-03	5.61E-02	7.26E-01

Table B.7: Maximum Concentration of Radionuclides for Ecological Receptors during Project Phases

Biota		Location	Maximum Concentration of Radionuclides duting Project Phases (Bq/kg fw)					
			Uranium-238	Uranium-234	Thorium-230	Radium-226	Lead-210	Polonium-210
Aquatic Plants	Macrophytes	Reference (Kratchkowsky Lake)	1.94E-02	1.94E-02	2.35E+00	9.29E-01	1.18E+01	1.85E+00
		Whitefish Lake North	1.90E-02	1.90E-02	2.35E+00	9.17E-01	1.08E+01	1.69E+00
		Whitefish Lake Middle	3.56E-01	3.56E-01	4.33E+00	1.12E+00	1.59E+01	1.96E+00
		Whitefish Lake South	3.39E-01	3.39E-01	4.30E+00	1.10E+00	1.57E+01	2.11E+00
		McGowan Lake	2.09E-01	2.09E-01	3.64E+00	1.03E+00	1.27E+01	1.82E+00
		Russell Lake Inlet	1.56E-01	1.56E-01	3.32E+00	1.00E+00	1.22E+01	1.80E+00
	Phytoplankton	Reference (Kratchkowsky Lake)	1.94E-02	1.94E-02	2.35E+00	9.29E-01	1.18E+01	1.85E+00
		Whitefish Lake North	1.90E-02	1.90E-02	2.35E+00	9.17E-01	1.08E+01	1.69E+00
		Whitefish Lake Middle	3.56E-01	3.56E-01	4.33E+00	1.12E+00	1.59E+01	1.96E+00
		Whitefish Lake South	3.39E-01	3.39E-01	4.30E+00	1.10E+00	1.57E+01	2.11E+00
		McGowan Lake	2.09E-01	2.09E-01	3.64E+00	1.03E+00	1.27E+01	1.82E+00
		Russell Lake Inlet	1.56E-01	1.56E-01	3.32E+00	1.00E+00	1.22E+01	1.80E+00
Aquatic Animals	Benthic Invertebrate	Reference (Kratchkowsky Lake)	3.57E-02	3.57E-02	5.02E+00	1.36E+00	7.17E+00	5.00E+01
		Whitefish Lake North	3.57E-02	3.57E-02	5.02E+00	1.36E+00	7.16E+00	5.00E+01
		Whitefish Lake Middle	4.41E-01	4.41E-01	8.28E+00	1.58E+00	1.07E+01	7.34E+01
		Whitefish Lake South	4.22E-01	4.22E-01	8.23E+00	1.57E+00	9.96E+00	6.86E+01
		McGowan Lake	2.93E-01	2.93E-01	7.38E+00	1.50E+00	8.47E+00	5.88E+01
		Russell Lake Inlet	2.24E-01	2.24E-01	6.82E+00	1.47E+00	7.94E+00	5.52E+01
	Northern pike	Reference (Kratchkowsky Lake)	7.71E-03	7.71E-03	6.09E-02	6.84E-02	3.73E-01	9.50E-01
		Whitefish Lake North	7.54E-03	7.54E-03	6.07E-02	6.75E-02	3.41E-01	8.67E-01
		Whitefish Lake Middle	1.41E-01	1.41E-01	1.12E-01	8.24E-02	5.01E-01	1.01E+00
		Whitefish Lake South	1.34E-01	1.34E-01	1.11E-01	8.07E-02	4.95E-01	1.08E+00
		McGowan Lake	8.30E-02	8.30E-02	9.41E-02	7.59E-02	4.01E-01	9.34E-01
		Russell Lake Inlet	6.18E-02	6.18E-02	8.58E-02	7.37E-02	3.85E-01	9.24E-01
	White sucker	Reference (Kratchkowsky Lake)	7.56E-03	7.56E-03	6.07E-02	6.76E-02	3.27E-01	8.31E-01
		Whitefish Lake North	7.44E-03	7.44E-03	6.06E-02	6.69E-02	3.02E-01	7.69E-01
		Whitefish Lake Middle	1.28E-01	1.28E-01	1.09E-01	8.07E-02	4.45E-01	9.29E-01
		Whitefish Lake South	1.22E-01	1.22E-01	1.08E-01	7.93E-02	4.36E-01	9.75E-01
		McGowan Lake	7.67E-02	7.67E-02	9.27E-02	7.50E-02	3.56E-01	8.40E-01
		Russell Lake Inlet	5.75E-02	5.75E-02	8.48E-02	7.28E-02	3.40E-01	8.24E-01

Biota		Location	Maximum Concentration of Radionuclides duting Project Phases (Bq/kg fw)					
			Uranium-238	Uranium-234	Thorium-230	Radium-226	Lead-210	Polonium-210
	Zooplankton	Reference (Kratchkowsky Lake)	3.85E-02	3.85E-02	5.07E+00	1.43E+00	1.43E+01	9.99E+01
		Whitefish Lake North	3.77E-02	3.77E-02	5.06E+00	1.41E+00	1.31E+01	9.12E+01
		Whitefish Lake Middle	7.05E-01	7.05E-01	9.34E+00	1.72E+00	1.92E+01	1.06E+02
		Whitefish Lake South	6.72E-01	6.72E-01	9.27E+00	1.68E+00	1.90E+01	1.14E+02
		McGowan Lake	4.15E-01	4.15E-01	7.84E+00	1.58E+00	1.54E+01	9.83E+01
		Russell Lake Inlet	3.09E-01	3.09E-01	7.15E+00	1.53E+00	1.47E+01	9.72E+01
Terrestrial Plants	Blueberries	Reference (Kratchkowsky Lake)	4.24E-01	4.24E-01	3.24E-01	4.73E+00	1.00E+01	1.31E+01
		Whitefish Lake	3.52E+00	3.52E+00	3.25E-01	4.73E+00	1.00E+01	1.31E+01
		McGowan Lake	8.30E-01	8.30E-01	3.24E-01	4.73E+00	1.00E+01	1.31E+01
		Russell Lake Inlet	5.32E-01	5.32E-01	3.24E-01	4.73E+00	1.00E+01	1.31E+01
	Browse	Reference (Kratchkowsky Lake)	3.63E-01	3.63E-01	1.25E-01	1.82E+00	3.85E+00	5.06E+00
		Whitefish Lake	1.28E+01	1.28E+01	1.25E-01	1.82E+00	3.85E+00	5.06E+00
		McGowan Lake	2.00E+00	2.00E+00	1.25E-01	1.82E+00	3.85E+00	5.06E+00
		Russell Lake Inlet	7.99E-01	7.99E-01	1.25E-01	1.82E+00	3.85E+00	5.06E+00
	Labrador Tea	Reference (Kratchkowsky Lake)	2.08E+00	2.08E+00	1.25E-01	1.82E+00	3.85E+00	5.06E+00
		Whitefish Lake	1.12E+02	1.12E+02	1.25E-01	1.82E+00	3.85E+00	5.06E+00
		McGowan Lake	1.65E+01	1.65E+01	1.25E-01	1.82E+00	3.85E+00	5.06E+00
		Russell Lake Inlet	5.93E+00	5.93E+00	1.25E-01	1.82E+00	3.85E+00	5.06E+00
	Lichen	Reference (Kratchkowsky Lake)	1.10E+00	1.10E+00	1.13E+00	2.72E+00	4.14E+02	2.77E+02
		Whitefish Lake	6.24E+02	6.24E+02	1.13E+00	2.72E+00	4.14E+02	2.77E+02
		McGowan Lake	8.29E+01	8.29E+01	1.13E+00	2.72E+00	4.14E+02	2.77E+02
		Russell Lake Inlet	2.29E+01	2.29E+01	1.13E+00	2.72E+00	4.14E+02	2.77E+02
	Terrestrial Invertebrate	Reference (Kratchkowsky Lake)	2.44E-01	2.44E-01	1.77E-01	1.36E+00	2.08E+00	1.82E+00
		Whitefish Lake	1.19E+01	1.19E+01	1.77E-01	1.36E+00	2.08E+00	1.82E+00
		McGowan Lake	1.78E+00	1.78E+00	1.77E-01	1.36E+00	2.08E+00	1.82E+00
		Russell Lake Inlet	6.53E-01	6.53E-01	1.77E-01	1.36E+00	2.08E+00	1.82E+00
	Black Bear	Reference (Kratchkowsky Lake)	3.70E-03	3.70E-03	3.10E-03	1.58E-01	1.49E-01	1.36E+00
		Whitefish Lake	6.30E-03	6.30E-03	3.15E-03	1.58E-01	1.49E-01	1.36E+00

Biota		Location	Maximum Concentration of Radionuclides duting Project Phases (Bq/kg fw)					
			Uranium-238	Uranium-234	Thorium-230	Radium-226	Lead-210	Polonium-210
Terrestrial Animals	Lynx	Reference (Kratchkowsky Lake)	6.58E-04	6.58E-04	1.38E-03	2.26E-02	2.02E-02	4.69E-01
		Whitefish Lake	7.36E-03	7.36E-03	1.42E-03	2.26E-02	2.03E-02	4.69E-01
		McGowan Lake	1.56E-03	1.56E-03	1.40E-03	2.26E-02	2.02E-02	4.69E-01
		Russell Lake Inlet	9.08E-04	9.08E-04	1.40E-03	2.26E-02	2.02E-02	4.69E-01
	Mink	Reference (Kratchkowsky Lake)	4.13E-04	4.13E-04	4.25E-03	1.50E-02	3.17E-02	1.22E+00
		Whitefish Lake	3.86E-03	3.86E-03	6.60E-03	1.69E-02	4.32E-02	1.75E+00
		McGowan Lake	1.74E-03	1.74E-03	5.94E-03	1.62E-02	3.58E-02	1.42E+00
		Russell Lake Inlet	1.28E-03	1.28E-03	5.53E-03	1.59E-02	3.41E-02	1.34E+00
	Moose	Reference (Kratchkowsky Lake)	6.38E-03	6.38E-03	7.88E-03	1.54E-01	2.19E-01	1.29E+00
		Whitefish Lake	2.12E-01	2.12E-01	1.28E-02	1.59E-01	2.55E-01	1.34E+00
		McGowan Lake	3.47E-02	3.47E-02	1.11E-02	1.57E-01	2.28E-01	1.30E+00
		Russell Lake Inlet	1.47E-02	1.47E-02	1.03E-02	1.56E-01	2.23E-01	1.30E+00
	Moose Organs	Reference (Kratchkowsky Lake)	1.13E-02	1.13E-02	2.16E+00	8.63E-02	6.88E+00	1.29E-02
		McGowan Lake	6.13E-02	6.13E-02	3.04E+00	8.77E-02	7.15E+00	1.30E-02
		Russell Lake Inlet	2.60E-02	2.60E-02	2.82E+00	8.73E-02	7.01E+00	1.30E-02
	Muskrat	Reference (Kratchkowsky Lake)	1.10E-03	1.10E-03	1.81E-02	8.25E-02	3.32E-01	8.73E-01
		Whitefish Lake	1.49E-02	1.49E-02	3.30E-02	9.79E-02	4.58E-01	1.17E+00
		McGowan Lake	9.54E-03	9.54E-03	2.79E-02	9.15E-02	3.66E-01	9.72E-01
		Russell Lake Inlet	7.25E-03	7.25E-03	2.54E-02	8.90E-02	3.49E-01	9.27E-01
	Snowshoe Hare	Reference (Kratchkowsky Lake)	5.92E-03	5.92E-03	2.73E-03	1.41E-01	1.32E-01	1.18E+00
		Whitefish Lake	1.76E-01	1.76E-01	2.76E-03	1.41E-01	1.32E-01	1.18E+00
		McGowan Lake	2.83E-02	2.83E-02	2.75E-03	1.41E-01	1.32E-01	1.18E+00
		Russell Lake Inlet	1.19E-02	1.19E-02	2.75E-03	1.41E-01	1.32E-01	1.18E+00
	Southern Red-Backed Vole	Reference (Kratchkowsky Lake)	2.53E-02	2.53E-02	9.81E-03	9.76E-01	8.55E-01	7.96E+00
		Whitefish Lake	4.56E-01	4.56E-01	9.82E-03	9.76E-01	8.55E-01	7.96E+00
		McGowan Lake	8.19E-02	8.19E-02	9.82E-03	9.76E-01	8.55E-01	7.96E+00
		Russell Lake Inlet	4.04E-02	4.04E-02	9.81E-03	9.76E-01	8.55E-01	7.96E+00
	WoodLand Caribou	Reference (Kratchkowsky Lake)	5.76E-03	5.76E-03	9.50E-03	1.11E-01	1.79E+00	8.55E+00
		Whitefish Lake	1.41E-01	1.41E-01	1.11E-02	1.13E-01	1.80E+00	8.58E+00

Biota		Location	Maximum Concentration of Radionuclides duting Project Phases (Bq/kg fw)					
			Uranium-238	Uranium-234	Thorium-230	Radium-226	Lead-210	Polonium-210
	Canada Goose	Reference (Kratchkowsky Lake)	2.40E-02	2.40E-02	3.39E-04	4.52E-03	1.83E-02	1.06E+00
		Whitefish Lake	7.30E-01	7.30E-01	3.30E-04	4.50E-03	1.83E-02	1.06E+00
		McGowan Lake	1.17E-01	1.17E-01	3.44E-04	4.52E-03	1.83E-02	1.06E+00
		Russell Lake Inlet	4.89E-02	4.89E-02	3.43E-04	4.52E-03	1.83E-02	1.06E+00
	Eagle	Reference (Kratchkowsky Lake)	8.50E-02	8.50E-02	4.82E-03	1.11E-02	9.01E-02	9.67E+00
		Whitefish Lake	9.60E-02	9.60E-02	4.83E-03	1.11E-02	9.01E-02	9.75E+00
	Flycatcher	Reference (Kratchkowsky Lake)	2.22E-01	2.22E-01	9.10E-03	4.76E-02	1.82E-01	1.69E+01
		Whitefish Lake	8.54E+00	8.54E+00	1.20E-02	4.82E-02	1.97E-01	2.18E+01
		McGowan Lake	1.33E+00	1.33E+00	1.12E-02	4.80E-02	1.87E-01	1.88E+01
		Russell Lake Inlet	5.24E-01	5.24E-01	1.07E-02	4.79E-02	1.85E-01	1.80E+01
	Loon	Reference (Kratchkowsky Lake)	2.46E-03	2.46E-03	1.71E-03	1.83E-03	1.61E-02	4.30E+00
		Whitefish Lake	4.00E-02	4.00E-02	2.86E-03	2.15E-03	2.32E-02	6.05E+00
		McGowan Lake	2.41E-02	2.41E-02	2.53E-03	2.03E-03	1.85E-02	4.93E+00
		Russell Lake Inlet	1.81E-02	1.81E-02	2.33E-03	1.97E-03	1.75E-02	4.66E+00
	Mallard	Reference (Kratchkowsky Lake)	2.52E-02	2.52E-02	1.67E-02	1.98E-02	2.10E-01	3.63E+01
		Whitefish Lake	3.17E-01	3.17E-01	2.80E-02	2.31E-02	3.05E-01	5.32E+01
		McGowan Lake	2.09E-01	2.09E-01	2.48E-02	2.20E-02	2.43E-01	4.26E+01
		Russell Lake Inlet	1.59E-01	1.59E-01	2.28E-02	2.14E-02	2.29E-01	4.01E+01
	Robin	Reference (Kratchkowsky Lake)	7.47E-01	7.47E-01	1.95E-02	2.21E-01	8.98E-01	4.95E+01
		Whitefish Lake	1.15E+01	1.15E+01	1.95E-02	2.21E-01	8.98E-01	4.95E+01
		McGowan Lake	2.16E+00	2.16E+00	1.95E-02	2.21E-01	8.98E-01	4.95E+01
		Russell Lake Inlet	1.13E+00	1.13E+00	1.95E-02	2.21E-01	8.98E-01	4.95E+01
	Scaup	Reference (Kratchkowsky Lake)	4.09E-02	4.09E-02	3.45E-02	3.96E-02	5.23E-01	5.87E+01
		Whitefish Lake	5.44E-01	5.44E-01	5.92E-02	4.65E-02	7.36E-01	8.53E+01
		McGowan Lake	3.51E-01	3.51E-01	5.16E-02	4.39E-02	5.87E-01	6.87E+01
		Russell Lake Inlet	2.67E-01	2.67E-01	4.75E-02	4.27E-02	5.57E-01	6.46E+01

Table B.8: Maximum Concentration of Radionuclides for Ecological Receptors during Future Centuries

Biota		Location	Maximum Concentration of Radionuclides duting Future Centuries (Bq/kg fw)					
			Uranium-238	Uranium-234	Thorium-230	Radium-226	Lead-210	Polonium-210
Aquatic Plants	Macrophytes	Reference (Kratchkowsky Lake)	1.87E-02	1.87E-02	2.34E+00	9.09E-01	1.00E+01	1.57E+00
		Whitefish Lake North	1.87E-02	1.87E-02	2.34E+00	9.09E-01	1.00E+01	1.57E+00
		Whitefish Lake Middle	2.29E-02	2.29E-02	2.40E+00	1.04E+00	1.15E+01	1.80E+00
		Whitefish Lake South	2.27E-02	2.27E-02	2.40E+00	1.04E+00	1.12E+01	1.76E+00
		McGowan Lake	2.15E-02	2.15E-02	2.39E+00	1.00E+00	1.06E+01	1.66E+00
		Russell Lake Inlet	2.08E-02	2.08E-02	2.38E+00	9.78E-01	1.04E+01	1.62E+00
	Phytoplankton	Reference (Kratchkowsky Lake)	1.87E-02	1.87E-02	2.34E+00	9.09E-01	1.00E+01	1.57E+00
		Whitefish Lake North	1.87E-02	1.87E-02	2.34E+00	9.09E-01	1.00E+01	1.57E+00
		Whitefish Lake Middle	2.29E-02	2.29E-02	2.40E+00	1.04E+00	1.15E+01	1.80E+00
		Whitefish Lake South	2.27E-02	2.27E-02	2.40E+00	1.04E+00	1.12E+01	1.76E+00
		McGowan Lake	2.15E-02	2.15E-02	2.39E+00	1.00E+00	1.06E+01	1.66E+00
		Russell Lake Inlet	2.08E-02	2.08E-02	2.38E+00	9.78E-01	1.04E+01	1.62E+00
Aquatic Animals	Benthic Invertebrate	Reference (Kratchkowsky Lake)	3.57E-02	3.57E-02	5.02E+00	1.36E+00	7.16E+00	5.00E+01
		Whitefish Lake North	3.57E-02	3.57E-02	5.02E+00	1.36E+00	7.16E+00	5.00E+01
		Whitefish Lake Middle	4.37E-02	4.37E-02	5.15E+00	1.55E+00	8.22E+00	5.74E+01
		Whitefish Lake South	4.33E-02	4.33E-02	5.15E+00	1.55E+00	8.04E+00	5.61E+01
		McGowan Lake	4.10E-02	4.10E-02	5.12E+00	1.50E+00	7.56E+00	5.28E+01
		Russell Lake Inlet	3.96E-02	3.96E-02	5.09E+00	1.46E+00	7.41E+00	5.17E+01
	Northern pike	Reference (Kratchkowsky Lake)	7.43E-03	7.43E-03	6.06E-02	6.69E-02	3.16E-01	8.05E-01
		Whitefish Lake North	7.43E-03	7.43E-03	6.06E-02	6.69E-02	3.16E-01	8.05E-01
		Whitefish Lake Middle	9.09E-03	9.09E-03	6.22E-02	7.67E-02	3.63E-01	9.23E-01
		Whitefish Lake South	9.02E-03	9.02E-03	6.22E-02	7.64E-02	3.55E-01	9.03E-01
		McGowan Lake	8.53E-03	8.53E-03	6.18E-02	7.38E-02	3.34E-01	8.49E-01
		Russell Lake Inlet	8.24E-03	8.24E-03	6.15E-02	7.20E-02	3.27E-01	8.30E-01
	White sucker	Reference (Kratchkowsky Lake)	7.36E-03	7.36E-03	6.05E-02	6.64E-02	2.84E-01	7.22E-01
		Whitefish Lake North	7.36E-03	7.36E-03	6.05E-02	6.64E-02	2.84E-01	7.22E-01
		Whitefish Lake Middle	9.00E-03	9.00E-03	6.21E-02	7.62E-02	3.26E-01	8.29E-01
		Whitefish Lake South	8.93E-03	8.93E-03	6.21E-02	7.59E-02	3.19E-01	8.10E-01
		McGowan Lake	8.45E-03	8.45E-03	6.17E-02	7.33E-02	3.00E-01	7.63E-01
		Russell Lake Inlet	8.16E-03	8.16E-03	6.14E-02	7.15E-02	2.94E-01	7.45E-01

Biota		Location	Maximum Concentration of Radionuclides duting Future Centuries (Bq/kg fw)					
			Uranium-238	Uranium-234	Thorium-230	Radium-226	Lead-210	Polonium-210
	Zooplankton	Reference (Kratchkowsky Lake)	3.71E-02	3.71E-02	5.05E+00	1.39E+00	1.21E+01	8.46E+01
		Whitefish Lake North	3.71E-02	3.71E-02	5.05E+00	1.39E+00	1.21E+01	8.46E+01
		Whitefish Lake Middle	4.54E-02	4.54E-02	5.18E+00	1.60E+00	1.39E+01	9.71E+01
		Whitefish Lake South	4.51E-02	4.51E-02	5.18E+00	1.59E+00	1.36E+01	9.50E+01
		McGowan Lake	4.26E-02	4.26E-02	5.15E+00	1.54E+00	1.28E+01	8.94E+01
		Russell Lake Inlet	4.12E-02	4.12E-02	5.13E+00	1.50E+00	1.25E+01	8.73E+01
Terrestrial Plants	Blueberries	Reference (Kratchkowsky Lake)	4.24E-01	4.24E-01	3.24E-01	4.73E+00	1.00E+01	1.31E+01
		Whitefish Lake	5.80E-01	5.80E-01	3.25E-01	4.73E+00	1.00E+01	1.31E+01
		McGowan Lake	4.44E-01	4.44E-01	3.25E-01	4.73E+00	1.00E+01	1.31E+01
		Russell Lake Inlet	4.29E-01	4.29E-01	3.24E-01	4.73E+00	1.00E+01	1.31E+01
	Browse	Reference (Kratchkowsky Lake)	3.63E-01	3.63E-01	1.25E-01	1.82E+00	3.85E+00	5.06E+00
		Whitefish Lake	4.23E-01	4.23E-01	1.25E-01	1.82E+00	3.85E+00	5.06E+00
		McGowan Lake	3.70E-01	3.70E-01	1.25E-01	1.82E+00	3.85E+00	5.06E+00
		Russell Lake Inlet	3.65E-01	3.65E-01	1.25E-01	1.82E+00	3.85E+00	5.06E+00
	Labrador Tea	Reference (Kratchkowsky Lake)	2.08E+00	2.08E+00	1.25E-01	1.82E+00	3.85E+00	5.06E+00
		Whitefish Lake	2.14E+00	2.14E+00	1.25E-01	1.82E+00	3.85E+00	5.06E+00
		McGowan Lake	2.09E+00	2.09E+00	1.25E-01	1.82E+00	3.85E+00	5.06E+00
		Russell Lake Inlet	2.09E+00	2.09E+00	1.25E-01	1.82E+00	3.85E+00	5.06E+00
	Lichen	Reference (Kratchkowsky Lake)	1.10E+00	1.10E+00	1.13E+00	2.72E+00	4.14E+02	2.77E+02
		Whitefish Lake	1.10E+00	1.10E+00	1.13E+00	2.72E+00	4.14E+02	2.77E+02
		McGowan Lake	1.10E+00	1.10E+00	1.13E+00	2.72E+00	4.14E+02	2.77E+02
		Russell Lake Inlet	1.10E+00	1.10E+00	1.13E+00	2.72E+00	4.14E+02	2.77E+02
	Terrestrial Invertebrate	Reference (Kratchkowsky Lake)	2.44E-01	2.44E-01	1.77E-01	1.36E+00	2.08E+00	1.82E+00
		Whitefish Lake	2.59E-01	2.59E-01	1.77E-01	1.36E+00	2.08E+00	1.82E+00
		McGowan Lake	2.46E-01	2.46E-01	1.77E-01	1.36E+00	2.08E+00	1.82E+00
		Russell Lake Inlet	2.44E-01	2.44E-01	1.77E-01	1.36E+00	2.08E+00	1.82E+00
	Black Bear	Reference (Kratchkowsky Lake)	3.70E-03	3.70E-03	3.10E-03	1.58E-01	1.48E-01	1.35E+00
		Whitefish Lake	3.83E-03	3.83E-03	3.10E-03	1.58E-01	1.48E-01	1.35E+00

Biota		Location	Maximum Concentration of Radionuclides duting Future Centuries (Bq/kg fw)					
			Uranium-238	Uranium-234	Thorium-230	Radium-226	Lead-210	Polonium-210
Terrestrial Animals	Lynx	Reference (Kratchkowsky Lake)	6.58E-04	6.58E-04	1.38E-03	2.26E-02	2.02E-02	4.69E-01
		Whitefish Lake	8.85E-04	8.85E-04	1.38E-03	2.26E-02	2.02E-02	4.69E-01
		McGowan Lake	6.88E-04	6.88E-04	1.38E-03	2.26E-02	2.02E-02	4.69E-01
		Russell Lake Inlet	6.66E-04	6.66E-04	1.38E-03	2.26E-02	2.02E-02	4.69E-01
	Mink	Reference (Kratchkowsky Lake)	4.12E-04	4.12E-04	4.25E-03	1.50E-02	3.13E-02	1.22E+00
		Whitefish Lake	5.19E-04	5.19E-04	4.34E-03	1.66E-02	3.48E-02	1.39E+00
		McGowan Lake	4.41E-04	4.41E-04	4.32E-03	1.61E-02	3.26E-02	1.28E+00
		Russell Lake Inlet	4.30E-04	4.30E-04	4.30E-03	1.58E-02	3.21E-02	1.25E+00
	Moose	Reference (Kratchkowsky Lake)	6.38E-03	6.38E-03	7.86E-03	1.54E-01	2.06E-01	1.27E+00
		Whitefish Lake	7.46E-03	7.46E-03	8.01E-03	1.57E-01	2.18E-01	1.30E+00
		McGowan Lake	6.53E-03	6.53E-03	7.97E-03	1.56E-01	2.11E-01	1.28E+00
		Russell Lake Inlet	6.43E-03	6.43E-03	7.94E-03	1.56E-01	2.09E-01	1.28E+00
	Moose Organs	Reference (Kratchkowsky Lake)	1.13E-02	1.13E-02	2.15E+00	8.61E-02	6.47E+00	1.27E-02
		McGowan Lake	1.15E-02	1.15E-02	2.18E+00	8.74E-02	6.62E+00	1.28E-02
		Russell Lake Inlet	1.14E-02	1.14E-02	2.18E+00	8.70E-02	6.56E+00	1.28E-02
	Muskrat	Reference (Kratchkowsky Lake)	1.09E-03	1.09E-03	1.80E-02	8.15E-02	2.94E-01	8.31E-01
		Whitefish Lake	1.34E-03	1.34E-03	1.85E-02	9.34E-02	3.37E-01	9.53E-01
		McGowan Lake	1.25E-03	1.25E-03	1.84E-02	8.98E-02	3.11E-01	8.77E-01
		Russell Lake Inlet	1.21E-03	1.21E-03	1.83E-02	8.77E-02	3.04E-01	8.58E-01
	Snowshoe Hare	Reference (Kratchkowsky Lake)	5.92E-03	5.92E-03	2.73E-03	1.41E-01	1.32E-01	1.18E+00
		Whitefish Lake	7.14E-03	7.14E-03	2.74E-03	1.41E-01	1.32E-01	1.18E+00
		McGowan Lake	6.07E-03	6.07E-03	2.73E-03	1.41E-01	1.32E-01	1.18E+00
		Russell Lake Inlet	5.96E-03	5.96E-03	2.73E-03	1.41E-01	1.32E-01	1.18E+00
	Southern Red-Backed Vole	Reference (Kratchkowsky Lake)	2.53E-02	2.53E-02	9.81E-03	9.76E-01	8.55E-01	7.96E+00
		Whitefish Lake	3.28E-02	3.28E-02	9.81E-03	9.76E-01	8.55E-01	7.96E+00
		McGowan Lake	2.63E-02	2.63E-02	9.81E-03	9.76E-01	8.55E-01	7.96E+00
		Russell Lake Inlet	2.56E-02	2.56E-02	9.81E-03	9.76E-01	8.55E-01	7.96E+00
	WoodLand Caribou	Reference (Kratchkowsky Lake)	5.75E-03	5.75E-03	9.48E-03	1.11E-01	1.78E+00	8.54E+00
		Whitefish Lake	5.83E-03	5.83E-03	9.54E-03	1.13E-01	1.79E+00	8.55E+00

Biota		Location	Maximum Concentration of Radionuclides duting Future Centuries (Bq/kg fw)					
			Uranium-238	Uranium-234	Thorium-230	Radium-226	Lead-210	Polonium-210
	Canada Goose	Reference (Kratchkowsky Lake)	2.40E-02	2.40E-02	3.39E-04	4.52E-03	1.83E-02	1.06E+00
		Whitefish Lake	2.88E-02	2.88E-02	3.30E-04	4.50E-03	1.83E-02	1.06E+00
		McGowan Lake	2.46E-02	2.46E-02	3.39E-04	4.52E-03	1.83E-02	1.06E+00
		Russell Lake Inlet	2.42E-02	2.42E-02	3.39E-04	4.52E-03	1.83E-02	1.06E+00
	Eagle	Reference (Kratchkowsky Lake)	8.49E-02	8.49E-02	4.82E-03	1.11E-02	8.94E-02	9.58E+00
		Whitefish Lake	8.55E-02	8.55E-02	4.82E-03	1.11E-02	8.94E-02	9.61E+00
	Flycatcher	Reference (Kratchkowsky Lake)	2.22E-01	2.22E-01	9.10E-03	4.76E-02	1.82E-01	1.69E+01
		Whitefish Lake	2.53E-01	2.53E-01	9.20E-03	4.81E-02	1.86E-01	1.84E+01
		McGowan Lake	2.26E-01	2.26E-01	9.19E-03	4.80E-02	1.83E-01	1.75E+01
		Russell Lake Inlet	2.23E-01	2.23E-01	9.17E-03	4.79E-02	1.83E-01	1.73E+01
	Loon	Reference (Kratchkowsky Lake)	2.40E-03	2.40E-03	1.71E-03	1.81E-03	1.54E-02	4.21E+00
		Whitefish Lake	2.94E-03	2.94E-03	1.76E-03	2.08E-03	1.76E-02	4.83E+00
		McGowan Lake	2.76E-03	2.76E-03	1.75E-03	2.00E-03	1.62E-02	4.44E+00
		Russell Lake Inlet	2.66E-03	2.66E-03	1.74E-03	1.95E-03	1.59E-02	4.35E+00
	Mallard	Reference (Kratchkowsky Lake)	2.52E-02	2.52E-02	1.67E-02	1.98E-02	2.02E-01	3.63E+01
		Whitefish Lake	3.08E-02	3.08E-02	1.72E-02	2.27E-02	2.32E-01	4.16E+01
		McGowan Lake	2.89E-02	2.89E-02	1.71E-02	2.18E-02	2.14E-01	3.83E+01
		Russell Lake Inlet	2.79E-02	2.79E-02	1.70E-02	2.13E-02	2.09E-01	3.75E+01
	Robin	Reference (Kratchkowsky Lake)	7.47E-01	7.47E-01	1.95E-02	2.21E-01	8.98E-01	4.95E+01
		Whitefish Lake	9.82E-01	9.82E-01	1.95E-02	2.21E-01	8.98E-01	4.95E+01
		McGowan Lake	7.78E-01	7.78E-01	1.95E-02	2.21E-01	8.98E-01	4.95E+01
		Russell Lake Inlet	7.56E-01	7.56E-01	1.95E-02	2.21E-01	8.98E-01	4.95E+01
	Scaup	Reference (Kratchkowsky Lake)	4.07E-02	4.07E-02	3.45E-02	3.93E-02	4.79E-01	5.85E+01
		Whitefish Lake	4.97E-02	4.97E-02	3.54E-02	4.50E-02	5.50E-01	6.71E+01
		McGowan Lake	4.67E-02	4.67E-02	3.52E-02	4.33E-02	5.06E-01	6.18E+01
		Russell Lake Inlet	4.51E-02	4.51E-02	3.50E-02	4.23E-02	4.95E-01	6.05E+01

Table B.9: Maximun Radiological Doses to Human Receptors during Project Phases

Human Receptor	COPC	Maximum Dose by Pathway during Project Phases (mSv/yr) Air (internal)	Air (external)	Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by Radionuclide
		Average Baseline												
Camp Worker Adult (Whitefish Lake)	Uranium-238	1.28E-04	3.51E-13	6.33E-06	4.80E-11	1.15E-07	1.27E-03	5.78E-08	6.16E-07	0.00E+00	4.42E-06	1.96E-04	2.98E-04	**1.91E-03**
	Uranium-234	1.54E-04	8.58E-13	6.89E-06	8.37E-12	1.25E-07	6.41E-06	6.29E-08	2.23E-09	0.00E+00	4.81E-06	2.13E-04	3.25E-04	**7.11E-04**
	Thorium-230	0.00E+00	0.00E+00	8.05E-04	5.45E-10	2.27E-06	3.47E-05	8.76E-07	2.17E-08	0.00E+00	1.69E-04	6.71E-04	1.86E-03	**3.54E-03**
	Radium-226	0.00E+00	0.00E+00	5.92E-04	2.64E-07	2.29E-06	5.93E-02	3.28E-06	3.93E-04	0.00E+00	2.48E-04	1.30E-02	8.26E-03	**8.19E-02**
	Lead-210	0.00E+00	0.00E+00	1.37E-03	1.21E-09	2.72E-05	6.30E-03	4.62E-05	2.62E-06	0.00E+00	2.74E-03	6.80E-02	3.10E-02	**1.09E-01**
	Polonium-210	0.00E+00	0.00E+00	2.43E-03	7.30E-12	4.24E-05	1.26E-06	8.18E-05	1.12E-08	0.00E+00	1.21E-02	1.55E-01	1.28E-01	**2.99E-01**
		Project Total Dose - Project Phases												
	Uranium-238	1.96E-03	5.37E-12	6.33E-05	4.80E-10	3.10E-07	3.43E-03	3.86E-07	4.12E-06	0.00E+00	4.79E-05	4.34E-04	3.34E-04	**6.28E-03**
	Uranium-234	2.36E-03	1.31E-11	6.89E-05	8.37E-11	3.37E-07	1.73E-05	4.20E-07	1.49E-08	0.00E+00	5.21E-05	4.73E-04	3.64E-04	**3.34E-03**
	Thorium-230	0.00E+00	0.00E+00	1.14E-03	7.76E-10	2.27E-06	3.47E-05	1.16E-06	2.87E-08	0.00E+00	2.61E-04	6.71E-04	2.29E-03	**4.40E-03**
	Radium-226	0.00E+00	0.00E+00	6.53E-04	2.91E-07	2.29E-06	5.93E-02	3.55E-06	4.25E-04	0.00E+00	2.81E-04	1.30E-02	8.27E-03	**8.20E-02**
	Lead-210	0.00E+00	0.00E+00	1.86E-03	1.64E-09	2.72E-05	6.30E-03	5.77E-05	3.26E-06	0.00E+00	3.48E-03	6.80E-02	3.23E-02	**1.12E-01**
	Polonium-210	0.00E+00	0.00E+00	2.97E-03	8.92E-12	4.24E-05	1.26E-06	1.01E-04	1.39E-08	0.00E+00	1.42E-02	1.55E-01	1.41E-01	**3.13E-01**
		Project Incremental Dose - Project Phases												
	Uranium-238	1.83E-03	5.02E-12	5.69E-05	4.32E-10	1.95E-07	2.16E-03	3.28E-07	3.50E-06	0.00E+00	4.35E-05	2.38E-04	3.59E-05	**4.37E-03**
	Uranium-234	2.21E-03	1.23E-11	6.20E-05	7.53E-11	2.12E-07	1.09E-05	3.58E-07	1.27E-08	0.00E+00	4.73E-05	2.60E-04	3.90E-05	**2.63E-03**
	Thorium-230	0.00E+00	0.00E+00	3.40E-04	2.30E-10	1.99E-10	3.06E-09	2.85E-07	7.05E-09	0.00E+00	9.20E-05	2.97E-08	4.31E-04	**8.63E-04**
	Radium-226	0.00E+00	0.00E+00	6.14E-05	2.74E-08	1.82E-12	4.10E-08	2.68E-07	3.21E-05	0.00E+00	3.31E-05	4.66E-09	1.08E-05	**1.38E-04**
	Lead-210	0.00E+00	0.00E+00	4.82E-04	4.24E-10	0.00E+00	0.00E+00	1.15E-05	6.48E-07	0.00E+00	7.32E-04	0.00E+00	1.30E-03	**2.52E-03**
	Polonium-210	0.00E+00	0.00E+00	5.39E-04	1.62E-12	0.00E+00	0.00E+00	1.94E-05	2.66E-09	0.00E+00	2.04E-03	0.00E+00	1.21E-02	**1.47E-02**
	Total by Pathway	**4.03E-03**	**1.73E-11**	**1.54E-03**	**2.86E-08**	**4.07E-07**	**2.17E-03**	**3.21E-05**	**3.63E-05**	**0.00E+00**	**2.98E-03**	**4.98E-04**	**1.39E-02**	**2.52E-02**
		Average Baseline												
Rec F/H Adult (McGowan Lake)	Uranium-238	1.28E-04	3.51E-13	6.33E-06	4.80E-11	1.15E-07	1.27E-03	5.78E-08	6.16E-07	0.00E+00	8.84E-06	3.92E-04	2.88E-04	**2.10E-03**
	Uranium-234	1.54E-04	8.58E-13	6.89E-06	8.37E-12	1.25E-07	6.41E-06	6.29E-08	2.23E-09	0.00E+00	9.63E-06	4.26E-04	3.14E-04	**9.18E-04**
	Thorium-230	0.00E+00	0.00E+00	8.05E-04	5.45E-10	2.27E-06	3.47E-05	8.76E-07	2.17E-08	0.00E+00	3.39E-04	1.34E-03	2.84E-03	**5.37E-03**
	Radium-226	0.00E+00	0.00E+00	5.92E-04	2.64E-07	2.29E-06	5.93E-02	3.28E-06	3.93E-04	0.00E+00	4.97E-04	2.61E-02	8.22E-03	**9.51E-02**
	Lead-210	0.00E+00	0.00E+00	1.37E-03	1.21E-09	2.72E-05	6.30E-03	4.62E-05	2.62E-06	0.00E+00	5.49E-03	1.36E-01	4.29E-02	**1.92E-01**
	Polonium-210	0.00E+00	0.00E+00	2.43E-03	7.30E-12	4.24E-05	1.26E-06	8.18E-05	1.12E-08	0.00E+00	2.43E-02	3.11E-01	2.18E-01	**5.56E-01**
		Project Total Dose - Project Phases												
	Uranium-238	4.12E-04	1.13E-12	2.55E-05	1.94E-10	1.44E-07	1.60E-03	1.83E-07	1.95E-06	0.00E+00	9.58E-05	8.69E-04	3.60E-04	**3.37E-03**
	Uranium-234	4.98E-04	2.77E-12	2.78E-05	3.37E-11	1.57E-07	8.07E-06	1.99E-07	7.08E-09	0.00E+00	1.04E-04	9.46E-04	3.92E-04	**1.98E-03**
	Thorium-230	0.00E+00	0.00E+00	9.35E-04	6.34E-10	2.27E-06	3.47E-05	1.00E-06	2.47E-08	0.00E+00	5.23E-04	1.34E-03	3.70E-03	**6.54E-03**
	Radium-226	0.00E+00	0.00E+00	6.24E-04	2.78E-07	2.29E-06	5.93E-02	3.39E-06	4.06E-04	0.00E+00	5.63E-04	2.61E-02	8.24E-03	**9.53E-02**
	Lead-210	0.00E+00	0.00E+00	1.67E-03	1.47E-09	2.72E-05	6.30E-03	4.89E-05	2.77E-06	0.00E+00	6.96E-03	1.36E-01	4.55E-02	**1.97E-01**
	Polonium-210	0.00E+00	0.00E+00	2.87E-03	8.62E-12	4.24E-05	1.26E-06	8.63E-05	1.18E-08	0.00E+00	2.84E-02	3.11E-01	2.42E-01	**5.85E-01**
		Project Incremental Dose - Project Phases												
	Uranium-238	2.84E-04	7.80E-13	1.92E-05	1.46E-10	2.97E-08	3.29E-04	1.25E-07	1.34E-06	0.00E+00	8.69E-05	4.77E-04	7.19E-05	**1.27E-03**
	Uranium-234	3.43E-04	1.91E-12	2.09E-05	2.54E-11	3.23E-08	1.66E-06	1.36E-07	4.85E-09	0.00E+00	9.47E-05	5.19E-04	7.82E-05	**1.06E-03**
	Thorium-230	0.00E+00	0.00E+00	1.31E-04	8.84E-11	3.00E-11	4.62E-10	1.24E-07	3.06E-09	0.00E+00	1.84E-04	5.94E-08	8.57E-04	**1.17E-03**
	Radium-226	0.00E+00	0.00E+00	3.21E-05	1.43E-08	2.27E-13	7.45E-09	1.09E-07	1.31E-05	0.00E+00	6.62E-05	9.31E-09	2.15E-05	**1.33E-04**
	Lead-210	0.00E+00	0.00E+00	2.92E-04	2.58E-10	0.00E+00	0.00E+00	2.63E-06	1.49E-07	0.00E+00	1.47E-03	0.00E+00	2.58E-03	**4.34E-03**
	Polonium-210	0.00E+00	0.00E+00	4.39E-04	1.32E-12	0.00E+00	0.00E+00	4.49E-06	6.16E-10	0.00E+00	4.07E-03	0.00E+00	2.45E-02	**2.90E-02**
	Total by Pathway	**6.28E-04**	**2.69E-12**	**9.34E-04**	**1.49E-08**	**6.20E-08**	**3.31E-04**	**7.61E-06**	**1.46E-05**	**0.00E+00**	**5.97E-03**	**9.96E-04**	**2.81E-02**	**3.70E-02**

Human Receptor	COPC	Maximum Dose by Pathway during Project Phases (mSv/yr)												
		Air (internal)	Air (external)	Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by Radionuclide
Rec F/H One-year-old (McGowan Lake)		Average Baseline												
	Uranium-238	1.28E-04	4.56E-13	4.40E-06	1.19E-11	4.67E-06	1.70E-03	2.35E-06	8.01E-07	0.00E+00	5.21E-06	5.58E-04	4.58E-04	**2.86E-03**
	Uranium-234	1.49E-04	1.12E-12	4.76E-06	2.07E-12	5.05E-06	8.58E-06	2.54E-06	2.90E-09	0.00E+00	5.65E-06	6.05E-04	4.96E-04	**1.28E-03**
	Thorium-230	0.00E+00	0.00E+00	4.09E-04	1.35E-10	6.75E-05	3.95E-05	2.61E-05	2.82E-08	0.00E+00	1.46E-04	1.44E-03	1.42E-03	**3.55E-03**
	Radium-226	0.00E+00	0.00E+00	5.29E-04	6.54E-08	1.20E-04	7.94E-02	1.71E-04	5.13E-04	0.00E+00	3.76E-04	4.91E-02	1.60E-02	**1.46E-01**
	Lead-210	0.00E+00	0.00E+00	1.87E-03	2.46E-10	2.16E-03	8.43E-03	3.68E-03	3.40E-06	0.00E+00	6.33E-03	3.89E-01	7.12E-02	**4.83E-01**
	Polonium-210	0.00E+00	0.00E+00	4.65E-03	1.81E-12	4.75E-03	1.64E-06	9.15E-03	1.46E-08	0.00E+00	3.94E-02	1.25E+00	3.84E-01	**1.69E+00**
		Project Total Dose - Project Phases												
	Uranium-238	4.11E-04	1.47E-12	1.77E-05	4.78E-11	5.87E-06	2.14E-03	7.44E-06	2.54E-06	0.00E+00	5.65E-05	1.15E-03	4.86E-04	**4.28E-03**
	Uranium-234	4.81E-04	3.60E-12	1.92E-05	8.35E-12	6.36E-06	1.08E-05	8.07E-06	9.20E-09	0.00E+00	6.12E-05	1.24E-03	5.27E-04	**2.36E-03**
	Thorium-230	0.00E+00	0.00E+00	4.76E-04	1.57E-10	6.75E-05	3.95E-05	2.98E-05	3.21E-08	0.00E+00	2.26E-04	1.44E-03	1.63E-03	**3.90E-03**
	Radium-226	0.00E+00	0.00E+00	5.57E-04	6.89E-08	1.20E-04	7.94E-02	1.77E-04	5.30E-04	0.00E+00	4.27E-04	4.91E-02	1.60E-02	**1.46E-01**
	Lead-210	0.00E+00	0.00E+00	2.27E-03	2.98E-10	2.16E-03	8.43E-03	3.89E-03	3.60E-06	0.00E+00	8.02E-03	3.89E-01	7.29E-02	**4.87E-01**
	Polonium-210	0.00E+00	0.00E+00	5.48E-03	2.14E-12	4.75E-03	1.64E-06	9.65E-03	1.54E-08	0.00E+00	4.60E-02	1.25E+00	4.16E-01	**1.73E+00**
		Project Incremental Dose - Project Phases												
	Uranium-238	2.84E-04	1.01E-12	1.33E-05	3.60E-11	1.21E-06	4.40E-04	5.10E-06	1.74E-06	0.00E+00	5.12E-05	5.90E-04	2.82E-05	**1.41E-03**
	Uranium-234	3.32E-04	2.48E-12	1.44E-05	6.28E-12	1.31E-06	2.22E-06	5.52E-06	6.30E-09	0.00E+00	5.55E-05	6.39E-04	3.06E-05	**1.08E-03**
	Thorium-230	0.00E+00	0.00E+00	6.64E-05	2.19E-11	9.02E-10	5.24E-10	3.68E-06	3.97E-09	0.00E+00	7.94E-05	6.37E-08	2.06E-04	**3.55E-04**
	Radium-226	0.00E+00	0.00E+00	2.87E-05	3.55E-09	1.46E-11	7.45E-09	5.70E-06	1.71E-05	0.00E+00	5.01E-05	2.24E-08	8.82E-06	**1.10E-04**
	Lead-210	0.00E+00	0.00E+00	3.97E-04	5.22E-11	0.00E+00	0.00E+00	2.09E-04	1.93E-07	0.00E+00	1.69E-03	0.00E+00	1.66E-03	**3.96E-03**
	Polonium-210	0.00E+00	0.00E+00	8.39E-04	3.27E-13	0.00E+00	0.00E+00	5.02E-04	8.00E-10	0.00E+00	6.60E-03	0.00E+00	3.21E-02	**4.00E-02**
	Total by Pathway	**6.15E-04**	**3.50E-12**	**1.36E-03**	**3.67E-09**	**2.51E-06**	**4.43E-04**	**7.31E-04**	**1.90E-05**	**0.00E+00**	**8.53E-03**	**1.23E-03**	**3.40E-02**	4.69E-02
Rec F/H Adult (Russell Lake)		Average Baseline												
	Uranium-238	1.28E-04	3.51E-13	6.33E-06	4.80E-11	1.15E-07	1.27E-03	5.78E-08	6.16E-07	0.00E+00	8.84E-06	3.92E-04	2.88E-04	**2.10E-03**
	Uranium-234	1.54E-04	8.58E-13	6.89E-06	8.37E-12	1.25E-07	6.41E-06	6.29E-08	2.23E-09	0.00E+00	9.63E-06	4.26E-04	3.14E-04	**9.18E-04**
	Thorium-230	0.00E+00	0.00E+00	8.05E-04	5.45E-10	2.27E-06	3.47E-05	8.76E-07	2.17E-08	0.00E+00	3.39E-04	1.34E-03	2.84E-03	**5.37E-03**
	Radium-226	0.00E+00	0.00E+00	5.92E-04	2.64E-07	2.29E-06	5.93E-02	3.28E-06	3.93E-04	0.00E+00	4.97E-04	2.61E-02	8.22E-03	**9.51E-02**
	Lead-210	0.00E+00	0.00E+00	1.37E-03	1.21E-09	2.72E-05	6.30E-03	4.62E-05	2.62E-06	0.00E+00	5.49E-03	1.36E-01	4.29E-02	**1.92E-01**
	Polonium-210	0.00E+00	0.00E+00	2.43E-03	7.30E-12	4.24E-05	1.26E-06	8.18E-05	1.12E-08	0.00E+00	2.43E-02	3.11E-01	2.18E-01	**5.56E-01**
		Project Total Dose - Project Phases												
	Uranium-238	2.04E-04	5.59E-13	2.01E-05	1.53E-10	1.23E-07	1.36E-03	1.49E-07	1.59E-06	0.00E+00	7.15E-05	5.19E-04	3.31E-04	**2.51E-03**
	Uranium-234	2.46E-04	1.37E-12	2.19E-05	2.66E-11	1.34E-07	6.86E-06	1.63E-07	5.77E-09	0.00E+00	7.79E-05	5.65E-04	3.60E-04	**1.28E-03**
	Thorium-230	0.00E+00	0.00E+00	9.02E-04	6.11E-10	2.27E-06	3.47E-05	9.70E-07	2.40E-08	0.00E+00	4.77E-04	1.34E-03	3.49E-03	**6.25E-03**
	Radium-226	0.00E+00	0.00E+00	6.19E-04	2.76E-07	2.29E-06	5.93E-02	3.36E-06	4.03E-04	0.00E+00	5.47E-04	2.61E-02	8.24E-03	**9.52E-02**
	Lead-210	0.00E+00	0.00E+00	1.64E-03	1.45E-09	2.72E-05	6.30E-03	4.78E-05	2.71E-06	0.00E+00	6.66E-03	1.36E-01	4.49E-02	**1.96E-01**
	Polonium-210	0.00E+00	0.00E+00	2.86E-03	8.60E-12	4.24E-05	1.26E-06	8.45E-05	1.16E-08	0.00E+00	2.80E-02	3.11E-01	2.33E-01	**5.75E-01**
		Project Incremental Dose - Project Phases												
	Uranium-238	7.60E-05	2.08E-13	1.38E-05	1.05E-10	7.92E-09	8.79E-05	9.15E-08	9.76E-07	0.00E+00	6.27E-05	1.27E-04	4.23E-05	**4.11E-04**
	Uranium-234	9.17E-05	5.10E-13	1.50E-05	1.82E-11	8.63E-09	4.43E-07	9.97E-08	3.54E-09	0.00E+00	6.83E-05	1.39E-04	4.60E-05	**3.60E-04**
	Thorium-230	0.00E+00	0.00E+00	9.75E-05	6.61E-11	7.73E-12	1.20E-10	9.40E-08	2.32E-09	0.00E+00	1.39E-04	1.59E-08	6.45E-04	**8.81E-04**
	Radium-226	0.00E+00	0.00E+00	2.75E-05	1.23E-08	0.00E+00	0.00E+00	8.11E-08	9.72E-06	0.00E+00	4.99E-05	1.86E-09	1.66E-05	**1.04E-04**
	Lead-210	0.00E+00	0.00E+00	2.71E-04	2.39E-10	0.00E+00	0.00E+00	1.60E-06	9.03E-08	0.00E+00	1.17E-03	0.00E+00	2.03E-03	**3.47E-03**
	Polonium-210	0.00E+00	0.00E+00	4.30E-04	1.29E-12	0.00E+00	0.00E+00	2.72E-06	3.74E-10	0.00E+00	3.66E-03	0.00E+00	1.48E-02	**1.89E-02**
	Total by Pathway	**1.68E-04**	**7.18E-13**	**8.55E-04**	**1.27E-08**	**1.66E-08**	**8.83E-05**	**4.69E-06**	**1.08E-05**	**0.00E+00**	**5.15E-03**	**2.66E-04**	**1.76E-02**	2.42E-02

Human Receptor	COPC	Maximum Dose by Pathway during Project Phases (mSv/yr)												
		Air (internal)	Air (external)	Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by Radionuclide
Rec F/H One-year-old (Russell Lake)		Average Baseline												
	Uranium-238	1.28E-04	4.56E-13	4.40E-06	1.19E-11	4.67E-06	1.70E-03	2.35E-06	8.01E-07	0.00E+00	5.21E-06	5.58E-04	4.58E-04	**2.86E-03**
	Uranium-234	1.49E-04	1.12E-12	4.76E-06	2.07E-12	5.05E-06	8.58E-06	2.54E-06	2.90E-09	0.00E+00	5.65E-06	6.05E-04	4.96E-04	**1.28E-03**
	Thorium-230	0.00E+00	0.00E+00	4.09E-04	1.35E-10	6.75E-05	3.95E-05	2.61E-05	2.82E-08	0.00E+00	1.46E-04	1.44E-03	1.42E-03	**3.55E-03**
	Radium-226	0.00E+00	0.00E+00	5.29E-04	6.54E-08	1.20E-04	7.94E-02	1.71E-04	5.13E-04	0.00E+00	3.76E-04	4.91E-02	1.60E-02	**1.46E-01**
	Lead-210	0.00E+00	0.00E+00	1.87E-03	2.46E-10	2.16E-03	8.43E-03	3.68E-03	3.40E-06	0.00E+00	6.33E-03	3.89E-01	7.12E-02	**4.83E-01**
	Polonium-210	0.00E+00	0.00E+00	4.65E-03	1.81E-12	4.75E-03	1.64E-06	9.15E-03	1.46E-08	0.00E+00	3.94E-02	1.25E+00	3.84E-01	**1.69E+00**
		Project Total Dose - Project Phases												
	Uranium-238	2.03E-04	7.27E-13	1.40E-05	3.77E-11	4.99E-06	1.82E-03	6.07E-06	2.07E-06	0.00E+00	4.22E-05	7.16E-04	4.74E-04	**3.28E-03**
	Uranium-234	2.38E-04	1.78E-12	1.51E-05	6.58E-12	5.40E-06	9.18E-06	6.58E-06	7.50E-09	0.00E+00	4.57E-05	7.75E-04	5.14E-04	**1.61E-03**
	Thorium-230	0.00E+00	0.00E+00	4.59E-04	1.51E-10	6.75E-05	3.95E-05	2.89E-05	3.12E-08	0.00E+00	2.06E-04	1.44E-03	1.58E-03	**3.82E-03**
	Radium-226	0.00E+00	0.00E+00	5.53E-04	6.84E-08	1.20E-04	7.94E-02	1.76E-04	5.25E-04	0.00E+00	4.14E-04	4.91E-02	1.60E-02	**1.46E-01**
	Lead-210	0.00E+00	0.00E+00	2.24E-03	2.94E-10	2.16E-03	8.43E-03	3.81E-03	3.52E-06	0.00E+00	7.68E-03	3.89E-01	7.25E-02	**4.86E-01**
	Polonium-210	0.00E+00	0.00E+00	5.47E-03	2.13E-12	4.75E-03	1.64E-06	9.46E-03	1.51E-08	0.00E+00	4.53E-02	1.25E+00	4.04E-01	**1.72E+00**
		Project Incremental Dose - Project Phases												
	Uranium-238	7.57E-05	2.71E-13	9.58E-06	2.58E-11	3.22E-07	1.18E-04	3.72E-06	1.27E-06	0.00E+00	3.69E-05	1.57E-04	1.65E-05	**4.19E-04**
	Uranium-234	8.86E-05	6.63E-13	1.04E-05	4.51E-12	3.49E-07	5.93E-07	4.03E-06	4.60E-09	0.00E+00	4.00E-05	1.71E-04	1.79E-05	**3.32E-04**
	Thorium-230	0.00E+00	0.00E+00	4.96E-05	1.64E-11	2.40E-10	1.42E-10	2.80E-06	3.02E-09	0.00E+00	5.98E-05	1.70E-08	1.55E-04	**2.67E-04**
	Radium-226	0.00E+00	0.00E+00	2.46E-05	3.04E-09	0.00E+00	0.00E+00	4.24E-06	1.27E-05	0.00E+00	3.78E-05	3.73E-09	6.80E-06	**8.61E-05**
	Lead-210	0.00E+00	0.00E+00	3.68E-04	4.84E-11	0.00E+00	0.00E+00	1.27E-04	1.17E-07	0.00E+00	1.35E-03	0.00E+00	1.30E-03	**3.15E-03**
	Polonium-210	0.00E+00	0.00E+00	8.22E-04	3.20E-13	0.00E+00	0.00E+00	3.05E-04	4.86E-10	0.00E+00	5.94E-03	0.00E+00	1.94E-02	**2.64E-02**
	Total by Pathway	**1.64E-04**	**9.34E-13**	**1.28E-03**	**3.14E-09**	**6.71E-07**	**1.18E-04**	**4.46E-04**	**1.41E-05**	**0.00E+00**	**7.46E-03**	**3.28E-04**	**2.09E-02**	3.07E-02
Seasonal Resident Adult (Russell Lake)		Average Baseline												
	Uranium-238	1.28E-04	3.51E-13	6.33E-06	4.80E-11	1.15E-07	1.27E-03	5.78E-08	6.16E-07	0.00E+00	8.84E-06	3.92E-04	2.88E-04	**2.10E-03**
	Uranium-234	1.54E-04	8.58E-13	6.89E-06	8.37E-12	1.25E-07	6.41E-06	6.29E-08	2.23E-09	0.00E+00	9.63E-06	4.26E-04	3.14E-04	**9.18E-04**
	Thorium-230	0.00E+00	0.00E+00	8.05E-04	5.45E-10	2.27E-06	3.47E-05	8.76E-07	2.17E-08	0.00E+00	3.39E-04	1.34E-03	2.84E-03	**5.37E-03**
	Radium-226	0.00E+00	0.00E+00	5.92E-04	2.64E-07	2.29E-06	5.93E-02	3.28E-06	3.93E-04	0.00E+00	4.97E-04	2.61E-02	8.22E-03	**9.51E-02**
	Lead-210	0.00E+00	0.00E+00	1.37E-03	1.21E-09	2.72E-05	6.30E-03	4.62E-05	2.62E-06	0.00E+00	5.49E-03	1.36E-01	4.29E-02	**1.92E-01**
	Polonium-210	0.00E+00	0.00E+00	2.43E-03	7.30E-12	4.24E-05	1.26E-06	8.18E-05	1.12E-08	0.00E+00	2.43E-02	3.11E-01	2.18E-01	**5.56E-01**
		Project Total Dose - Project Phases												
	Uranium-238	2.04E-04	5.59E-13	2.01E-05	1.53E-10	1.23E-07	1.36E-03	1.49E-07	1.59E-06	0.00E+00	2.74E-05	4.30E-04	3.07E-04	**2.35E-03**
	Uranium-234	2.46E-04	1.37E-12	2.19E-05	2.66E-11	1.34E-07	6.86E-06	1.63E-07	5.77E-09	0.00E+00	2.99E-05	4.68E-04	3.35E-04	**1.11E-03**
	Thorium-230	0.00E+00	0.00E+00	9.02E-04	6.11E-10	2.27E-06	3.47E-05	9.70E-07	2.40E-08	0.00E+00	3.79E-04	1.34E-03	3.03E-03	**5.69E-03**
	Radium-226	0.00E+00	0.00E+00	6.19E-04	2.76E-07	2.29E-06	5.93E-02	3.36E-06	4.03E-04	0.00E+00	5.19E-04	2.61E-02	8.23E-03	**9.52E-02**
	Lead-210	0.00E+00	0.00E+00	1.64E-03	1.45E-09	2.72E-05	6.30E-03	4.78E-05	2.71E-06	0.00E+00	6.50E-03	1.36E-01	4.45E-02	**1.95E-01**
	Polonium-210	0.00E+00	0.00E+00	2.86E-03	8.60E-12	4.24E-05	1.26E-06	8.45E-05	1.16E-08	0.00E+00	2.83E-02	3.11E-01	2.23E-01	**5.65E-01**
		Project Incremental Dose - Project Phases												
	Uranium-238	7.60E-05	2.08E-13	1.38E-05	1.05E-10	7.92E-09	8.79E-05	9.15E-08	9.76E-07	0.00E+00	1.86E-05	3.83E-05	1.91E-05	**2.55E-04**
	Uranium-234	9.17E-05	5.10E-13	1.50E-05	1.82E-11	8.63E-09	4.43E-07	9.97E-08	3.54E-09	0.00E+00	2.03E-05	4.18E-05	2.08E-05	**1.90E-04**
	Thorium-230	0.00E+00	0.00E+00	9.75E-05	6.61E-11	7.73E-12	1.20E-10	9.40E-08	2.32E-09	0.00E+00	4.05E-05	4.77E-09	1.85E-04	**3.23E-04**
	Radium-226	0.00E+00	0.00E+00	2.75E-05	1.23E-08	0.00E+00	0.00E+00	8.11E-08	9.72E-06	0.00E+00	2.17E-05	0.00E+00	7.15E-06	**6.62E-05**
	Lead-210	0.00E+00	0.00E+00	2.71E-04	2.39E-10	0.00E+00	0.00E+00	1.60E-06	9.03E-08	0.00E+00	1.01E-03	0.00E+00	1.67E-03	**2.96E-03**
	Polonium-210	0.00E+00	0.00E+00	4.30E-04	1.29E-12	0.00E+00	0.00E+00	2.72E-06	3.74E-10	0.00E+00	4.02E-03	0.00E+00	4.82E-03	**9.28E-03**
	Total by Pathway	**1.68E-04**	**7.18E-13**	**8.55E-04**	**1.27E-08**	**1.66E-08**	**8.83E-05**	**4.69E-06**	**1.08E-05**	**0.00E+00**	**5.13E-03**	**8.01E-05**	**6.73E-03**	1.31E-02

Human Receptor	COPC	Maximum Dose by Pathway during Project Phases (mSv/yr)												
		Air (internal)	Air (external)	Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by Radionuclide
Seasonal Resident One-year-old (Russell Lake)	**Average Baseline**													
	Uranium-238	1.28E-04	4.56E-13	4.40E-06	1.19E-11	4.67E-06	1.70E-03	2.35E-06	8.01E-07	0.00E+00	5.21E-06	5.58E-04	4.58E-04	**2.86E-03**
	Uranium-234	1.49E-04	1.12E-12	4.76E-06	2.07E-12	5.05E-06	8.58E-06	2.54E-06	2.90E-09	0.00E+00	5.65E-06	6.05E-04	4.96E-04	**1.28E-03**
	Thorium-230	0.00E+00	0.00E+00	4.09E-04	1.35E-10	6.75E-05	3.95E-05	2.61E-05	2.82E-08	0.00E+00	1.46E-04	1.44E-03	1.42E-03	**3.55E-03**
	Radium-226	0.00E+00	0.00E+00	5.29E-04	6.54E-08	1.20E-04	7.94E-02	1.71E-04	5.13E-04	0.00E+00	3.76E-04	4.91E-02	1.60E-02	**1.46E-01**
	Lead-210	0.00E+00	0.00E+00	1.87E-03	2.46E-10	2.16E-03	8.43E-03	3.68E-03	3.40E-06	0.00E+00	6.33E-03	3.89E-01	7.12E-02	**4.83E-01**
	Polonium-210	0.00E+00	0.00E+00	4.65E-03	1.81E-12	4.75E-03	1.64E-06	9.15E-03	1.46E-08	0.00E+00	3.94E-02	1.25E+00	3.84E-01	**1.69E+00**
	Project Total Dose - Project Phases													
	Uranium-238	2.03E-04	7.27E-13	1.40E-05	3.77E-11	4.99E-06	1.82E-03	6.07E-06	2.07E-06	0.00E+00	1.62E-05	6.05E-04	4.65E-04	**3.14E-03**
	Uranium-234	2.38E-04	1.78E-12	1.51E-05	6.58E-12	5.40E-06	9.18E-06	6.58E-06	7.50E-09	0.00E+00	1.75E-05	6.56E-04	5.04E-04	**1.45E-03**
	Thorium-230	0.00E+00	0.00E+00	4.59E-04	1.51E-10	6.75E-05	3.95E-05	2.89E-05	3.12E-08	0.00E+00	1.64E-04	1.44E-03	1.47E-03	**3.66E-03**
	Radium-226	0.00E+00	0.00E+00	5.53E-04	6.84E-08	1.20E-04	7.94E-02	1.76E-04	5.25E-04	0.00E+00	3.93E-04	4.91E-02	1.60E-02	**1.46E-01**
	Lead-210	0.00E+00	0.00E+00	2.24E-03	2.94E-10	2.16E-03	8.43E-03	3.81E-03	3.52E-06	0.00E+00	7.50E-03	3.89E-01	7.23E-02	**4.86E-01**
	Polonium-210	0.00E+00	0.00E+00	5.47E-03	2.13E-12	4.75E-03	1.64E-06	9.46E-03	1.51E-08	0.00E+00	4.59E-02	1.25E+00	3.90E-01	**1.71E+00**
	Project Incremental Dose - Project Phases													
	Uranium-238	7.57E-05	2.71E-13	9.58E-06	2.58E-11	3.22E-07	1.18E-04	3.72E-06	1.27E-06	0.00E+00	1.10E-05	4.71E-05	7.17E-06	**2.73E-04**
	Uranium-234	8.86E-05	6.63E-13	1.04E-05	4.51E-12	3.49E-07	5.93E-07	4.03E-06	4.60E-09	0.00E+00	1.19E-05	5.11E-05	7.77E-06	**1.75E-04**
	Thorium-230	0.00E+00	0.00E+00	4.96E-05	1.64E-11	2.40E-10	1.42E-10	2.80E-06	3.02E-09	0.00E+00	1.75E-05	5.12E-09	4.30E-05	**1.13E-04**
	Radium-226	0.00E+00	0.00E+00	2.46E-05	3.04E-09	0.00E+00	0.00E+00	4.24E-06	1.27E-05	0.00E+00	1.65E-05	3.73E-09	2.97E-06	**6.10E-05**
	Lead-210	0.00E+00	0.00E+00	3.68E-04	4.84E-11	0.00E+00	0.00E+00	1.27E-04	1.17E-07	0.00E+00	1.17E-03	0.00E+00	1.07E-03	**2.73E-03**
	Polonium-210	0.00E+00	0.00E+00	8.22E-04	3.20E-13	0.00E+00	0.00E+00	3.05E-04	4.86E-10	0.00E+00	6.52E-03	0.00E+00	5.86E-03	**1.35E-02**
	Total by Pathway	**1.64E-04**	**9.34E-13**	**1.28E-03**	**3.14E-09**	**6.71E-07**	**1.18E-04**	**4.46E-04**	**1.41E-05**	**0.00E+00**	**7.74E-03**	**9.82E-05**	**6.99E-03**	1.69E-02
Fisher/ Trapper Adult (Russell Lake)	**Average Baseline**													
	Uranium-238	1.28E-04	3.51E-13	6.33E-06	4.80E-11	1.15E-07	1.27E-03	5.78E-08	6.16E-07	0.00E+00	6.09E-05	0.00E+00	1.98E-04	**1.67E-03**
	Uranium-234	1.54E-04	8.58E-13	6.89E-06	8.37E-12	1.25E-07	6.41E-06	6.29E-08	2.23E-09	0.00E+00	6.63E-05	0.00E+00	2.15E-04	**4.50E-04**
	Thorium-230	0.00E+00	0.00E+00	8.05E-04	5.45E-10	2.27E-06	3.47E-05	8.76E-07	2.17E-08	0.00E+00	2.33E-03	0.00E+00	7.78E-04	**3.95E-03**
	Radium-226	0.00E+00	0.00E+00	5.92E-04	2.64E-07	2.29E-06	5.93E-02	3.28E-06	3.93E-04	0.00E+00	3.42E-03	0.00E+00	9.66E-03	**7.34E-02**
	Lead-210	0.00E+00	0.00E+00	1.37E-03	1.21E-09	2.72E-05	6.30E-03	4.62E-05	2.62E-06	0.00E+00	3.78E-02	0.00E+00	2.26E-01	**2.71E-01**
	Polonium-210	0.00E+00	0.00E+00	2.43E-03	7.30E-12	4.24E-05	1.26E-06	8.18E-05	1.12E-08	0.00E+00	1.67E-01	0.00E+00	1.89E+00	**2.06E+00**
	Project Total Dose - Project Phases													
	Uranium-238	2.55E-04	6.98E-13	2.95E-05	2.24E-10	1.28E-07	1.42E-03	2.10E-07	2.24E-06	0.00E+00	4.92E-04	0.00E+00	1.28E-03	**3.47E-03**
	Uranium-234	3.07E-04	1.71E-12	3.21E-05	3.89E-11	1.39E-07	7.15E-06	2.29E-07	8.13E-09	0.00E+00	5.36E-04	0.00E+00	1.39E-03	**2.27E-03**
	Thorium-230	0.00E+00	0.00E+00	9.70E-04	6.57E-10	2.27E-06	3.47E-05	1.03E-06	2.55E-08	0.00E+00	3.29E-03	0.00E+00	8.44E-04	**5.14E-03**
	Radium-226	0.00E+00	0.00E+00	6.28E-04	2.80E-07	2.29E-06	5.93E-02	3.41E-06	4.09E-04	0.00E+00	3.76E-03	0.00E+00	9.76E-03	**7.39E-02**
	Lead-210	0.00E+00	0.00E+00	1.65E-03	1.46E-09	2.72E-05	6.30E-03	4.89E-05	2.77E-06	0.00E+00	4.59E-02	0.00E+00	2.28E-01	**2.82E-01**
	Polonium-210	0.00E+00	0.00E+00	2.85E-03	8.55E-12	4.24E-05	1.26E-06	8.63E-05	1.18E-08	0.00E+00	1.92E-01	0.00E+00	1.91E+00	**2.10E+00**
	Project Incremental Dose - Project Phases													
	Uranium-238	1.27E-04	3.47E-13	2.31E-05	1.76E-10	1.32E-08	1.46E-04	1.53E-07	1.63E-06	0.00E+00	4.32E-04	0.00E+00	1.08E-03	**1.81E-03**
	Uranium-234	1.53E-04	8.50E-13	2.52E-05	3.06E-11	1.44E-08	7.38E-07	1.66E-07	5.90E-09	0.00E+00	4.70E-04	0.00E+00	1.17E-03	**1.82E-03**
	Thorium-230	0.00E+00	0.00E+00	1.65E-04	1.12E-10	1.32E-11	2.04E-10	1.57E-07	3.88E-09	0.00E+00	9.53E-04	0.00E+00	6.56E-05	**1.18E-03**
	Radium-226	0.00E+00	0.00E+00	3.65E-05	1.63E-08	0.00E+00	0.00E+00	1.35E-07	1.62E-05	0.00E+00	3.43E-04	0.00E+00	1.04E-04	**5.00E-04**
	Lead-210	0.00E+00	0.00E+00	2.81E-04	2.47E-10	0.00E+00	0.00E+00	2.63E-06	1.49E-07	0.00E+00	8.06E-03	0.00E+00	2.25E-03	**1.06E-02**
	Polonium-210	0.00E+00	0.00E+00	4.15E-04	1.25E-12	0.00E+00	0.00E+00	4.48E-06	6.15E-10	0.00E+00	2.52E-02	0.00E+00	1.56E-02	**4.12E-02**
	Total by Pathway	**2.79E-04**	**1.20E-12**	**9.45E-04**	**1.68E-08**	**2.76E-08**	**1.47E-04**	**7.72E-06**	**1.80E-05**	**0.00E+00**	**3.55E-02**	**0.00E+00**	**2.02E-02**	5.71E-02

Table B.10: Maximun Radiological Doses to Human Receptors during Future Centuries

Human receptor	COPC	Maximum Dose by Pathway during Future Centuries (mSv/yr)												
		Air (internal)	Air (external)	Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by Radionuclide
Permanent Resident Adult (Whitefish Lake)		**Baseline Dose**												
	Uranium-238	1.28E-04	3.51E-13	6.34E-06	4.81E-11	1.15E-07	1.27E-03	5.79E-08	6.17E-07	0.00E+00	8.86E-06	3.92E-04	2.88E-04	**2.10E-03**
	Uranium-234	1.54E-04	8.58E-13	6.91E-06	8.39E-12	1.25E-07	6.41E-06	6.30E-08	2.24E-09	0.00E+00	9.65E-06	4.26E-04	3.14E-04	**9.18E-04**
	Thorium-230	0.00E+00	0.00E+00	8.05E-04	5.46E-10	2.27E-06	3.47E-05	8.76E-07	2.17E-08	0.00E+00	3.39E-04	1.34E-03	2.84E-03	**5.37E-03**
	Radium-226	0.00E+00	0.00E+00	5.93E-04	2.64E-07	2.29E-06	5.93E-02	3.28E-06	3.93E-04	0.00E+00	4.97E-04	2.61E-02	8.22E-03	**9.51E-02**
	Lead-210	0.00E+00	0.00E+00	1.38E-03	1.22E-09	2.72E-05	6.30E-03	4.64E-05	2.63E-06	0.00E+00	5.52E-03	1.36E-01	4.29E-02	**1.92E-01**
	Polonium-210	0.00E+00	0.00E+00	2.44E-03	7.34E-12	4.24E-05	1.26E-06	8.21E-05	1.13E-08	0.00E+00	2.44E-02	3.11E-01	2.18E-01	**5.56E-01**
		Project Total Dose - Future Centuries												
	Uranium-238	1.28E-04	3.51E-13	7.76E-06	5.89E-11	1.37E-07	1.52E-03	7.08E-08	7.55E-07	0.00E+00	1.08E-05	5.30E-04	2.90E-04	**2.48E-03**
	Uranium-234	1.54E-04	8.58E-13	8.45E-06	1.03E-11	1.49E-07	7.65E-06	7.71E-08	2.74E-09	0.00E+00	1.18E-05	5.77E-04	3.16E-04	**1.07E-03**
	Thorium-230	0.00E+00	0.00E+00	8.26E-04	5.60E-10	2.27E-06	3.48E-05	9.00E-07	2.22E-08	0.00E+00	3.48E-04	1.34E-03	2.87E-03	**5.43E-03**
	Radium-226	0.00E+00	0.00E+00	6.79E-04	3.03E-07	2.29E-06	5.93E-02	3.76E-06	4.51E-04	0.00E+00	5.70E-04	2.61E-02	8.24E-03	**9.54E-02**
	Lead-210	0.00E+00	0.00E+00	1.58E-03	1.40E-09	2.72E-05	6.30E-03	5.33E-05	3.01E-06	0.00E+00	6.33E-03	1.36E-01	4.36E-02	**1.94E-01**
	Polonium-210	0.00E+00	0.00E+00	2.80E-03	8.42E-12	4.24E-05	1.26E-06	9.42E-05	1.29E-08	0.00E+00	2.80E-02	3.11E-01	2.39E-01	**5.81E-01**
		Project Incremental Dose - Future Centuries												
	Uranium-238	0.00E+00	0.00E+00	1.42E-06	1.07E-11	2.20E-08	2.44E-04	1.29E-08	1.38E-07	0.00E+00	1.98E-06	1.38E-04	1.48E-06	**3.87E-04**
	Uranium-234	0.00E+00	0.00E+00	1.54E-06	1.87E-12	2.40E-08	1.23E-06	1.41E-08	4.99E-10	0.00E+00	2.15E-06	1.50E-04	1.62E-06	**1.57E-04**
	Thorium-230	0.00E+00	0.00E+00	2.12E-05	1.44E-11	7.69E-10	1.18E-08	2.31E-08	5.71E-10	0.00E+00	8.93E-06	8.84E-07	3.11E-05	**6.22E-05**
	Radium-226	0.00E+00	0.00E+00	8.68E-05	3.87E-08	9.39E-11	2.43E-06	4.80E-07	5.75E-05	0.00E+00	7.28E-05	2.07E-06	2.40E-05	**2.46E-04**
	Lead-210	0.00E+00	0.00E+00	2.03E-04	1.79E-10	0.00E+00	0.00E+00	6.83E-06	3.86E-07	0.00E+00	8.12E-04	0.00E+00	7.09E-04	**1.73E-03**
	Polonium-210	0.00E+00	0.00E+00	3.59E-04	1.08E-12	0.00E+00	0.00E+00	1.21E-05	1.66E-09	0.00E+00	3.59E-03	0.00E+00	2.02E-02	**2.42E-02**
	Total by Pathway	**0.00E+00**	**0.00E+00**	**6.73E-04**	**3.89E-08**	**4.68E-08**	**2.48E-04**	**1.94E-05**	**5.81E-05**	**0.00E+00**	**4.49E-03**	**2.91E-04**	**2.10E-02**	**2.67E-02**
Permanent Resident One-year-old (Whitefish Lake)		**Baseline Dose**												
	Uranium-238	1.28E-04	4.56E-13	4.41E-06	1.19E-11	4.67E-06	1.70E-03	2.35E-06	8.02E-07	0.00E+00	5.22E-06	5.58E-04	4.58E-04	**2.86E-03**
	Uranium-234	1.49E-04	1.12E-12	4.78E-06	2.08E-12	5.05E-06	8.58E-06	2.55E-06	2.91E-09	0.00E+00	5.66E-06	6.05E-04	4.96E-04	**1.28E-03**
	Thorium-230	0.00E+00	0.00E+00	4.10E-04	1.35E-10	6.75E-05	3.95E-05	2.61E-05	2.82E-08	0.00E+00	1.46E-04	1.44E-03	1.42E-03	**3.55E-03**
	Radium-226	0.00E+00	0.00E+00	5.29E-04	6.55E-08	1.20E-04	7.94E-02	1.72E-04	5.13E-04	0.00E+00	3.77E-04	4.91E-02	1.60E-02	**1.46E-01**
	Lead-210	0.00E+00	0.00E+00	1.88E-03	2.47E-10	2.16E-03	8.43E-03	3.69E-03	3.42E-06	0.00E+00	6.36E-03	3.89E-01	7.12E-02	**4.83E-01**
	Polonium-210	0.00E+00	0.00E+00	4.67E-03	1.82E-12	4.75E-03	1.64E-06	9.19E-03	1.46E-08	0.00E+00	3.96E-02	1.25E+00	3.85E-01	**1.69E+00**
		Project Total Dose - Future Centuries												
	Uranium-238	1.28E-04	4.56E-13	5.39E-06	1.46E-11	5.56E-06	2.03E-03	2.88E-06	9.81E-07	0.00E+00	6.39E-06	7.60E-04	4.59E-04	**3.40E-03**
	Uranium-234	1.49E-04	1.12E-12	5.84E-06	2.54E-12	6.02E-06	1.02E-05	3.12E-06	3.56E-09	0.00E+00	6.92E-06	8.23E-04	4.97E-04	**1.50E-03**
	Thorium-230	0.00E+00	0.00E+00	4.20E-04	1.39E-10	6.75E-05	3.95E-05	2.68E-05	2.89E-08	0.00E+00	1.50E-04	1.44E-03	1.43E-03	**3.57E-03**
	Radium-226	0.00E+00	0.00E+00	6.07E-04	7.51E-08	1.20E-04	7.94E-02	1.97E-04	5.88E-04	0.00E+00	4.32E-04	4.91E-02	1.60E-02	**1.46E-01**
	Lead-210	0.00E+00	0.00E+00	2.15E-03	2.83E-10	2.16E-03	8.43E-03	4.24E-03	3.92E-06	0.00E+00	7.30E-03	3.89E-01	7.17E-02	**4.85E-01**
	Polonium-210	0.00E+00	0.00E+00	5.36E-03	2.09E-12	4.75E-03	1.64E-06	1.05E-02	1.68E-08	0.00E+00	4.54E-02	1.25E+00	4.12E-01	**1.73E+00**
		Project Incremental Dose - Future Centuries												
	Uranium-238	0.00E+00	0.00E+00	9.84E-07	2.66E-12	8.95E-07	3.27E-04	5.25E-07	1.79E-07	0.00E+00	1.17E-06	2.02E-04	6.43E-07	**5.33E-04**
	Uranium-234	0.00E+00	0.00E+00	1.07E-06	4.64E-13	9.70E-07	1.65E-06	5.69E-07	6.49E-10	0.00E+00	1.26E-06	2.19E-04	6.97E-07	**2.25E-04**
	Thorium-230	0.00E+00	0.00E+00	1.08E-05	3.56E-12	2.29E-08	1.34E-08	6.88E-07	7.42E-10	0.00E+00	3.85E-06	9.46E-07	7.46E-06	**2.38E-05**
	Radium-226	0.00E+00	0.00E+00	7.75E-05	9.59E-09	4.90E-09	3.26E-06	2.51E-05	7.51E-05	0.00E+00	5.52E-05	3.90E-06	9.87E-06	**2.50E-04**
	Lead-210	0.00E+00	0.00E+00	2.76E-04	3.63E-11	0.00E+00	0.00E+00	5.43E-04	5.02E-07	0.00E+00	9.36E-04	0.00E+00	4.63E-04	**2.22E-03**
	Polonium-210	0.00E+00	0.00E+00	6.87E-04	2.68E-13	0.00E+00	0.00E+00	1.35E-03	2.15E-09	0.00E+00	5.82E-03	0.00E+00	2.65E-02	**3.43E-02**
	Total by Pathway	**0.00E+00**	**0.00E+00**	**1.05E-03**	**9.63E-09**	**1.89E-06**	**3.32E-04**	**1.92E-03**	**7.58E-05**	**0.00E+00**	**6.82E-03**	**4.26E-04**	**2.69E-02**	**3.76E-02**

Human receptor	COPC	Maximum Dose by Pathway during Future Centuries (mSv/yr)												
		Air (internal)	Air (external)	Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by Radionuclide
Rec F/H Adult (McGowan Lake)		**Baseline Dose**												
	Uranium-238	1.28E-04	3.51E-13	6.34E-06	4.81E-11	1.15E-07	1.27E-03	5.79E-08	6.17E-07	0.00E+00	8.86E-06	3.92E-04	2.88E-04	**2.10E-03**
	Uranium-234	1.54E-04	8.58E-13	6.91E-06	8.39E-12	1.25E-07	6.41E-06	6.30E-08	2.24E-09	0.00E+00	9.65E-06	4.26E-04	3.14E-04	**9.18E-04**
	Thorium-230	0.00E+00	0.00E+00	8.05E-04	5.46E-10	2.27E-06	3.47E-05	8.76E-07	2.17E-08	0.00E+00	3.39E-04	1.34E-03	2.84E-03	**5.37E-03**
	Radium-226	0.00E+00	0.00E+00	5.93E-04	2.64E-07	2.29E-06	5.93E-02	3.28E-06	3.93E-04	0.00E+00	4.97E-04	2.61E-02	8.22E-03	**9.51E-02**
	Lead-210	0.00E+00	0.00E+00	1.38E-03	1.22E-09	2.72E-05	6.30E-03	4.64E-05	2.63E-06	0.00E+00	5.52E-03	1.36E-01	4.29E-02	**1.92E-01**
	Polonium-210	0.00E+00	0.00E+00	2.44E-03	7.34E-12	4.24E-05	1.26E-06	8.21E-05	1.13E-08	0.00E+00	2.44E-02	3.11E-01	2.18E-01	**5.56E-01**
		Project Total Dose - Future Centuries												
	Uranium-238	1.28E-04	3.51E-13	6.63E-06	5.03E-11	1.16E-07	1.29E-03	6.04E-08	6.45E-07	0.00E+00	1.02E-05	4.10E-04	2.89E-04	**2.14E-03**
	Uranium-234	1.54E-04	8.58E-13	7.21E-06	8.76E-12	1.27E-07	6.51E-06	6.58E-08	2.34E-09	0.00E+00	1.11E-05	4.46E-04	3.15E-04	**9.40E-04**
	Thorium-230	0.00E+00	0.00E+00	8.10E-04	5.49E-10	2.27E-06	3.47E-05	8.82E-07	2.18E-08	0.00E+00	3.46E-04	1.34E-03	2.87E-03	**5.41E-03**
	Radium-226	0.00E+00	0.00E+00	6.11E-04	2.73E-07	2.29E-06	5.93E-02	3.38E-06	4.06E-04	0.00E+00	5.49E-04	2.61E-02	8.24E-03	**9.52E-02**
	Lead-210	0.00E+00	0.00E+00	1.40E-03	1.24E-09	2.72E-05	6.30E-03	4.72E-05	2.67E-06	0.00E+00	5.83E-03	1.36E-01	4.35E-02	**1.93E-01**
	Polonium-210	0.00E+00	0.00E+00	2.48E-03	7.46E-12	4.24E-05	1.26E-06	8.35E-05	1.15E-08	0.00E+00	2.58E-02	3.11E-01	2.26E-01	**5.65E-01**
		Project Incremental Dose - Future Centuries												
	Uranium-238	0.00E+00	0.00E+00	2.82E-07	2.14E-12	1.67E-09	1.86E-05	2.57E-09	2.75E-08	0.00E+00	1.31E-06	1.80E-05	6.51E-07	**3.89E-05**
	Uranium-234	0.00E+00	0.00E+00	3.07E-07	3.73E-13	1.82E-09	9.36E-08	2.80E-09	9.95E-11	0.00E+00	1.43E-06	1.96E-05	7.09E-07	**2.22E-05**
	Thorium-230	0.00E+00	0.00E+00	4.78E-06	3.24E-12	5.84E-11	8.91E-10	5.20E-09	1.29E-10	0.00E+00	6.70E-06	1.15E-07	3.09E-05	**4.25E-05**
	Radium-226	0.00E+00	0.00E+00	1.82E-05	8.15E-09	7.05E-12	1.83E-07	1.01E-07	1.21E-05	0.00E+00	5.11E-05	2.68E-07	1.76E-05	**9.96E-05**
	Lead-210	0.00E+00	0.00E+00	2.31E-05	2.03E-11	0.00E+00	0.00E+00	7.76E-07	4.39E-08	0.00E+00	3.07E-04	0.00E+00	5.62E-04	**8.93E-04**
	Polonium-210	0.00E+00	0.00E+00	4.08E-05	1.23E-13	0.00E+00	0.00E+00	1.37E-06	1.88E-10	0.00E+00	1.36E-03	0.00E+00	7.67E-03	**9.07E-03**
	Total by Pathway	**0.00E+00**	**0.00E+00**	**8.75E-05**	**8.17E-09**	**3.56E-09**	**1.88E-05**	**2.26E-06**	**1.22E-05**	**0.00E+00**	**1.73E-03**	**3.80E-05**	**8.28E-03**	**1.02E-02**
Rec F/H One-year-old (McGowan Lake)		**Baseline Dose**												
	Uranium-238	1.28E-04	4.56E-13	4.41E-06	1.19E-11	4.67E-06	1.70E-03	2.35E-06	8.02E-07	0.00E+00	5.22E-06	5.58E-04	4.58E-04	**2.86E-03**
	Uranium-234	1.49E-04	1.12E-12	4.78E-06	2.08E-12	5.05E-06	8.58E-06	2.55E-06	2.91E-09	0.00E+00	5.66E-06	6.05E-04	4.96E-04	**1.28E-03**
	Thorium-230	0.00E+00	0.00E+00	4.10E-04	1.35E-10	6.75E-05	3.95E-05	2.61E-05	2.82E-08	0.00E+00	1.46E-04	1.44E-03	1.42E-03	**3.55E-03**
	Radium-226	0.00E+00	0.00E+00	5.29E-04	6.55E-08	1.20E-04	7.94E-02	1.72E-04	5.13E-04	0.00E+00	3.77E-04	4.91E-02	1.60E-02	**1.46E-01**
	Lead-210	0.00E+00	0.00E+00	1.88E-03	2.47E-10	2.16E-03	8.43E-03	3.69E-03	3.42E-06	0.00E+00	6.36E-03	3.89E-01	7.12E-02	**4.83E-01**
	Polonium-210	0.00E+00	0.00E+00	4.67E-03	1.82E-12	4.75E-03	1.64E-06	9.19E-03	1.46E-08	0.00E+00	3.96E-02	1.25E+00	3.85E-01	**1.69E+00**
		Project Total Dose - Future Centuries												
	Uranium-238	1.28E-04	4.56E-13	4.60E-06	1.24E-11	4.73E-06	1.73E-03	2.46E-06	8.38E-07	0.00E+00	6.00E-06	5.85E-04	4.58E-04	**2.92E-03**
	Uranium-234	1.49E-04	1.12E-12	4.99E-06	2.17E-12	5.13E-06	8.71E-06	2.66E-06	3.04E-09	0.00E+00	6.50E-06	6.33E-04	4.96E-04	**1.31E-03**
	Thorium-230	0.00E+00	0.00E+00	4.12E-04	1.36E-10	6.75E-05	3.95E-05	2.62E-05	2.83E-08	0.00E+00	1.49E-04	1.44E-03	1.43E-03	**3.56E-03**
	Radium-226	0.00E+00	0.00E+00	5.46E-04	6.75E-08	1.20E-04	7.94E-02	1.77E-04	5.29E-04	0.00E+00	4.16E-04	4.91E-02	1.60E-02	**1.46E-01**
	Lead-210	0.00E+00	0.00E+00	1.91E-03	2.51E-10	2.16E-03	8.43E-03	3.76E-03	3.47E-06	0.00E+00	6.72E-03	3.89E-01	7.16E-02	**4.84E-01**
	Polonium-210	0.00E+00	0.00E+00	4.75E-03	1.85E-12	4.75E-03	1.64E-06	9.34E-03	1.49E-08	0.00E+00	4.18E-02	1.25E+00	3.95E-01	**1.71E+00**
		Project Incremental Dose - Future Centuries												
	Uranium-238	0.00E+00	0.00E+00	1.96E-07	5.30E-13	6.81E-08	2.48E-05	1.05E-07	3.57E-08	0.00E+00	7.75E-07	2.63E-05	2.95E-07	**5.27E-05**
	Uranium-234	0.00E+00	0.00E+00	2.13E-07	9.24E-14	7.38E-08	1.25E-07	1.13E-07	1.29E-10	0.00E+00	8.39E-07	2.85E-05	3.19E-07	**3.02E-05**
	Thorium-230	0.00E+00	0.00E+00	2.43E-06	8.02E-13	1.75E-09	1.02E-09	1.55E-07	1.67E-10	0.00E+00	2.89E-06	1.23E-07	7.40E-06	**1.30E-05**
	Radium-226	0.00E+00	0.00E+00	1.63E-05	2.02E-09	3.78E-10	2.46E-07	5.28E-06	1.58E-05	0.00E+00	3.87E-05	5.07E-07	7.27E-06	**8.41E-05**
	Lead-210	0.00E+00	0.00E+00	3.14E-05	4.13E-12	0.00E+00	0.00E+00	6.17E-05	5.71E-08	0.00E+00	3.55E-04	0.00E+00	3.63E-04	**8.10E-04**
	Polonium-210	0.00E+00	0.00E+00	7.80E-05	3.04E-14	0.00E+00	0.00E+00	1.54E-04	2.45E-10	0.00E+00	2.20E-03	0.00E+00	1.00E-02	**1.25E-02**
	Total by Pathway	**0.00E+00**	**0.00E+00**	**1.29E-04**	**2.02E-09**	**1.44E-07**	**2.52E-05**	**2.21E-04**	**1.59E-05**	**0.00E+00**	**2.60E-03**	**5.55E-05**	**1.04E-02**	**1.35E-02**

Human receptor	COPC	Maximum Dose by Pathway during Future Centuries (mSv/yr)												
		Air (internal)	Air (external)	Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by Radionuclide
Rec F/H Adult (Russell Lake)	**Baseline Dose**													
	Uranium-238	1.28E-04	3.51E-13	6.34E-06	4.81E-11	1.15E-07	1.27E-03	5.79E-08	6.17E-07	0.00E+00	8.86E-06	3.92E-04	2.88E-04	**2.10E-03**
	Uranium-234	1.54E-04	8.58E-13	6.91E-06	8.39E-12	1.25E-07	6.41E-06	6.30E-08	2.24E-09	0.00E+00	9.65E-06	4.26E-04	3.14E-04	**9.18E-04**
	Thorium-230	0.00E+00	0.00E+00	8.05E-04	5.46E-10	2.27E-06	3.47E-05	8.76E-07	2.17E-08	0.00E+00	3.39E-04	1.34E-03	2.84E-03	**5.37E-03**
	Radium-226	0.00E+00	0.00E+00	5.93E-04	2.64E-07	2.29E-06	5.93E-02	3.28E-06	3.93E-04	0.00E+00	4.97E-04	2.61E-02	8.22E-03	**9.51E-02**
	Lead-210	0.00E+00	0.00E+00	1.38E-03	1.22E-09	2.72E-05	6.30E-03	4.64E-05	2.63E-06	0.00E+00	5.52E-03	1.36E-01	4.29E-02	**1.92E-01**
	Polonium-210	0.00E+00	0.00E+00	2.44E-03	7.34E-12	4.24E-05	1.26E-06	8.21E-05	1.13E-08	0.00E+00	2.44E-02	3.11E-01	2.18E-01	**5.56E-01**
	Project Total Dose - Future Centuries													
	Uranium-238	1.28E-04	3.51E-13	6.55E-06	4.97E-11	1.15E-07	1.28E-03	5.97E-08	6.37E-07	0.00E+00	9.83E-06	3.96E-04	2.89E-04	**2.11E-03**
	Uranium-234	1.54E-04	8.58E-13	7.13E-06	8.66E-12	1.25E-07	6.44E-06	6.51E-08	2.31E-09	0.00E+00	1.07E-05	4.32E-04	3.14E-04	**9.25E-04**
	Thorium-230	0.00E+00	0.00E+00	8.09E-04	5.48E-10	2.27E-06	3.47E-05	8.80E-07	2.18E-08	0.00E+00	3.44E-04	1.34E-03	2.87E-03	**5.40E-03**
	Radium-226	0.00E+00	0.00E+00	6.06E-04	2.71E-07	2.29E-06	5.93E-02	3.36E-06	4.03E-04	0.00E+00	5.36E-04	2.61E-02	8.23E-03	**9.52E-02**
	Lead-210	0.00E+00	0.00E+00	1.39E-03	1.23E-09	2.72E-05	6.30E-03	4.69E-05	2.65E-06	0.00E+00	5.71E-03	1.36E-01	4.33E-02	**1.93E-01**
	Polonium-210	0.00E+00	0.00E+00	2.47E-03	7.41E-12	4.24E-05	1.26E-06	8.30E-05	1.14E-08	0.00E+00	2.52E-02	3.11E-01	2.23E-01	**5.62E-01**
	Project Incremental Dose - Future Centuries													
	Uranium-238	0.00E+00	0.00E+00	2.07E-07	1.57E-12	4.47E-10	4.95E-06	1.89E-09	2.02E-08	0.00E+00	9.65E-07	4.80E-06	4.36E-07	**1.14E-05**
	Uranium-234	0.00E+00	0.00E+00	2.26E-07	2.74E-13	4.86E-10	2.50E-08	2.06E-09	7.31E-11	0.00E+00	1.05E-06	5.23E-06	4.74E-07	**7.01E-06**
	Thorium-230	0.00E+00	0.00E+00	3.64E-06	2.47E-12	1.55E-11	2.40E-10	3.97E-09	9.81E-11	0.00E+00	5.11E-06	3.07E-08	2.35E-05	**3.23E-05**
	Radium-226	0.00E+00	0.00E+00	1.36E-05	6.08E-09	1.82E-12	4.84E-08	7.54E-08	9.04E-06	0.00E+00	3.81E-05	7.26E-08	1.35E-05	**7.45E-05**
	Lead-210	0.00E+00	0.00E+00	1.40E-05	1.23E-11	0.00E+00	0.00E+00	4.69E-07	2.65E-08	0.00E+00	1.86E-04	0.00E+00	3.42E-04	**5.42E-04**
	Polonium-210	0.00E+00	0.00E+00	2.33E-05	7.01E-14	0.00E+00	0.00E+00	8.27E-07	1.14E-10	0.00E+00	7.80E-04	0.00E+00	4.63E-03	**5.44E-03**
	Total by Pathway	**0.00E+00**	**0.00E+00**	**5.50E-05**	**6.10E-09**	**9.50E-10**	**5.03E-06**	**1.38E-06**	**9.09E-06**	**0.00E+00**	**1.01E-03**	**1.01E-05**	**5.01E-03**	**6.10E-03**
Rec F/H One-year-old (Russell Lake)	**Baseline Dose**													
	Uranium-238	1.28E-04	4.56E-13	4.41E-06	1.19E-11	4.67E-06	1.70E-03	2.35E-06	8.02E-07	0.00E+00	5.22E-06	5.58E-04	4.58E-04	**2.86E-03**
	Uranium-234	1.49E-04	1.12E-12	4.78E-06	2.08E-12	5.05E-06	8.58E-06	2.55E-06	2.91E-09	0.00E+00	5.66E-06	6.05E-04	4.96E-04	**1.28E-03**
	Thorium-230	0.00E+00	0.00E+00	4.10E-04	1.35E-10	6.75E-05	3.95E-05	2.61E-05	2.82E-08	0.00E+00	1.46E-04	1.44E-03	1.42E-03	**3.55E-03**
	Radium-226	0.00E+00	0.00E+00	5.29E-04	6.55E-08	1.20E-04	7.94E-02	1.72E-04	5.13E-04	0.00E+00	3.77E-04	4.91E-02	1.60E-02	**1.46E-01**
	Lead-210	0.00E+00	0.00E+00	1.88E-03	2.47E-10	2.16E-03	8.43E-03	3.69E-03	3.42E-06	0.00E+00	6.36E-03	3.89E-01	7.12E-02	**4.83E-01**
	Polonium-210	0.00E+00	0.00E+00	4.67E-03	1.82E-12	4.75E-03	1.64E-06	9.19E-03	1.46E-08	0.00E+00	3.96E-02	1.25E+00	3.85E-01	**1.69E+00**
	Project Total Dose - Future Centuries													
	Uranium-238	1.28E-04	4.56E-13	4.55E-06	1.23E-11	4.68E-06	1.71E-03	2.43E-06	8.28E-07	0.00E+00	5.79E-06	5.65E-04	4.58E-04	**2.88E-03**
	Uranium-234	1.49E-04	1.12E-12	4.93E-06	2.14E-12	5.07E-06	8.62E-06	2.63E-06	3.00E-09	0.00E+00	6.28E-06	6.12E-04	4.96E-04	**1.29E-03**
	Thorium-230	0.00E+00	0.00E+00	4.11E-04	1.36E-10	6.75E-05	3.95E-05	2.62E-05	2.83E-08	0.00E+00	1.48E-04	1.44E-03	1.43E-03	**3.56E-03**
	Radium-226	0.00E+00	0.00E+00	5.42E-04	6.70E-08	1.20E-04	7.94E-02	1.76E-04	5.25E-04	0.00E+00	4.06E-04	4.91E-02	1.60E-02	**1.46E-01**
	Lead-210	0.00E+00	0.00E+00	1.90E-03	2.49E-10	2.16E-03	8.43E-03	3.73E-03	3.45E-06	0.00E+00	6.58E-03	3.89E-01	7.14E-02	**4.84E-01**
	Polonium-210	0.00E+00	0.00E+00	4.71E-03	1.84E-12	4.75E-03	1.64E-06	9.28E-03	1.48E-08	0.00E+00	4.08E-02	1.25E+00	3.91E-01	**1.70E+00**
	Project Incremental Dose - Future Centuries													
	Uranium-238	0.00E+00	0.00E+00	1.44E-07	3.89E-13	1.82E-08	6.63E-06	7.69E-08	2.62E-08	0.00E+00	5.69E-07	7.02E-06	2.01E-07	**1.47E-05**
	Uranium-234	0.00E+00	0.00E+00	1.56E-07	6.79E-14	1.97E-08	3.34E-08	8.33E-08	9.50E-11	0.00E+00	6.16E-07	7.61E-06	2.17E-07	**8.74E-06**
	Thorium-230	0.00E+00	0.00E+00	1.85E-06	6.11E-13	4.66E-10	2.73E-10	1.18E-07	1.27E-10	0.00E+00	2.21E-06	3.28E-08	5.65E-06	**9.86E-06**
	Radium-226	0.00E+00	0.00E+00	1.22E-05	1.51E-09	9.46E-11	6.71E-08	3.94E-06	1.18E-05	0.00E+00	2.89E-05	1.38E-07	5.56E-06	**6.26E-05**
	Lead-210	0.00E+00	0.00E+00	1.90E-05	2.49E-12	0.00E+00	0.00E+00	3.73E-05	3.45E-08	0.00E+00	2.14E-04	0.00E+00	2.21E-04	**4.92E-04**
	Polonium-210	0.00E+00	0.00E+00	4.46E-05	1.74E-14	0.00E+00	0.00E+00	9.25E-05	1.48E-10	0.00E+00	1.26E-03	0.00E+00	6.06E-03	**7.46E-03**
	Total by Pathway	**0.00E+00**	**0.00E+00**	**7.79E-05**	**1.51E-09**	**3.84E-08**	**6.73E-06**	**1.34E-04**	**1.19E-05**	**0.00E+00**	**1.51E-03**	**1.48E-05**	**6.29E-03**	**8.04E-03**

Human receptor	COPC	Maximum Dose by Pathway during Future Centuries (mSv/yr)												
		Air (internal)	Air (external)	Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by Radionuclide
Seasonal Resident Adult (Russell Lake)		**Baseline Dose**												
	Uranium-238	1.28E-04	3.51E-13	6.34E-06	4.81E-11	1.15E-07	1.27E-03	5.79E-08	6.17E-07	0.00E+00	8.86E-06	3.92E-04	2.88E-04	**2.10E-03**
	Uranium-234	1.54E-04	8.58E-13	6.91E-06	8.39E-12	1.25E-07	6.41E-06	6.30E-08	2.24E-09	0.00E+00	9.65E-06	4.26E-04	3.14E-04	**9.18E-04**
	Thorium-230	0.00E+00	0.00E+00	8.05E-04	5.46E-10	2.27E-06	3.47E-05	8.76E-07	2.17E-08	0.00E+00	3.39E-04	1.34E-03	2.84E-03	**5.37E-03**
	Radium-226	0.00E+00	0.00E+00	5.93E-04	2.64E-07	2.29E-06	5.93E-02	3.28E-06	3.93E-04	0.00E+00	4.97E-04	2.61E-02	8.22E-03	**9.51E-02**
	Lead-210	0.00E+00	0.00E+00	1.38E-03	1.22E-09	2.72E-05	6.30E-03	4.64E-05	2.63E-06	0.00E+00	5.52E-03	1.36E-01	4.29E-02	**1.92E-01**
	Polonium-210	0.00E+00	0.00E+00	2.44E-03	7.34E-12	4.24E-05	1.26E-06	8.21E-05	1.13E-08	0.00E+00	2.44E-02	3.11E-01	2.18E-01	**5.56E-01**
		Project Total Dose - Future Centuries												
	Uranium-238	1.28E-04	3.51E-13	6.55E-06	4.97E-11	1.15E-07	1.28E-03	5.97E-08	6.37E-07	0.00E+00	9.15E-06	3.93E-04	2.88E-04	**2.10E-03**
	Uranium-234	1.54E-04	8.58E-13	7.13E-06	8.66E-12	1.25E-07	6.44E-06	6.51E-08	2.31E-09	0.00E+00	9.97E-06	4.28E-04	3.14E-04	**9.20E-04**
	Thorium-230	0.00E+00	0.00E+00	8.09E-04	5.48E-10	2.27E-06	3.47E-05	8.80E-07	2.18E-08	0.00E+00	3.40E-04	1.34E-03	2.85E-03	**5.38E-03**
	Radium-226	0.00E+00	0.00E+00	6.06E-04	2.71E-07	2.29E-06	5.93E-02	3.36E-06	4.03E-04	0.00E+00	5.09E-04	2.61E-02	8.22E-03	**9.52E-02**
	Lead-210	0.00E+00	0.00E+00	1.39E-03	1.23E-09	2.72E-05	6.30E-03	4.69E-05	2.65E-06	0.00E+00	5.58E-03	1.36E-01	4.30E-02	**1.92E-01**
	Polonium-210	0.00E+00	0.00E+00	2.47E-03	7.41E-12	4.24E-05	1.26E-06	8.30E-05	1.14E-08	0.00E+00	2.46E-02	3.11E-01	2.20E-01	**5.58E-01**
		Project Incremental Dose - Future Centuries												
	Uranium-238	0.00E+00	0.00E+00	2.07E-07	1.57E-12	4.47E-10	4.95E-06	1.89E-09	2.02E-08	0.00E+00	2.90E-07	1.44E-06	1.35E-07	**7.05E-06**
	Uranium-234	0.00E+00	0.00E+00	2.26E-07	2.74E-13	4.86E-10	2.50E-08	2.06E-09	7.31E-11	0.00E+00	3.15E-07	1.57E-06	1.47E-07	**2.28E-06**
	Thorium-230	0.00E+00	0.00E+00	3.64E-06	2.47E-12	1.55E-11	2.40E-10	3.97E-09	9.81E-11	0.00E+00	1.53E-06	9.31E-09	6.94E-06	**1.21E-05**
	Radium-226	0.00E+00	0.00E+00	1.36E-05	6.08E-09	1.82E-12	4.84E-08	7.54E-08	9.04E-06	0.00E+00	1.14E-05	2.05E-08	4.51E-06	**3.88E-05**
	Lead-210	0.00E+00	0.00E+00	1.40E-05	1.23E-11	0.00E+00	0.00E+00	4.69E-07	2.65E-08	0.00E+00	5.58E-05	0.00E+00	1.03E-04	**1.73E-04**
	Polonium-210	0.00E+00	0.00E+00	2.33E-05	7.01E-14	0.00E+00	0.00E+00	8.27E-07	1.14E-10	0.00E+00	2.34E-04	0.00E+00	1.42E-03	**1.68E-03**
	Total by Pathway	**0.00E+00**	**0.00E+00**	**5.50E-05**	**6.10E-09**	**9.50E-10**	**5.03E-06**	**1.38E-06**	**9.09E-06**	**0.00E+00**	**3.03E-04**	**3.04E-06**	**1.54E-03**	**1.91E-03**
Seasonal Resident One-year-old (Russell Lake)		**Baseline Dose**												
	Uranium-238	1.28E-04	4.56E-13	4.41E-06	1.19E-11	4.67E-06	1.70E-03	2.35E-06	8.02E-07	0.00E+00	5.22E-06	5.58E-04	4.58E-04	**2.86E-03**
	Uranium-234	1.49E-04	1.12E-12	4.78E-06	2.08E-12	5.05E-06	8.58E-06	2.55E-06	2.91E-09	0.00E+00	5.66E-06	6.05E-04	4.96E-04	**1.28E-03**
	Thorium-230	0.00E+00	0.00E+00	4.10E-04	1.35E-10	6.75E-05	3.95E-05	2.61E-05	2.82E-08	0.00E+00	1.46E-04	1.44E-03	1.42E-03	**3.55E-03**
	Radium-226	0.00E+00	0.00E+00	5.29E-04	6.55E-08	1.20E-04	7.94E-02	1.72E-04	5.13E-04	0.00E+00	3.77E-04	4.91E-02	1.60E-02	**1.46E-01**
	Lead-210	0.00E+00	0.00E+00	1.88E-03	2.47E-10	2.16E-03	8.43E-03	3.69E-03	3.42E-06	0.00E+00	6.36E-03	3.89E-01	7.12E-02	**4.83E-01**
	Polonium-210	0.00E+00	0.00E+00	4.67E-03	1.82E-12	4.75E-03	1.64E-06	9.19E-03	1.46E-08	0.00E+00	3.96E-02	1.25E+00	3.85E-01	**1.69E+00**
		Project Total Dose - Future Centuries												
	Uranium-238	1.28E-04	4.56E-13	4.55E-06	1.23E-11	4.68E-06	1.71E-03	2.43E-06	8.28E-07	0.00E+00	5.39E-06	5.60E-04	4.58E-04	**2.87E-03**
	Uranium-234	1.49E-04	1.12E-12	4.93E-06	2.14E-12	5.07E-06	8.62E-06	2.63E-06	3.00E-09	0.00E+00	5.84E-06	6.07E-04	4.96E-04	**1.28E-03**
	Thorium-230	0.00E+00	0.00E+00	4.11E-04	1.36E-10	6.75E-05	3.95E-05	2.62E-05	2.83E-08	0.00E+00	1.47E-04	1.44E-03	1.42E-03	**3.55E-03**
	Radium-226	0.00E+00	0.00E+00	5.42E-04	6.70E-08	1.20E-04	7.94E-02	1.76E-04	5.25E-04	0.00E+00	3.86E-04	4.91E-02	1.60E-02	**1.46E-01**
	Lead-210	0.00E+00	0.00E+00	1.90E-03	2.49E-10	2.16E-03	8.43E-03	3.73E-03	3.45E-06	0.00E+00	6.43E-03	3.89E-01	7.13E-02	**4.83E-01**
	Polonium-210	0.00E+00	0.00E+00	4.71E-03	1.84E-12	4.75E-03	1.64E-06	9.28E-03	1.48E-08	0.00E+00	4.00E-02	1.25E+00	3.87E-01	**1.70E+00**
		Project Incremental Dose - Future Centuries												
	Uranium-238	0.00E+00	0.00E+00	1.44E-07	3.89E-13	1.82E-08	6.63E-06	7.69E-08	2.62E-08	0.00E+00	1.71E-07	2.11E-06	5.89E-08	**9.23E-06**
	Uranium-234	0.00E+00	0.00E+00	1.56E-07	6.79E-14	1.97E-08	3.34E-08	8.33E-08	9.50E-11	0.00E+00	1.85E-07	2.28E-06	6.39E-08	**2.82E-06**
	Thorium-230	0.00E+00	0.00E+00	1.85E-06	6.11E-13	4.66E-10	2.73E-10	1.18E-07	1.27E-10	0.00E+00	6.62E-07	9.90E-09	1.62E-06	**4.26E-06**
	Radium-226	0.00E+00	0.00E+00	1.22E-05	1.51E-09	9.46E-11	6.71E-08	3.94E-06	1.18E-05	0.00E+00	8.67E-06	4.10E-08	1.91E-06	**3.86E-05**
	Lead-210	0.00E+00	0.00E+00	1.90E-05	2.49E-12	0.00E+00	0.00E+00	3.73E-05	3.45E-08	0.00E+00	6.43E-05	0.00E+00	6.53E-05	**1.86E-04**
	Polonium-210	0.00E+00	0.00E+00	4.46E-05	1.74E-14	0.00E+00	0.00E+00	9.25E-05	1.48E-10	0.00E+00	3.79E-04	0.00E+00	1.75E-03	**2.26E-03**
	Total by Pathway	**0.00E+00**	**0.00E+00**	**7.79E-05**	**1.51E-09**	**3.84E-08**	**6.73E-06**	**1.34E-04**	**1.19E-05**	**0.00E+00**	**4.53E-04**	**4.44E-06**	**1.82E-03**	**2.50E-03**
		Baseline Dose												
	Uranium-238	1.28E-04	3.51E-13	6.34E-06	4.81E-11	1.15E-07	1.27E-03	5.79E-08	6.17E-07	0.00E+00	6.10E-05	0.00E+00	1.98E-04	**1.67E-03**
	Uranium-234	1.54E-04	8.58E-13	6.91E-06	8.39E-12	1.25E-07	6.41E-06	6.30E-08	2.24E-09	0.00E+00	6.64E-05	0.00E+00	2.15E-04	**4.50E-04**
	Thorium-230	0.00E+00	0.00E+00	8.05E-04	5.46E-10	2.27E-06	3.47E-05	8.76E-07	2.17E-08	0.00E+00	2.33E-03	0.00E+00	7.78E-04	**3.95E-03**
	Radium-226	0.00E+00	0.00E+00	5.93E-04	2.64E-07	2.29E-06	5.93E-02	3.28E-06	3.93E-04	0.00E+00	3.42E-03	0.00E+00	9.66E-03	**7.34E-02**
	Lead-210	0.00E+00	0.00E+00	1.38E-03	1.22E-09	2.72E-05	6.30E-03	4.64E-05	2.63E-06	0.00E+00	3.80E-02	0.00E+00	2.26E-01	**2.72E-01**
	Polonium-210	0.00E+00	0.00E+00	2.44E-03	7.34E-12	4.24E-05	1.26E-06	8.21E-05	1.13E-08	0.00E+00	1.68E-01	0.00E+00	1.89E+00	**2.06E+00**

Human receptor	COPC	Maximum Dose by Pathway during Future Centuries (mSv/yr)												
		Air (internal)	Air (external)	Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by Radionuclide
Fisher/ Trapper Adult (Russell Lake)		**Project Total Dose - Future Centuries**												
	Uranium-238	1.28E-04	3.51E-13	6.69E-06	5.08E-11	1.15E-07	1.28E-03	6.10E-08	6.51E-07	0.00E+00	6.77E-05	0.00E+00	1.99E-04	**1.68E-03**
	Uranium-234	1.54E-04	8.58E-13	7.28E-06	8.84E-12	1.26E-07	6.46E-06	6.64E-08	2.36E-09	0.00E+00	7.37E-05	0.00E+00	2.16E-04	**4.58E-04**
	Thorium-230	0.00E+00	0.00E+00	8.11E-04	5.50E-10	2.27E-06	3.47E-05	8.83E-07	2.18E-08	0.00E+00	2.37E-03	0.00E+00	7.81E-04	**4.00E-03**
	Radium-226	0.00E+00	0.00E+00	6.15E-04	2.75E-07	2.29E-06	5.93E-02	3.41E-06	4.09E-04	0.00E+00	3.69E-03	0.00E+00	9.74E-03	**7.38E-02**
	Lead-210	0.00E+00	0.00E+00	1.40E-03	1.24E-09	2.72E-05	6.30E-03	4.72E-05	2.67E-06	0.00E+00	3.93E-02	0.00E+00	2.26E-01	**2.73E-01**
	Polonium-210	0.00E+00	0.00E+00	2.48E-03	7.46E-12	4.24E-05	1.26E-06	8.35E-05	1.15E-08	0.00E+00	1.73E-01	0.00E+00	1.90E+00	**2.07E+00**
		Project Incremental Dose - Future Centuries												
	Uranium-238	0.00E+00	0.00E+00	3.45E-07	2.62E-12	7.44E-10	8.26E-06	3.15E-09	3.36E-08	0.00E+00	6.65E-06	0.00E+00	8.10E-07	**1.61E-05**
	Uranium-234	0.00E+00	0.00E+00	3.76E-07	4.57E-13	8.11E-10	4.16E-08	3.43E-09	1.22E-10	0.00E+00	7.24E-06	0.00E+00	8.82E-07	**8.54E-06**
	Thorium-230	0.00E+00	0.00E+00	6.07E-06	4.11E-12	2.57E-11	4.00E-10	6.61E-09	1.63E-10	0.00E+00	3.52E-05	0.00E+00	2.40E-06	**4.37E-05**
	Radium-226	0.00E+00	0.00E+00	2.27E-05	1.01E-08	3.18E-12	8.20E-08	1.26E-07	1.51E-05	0.00E+00	2.63E-04	0.00E+00	8.59E-05	**3.86E-04**
	Lead-210	0.00E+00	0.00E+00	2.33E-05	2.05E-11	0.00E+00	0.00E+00	7.82E-07	4.42E-08	0.00E+00	1.28E-03	0.00E+00	3.90E-04	**1.69E-03**
	Polonium-210	0.00E+00	0.00E+00	3.89E-05	1.17E-13	0.00E+00	0.00E+00	1.38E-06	1.89E-10	0.00E+00	5.37E-03	0.00E+00	4.57E-03	**9.98E-03**
	Total by Pathway	**0.00E+00**	**0.00E+00**	**9.16E-05**	**1.02E-08**	**1.58E-09**	**8.38E-06**	**2.30E-06**	**1.51E-05**	**0.00E+00**	**6.96E-03**	**0.00E+00**	**5.05E-03**	**1.21E-02**

Table B. 11: Sample Calculation - Mallard (McGowan Lake) Dose and Risk Calculations for Selenium

Parameter	Symbol	Calculation	Selenium		
			Value	Unit	Source
Environmental Media Concentration					
Water Concentration	C_w	-	2.59E-04	mg/L	Table 3-3
Sediment Concentration (dry weight)	$C_{sed(dw)}$	-	3.71E+00	mg/kg dw	Table 3-3
Outdoor Air Concentration	C_{air}	-	1.55E-07	mg/m^3	Table 3-13
Aquatic Plant Concentration					
Bioaccumulation Factor (BAF)	$BAF_{aquatic\ plant}$	-	1.77E+02	L/kg fw	Table 3-9 (IMPACT Model Report)
Aquatic Plant Tissue Concentration	$C_{aquatic\ plant}$	$C_{aquatic\ plant} = C_w * BAF_{aquatic\ plant}$	4.59E-02	mg/kg fw	Calculated
Benthic Invertebrate Concentration					
Water-to-Sediment Partitioning Coefficient	k_d	-	2.00E+04	L/kg	Table 3-6 (IMPACT Model Report)
Dry Bulk Density	ρ	-	1.10E-01	kg/L	Table 2-1 (IMPACT Model Report)
Water Content (Volume Basis)	θ	-	9.60E-01	unitless	Table 2-1 (IMPACT Model Report)
Fraction in Porewater Phase	$C_{pw\ (fraction)}$	$C_{pw\ (fraction)} = 1 - (k_d * \rho / \theta) / (1 + k_d * \rho / \theta)$	4.36E-04	unitless	Calculated
Concentration Ratio – Porewater to Sediment	$Ratio_{pw\text{-}sed}$	$Ratio_{pw\text{-}sed} = C_{pw\ (fraction)} * \rho / \theta$	5.00E-05	kg/L	Calculated
Sediment Porewater Concentration	$C_{pw\ (sed)}$	$C_{pw\ (sed)} = C_{sed(dw)} * Ratio_{pw\text{-}sed}$	1.86E-04	mg/L	Calculated
Bioaccumulation Factor (BAF)	$BAF_{benthic\ inv}$	-	1.07E+03	L/kg fw	Table 3-9 (IMPACT Model Report)
Sediment Occupancy Factor	OF_{sed}	-	1.00E+02	%	Table 2-5 (IMPACT Model Report)
Benthic Invertebrate Tissue Concentration	$C_{benthic\ inv}$	$C_{benthic\ inv} = (1 - (OF_{sed}/100) * C_{sed(dw)} + (OF_{sed}/100) * C_{pw\ (sed)}) * BAF_{benthic\ inv}$	1.99E-01	Bq/kg fw	Calculated
Mallard Exposure Factors					
Water Intake	IR_w	-	6.40E-02	L/d	Table 5-7
Sediment Intake	IR_s	-	2.00E-03	kg dw/d	Table 5-7
Air Intake	IR_{air}	-	2.00E-02	m^3/d	Table 5-7
Aquatic Plant Intake	$IR_{aquatic\ plant}$	-	6.00E-02	kg fw/d	Table 5-7
Benthic Invertebrate Intake	$IR_{benthic\ inv}$	-	1.80E-01	kg fw/d	Table 5-7
Body Weight	BW	-	1.13	kg fw	Table 5-7
Toxicological Benchmark	TRV	-	1.29E+00	mg/kg d	Table 5-13
Mallard Dose and HQ					
Total Dose	D_{total}	$D_{total} = (C_w*IR_w + C_{s(dw)}*IR_s + C_{air}*IR_{air} + C_{aquatic\ plant}*IR_{aquatic\ plant} + C_{benthic\ inv}*IR_{benthic\ inv})/BW$	4.07E-02	mg/kg d	Calculated (Table 5-9)
Hazard Quotient	HQ	$HQ = D_{total}/TRV$	3.15E-02	unitless	Calculated (Table 5-24)

Table B.12: Sample Calculation - Adult Recreational Fisher/Hunter (McGowan Lake) Dose and Risk Calculations for Selenium

Parameter	Symbol	Calculation	Selenium		
			Value	Unit	Source
Water Ingestion Dose					
Water Concentration (LA-1)	$C_{w\ (LA-1)}$	-	2.59E-04	mg/L	Table 3-3
Water Concentration (Reference)	$C_{w\ (Ref)}$	-	3.35E-05	mg/L	Table 3-3
Linkage Fraction of Water (LA-1)	$LF_{w\ (LA-1)}$	-	3.00E-01	Unitless	Assumed
Linkage Fraction of Water (Reference)	$LF_{w\ (Ref)}$	-	7.00E-01	Unitless	Assumed
Water Intake	IR_w	-	1.04E+00	L/d	Table 2-7 (IMPACT Model Report)
Human Adult Body Mass	BW	-	7.07E+01	kg	Health Canada, 2021
Ingestion Dose (Water)	D_w	$D_w = ((C_{w\ (LA-1)} * LF_{w\ (LA-1)} + C_{w\ (Ref)} * LF_{w\ (Ref)}) * IR_w) / BW$	1.49E-06	mg/kg/d fw	Calculated
Soil Ingestion Dose					
Soil Concentration (LA-1)	$C_{s\ (LA-1)}$	-	1.07E-01	mg/kg dw	Table 3-13
Soil Concentration (Reference)	$C_{s\ (Ref)}$	-	1.07E-01	mg/kg dw	Table 3-13
Linkage Fraction of Soil (LA-1)	$LF_{s\ (LA-1)}$	-	3.00E-01	Unitless	Assumed
Linkage Fraction of Soil (Reference)	$LF_{s\ (Ref)}$	-	7.00E-01	Unitless	Assumed
Soil Intake	IR_s	-	4.00E-06	kg dw/d	Table 2-7 (IMPACT Model Report)
Days Exposed to Soil per Year	Exp_{days}	-	1.35E+02	d/y	Assumed
Human Adult Body Mass	BW	-	7.07E+01	kg	Health Canada, 2021
Ingestion Dose (Soil)	D_s	$D_s = (((C_{s\ (LA-1)} * LF_{s\ (LA-1)} + C_{s\ (Ref)} * LF_{s\ (Ref)}) * IR_s) / BW) * (Exp_{days} / 365)$	2.24E-09	mg/kg/d fw	Calculated
Terrestrial Plant Ingestion Dose					
Labrador Tea Concentration (LA-1)	$C_{LT\ (LA-1)}$	-	6.16E-02	mg/kg fw	Table B.5
Blueberry Concentration (LA-1)	$C_{BB\ (LA-1)}$	-	5.71E-02	mg/kg fw	Table B.5
Labrador Tea Concentration (Reference)	$C_{LT\ (Ref)}$	-	6.14E-02	mg/kg fw	Table B.5
Blueberry Concentration (Reference)	$C_{BB\ (Ref)}$	-	5.71E-02	mg/kg fw	Table B.5
Food Intake (Terrestrial Plants)	IR_{TP}	-	1.98E+01	kg/y fw	Assumed, site-specific
Linkage Fraction of Labrador Tea (Reference)	$LF_{LT\ (Ref)}$	-	0.00E+00	Unitless	Assumed
Linkage Fraction of Blueberry (Reference)	$LF_{BB\ (Ref)}$	-	0.00E+00	Unitless	Assumed
Linkage Fraction of Labrador Tea (LA-1)	$LF_{LT\ (LA-1)}$	-	9.20E-03	Unitless	Table 2-10 (IMPACT Model Report)
Linkage Fraction of Blueberry (LA-1)	$LF_{BB\ (LA-1)}$	-	9.91E-01	Unitless	Table 2-10 (IMPACT Model Report)
Human Adult Body Mass	BW	-	7.07E+01	kg	Health Canada, 2021
Food Processing Factor	FPF	-	1.00E+00	Unitless	Assumed
Ingestion Dose (Terrestrial Plants)	D_{TP}	$D_{TP} = ((C_{LT\ (LA-1)} * LF_{LT\ (LA-1)} + C_{BB\ (LA-1)} * LF_{BB\ (LA-1)} + C_{LT\ (Ref)} * LF_{LT\ (Ref)} + C_{BB\ (Ref)} * LF_{BB\ (Ref)}) * IR_{TP} * FPF) / (BW * 365)$	4.39E-05	mg/kg/d fw	Calculated
Aquatic Animal Ingestion Dose					
Northern Pike Concentration (LA-1)	$C_{NP\ (LA-1)}$	-	1.02E+00	mg/kg fw	Table B.5
White Sucker Concentration (LA-1)	$C_{WS\ (LA-1)}$	-	1.06E+00	mg/kg fw	Table B.5
Northern Pike Concentration (Reference)	$C_{NP\ (Ref)}$	-	1.89E-01	mg/kg fw	Table B.5
White Sucker Concentration (Reference)	$C_{WS\ (Ref)}$	-	1.46E-01	mg/kg fw	Table B.5
Food Intake (Aquatic Animals)	IR_{AA}	-	2.67E+01	kg/y fw	Assumed, site-specific

Parameter	Symbol	Calculation	Selenium		
			Value	Unit	Source
Linkage Fraction of Northern Pike (Reference)	$LF_{NP\ (Ref)}$	-	0.00E+00	Unitless	Assumed
Linkage Fraction of White Sucker (Reference)	$LF_{WS\ (Ref)}$	-	0.00E+00	Unitless	Assumed
Linkage Fraction of Northern Pike (LA-1)	$LF_{NP\ (LA-1)}$	-	5.00E-01	Unitless	Table 2-10 (IMPACT Model Report)
Linkage Fraction of White Sucker (LA-1)	$LF_{WS\ (LA-1)}$	-	5.00E-01	Unitless	Table 2-10 (IMPACT Model Report)
Human Adult Body Mass	BW	-	7.07E+01	kg	Health Canada, 2021
Food Processing Factor	FPF	-	1.00E+00	Unitless	Assumed
Ingestion Dose (Aquatic Animals)	D_{AA}	$D_{AA} = ((C_{NP\ (LA-1)} * LF_{NP\ (LA-1)} + C_{WS\ (LA-1)} * LF_{WS\ (LA-1)} + C_{NP\ (Ref)} * LF_{NP\ (Ref)} + C_{WS\ (Ref)} * LF_{WS\ (Ref)}) * IR_{AA} * FPF) / (BW * 365)$	1.08E-03	mg/kg/d fw	Calculated
Terrestrial Animal Ingestion Dose					
Woodland Caribou Concentration (LA-5)	$C_{WC\ (LA-5)}$	-	1.50E-01	mg/kg fw	Table B.5
Moose Concentration (LA-1)	$C_{M\ (LA-1)}$	-	1.75E-01	mg/kg fw	Table B.5
Moose Organs Concentration (LA-1)	$C_{MO\ (LA-1)}$	-	1.75E-01	mg/kg fw	Table B.5
Muskrat Concentration (LA-1)	$C_{Mus\ (LA-1)}$	-	2.54E-01	mg/kg fw	Table B.5
Mallard Concentration (LA-1)	$C_{Mal\ (LA-1)}$	-	6.80E-01	mg/kg fw	Table B.5
Goose Concentration (LA-1)	$C_{G\ (LA-1)}$	-	1.95E-02	mg/kg fw	Table B.5
Store Food Concentration (LA-1)	$C_{SF\ (LA-1)}$	-	6.30E-02	mg/kg fw	Table 2-11 (IMPACT Model Report)
Woodland Caribou Concentration (Reference)	$C_{WC\ (Ref)}$	-	1.06E-01	mg/kg fw	Table B.5
Moose Concentration (Reference)	$C_{M\ (Ref)}$	-	1.17E-01	mg/kg fw	Table B.5
Moose Organs Concentration (Reference)	$C_{MO\ (Ref)}$	-	1.17E-01	mg/kg fw	Table B.5
Muskrat Concentration (Reference)	$C_{Mus\ (Ref)}$	-	3.74E-02	mg/kg fw	Table B.5
Mallard Concentration (Reference)	$C_{Mal\ (Ref)}$	-	1.13E-01	mg/kg fw	Table B.5
Goose Concentration (Reference)	$C_{G\ (Ref)}$	-	1.93E-02	mg/kg fw	Table B.5
Store Food Concentration (Reference)	$C_{SF\ (Ref)}$	-	6.30E-02	mg/kg fw	Table 2-11 (IMPACT Model Report)
Food Intake (Terrestrial Animals)	IR_{TA}	-	6.60E+02	kg/y fw	Assumed, site-specific
Linkage Fraction of Woodland Caribou (LA-5)	$LF_{WC\ (LA-5)}$		4.00E-03	Unitless	Table 2-10 (IMPACT Model Report)
Linkage Fraction of Moose (LA-1)	$LF_{M\ (LA-1)}$	-	1.78E-02	Unitless	Table 2-10 (IMPACT Model Report)
Linkage Fraction of Moose Organs (LA-1)	$LF_{MO\ (LA-1)}$	-	6.80E-03	Unitless	Table 2-10 (IMPACT Model Report)
Linkage Fraction of Muskrat (LA-1)	$LF_{Mus\ (LA-1)}$	-	3.70E-03	Unitless	Table 2-10 (IMPACT Model Report)
Linkage Fraction of Mallard (LA-1)	$LF_{Mal\ (LA-1)}$	-	4.60E-03	Unitless	Table 2-10 (IMPACT Model Report)
Linkage Fraction of Goose (LA-1)	$LF_{G\ (LA-1)}$	-	2.80E-03	Unitless	Table 2-10 (IMPACT Model Report)
Linkage Fraction of Store Food (LA-1)	$LF_{SF\ (LA-1)}$	-	9.60E-01	Unitless	Table 2-10 (IMPACT Model Report)
Linkage Fraction of Woodland Caribou	$LF_{WC\ (Ref)}$		0.00E+00	Unitless	Assumed
Linkage Fraction of Moose (Reference)	$LF_{M\ (Ref)}$	-	0.00E+00	Unitless	Assumed
Linkage Fraction of Moose Organs (Reference)	$LF_{MO\ (Ref)}$	-	0.00E+00	Unitless	Assumed
Linkage Fraction of Muskrat (Reference)	$LF_{Mus\ (Ref)}$	-	0.00E+00	Unitless	Assumed
Linkage Fraction of Mallard (Reference)	$LF_{Mal\ (Ref)}$	-	0.00E+00	Unitless	Assumed
Linkage Fraction of Goose (Reference)	$LF_{G\ (Ref)}$	-	0.00E+00	Unitless	Assumed
Linkage Fraction of Store Food (Reference)	$LF_{SF\ (Ref)}$	-	0.00E+00	Unitless	Assumed
Human Adult Body Mass	BW	-	7.07E+01	kg	Health Canada, 2021
Food Processing Factor	FPF	-	1.00E+00	Unitless	Assumed

Parameter	Symbol	Calculation	Selenium		
			Value	Unit	Source
Ingestion Dose (Terrestrial Animals)	D_{TA}	$D_{AA} = ((C_{WC\ (LA-5)} * LF_{WC\ (LA-5)} + C_{M\ (LA-1)} * LF_{M\ (LA-1)} + C_{MO\ (LA-1)} * LF_{MO\ (LA-1)} + C_{Mus\ (LA-1)} * LF_{Mus\ (LA-1)} + C_{Mal\ (LA-1)} * LF_{Mal\ (LA-1)} + C_{G\ (LA-1)} * LF_{G\ (LA-1)} + C_{SF\ (LA-1)} * LF_{SF\ (LA-1)} + C_{WC\ (Ref)} * LF_{WC\ (Ref)} + C_{M\ (Ref)} * LF_{M\ (Ref)} + C_{MO\ (Ref)} * LF_{MO\ (Ref)} + C_{Mus\ (Ref)} * LF_{Mus\ (Ref)} + C_{Mal\ (Ref)} * LF_{Mal\ (Ref)} + C_{G\ (Ref)} * LF_{G\ (Ref)} + C_{SF\ (Ref)} * LF_{SF\ (Ref)})* IR_{TA} * FPF) / (BW * 365)$	1.78E-03	mg/kg/d fw	Calculated
Adult Recreational Fisher/Hunter Total Dose and HQ					
Total Ingestion Dose	D_{total}	$D_{total} = D_w + D_s + D_{TP} + D_{AA} + D_{TA}$	2.90E-03	mg/kg/d fw	Calculated (Table 4-5)
Toxicological Benchmark	TRV	-	5.70E-03	mg/kg d	Table 4-14
Hazard Quotient	HQ	$HQ = D_{total} / TRV$	5.08E-01	Unitless	Calculated (Table 4-15)

Table B.13: Sample Calculation - Mallard (McGowan Lake) Radiological Dose for Polonium-210

Parameter	Symbol	Calculation	Polonium-210		
			Value	Unit	Source
Environmental Media Concentrations					
Water Concentration	C_w	-	6.23E-03	Bq/L	Table 3-3
Sediment Concentration (dry weight)	$C_{s(dw)}$	-	4.47E+02	Bq/kg dw	Table 3-3
Outdoor Air Concentration	C_{air}	-	0.00E+00	Bq/m^3	Table 3-13
Sediment Dry Bulk Density	ρ_s	-	1.10E-01	kg dw/ L	Table 2-1 (IMPACT Model Report)
Mixing Depth	d	-	3.00E-02	m	Table 2-1 (IMPACT Model Report)
Sediment Surface Concentration (dry weight)	$C_{s(dw)}'$	$C_{s(dw)}' = C_{s(dw)} * \rho_s * d * 1000\ L/m^3$	1.48E+03	$Bq\ dw/\ m^2$	Calculated
Aquatic Plant Concentration					
Bioaccumulation Factor - Aquatic Plant	$BAF_{aquatic\ plant}$	-	2.93E+02	L/kg fw	Table 3-9 (IMPACT Model Report)
Aquatic Plant Concentration (fresh weight)	$C_{aquatic\ plant}$	$C_{aquatic\ plant} = C_w * BAF_{aquatic\ plant}$	1.82E+00	Bq/kg fw	Calculated
Benthic Invertebrate Concentration					
Water-to-Sediment Partitioning Coefficient	k_d	-	1.20E+05	L/kg	Table 3-6 (IMPACT Model Report)
Dry Bulk Density	ρ	-	1.10E-01	kg/L	Table 2-1 (IMPACT Model Report)
Water Content (Volume Basis)	θ	-	9.60E-01	unitless	Table 2-1 (IMPACT Model Report)
Fraction in Porewater Phase	$C_{pw\ (fraction)}$	$C_{pw\ (fraction)} = 1 - (k_d * \rho / \theta) / (1 + k_d * \rho / \theta)$	7.27E-05	unitless	Calculated
Concentration Ratio – Porewater to Sediment	$Ratio_{pw\text{-}sed}$	$Ratio_{pw\text{-}sed} = C_{pw\ (fraction)} * \rho / \theta$	8.33E-06	kg/L	Calculated
Sediment Porewater Concentration	$C_{pw\ (sed)}$	$C_{pw\ (sed)} = C_{sed(dw)} * Ratio_{pw\text{-}sed}$	3.73E-03	Bq/L	Calculated
Bioaccumulation Factor (BAF)	$BAF_{benthic\ inv}$	-	1.58E+04	L/kg fw	Table 3-9 (IMPACT Model Report)
Sediment Occupancy Factor	OF_{sed}	-	1.00E+02	%	Table 2-5 (IMPACT Model Report)
Benthic Invertebrate Tissue Concentration	$C_{benthic\ inv}$	$C_{benthic\ inv} = (1 - (OF_{sed}/100) * C_{sed(dw)} + (OF_{sed}/100) * C_{pw\ (sed)}) * BAF_{benthic\ inv}$	5.88E+01	Bq/kg fw	Calculated
Mallard Exposure Factors					
Water Intake	IR_w	-	6.40E-02	L/d	Table 5-7
Sediment Intake	IR_s	-	2.00E-03	kg dw/d	Table 5-7
Air Intake	IR_{air}	-	2.00E-02	m^3/d	Table 5-7
Aquatic Plant Intake	$IR_{aquatic\ plant}$	-	6.00E-02	kg fw/d	Table 5-7
Benthic Invertebrate Intake	$IR_{benthic\ inv}$	-	1.80E-01	kg fw/d	Table 5-7
Fraction of Time Spent on Site	f_0	-	1.00E+00	unitless	Assumed
Mallard Internal Dose (Radiological)					
Ingestion Transfer Factor	TF_{ing}	-	3.68E+00	d/kg fw	Table 3-16 (IMPACT Model Report)
Mallard Tissue Concentration	C_t	$C_t = f_0 * TF_{ing} * (C_w*IR_w + C_{s(dw)} * IR_s + C_{aquatic\ plant} * IR_{aquatic\ plant} + C_{benthic\ inv} * IR_{benthic\ inv})$	4.27E+01	Bq/kg fw	Calculated
Dose Conversion Factor (Internal) - Duck	DC_{int}	-	3.04E-02	(µGy/hr)/(Bq/kg fw)	Table 3-18 (IMPACT Model Report)
Internal Dose	D_{int}	$D_{int} = C_t * DC_{int}$	1.30E+00	µGy/hr	Calculated
Internal Dose (converted units)	D_{int}'	$D_{int}' = D_{int} * 24\ h/d / 1000\ \mu Gy/mGy$	3.12E-02	mGy/d	Calculated
Mallard External Dose (Radiological)					
Occupancy Factor, Sediment - Riparian Birds	OF_s	-	0.00E+00	unitless	Table 2-5 (IMPACT Model Report)

Parameter	Symbol	Calculation	Polonium-210		
			Value	Unit	Source
Occupancy Factor, Sediment Surface - Riparian Birds	OF_{ss}	-	5.00E-01	unitless	Table 2-5 (IMPACT Model Report)
Dose Conversion Factor (External) - Duck	$DC_{ext\ (on\ soil)}$	-	2.63E-11	$(\mu Gy/hr)/(Bq/m^2)$	Table 3-19 (IMPACT Model Report)
External Dose	D_{ext}	$D_{ext} = f_0 * (C_{s(dw)}' * OF_{ss} * DC_{ext\ (on\ soil)})$	5.87E-09	µGy/hr	Calculated
External Dose (converted units)	D_{ext}'	$D_{ext}' = D_{ext}$ * 24 h/d / 1000 µGy/mGy	1.41E-10	mGy/d	Calculated
Mallard Total Dose (Radiological)					
Total Dose	D_{total}	$D_{total} = D_{int} + D_{ext}$	1.30E+00	µGy/hr	Calculated
Total Dose (converted units)	D_{total}'	$D_{total}' = D_{int}' + D_{ext}'$	3.12E-02	mGy/d	Calculated (Table 5-10)

Table B.14: Sample Calculation - Adult Recreational Fisher/Hunter (McGowan Lake) Radiological Dose for Polonium-210

Parameter	Symbol	Calculation	Polonium-210		
			Value	Unit	Source
Environmental Media Concentrations					
Water Concentration (LA-1)	C_w	-	6.23E-03	Bq/L	Table 3-3
Water Concentration reference (Max)	$C_{w\ (Ref-M)}$	-	6.33E-03	Bq/L	Table 3-3
Water Concentration reference (Ave)	$C_{w\ (Ref-A)}$		5.34E-03	Bq/L	
Soil Concentration (dry weight)	$C_{s(dw)}$	-	6.55E+01	Bq/kg dw	Table 3-13
Soil Concentration reference (dry weight)	$C_{s(dw)\ (Ref)}$	-	6.55E+01	Bq/kg dw	Table 3-13
Soil Concentration incremental (dry weight)	$C_{s(dw)}'$	$C_{s(dw)}' = C_{s(dw)} - C_{s(dw)\ (Ref)}$	0.00E+00	Bq/kg dw	Calculated
Outdoor Air Concentration	C_{air}	-	0.00E+00	Bq/m^3	Table 3-13
Soil Dry Bulk Density (Sand)	ρ_s	-	1.50E+00	kg(dw)/ L	CSA N288.1-20 (cl. 6.3.2.2)
Mixing Depth	d	-	2.00E-01	m	CSA N288.1-20 (cl. 6.3.1.1)
Soil Surface Concentration	C_{ss}	$C_{ss} = C_{s(dw)}' * \rho_s * d * 1000\ L/m^3$	0.00E+00	$Bq(dw)/m^2$	Calculated
Linkage Fraction of Environmental Media (LA-1)	$LF_{EM\ (LA-1)}$	-	3.00E-01	Unitless	Assumed
Linkage Fraction ofEnvironmental Media (Reference)	$LF_{EM\ (Ref)}$	-	7.00E-01	Unitless	Assumed
Air Immersion Dose					
Air Immersion Dose	D_{air}	$D_{air} = C_{air} * f_o * (f_u + (1 - f_u) * S_b) * DCF_a$	0.00E+00	Sv/a	Calculated
Unit conversion	D_{air}'	$D_{air}' = D_{air} * 1000$ mSv / Sv	0.00E+00	mSv/a	Calculated (Table 4-9)
Air Inhalation Dose					
Inhalation Rate	IR_{air}	-	5.95E+03	m^3/a	Table 2-7 (IMPACT Model Report)
Dose Conversion Factor (Inhalation)	DCF_{inh}	-	3.30E-06	Sv/Bq	Table 3-20 (IMPACT Model Report)
Air Inhalation Dose	D_{inh}	$D_{inh} = C_{air} * IR_{air} * DCF_{inh}$	0.00E+00	Sv/a	Calculated
Unit conversion	D_{inh}'	$D_{inh}' = D_{inh} * 1000$ mSv / Sv	0.00E+00	mSv/a	Calculated (Table 4-9)
Water Ingestion Dose					
Ingestion Rate	IR_w	-	3.80E+02	L/a	Table 2-7 (IMPACT Model Report)
Dose Conversion Factor (Food)	DCF_f	-	1.20E-06	Sv/Bq	Table 3-20 (IMPACT Model Report)
Water Ingestion Dose (Total)	D_{w-T}	$D_w = (C_w * LF_{EM(LA-1)} + C_{w(Ref-M)} * LF_{EM(Ref)}) * IR_w * DCF_f$	2.87E-06	Sv/a	Calculated
Water Ingestion Dose (Reference)	D_{w-R}	$D_{w-R} = C_{w\ (Ref-A)} * IR_w * DCF_f$	2.43E-06	Sv/a	Calculated
Water Ingestion Dose (Incremental)	D_w	$D_w = D_{w-T} - D_{w-R}$	4.39E-07	Sv/a	Calculated
Unit Conversion	D_w'	$D_w' = D_w * 1000$ mSv / Sv	4.39E-04	mSv/a	Calculated (Table 4-9)
Water Immersion Dose					
Bathtub Correction Factor	D_c	-	7.00E-01	Unitless	CSA N288.1-20 (cl. 6.16.12)
Occupancy Factor - Swimming Surface Water	OF^s_w	-	1.04E-02	Unitless	CSA N288.1-20 (cl. 6.16.1.3)
Occupancy Factor - Pool Water	OF^p_w	-	3.13E-02	Unitless	CSA N288.1-20 (cl. 7.6.1.2)
Occupancy Factor - Bath Water	OF^b_w	-	1.40E-02	Unitless	CSA N288.1-20 (cl. 6.16.1.3)
Dose Conversion Factor (Water)	DCF_w	-	2.66E-11	Sv/Bq	Table 3-20 (IMPACT Model Report)
Water Immersion Dose (Total)	D_{imm-T}	$D_{imm-T} = (Cw * LF_{EM(LA-1)} + C_{w(Ref-M)} * LF_{EM(Ref)})* (OF^s_w + D_c *$	8.62E-15	Sv/a	Calculated
Water Immersion Dose (Reference)	D_{imm-R}	$D_{imm-R} = C_{w\ (Ref-A)} * (OF^s_w + D_c * OF^b_w + OF^p_w) * DCF_w$	7.30E-15	Sv/a	Calculated
Water Immersion Dose (Incremental)		$D_{imm} = D_{imm-T} - D_{imm-R}$	1.32E-15	Sv/a	Calculated
Unit Conversion	D_{imm}'	$D_{imm}' = D_{imm} * 1000$ mSv / Sv	1.32E-12	mSv/a	Calculated (Table 4-9)
External Soil Dose					
Soil reduction factor	f_r	-	6.80E-01	Unitless	CSA N288.1-20 (cl. 6.4.6.3)
Groundshine Shielding Factor	S_g	-	2.00E-01	Unitless	CSA N288.1-20 (cl. 6.14.3)

Parameter	Symbol	Calculation	Polonium-210		
			Value	Unit	Source
Dose Conversion Factor (Soil)	DCF_g	-	2.61E-13	(Sv/a)/(Bq/m^2)	Table 3-20 (IMPACT Model Report)
Soil External Dose (Incremental)	D_g	$D_g = C_{ss} * f_o * f_r * (f_u + (1 - f_u) * S_g) * DCF_g$	0.00E+00	Sv/a	Calculated
Unit conversion	D_g'	$D_g' = D_g * 1000$ mSv / Sv	0.00E+00	mSv/a	Calculated (Table 4-9)
Internal Soil Dose					
Soil Intake Rate	IR_s	-	4.00E-06	kg(dw)/d	CSA N288.1-20 (Table 20)
Soil Exposure Frequency	t_d	-	1.35E+02	d/y	Assumed
Dose Conversion Factor (Food)	DCF_f	-	1.20E-06	Sv/Bq	Table 3-20 (IMPACT Model Report)
Internal Soil Dose (Incremental)	D_s	$D_s = C_{s(dw)}' * IR_s * t_d * DCF_f$	0.00E+00	Sv/a	Calculated
Unit conversion	D_s'	$D_s' = D_s * 1000$ mSv / Sv	0.00E+00	mSv/a	Calculated (Table 4-9)
Terrestrial Plant Ingestion Dose					
Labrador Tea Concentration (LA-1)	$C_{LT\ (LA-1)}$	-	5.06E+00	Bq/kg fw	Table B.7
Blueberry Concentration (LA-1)	$C_{BB\ (LA-1)}$	-	1.31E+01	Bq/kg fw	Table B.7
Labrador Tea Concentration (Reference)	$C_{LT\ (Ref)}$	-	5.06E+00	Bq/kg fw	Table B.7
Blueberry Concentration (Reference)	$C_{BB\ (Ref)}$	-	1.31E+01	Bq/kg fw	Table B.7
Labrador Tea Concentration (Incremental)	$C_{LT\ (LA-1)}'$	$C_{LT\ (LA-1)}' = C_{LT\ ((LA-1)} - C_{LT\ (Ref)}$	0.00E+00	Bq/kg fw	Calculated
Blueberry Concentration (Incremental)	$C_{BB\ (LA-1)}'$	$C_{BB\ (LA-1)}' = C_{BB\ ((LA-1)} - C_{BB\ (Ref)}$	0.00E+00	Bq/kg fw	Calculated
Food Intake (Terrestrial Plants)	IR_{TP}	-	1.98E+01	kg/a fw	Assumed, site-specific
Linkage Fraction of Labrador Tea (LA-1)	$LF_{LT\ (LA-1)}$	-	9.20E-03	Unitless	Table 2-10 (IMPACT Model Report)
Linkage Fraction of Blueberry (LA-1)	$LF_{BB\ (LA-1)}$	-	9.91E-01	Unitless	Table 2-10 (IMPACT Model Report)
Dose Conversion Factor (Food)	DCF_f	-	1.20E-06	Sv/Bq	Table 3-20 (IMPACT Model Report)
Incremental Ingestion Dose (Terrestrial Plants)	D_{TP}	$D_{TP} = (C_{LT\ (LA-1)}' * LF_{LT\ (LA-1)} + C_{BB\ (LA-1)}' * LF_{BB\ (LA-1)}) * IR_{TP} * DCF_f$	0.00E+00	Sv/a	Calculated
Unit conversion	D_{TP}'	$D_{TP}' = D_{TP} * 1000$ mSv / Sv	0.00E+00	mSv/a	Calculated (Table 4-9)
Aquatic Animal Ingestion Dose					
Northern Pike Concentration (LA-1)	$C_{NP\ (LA-1)}$	-	9.34E-01	Bq/kg fw	Table B.7
White Sucker Concentration (LA-1)	$C_{WS\ (LA-1)}$	-	8.40E-01	Bq/kg fw	Table B.7
Northern Pike Concentration (Reference_Average)	$C_{NP\ (Ref)}$	-	8.00E-01	Bq/kg fw	
White Sucker Concentration (Reference_Average)	$C_{WS\ (Ref)}$	-	7.19E-01	Bq/kg fw	
Northern Pike Concentration (Incremental)	$C_{NP\ (LA-1)}'$	$C_{NP\ (LA-1)}' = C_{NP\ (LA-1)} - C_{NP\ (Ref)}$	1.34E-01	Bq/kg fw	Calculated
White Sucker Concentration (Incremental)	$C_{WS\ (LA-1)}'$	$C_{WS\ (LA-1)}' = C_{WS\ (LA-1)} - C_{WS\ (Ref)}$	1.21E-01	Bq/kg fw	Calculated
Food Intake (Aquatic Animals)	IR_{AA}	-	2.67E+01	kg/a fw	Assumed, site-specific
Linkage Fraction of Northern Pike (LA-1)	$LF_{NP\ (LA-1)}$	-	5.00E-01	Unitless	Assumed
Linkage Fraction of White Sucker (LA-1)	$LF_{WS\ (LA-1)}$	-	5.00E-01	Unitless	Assumed
Dose Conversion Factor (Food)	DCF_f	-	1.20E-06	Sv/Bq	Table 3-20 (IMPACT Model Report)
Incremental Ingestion Dose (Aquatic Animals)	D_{AA}	$D_{AA} = ((C_{NP\ (LA-1)}' * LF_{NP\ (LA-1)} + C_{WS\ LA-1)}' * LF_{WS\ (LA-1))} * IR_{AA} *$	4.07E-06	mg/kg/d fw	Calculated
Unit conversion	D_{AA}'	$D_{AA}' = D_{AA} * 1000$ mSv / Sv	4.07E-03	mSv/a	Calculated (Table 4-9)
Terrestrial Animal Ingestion Dose					
Woodland Caribou Concentration (LA-5)	$C_{WC\ (LA-5)}$		8.58E+00	Bq/kg fw	Table B.7
Moose Concentration (LA-1)	$C_{M\ (LA-1)}$	-	1.30E+00	Bq/kg fw	Table B.7
Moose Organs Concentration (LA-1)	$C_{MO\ (LA-1)}$	-	1.30E-02	Bq/kg fw	Table B.7
Muskrat Concentration (LA-1)	$C_{Mus\ (LA-1)}$	-	9.72E-01	Bq/kg fw	Table B.7
Mallard Concentration (LA-1)	$C_{Mal\ (LA-1)}$	-	4.26E+01	Bq/kg fw	Table B.7
Goose Concentration (LA-1)	$C_{G\ (LA-1)}$	-	1.06E+00	Bq/kg fw	Table B.7
Store Food Concentration (LA-1)	$C_{SF\ (LA-1)}$	-	4.80E-02	Bq/kg fw	Table 2-11 (IMPACT Model Report)

Parameter	Symbol	Calculation	Polonium-210		
			Value	Unit	Source
Woodland Caribou Concentration (Reference_Average)	$C_{WC\ (Ref)}$		8.54E+00	Bq/kg fw	
Moose Concentration (Reference_Average)	$C_{M\ (Ref)}$	-	1.27E+00	Bq/kg fw	
Moose Organs Concentration (Reference_Average)	$C_{MO\ (Ref)}$	-	1.27E-02	Bq/kg fw	
Muskrat Concentration (Reference_Average)	$C_{Mus\ (Ref)}$	-	8.27E-01	Bq/kg fw	
Mallard Concentration(Reference_Average)	$C_{Mal\ (Ref)}$	-	3.62E+01	Bq/kg fw	
Goose Concentration (Reference_Average)	$C_{G\ (Ref)}$	-	1.07E+00	Bq/kg fw	
Store Food Concentration (Reference)	$C_{SF\ (Ref)}$	-	4.80E-02	Bq/kg fw	Table 2-11 (IMPACT Model Report)
Woodland Caribou Concentration (Incremental)	$C_{WC\ (LA-1)}'$	$C_{WC\ (LA-5)}' = C_{WC\ (LA-5)} - C_{WC\ (Ref)}$	3.67E-02	Bq/kg fw	Calculated
Moose Concentration (Incremental)	$C_{M\ (LA-1)}'$	$C_{M\ (LA-1)}' = C_{M\ (LA-1)} - C_{M\ (Ref)}$	3.09E-02	Bq/kg fw	Calculated
Moose Organs Concentration (Incremental)	$C_{MO\ (LA-1)}'$	$C_{MO\ (LA-1)}' = C_{MO\ (LA-1)} - C_{MO\ (Ref)}$	3.09E-04	Bq/kg fw	Calculated
Muskrat Concentration (Incremental)	$C_{Mus\ (LA-1)}'$	$C_{Mus\ (LA-1)}' = C_{Mus\ (LA-1)} - C_{Mus\ (Ref)}$	1.45E-01	Bq/kg fw	Calculated
Mallard Concentration (Incremental)	$C_{Mal\ (LA-1)}'$	$C_{Mal\ (LA-1)}' = C_{Mal\ (LA-1)} - C_{Mal\ (Ref)}$	6.47E+00	Bq/kg fw	Calculated
Goose Concentration (Incremental)	$C_{G\ (LA-1)}'$	$C_{G\ (LA-1)}' = C_{G\ (LA-1)} - C_{G\ (Ref)}$	-5.04E-03	Bq/kg fw	Calculated
Store Food Concentration (Incremental)	$C_{SF\ (LA-1)}'$	$C_{SF\ (LA-1)}' = C_{SF\ (LA-1)} - C_{SF\ (Ref)}$	0.00E+00	Bq/kg fw	Calculated
Linkage Fraction of Woodland Caribou (LA-5)	$LF_{WC\ (LA-5)}$		4.00E-03	Unitless	Table 2-10 (IMPACT Model Report)
Linkage Fraction of Moose (LA-1)	$LF_{M\ (LA-1)}$	-	1.78E-02	Unitless	Table 2-10 (IMPACT Model Report)
Linkage Fraction of Moose Organs (LA-1)	$LF_{MO\ (LA-1)}$	-	6.80E-03	Unitless	Table 2-10 (IMPACT Model Report)
Linkage Fraction of Muskrat (LA-1)	$LF_{Mus\ (LA-1)}$	-	3.70E-03	Unitless	Table 2-10 (IMPACT Model Report)
Linkage Fraction of Mallard (LA-1)	$LF_{Mal\ (LA-1)}$	-	4.60E-03	Unitless	Table 2-10 (IMPACT Model Report)
Linkage Fraction of Goose (LA-1)	$LF_{G\ (LA-1)}$	-	2.80E-03	Unitless	Table 2-10 (IMPACT Model Report)
Linkage Fraction of Store Food (LA-1)	$LF_{SF\ (LA-1)}$	-	9.60E-01	Unitless	Table 2-10 (IMPACT Model Report)
Food Intake (Terrestrial Animals)	IR_{TA}	-	6.60E+02	kg/a fw	Assumed, site-specific
Dose Conversion Factor (Food)	DCF_f	-	1.20E-06	Sv/Bq	Table 3-20 (IMPACT Model Report)
Incremental Ingestion Dose (Terrestrial Animals)	D_{TA}	$D_{TA} = ((C_{WC\ (LA-5)}' * LF_{WC\ (LA-5)} + C_{M\ (LA-1)}' * LF_{M\ (LA-1)} + C_{MO\ (LA-1)}' * LF_{MO\ (LA-1)} + C_{Mus\ (LA-1)}' * LF_{Mus\ (LA-1)} + C_{Mal\ (LA-1)}' * LF_{Mal\ (LA-1)} + C_{G\ (LA-1)}' * LF_{G\ (LA-1)} + C_{SF\ (LA-1)}' * LF_{SF\ (LA-1)}) * IR_{TA} * DCF_f$	2.45E-05	Sv/a	Calculated
Unit conversion	D_{TA}'	$D_{TA}' = D_{TA} * 1000$ mSv / Sv	2.45E-02	mSv/a	Calculated (Table 4-9)
Adult Recreational Fisher/Hunter Total Incremental Dose					
Total Incremental Dose	D_{total}	$D_{total} = D_{air}' + D_{inh}' + D_w' + D_{imm}' + D_g' + D_s' + D_{TP}' + D_{AA}' + D_{TA}'$	2.90E-02	mSv/a	Calculated (Table 4-9)

Appendix C Ecological Receptor Profiles

Appendix C Ecological Receptor Profiles

One of the key considerations, which defines the scope of a risk assessment is the selection of ecological receptors. In selecting ecological receptors, it is important to identify plants and animals that are likely to be most exposed to the effects of the project. As it is not possible to evaluate all ecological species at a site, representative species were selected based on the selection process provided in Table 7.1 of CSA N288.6 (2012).

This appendix describes the aquatic and terrestrial ecological receptors (groups or species) selected for the assessment. The general characteristics of each receptor including any status under COSEWIC, SARA or provincial ranking, its distribution and presence in the Regional Study Area (RSA), its home range and diet, as well as how it is incorporated into the ecological and/or human health models and the protection level that it is afforded in the risk assessment.

1.0 Aquatic and Riparian Biota

1.1 Aquatic Vegetation

1.1.1 Macrophytes

Macrophytes are aquatic plants growing in or near water and can be either emergent, submergent or floating. Emergent macrophytes are rooted in shallow water whereas submergent macrophytes are typically rooted in sediment and the entire plant is submerged. Macrophytes are primary producers that provide food, cover and shelter for wildlife, such as spawning and nursery habitats for fish and nesting habitats for waterfowl, improve water quality and clarity, and help to stabilize shorelines and bottom sediments.

Patches of emergent and submergent macrophyte occurred in several areas in Kratchkowsky Lake (LA-7), Whitefish Lake (LA-5 & LA-6), McGowan Lake (LA-1) and Russell Lake (Ecometrix, 2020). Dense patches of long-stemmed submergent vegetation were observed near the inlet delta edge on the west side of the Whitefish Lake. Some sparse submergent vegetation stems were observed in the mid-basin, however the stem heights were only approximately 10 to 20 cm. Emergent vegetation was limited to the nearshore and shoreline areas. Larger emergent and submergent macrophyte beds were also generally limited to embayments of Kratchkowsky Lake.

In the ecological model, macrophytes are exposed to aquatic release through surface water, and they provide food for woodland caribou, moose, muskrat, lesser scaup and mallard. Because of their importance as a potential link between constituents in sediments and surface water to other aquatic and terrestrial receptors, macrophytes were conservatively assumed to be present in every surface water body within the RSA.

In the ERA, macrophytes are assessed as a group at a community level.

1.1.2 Phytoplankton

Phytoplankton are small primary producers that use sunlight to produce oxygen and nutrients for other organisms. Phytoplankton are an important food source for organisms in an aquatic environment.

Phytoplankton samples were collected in 2016 at six locations within the study area (Ecometrix, 2020). The phytoplankton community within the study area consisted of 55 taxa from 7 classes. At least 6 classes were identified at each location. Diatoms (*Bacilliarophyceae*) were numerically dominant, based on measured biovolume, at most locations. The cryptophytes (*Cryptophyceae*), cyanophytes (*Cyanophyceae*), and dinoflagellates (*Dinophyceae*) were also numerically important, comprising > 10% of total phytoplankton biovolume, at some locations.

In the model, phytoplankton are exposed to aquatic release through surface water. Phytoplankton communities represent a potential link between constituents in surface water and other aquatic and terrestrial receptors.

In the ERA, phytoplankton are assessed as a group at a community level.

1.2 Aquatic Invertebrates

1.2.1 Benthic Invertebrates

Benthic invertebrates or "benthos" live on or within the sediments of surface water bodies. Benthic invertebrates play an integral role in the freshwater ecosystem through nutrient cycling and they function as an important food source for wildlife such as the diving and dabbling (e.g. Mallard) ducks, and fish (e.g. White Sucker). Epifaunal benthic invertebrates live in water bodies on or attached to submerged substrates such as the bottom sediment or hard surfaces and feed at the substrate surface. Epifaunal benthic invertebrates primarily include amphipods, bivalves, shrimps, crabs, snails, and some aquatic insects. Infaunal benthic invertebrates live and burrow in the sediments and feed within sediments. Infaunal benthic invertebrates primarily include bivalves, worms, and some aquatic insects.

Benthic invertebrate samples were collected in 2016 at ten lake locations and a total of 78 benthic invertebrate taxa from 38 major taxonomic groups (Families) were identified within the study area (Ecometrix, 2020). Chironomids were prevalent across the study area and were the most numerically dominant taxon at most locations. Other taxonomic groups that represented more than 10% of the total benthic invertebrate density at a sampling location were detritus worms (*Naididae*), pill clams (*Pisidiidae*), water fleas from the families Holopedidae and Macrothricidae, and phantom midges (*Chaoboridae*). From a feeding group perspective, predatory taxa and those that feed on fine particulate organic matter (collector-gatherers) were generally the most abundant groups in lakes within the study area.

In the model, benthic invertebrates are exposed to aquatic release through surface water and sediment. Benthic invertebrates provide links from water to fish and sediment to fish pathways and a link between aquatic and terrestrial ecosystems. Many benthic invertebrate species feed on decaying organic matter and thereby form an important link between the decomposer and primary consumer levels.

In the ERA, benthic invertebrates are assessed as a group at a community level.

1.2.2 Zooplankton

Zooplankton are small aquatic animals that are intermediaries in the aquatic food chain. Zooplankton are primary or secondary consumers that are also prey of other larger zooplankton predators or fish. Zooplankton are exposed to aquatic release through surface water.

Zooplankton samples were collected in 2016 at six locations within the study area (Ecometrix, 2020). The zooplankton community within the study area consisted of 32 taxa from 10 classes. At least 7 classes were identified at each location. Branchiopods (*Branchiopoda*) were numerically dominant, based on measured biovolume, at all locations. The copepods (*Copepoda*) and rotifers (*Monogononta*) were also numerically important at some locations.

In the model, zooplankton are exposed to aquatic release through surface water. Zooplankton communities represent a potential link between constituents in surface water and phytoplankton, and other aquatic and terrestrial receptors.

In the ERA, zooplankton are assessed as a group at a community level.

1.3 Fish

1.3.1 Northern Pike

Northern pike (*Esox lucius*) is a pelagic top predator fish, of the family Esicidae, that is widely distributed in freshwater environments across Canada. It is of ecological and economic importance.

Eleven fish species were collected within study area lakes including representative forage and sport fish species (Ecometrix, 2020). Northern Pike and its spawning habitats were present in nearly all study area lakes, as well as most stream stations. Adult and juvenile Northern Pike were most abundant in Kratchkowsky Lake and Whitefish Lake. Northern pike tissue samples were retained for chemical analysis. It is assumed that the northern pike spends 100% of its time in the project area waterbody where it is assessed.

Northern pike is exposed to aquatic release through surface water and consumption of prey (aquatic vertebrates and/or aquatic invertebrates). In the model, northern pike is exposed to aquatic release through surface water. Northern pike represent a potential link between constituents in surface water, other aquatic and terrestrial receptors, and human receptor groups. In the ecological model, northern pike is consumed by black bear, mink, bald eagle and common loon. In the human health model, they are a component of the human Traditional Foods diet and are used as a surrogate for other common predatory fish, such as walleye, which are also items in the human Traditional Foods diet.

In the ERA, northern pike is assessed as a representative pelagic predator fish species at a population level.

1.3.2 White Sucker

White sucker (*Catostomus commersonii*) was selected to represent a bottom-feeding forage fish species. White suckers spawn in inlet or outlet streams, usually with a gravel bottom, often in the same areas as, but later than, Longnose Sucker (McPhail and Lindsey, 1970). White suckers were found in nearly all study area lakes (Ecometrix, 2020). White suckers spawning habitats were observed within the inlet tributary from nearly all study area lakes. Adult and juvenile white sucker were most abundant in Kratchkowsky Lake, Whitefish Lake, McGowan Lake and Russell Lake. White sucker tissue samples were retained for chemical analysis. It is assumed that the white sucker spends 50% of its time in the project area waterbody and 50% of its time in the sediment of lakes where it is assessed.

White sucker is exposed to aquatic release through surface water and sediment. In the model, white sucker represents a potential link between constituents in surface water, sediment, and human receptor groups. In the human health model, they are a component of the human Traditional Foods diet and are used as a surrogate for other common forage fish, such as lake whitefish and longnose Sucker, which are also items in the human Traditional Foods diet.

In the ERA, white sucker is assessed as a representative forage fish species at a population level.

1.4 Riparian Mammals

1.4.1 American Mink

American mink (*Neovison vison*) is a semi-aquatic, carnivorous mammal belonging to the weasel family (Mustelidae), measuring approximately 30 to 40 cm not including the tail and weighing on average 1 kg. Minks are widely distributed throughout North America, except in the far north, arid areas in southwestern United States, and Mexico. Mink trails were observed in the RSA and are trapped for fur and traditional lifestyles (Omnia, 2020).

Preferred habitats for minks generally consist of aquatic habitats such as rivers, lakes, streams, marshes, and swamps, with wooded cover. Mink typically use bank burrows of other animals such as muskrats, cavities in tree roots, rock or brush piles, log jams, and beaver lodges for denning instead of constructing their own (US EPA, 1993). Minks have been known to travel up to 200 m away from a water body and males have the largest home ranges of up to 10 km^2 (US EPA, 1993). For the ecological model, it is assumed that the mink spends 100% of its time at the location where it is assessed.

Minks are nocturnal opportunistic hunters, consuming a variety of prey around shorelines or emergent vegetation, preferring small mammals such as voles, muskrats and shrews. Other secondary prey items include aquatic birds, fish, amphibians, and crustaceans (US EPA, 1993). For the ecological model it is assumed that the mink's diet consists of small mammals, represented by muskrat (45%); fish, represented by northern pike (30%); benthic invertebrates (15%) and aquatic birds; represented by mallard (10%).

In the ERA, minks are assessed as a representative riparian carnivore species at a population level.

1.4.2 Muskrat

The muskrat (*Ondatra zibethicus*) is a large rodent (Muridae), measuring approximately 50 cm from tip of the nose to tail, and weighing on average 1 kg. Muskrats exist all over North America, from the Arctic Ocean in the north to the Gulf of Mexico in the south, from the Pacific Ocean in the west to the Atlantic Ocean in the east. Their mean home range size in the summer is between 0.048 to 0.17 hectares (U.S. EPA, 1993). Muskrats are present in the RSA and are trapped for fur and meat for traditional lifestyles (Omnia, 2020).

Muskrats prefer freshwater marshes, marshy areas of lakes, and slow-moving streams. The preferred water depth in these areas is 1 to 2 m, deep enough not to freeze fully during the winter but shallow enough to allow aquatic vegetation to grow. Muskrats nest in compact mounds of partially dried and decayed plant material such as cattails and bulrushes. In winter, muskrats generally occupy lodges that they build through burrowing underneath their mounds, and spends most of its time eating and sleeping. They are capable of extended dives, allowing them to dig channels and burrows underwater, cut submerged stems and roots with their teeth, and travel long distances beneath the ice (EC & CWF 1986). Breeding generally occurs in March, April, or May. Birth of the litter usually occurs within 1 month of mating and usually contains 5 to 10 young. Breeding can occur multiple times throughout the season (EC & CWF, 1986). For the ecological model, it is assumed that the muskrat spends 100% of its time at the location where it is assessed.

Muskrats mainly feed on aquatic plants such as cattails, bulrushes, horsetails, or pondweeds; although they prefer cattails. When aquatic plants are unavailable, muskrats are also known to feed on fish, frogs, and clams. In the model, muskrats are exposed to aquatic release through water, food and sediment. For the ecological model, it is assumed that the muskrat's diet consists of aquatic plants (80%) and benthic invertebrates (20%).

In the ERA, muskrats are assessed as a representative riparian herbivore species at a population level.

1.5 Riparian Birds

1.5.1 Common Loon

The loon (*Gavia immer*) is a piscivorous migratory waterfowl of the family Gaviidae, that breeds in Canada during the summer (FCSAP, 2012). Male loons average 5.3 kg in weight and females about 4.7 kg in weight (FCSAP, 2012). Loons are common to northern Saskatchewan and are known to breed in the RSA (Omnia, 2020).

Loons commonly inhabit open water areas of lakes and rivers during the summer (FCSAP, 2012). Loons do not walk well on land, so they spend their time on water. They prefer to nest offshore, on islands, islets, or floating mounds of vegetation in shallow water. Loon pairs may reuse the same nesting site year after year. They have one brood per year with 1 or 2 chicks being produced. Eggs hatch after an incubation period of 26-29 days (Cornell Lab (no date)). For the ecological model, it is conservatively assumed that the loon spends 100% of its time at the location where it is assessed.

Loons surface dive to the water column to catch fish. Loons are opportunistic feeders but appear to prefer perch to salmons (FCSAP, 2012). Aquatic invertebrates and crayfish are significant secondary components of their diet especially if the water is not clear. For the ecological model, loons are assumed to eat 90% fish (northern pike) and 10% aquatic invertebrates. In the model, loons are exposed to aquatic release through water and food.

In the ERA, loons are assessed as a representative avian piscivorous species at a population level.

1.5.2 Lesser Scaup

The lesser scaup (*Aythya affinis*) is one of the most abundant North American ducks. They breed principally throughout western Canada and Alaska, although their breeding range extends into the western United States as far south as Colorado and Ohio (U.S. EPA, 1993). The lesser scaup averages 42 cm from bill tip to tail tip with average 0.8 kg in weight. Males are larger and more colorful than the brown females.

Lesser scaup are found on large lakes and bays during the fall and winter and are common on smaller bodies of water (e.g., ponds) during the spring. They breed in the prairie potholes region, most often on permanent or semipermanent wetlands of 0.85 to 2.0 ha with trees and shrubs bordering at least half of the shorelines. Primary brood habitat is characterized by permanent wetlands dominated by emergent vegetation. Lesser scaup are known to breed in the RSA (Omnia, 2020). For the ecological model, it is assumed that the scaup spends 100% of its time at the location where it is assessed.

Most populations of lesser scaup consume primarily aquatic invertebrates, both from the water column and from the surfaces of aquatic vegetation and other substrates. Common prey includes snails, clams, scuds (amphipods), midges, chironomids, and leeches. Scaup are omnivorous, however, and the percentage of plant materials (almost exclusively seeds) in the diet varies seasonally as the availability of different foods changes. For the ecological model, lesser scaup are assumed to eat 90% aquatic invertebrates and 10% aquatic plants. In the model, lesser scaup are exposed to aquatic release through water and food.

In the ERA, lesser scaup are assessed as a representative avian omnivorous species at a population level.

1.5.3 Mallard

The mallard (*Anas platyrhynchos*) is an omnivorous migratory duck (Anatidae) that has a summer breeding range in Canada (U.S. EPA, 1993; FCSAP, 2012). Male mallards average 1.1 kg in weight and females about 1.2 kg in weight (FCSAP, 2012). Mallards are common to northern Saskatchewan and are known to breed in the RSA (Omnia, 2020). Mallards are an important component of the traditional foods diet for First Nations living in the Boreal Shield ecozone of Saskatchewan (Chan *et al*. 2018 and 2019).

The general habitat of the mallard is wetlands. The mean home range of a mallard in spring is between 111 and 620 hectares (U.S. EPA, 1993). Mallard typically nest on the ground in thick vegetation away from a waterbody. Mating pairs may produce more than one clutch per season, with the first clutch generally being finished by in late Spring, in the northern United States (US EPA, 1993). Females remain with their brood until fledging (US EPA, 1993). Although mallards are not present in the vicinity of the Project for over half the year due to migration, they have a small home range while nesting and rearing of their young. For the ecological model, it is conservatively assumed that the mallard spends 100% of its time at the location where it is assessed.

The mallard forages by dabbling and filtering though sediment (U.S. EPA, 1993). The bulk of the mallard`s diet is plant material, mostly aquatic plants and seeds, with the remaining portions of the diet consisting of aquatic invertebrates, especially during the breeding season (FCSAP, 2012). For the ecological model it is assumed that the mallard's diet while in the RSA consists of benthic invertebrates (75%) and aquatic plants (25%).

In the model, mallards are exposed to aquatic release through water, food and sediment. In the ecological model, mallards are prey for mink and bald eagle. In the human health model, mallards are a component of the First Nation's traditional foods diet and are used as a surrogate for other water birds with a similar diet.

In the ERA, mallards are assessed as a representative riparian avian species at a population level.

2.0 Terrestrial Biota

2.1 Terrestrial Invertebrates

Terrestrial invertebrates are considered to be primary consumers. They are represented by earthworms, which live in soil and are therefore exposed to constituents in soil layers through direct contact. Earthworms live in soil and depending on the species they either move vertically or horizontally indifferent soil layers. Earthworms acquire their nutrition through the organic matter in soil as well as the decomposing remains of other animals. They can devour one third of their own body weight per day.

For the ecological model, terrestrial invertebrates represented by the earthworm are assumed to spend 100% of their time at the location where they are assessed.

In the model, terrestrial invertebrates are exposed to atmospheric release through deposition to soil. Terrestrial invertebrate communities represent a potential link between constituents in air and other terrestrial receptors. In the ecological model, terrestrial invertebrates are part of the diet for the American robin (*Turdus migratorius*) and olive-sided flycatcher (*Contopus cooperi*).

In the ERA, terrestrial invertebrates are assessed as a group at a community level.

2.2 Terrestrial Vegetation

Terrestrial vegetation types are dietary components for terrestrial animals and humans. They are represented by browse (various shrubs and grasses), lichen (various species), blueberries (*Vaccinium myrtilloides*), and Labrador tea (*Rhododendron groenlandicum)*.

Individual plant species are included as food for other ecological receptors and for human receptors in the ecological and human health models. Three individual species are assessed in the model as representative species for lichen, fruits and berries (blueberry), and leafy plants and browse (Labrador tea). Plants are immobile and therefore are assumed to spend 100% of their time at the location where they are assessed.

In the ERA, terrestrial vegetation is assessed as a group at a community level.

2.2.1 Blueberry

Blueberry (*Vaccinium myrtilloides*) is a low spreading deciduous shrub that is common to Canada and northern United States. It often grows in the form of small thickets in open areas of coniferous forests in loose acidic soil, and in burn areas. Blueberries produce clusters of small sweet fruits. Blueberries are generally present in the RSA and is the most prevalent ground cover species in the uplands (Omnia, 2020). Blueberries are an important Traditional Foods component for First Nations living in the Boreal Shield and Boreal Plains ecozones of Saskatchewan (Chan *et al.* 2018 and 2019).

In the model, plants like blueberry are exposed to atmospheric release through deposition to soil and uptake from soil. In the ecological model, blueberries are part of the diet for a number of mammals and birds including snowshoe hare; southern red-backed vole and black bear. In the human health model, blueberries are a component of the Traditional Foods diet, and is used as a surrogate for other fruits and berries in the human Traditional Foods diet, such as rosehips, cranberries, mooseberry and squashberry (Chan *et al*. 2018 and 2019).

2.2.2 Labrador Tea

Labrador tea (*Rhododendron groenlandicum*) is a common name for three closely related plant species in the genus Rhododendron, including *Rhododendron groenlandicum* which is the most common ground cover plant in low sites in the RSA (Omnia, 2020). Labrador tea is an important Traditional Foods component for First Nations living in the Boreal Shield ecozone of Saskatchewan (Chan *et al*. 2018 and 2019), and is infused as a tea.

In the model, plants like Labrador tea are exposed to atmospheric release through deposition to soil. In the human health model Labrador tea is a component of the Traditional Foods diet, and is used as a surrogate for other plants in the human Traditional Foods diet, such as mint and rat root (Chan *et al*. 2018 and 2019).

2.2.3 Lichen

Lichens are not plants, but rather they are composite organisms and symbiotic partnerships between fungus and algae. Some species are arboreal and grow on branches of higher plants, while others are terrestrial and grow on rocks and soil. The fungus provides structure and protection to the algae, while the algae which has chlorophyll, photosynthesizes and provides nutrition to the fungus. Lichens are found around the world in many different habitats.

Stands of jack pine with a ground cover of lichen occupy the dry sandy sites, and open jack pine (*Pinus banksiana*) forests with a thin cover of lichen are common and dominate the uplands in the RSA (Omnia, 2020).

In the model, lichen is exposed to atmospheric release depositing from air. In the ecological model lichens are food for woodland caribou.

2.3 Terrestrial Mammals

2.3.1 Black Bear

Black bear (*Ursus americanus*) is a large terrestrial omnivore. The body weight of black bears varies seasonally and is at its greatest in the fall before winter hibernation. Adult males weigh about 135 kg and females are much smaller than males, averaging 70 kg, resulting in an average weight of 102.5 kg (Hinterland's Who's Who, 2007a). Although its natural range is across North America, black bears have been extirpated from much of their territory in the continental United States. Currently, black bears are commonly found across most of Canada and Alaska (EC & CWF, 2007). Black bears are widespread within the RSA (Omnia, 2020)

Black bears are found in a variety of habitats but appear to prefer heavily wooded areas and dense bushland. Black bears mate in June or early July, and the cubs, generally one or two, are born the following January or February while the mother is still in her winter den (EC & CWF, 2007). The availability of food in the foraging range leading up to denning is important to reproductive success because the bear's fetuses do not "implant" into the uterus until late fall when she enters her winter den (EC & CWF, 2007). Home ranges from for female black bears in the Saskatchewan Boreal Shield range from 40 km^2 to 130 km^2, as determined from GPS tracking data (McLoughlin et al., 2019). In the ecological model an average female home range of 80 km^2 is used. For the ecological model, the black bear is assumed to interact with more than one exposure location in the RSA for feeding and water intake, due to the large home range.

Black bears are omnivores and eat seasonally available food. Most of their diet is composed of plant material, including many berries (blueberries, buffalo berries, strawberries, elderberries, Saskatoon berries), fruits (black cherries, and apples) and nuts (acorns, hazelnuts, and beechnuts) (EC & CWF, 2007; FCSAP, 2012). Black bears also consume animals, especially invertebrates (ants, bee larvae), fish, small mammals and birds, and carrion (EC & CWF, 2007; FCSAP, 2012). In the ecological model, black bears are assumed to eat 70% berries (blueberries) and 30% fish (northern pike).

In the model, black bears are exposed to aquatic and atmospheric releases through water and food.

In the ERA, black bears are assessed as a representative terrestrial mammalian omnivorous species at a population level.

2.3.2 Canada Lynx

The Canada lynx (*Lynx canadensis*) is a medium-sized cat with long legs and large, well-furred paws. Lynx generally measures 75 to 90 cm long and weigh 6 to 14 kg, and males are 13-25 percent larger than females (U.S. FWS, 2017). For the ecological model a body weight of 14 kg was selected. The lynx generally inhabits forested wilderness areas. It favours old growth boreal forests with a dense undercover of thickets and windfalls. The size of the home range varies with numbers of lynxes and snowshoe hares in the area, available cover, and season. In summer, home ranges are larger than in winter (Hinterland's Who's Who, 2007b).

More than 75 percent of the lynx's diet in winter is snowshoe hares. In summer the lynx's diet is more varied. But even in summer hares remain the main prey, supplemented by grouse, voles, mice, squirrels, and foxes. In the ecological model, Canada lynx are assumed to eat 80% snowshoe hares, 15% small mammals represented by southern red-backed vole and 5% terrestrial birds represented by Canada goose.

In the model, Canada lynx are exposed to aquatic and atmospheric release through water and food.

In the ERA, Canada lynx is assessed as a representative upland mammalian carnivore species at a population level.

2.3.3 Moose

Moose (*Alces alces*) is a large ungulate of the family Cervidae, with an average weight for males and females of 453 kg and 350 kg, respectively (FCSAP, 2012). For the ecological model a body weight of 400 kg was selected. Moose are found in Canadian forests from the Alaska boundary to the eastern tip of Newfoundland and Labrador (EC & CWF, 1997). Moose are present in the RSA too (Omnia, 2020). Moose meat and organs are important components of the traditional foods diet for First Nations living in the Boreal Shield ecozone of Saskatchewan (Chan *et al.* 2018 and 2019).

Moose are essentially solitary animals that have one or several distinct seasonal home ranges to which they are strongly attached. Movements between seasonal home ranges may be extensive but home ranges are generally small and moose usually return to the same home ranges year after year (Franzmann, 1981; Wilson and Ruff, 1999). A seasonal home range of 10 km^2 was selected for the ecological model.

Breeding season, or rut, begins in mid-September. Cows usually bear one or two calves in the Spring, and the calves stay with the cow until she calves again the following spring. The number of calves born to a cow reflects the availability of nutrition during the rut. During the winter months, moose live almost solely on twigs and shrubs such as balsam fir, poplar, red osier dogwood, birch, willow, and red and striped maples (EC & CWF, 1997). In summer the moose's diet includes leaves, some upland plants, and water plants in great quantity where available (EC & CWF, 1997). The diet used in the ecological model reflects a spring/summer diet at the end of gestation and when calves are nursing. It assumes 80% browse and 20% macrophytes.

In the model, moose are exposed to aquatic and atmospheric releases through water and food. The moose is part of the Traditional Foods diet in the human health model, and is used as a surrogate for other ungulate species such as white-tailed deer (*Odocoileus virginianus*) and woodland caribou.

In the ERA, moose are assessed as a representative ungulate species at a population level.

2.3.4 Snowshoe Hare

The snowshoe hare (*Lepus americanus*) is a North American hare of the family Leporidae. Adult snowshoe hares typically weigh between 0.9 kg to 1.9 kg (FCSAP, 2012) and females are often slightly larger than males (EC & CWF 2005). For the ecological model a bodyweight of 1.8 kg was selected for snowshoe hare. Snowshoe hares are one of the most common woodland mammals of every province and territory of Canada, and are present in the RSA (Omnia, 2020).

Snowshoe hares prefer forested areas with a heavy understory such as conifer-dominated habitats and deciduous riparian forests. The size of their home range can reach up to 10 ha (EC & CWF, 2005), but their foraging range is relatively small (1.6 ha) especially for females during the spring and summer reproductive season (FCSAP, 2012). In the ecological model snowshoe hare are assumed to reside 100% of the time at the location where they are assessed.

During the summer, the snowshoe hare's diet consists of grasses, sedges, and forbs while during the winter they eat stems and branches of woody plants (FCSAP, 2012). They are also known to consume fruits and berries and some animal protein. In the ecological model, snowshoe hares are assumed to eat 90% browse and 10% berries represented by blueberries.

In the model, snowshoe hares are exposed to aquatic and atmospheric release through water and food. In the ecological model, snowshoe hare is part of the diet for the Canada lynx. Hare are represented by muskrat in the human traditional foods diet in the human health model.

In the ERA, snowshoe hare is assessed as a representative upland mammalian herbivore species at a population level.

2.3.5 Southern Red-Backed Vole

Southern red-backed vole (*Myodes gapperi*), is a woodland vole of the family Cricetidae, found in Canada and the northern United States, that weighs up to 0.042 kg. Red-backed voles are present in the RSA and were among the most abundant small mammals trapped during baseline studies (Omnia, 2020). A total of 197 individual small mammals of three species were captured during baseline studies. Red-backed voles (*Clethrionomys gapperi*) were most abundant with 140 captures, followed by meadow voles (*Microtis pennsylvanicus*), and dusky shrews (*Sorex monticolus*). Red-backed vole tissue samples were retained for chemical analysis. For the model, the body weight and total feed intake for the meadow vole were used because it is a similar species that is well characterized and commonly used in risk assessments (FCSAP, 2012).

Baseline studies indicate that red-backed voles are present in all ecosites and vegetation cover types in the RSA. Coarse woody debris and shrub cover are two major components of red-backed vole habitat (Omnia, 2020). They often reside in burrows created by other small mammals, and use runways they created through the vegetation understory or snow. They remain active year-round and generally feed during the night. Females may have two to four litters a year. In the ecological model, voles are assumed to reside 100% of the time at the location where they are assessed.

Southern red-backed voles are omnivorous. They generally feed on green plants, underground fungi, seeds, nuts, roots, and berries, but also eat small terrestrial invertebrates such as insects, snails. They are known to store food for later use. In the ecological model, voles are assumed to eat 60% berries (blueberries) and 40% browse.

In the model, voles are exposed to aquatic and atmospheric releases through water and food. In the ecological model voles are part of the diet for Canada lynx.

In the ERA, voles are assessed as a representative mammalian herbivore at a population level.

2.3.6 Woodland Caribou

Woodland caribou (*Rangifer tarandus caribou*) is a medium sized member of the deer family (Cervidae), weighing between 100 and 250 kg (COSEWIC, 2002). A body weight of 180 kg, representing the upper range mean for adult male and female woodland caribou (COSEWIC, 2002) was selected for the ecological model. The boreal population of woodland caribou is designated as Threatened by COSEWIC and SARA and is provincially-ranked S3, meaning that the species is vulnerable/rare to uncommon in Saskatchewan. Woodland caribou were observed in winter tracking, pellet and incidentally in the RSA during baseline studies (Omnia, 2020).

Woodland caribou have a relatively large home range that varies from 67 km^2 to 267 km^2 (McLoughlin, 2016). Caribou seek mature jack pine- and black spruce-dominated forest, black spruce bog, and open muskeg habitats common to the Boreal Shield during most of the year, and inaccessible rough terrain such as muskeg or islands on lakes for calving (McLoughlin 2016). For the ecological model, a home rage of 80 km^2 was considered appropriate based on the average female range during the most sensitive life stage of the caribou (calving and post calving). For the ecological model, the caribou is assumed to interact with more than one exposure location in the RSA for feeding and water intake, due to the large home range.

The food source for the woodland caribou in the winter is terrestrial or arboreal lichens; terrestrial and aquatic vegetation are also food sources in the remainder of the year. For the ecological model a diet comprised of 50% browse, 20% lichen and 30% macrophytes is assumed for the woodland caribou.

In the model, woodland caribou are exposed to aquatic and atmospheric release through water and food. The woodland caribou is part of the Traditional Foods diet in the human health model.

In the ERA, woodland caribou are assessed as a species of concern at an individual level and as a representative mammalian herbivore species at a population level.

2.4 Terrestrial Birds

2.4.1 American Robin

American Robin (*Turdus migratorius*) is a common, medium-sized songbird that averages 25 cm from tail-to-tip. There is little variation between the sexes in terms of size (U.S. EPA, 1993). They have a distinctive rust-orange coloured breast and a dark gray-brown back, with a yellow beak. For the ecological model a body weight of 0.1 kg was selected.

The American robin can live in a variety of habitats, including woodlands, swamps, suburbs, and parkland. They require access to freshwater, protected nesting sites, and productive foraging areas for their habitats. Breeding habitat includes moist forests, swamps, open woodlands, orchards, parks and lawns. They will form their nests out of mud and vegetation near the edges of a forest or other opening in vegetation, on horizontal branches, within shrubs, or on man-made structures with horizontal surfaces. The American robin is migratory, breeding in northern latitudes and wintering in the south (U.S. EPA, 1993). The American robin is present in the RSA (Omnia, 2020).

The diet of the American robin is made up of earthworms, insects, and fruit. The American robin forages on the ground in open areas, along habitat edges or streams by probing and gleaning; they also forage above ground in shrubs or in lower tree branches. The robin forages for ground-dwelling invertebrates on the ground, and in shrubs and lower tree branches for fruit and foliage-dwelling insects. During the breeding season the American robin eats primarily invertebrates with some fruit; the rest of the year the robin’s diet is primarily made up of fruit (U.S. EPA, 1993). In the ecological model, American robins are assumed to eat 60% fruit represented by blueberries and 40% earthworms.

In the model, American robins are exposed to aquatic and atmospheric releases through water and food.

In the ERA, American robins are assessed as a representative avian herbivore species at a population level.

2.4.2 Bald Eagle

The bald eagle (*Haliaeetus leucocephalus*) is a large bird of prey with pale eyes; yellow bills; white heads, necks and tails; and dark brown bodies. Young eagles are a mixture of brown and white, with a black bill in young birds. Bald eagles have long rounded wings, a large hooked bill, and sharp talons. Bald eagles are sexually dimorphic; females are significantly larger than males, but otherwise they look alike (US EPA, 1993). For the ecological model a body weight of 5.8 kg was selected.

Bald eagles are found throughout North America; they nest in a variety of habitats and forest types. Their habitats are usually restricted to coastal areas, lakes, or rivers; they prefer mature trees with large, open crowns and stout limbs for perching or roosting. Bald eagles are migratory under certain conditions; they will migrate from areas where the water bodies become completely frozen over in winter, but will remain as far north as open water and a reliable food supply allow (US EPA, 1993). The nests are nearly always near a major lake or river where most of their hunting is done; they prefer to build their nests in large trees with sturdy branches, but they will also nest in rocky outcrops. Bald eagles are present in the RSA (Omnia, 2020). The bald eagle has a home range of approximately 314 km^2. For the ecological model, the bald eagle is assumed to interact with more than one exposure location in the RSA for feeding and water intake, due to the large home range.

The bald eagle feeds primarily on fish, aquatic birds, and mammals, which it may take alive or find dead. Much of its live prey, especially the waterfowl, consists of sickly individuals or those wounded by hunters. For the ecological model a diet comprised of 80% fish represented by northern pike and 20% riparian birds represented by mallard is assumed for the bald eagle.

In the model, bald eagles are exposed to aquatic and atmospheric release through water and food.

In the ERA, bald eagles are assessed as a representative avian carnivore species at a population level.

2.4.3 Canada Goose

Canada goose (*Branta canadensis*) is a large terrestrial herbivore of the family Anatidae. Canada geese breed in open forested areas near lake shores and coastal marshes from the arctic tundra through temperate climates (US EPA, 1993). Canada goose was the most commonly detected bird species in the RSA during baseline studies (Omnia, 2020). Geese, including Canada geese and brant geese (*Branta bernicla*), are part of the Traditional Foods diet for the Boreal Shield ecozone of Saskatchewan (Chan *et al*. 2018 and 2019). The US EPA (1993) considers brant geese to be similar to Canada geese.

Body weights for Canada geese vary seasonally and are at their maximum in spring prior to migrating to their northern breeding grounds. Their body weights decline during reproduction and rearing of young (US EPA, 1993). For the ecological model, a body weight of 3.7 kg is used for the Canada goose.

The foraging areas for Canada geese vary seasonally. After hatching, goose families tend to move away from their nesting site to other areas, generally on land in riparian areas and near water, with adequate cover and forage to rear their broods (US EPA, 1993). Canada geese are almost exclusively vegetarian. They are primarily grazers but consume some grit to aid digestion (US EPA, 1993). In the ecological model, Canada geese are assumed to eat 100% browse, and they are assumed to spend 100% of their time at the location where they are assessed. In the model, Canada geese are exposed to aquatic and atmospheric releases through water and food. Canada goose is part of the diet for the Canada lynx.

In the ERA, Canada geese are assessed as a representative avian herbivore species at a population level.

2.4.4 Olive-sided Flycatcher

The olive-sided flycatcher (*Contopus cooperi*) is a small to medium sized passerine bird in the family Tyrannidae, the Tyrant flycatcher family. It is a migratory species that travels from South to North America to breed during the summer. Olive-sided flycatcher is a widespread migratory species, with 53% of its breeding range across most of forested Canada, and the remainder in the western and northeastern United States. It is a very agile flyer and mainly consumes flying insects on flight. The olive-sided flycatcher is designated as Special Concern by COSEWIC and as Threatened by SARA and is provincially-ranked S4, meaning that the species is apparently secure in Saskatchewan. Olive-sided flycatcher is most often associated with edges of coniferous or mixed forests with tall trees or snags for perching, alongside open areas, or in burned forest with standing trees and snags. Olive-sided flycatchers were observed in the RSA during baseline studies (Omnia, 2020).

Olive-sided flycatcher is an aerial insectivore, generally making short foraging flights from a high perch to intercept flying insects. The egg and nestling stages in Canada can last from late May/mid-June to early/mid-August, depending on latitude. Olive-sided flycatchers arrive on their Canadian breeding grounds between April and June, but predominantly around mid-May. They are socially monogamous, with large territories of 10-20 ha. Nests are typically built in coniferous trees. Average clutch size is three eggs, and a single brood is raised. Nest success ranges from 30 to 65%, differing by region and habitat type. Renesting is common if the first clutch fails. Olive-sided flycatchers have been known to live for at least 7 years. Fall migration begins in late July, with most birds departing for the wintering grounds between mid-August and early September.

For the ecological model a diet comprised of 90% earthworms and 10% benthic invertebrates is assumed for the olive-sided flycatcher. In the model, the olive-sided flycatcher is exposed to aquatic and atmospheric release through water and food.

In the ERA, olive-sided flycatchers are assessed as a species of concern at an individual level and as a representative avian herbivore species at a population level.

3.0 References

Chan L, Receveur O, Batal M, Sadik T, Schwartz H, Ing A, Fediuk K, Tikhonov C. 2018. First Nations Food, Nutrition and Environment Study (FNFNES): Results from Saskatchewan (2015). Ottawa: University of Ottawa.

Chan L, Receveur O, Batal M, Sadik T, Schwartz H, Ing A, Fediuk K, Tikhonov C. 2019. Erratum to the First Nations Food, Nutrition and Environment Study (FNFNES): Results from Saskatchewan 2015. Ottawa: University of Ottawa, 2018. July.

Cornell Lab. (no date) All about Birds. Common Loon. Retrieved September 2021 from: **https://www.allaboutbirds.org/guide/Common_Loon/lifehistory#**

COSEWIC 2002. COSEWIC assessment and update status report on the woodland caribou *Rangifer tarandus caribou* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xi + 98 pp.

Drilling, N., R. Titman and F. McKinney. 2002. Mallard (*Anas platyrhynchos*). In the Birds of North America, No. 658 (A. Poole and F. Gill, eds). The Birds of North America Online, Ithaca, New York.

Ecometrix (Ecometrix Incorporated), 2020. Wheeler River Project: Baseline Hydrology Summary Report. Report prepared for Denison Mines Corporation. March 2020.

Environment Canada and Canada Wildlife Federation (EC & CWF). 1986 (last revised by M. Aleksuik). Muskrat. Retrieved in September 2021 from **https://www.hww.ca/en/wildlife/mammals/muskrat.html**

Environment Canada and Canada Wildlife Federation (EC & CWF). 1997. Moose. Retrieved in September 2021 from **https://www.hww.ca/en/wildlife/mammals/moose.html**

Environment Canada and Canada Wildlife Federation (EC & CWF). 2005 (last revised by K.E. Hodges). Snowshoe Hare. Retrieved in September 2021 from **https://www.hww.ca/en/wildlife/mammals/snowshoe-hare.html**

Environment Canada and Canada Wildlife Federation (EC & CWF). 2007 (last revised by C. Samson). Black Bear. Retrieved in September 2021 from **https://www.hww.ca/en/wildlife/mammals/black-bear.html**

Federal Contaminated Sites Action Plan (FCSAP). 2012. Ecological Risk Assessment Guidance, Module 3: Standardization of Wildlife Receptor Characteristics. Prepared for: Environment Canada (Government of Canada), Vancouver, B.C., Prepared by Azimuth Consulting Group, Vancouver, B.C. March 2012.

Franzmann AW. 1981. Alces alces. Mammalian Species. 154:1–7. May.

Hinterland's Who's Who. 2007a. Black Bear. **https://hww.ca/en/wildlife/mammals/black-bear.html**

Hinterland's Who's Who. 2007a. Canada Lynx. **https://www.hww.ca/en/wildlife/mammals/canada-lynx-1.html**

McLoughlin PD, Stewart K, Superbie C, Perry T, Tomchuk P, Greuel R, Singh K, Truchon-Savard A, Henkelman J, Johnstone JF (Department of Biology, University of Saskatchewan). 2016. Population dynamics and critical habitat of woodland caribou in the Saskatchewan Boreal Shield. Interim Project Report, 2013-2016.

McPhail, J.D. and C.C. Lindsey. 1970. Freshwater fishes of northwestern Canada and Alaska. Bull. Fish. Res. Board Can. 173. Ottawa, ON. 381 pp.

Newfoundland and Labrador Fisheries and Land Resources (NL FLR). 2019. American Mink. Retrieved from, **https://www.flr.gov.nl.ca/wildlife/snp/programs/education/animal_facts/mammals/mink.html**

Omnia (Omnia Ecological Services), 2020. Denison Mines Corporation Wheeler River Project - Terrestrial Environment Wildlife and Vegetation Baseline Inventory.

United States Environmental Protection Agency (U.S. EPA). 1993. Wildlife Exposure Factors Handbook. Document No. EPA/600/R-93/187. December.

U.S. FWS (Fish and Wildlife Service), 2017. Species Status Assessment for the Canada Lynx (Lynxcanadensis), Contiguous United States Distinct Population Segment. Version 1.0 - Final, October 2017.

Wilson D, and Ruff S. 1999. The Smithsonian Book of North American Mammals. Smithsonian Institution Press, Washington.

Denison Mines

Wheeler River Project

Final Environmental Impact Statement

November 2024

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Section 10: Engagement Database Summary Table – Human Health and Safety

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments (From Interested Party)	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
18-EN-VB-4.38	4	Workshop	2018-18-01	As part of the engagement program for the Wheeler River Project, Denison organized a workshop in Beauval for community members to attend. The workshop gathered community input in relation to road alignment options, treated effluent discharge locations, and mining methods.	Village of Beauval	Once mining is over, is the water drinking water quality?	Denison considered this in section: Residual Effects Evaluation, Summary of Human Health Risk Assessment, Human Receptors Selection Characterization	The context in which this comment was used within the Human Health and Safety section of the EIS serves as a local perspective, documented as coming from an individual who attended workshop in Beauval in the year 2018. The record reference serves to highlight dialogue surrounding drinking water quality in relation to baseline monitoring data. At present, groundwater is unsuitable for consumption as it interacts with the uranium ore body, resulting in high levels of uranium. When mining is over, the groundwater will remain unsuitable for consumption. Denison will remediate groundwater to meet acceptable regulatory standards.
18-EN-ERFN-5.69	5	Workshop	2018-05-03	As part of the engagement program for the Wheeler River Project, Denison organized a workshop for ERFN at their Patuanak Reserve location for ERFN and Patuanak members to attend. The workshop aimed to gather community input in relation to road alignment options, treated effluent discharge locations, and mining methods. The meeting had been delayed many times, and was held in the Health Clinic because there was a regional power outage.	English River First Nation	A lot of those lakes would not be immediately impacted, but what about down the road? It changes. One lake (Lanspur Lake) about three years ago had no pickerel. In the last 2-3 years, with high water, that lake now has an abundance of pickerel. Those are some of the changes that happen. That comes from our elders, not from me.	Denison considered this in section: Existing Environment, Baseline Monitoring Data	The context in which this comment was used within the Human Health and Safety section of the EIS serves as a local perspective, documented as coming from a member of English River First Nation who attended a workshop in the year 2018. The record reference serves to highlight dialogue surrounding local fisheries in relation to baseline monitoring data. Denison has completed an environmental assessment to understand Project impacts on the environment. The assessment considers potential impacts to the aquatic environment and potential cumulative effects. Significance determination includes, but is not limited to, consideration of time, frequency, and duration Denison has determined that there will be no significant impacts as a result of Project activities.
19-LK-ERFNTrap-134.72	134	Site Visit	2019-10-29	Denison met with local land user and English River First Nation Trapper at the Wheeler River Project site location for a full-day to interview them regarding their knowledge of the area, including providing information and feedback on specifics pertaining to wildlife and wildlife movement patterns, fish and spawning areas, local lakes and lake names, recreational and commercial use, traditional food consumption, and specific aspects of the Wheeler River Project. ERFN Trapper provided consent to Denison to use the information provided in the environmental assessment. ERFN Trapper reviewed the notes taken from the meeting, and provided revisions / modifications to Denison on January 2, 2020.	ERFN Trapper	Fishing is a big part of my income. Right now, it is more worthwhile to fish commercially than it is to spend time trapping because fur prices, except for marten, are poor.	Denison considered this in section: Existing Environment, Baseline Monitoring Data	The context in which this comment was used within the Human Health and Safety section of the EIS serves as a local perspective, documented as coming from ERFN Trapper who attended a site visit in the year 2019. The record reference serves to highlight dialogue surrounding local fisheries in relation to baseline monitoring data.
19-LK-ERFNTrap-134.131	134	Site Visit	2019-10-29	Same as above	ERFN Trapper	Food – natives prefer jackfish, whitefish, trout; whites go for walleye; Ceremonial purposes – don't know of any; commercial purposes (e.g., bait fish) – mullet (white	Denison considered this in section: Existing Environment, Traditional Foods Diet	The context in which this comment was used within the Human Health and Safety section of the EIS serves as a local perspective, documented as coming from ERFN Trapper who attended a site visit in the year

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments (From Interested Party)	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
						sucker) collected for bait; Walleye is the most valuable catch=> highest price per kilo at the fish plant.		2019. The record reference serves to highlight aspects of the traditional foods diet in relation to the existing environment.
19-LK-ERFNTrap-134.151	134	Site Visit	2019-10-29	Same as above	ERFN Trapper	Caribou: ERFN Trapper sees more caribou and less moose. When ERFN Trapper goes out to check traplines in the winter they see caribou quite regularly. They also see caribou in the summer.	Denison considered this in section: Existing Environment, Traditional Foods Diet	The context in which this comment was used within the Human Health and Safety section of the EIS serves as a local perspective, documented as coming from ERFN Trapper who attended a site visit in the year 2019. The record reference serves to highlight aspects of the traditional foods diet in relation to the existing environment.
19-LK-ERFNTrap-134.156	134	Site Visit	2019-10-29	Same as above	ERFN Trapper	Caribou: Overall, there are the same number of caribou in the area over the years but there is less moose.	Denison considered this in section: Existing Environment, Traditional Foods Diet	The context in which this comment was used within the Human Health and Safety section of the EIS serves as a local perspective, documented as coming from ERFN Trapper who attended a site visit in the year 2019. The record reference serves to highlight aspects of the traditional foods diet in relation to the existing environment.
19-LK-ERFNTrap-134.160	134	Site Visit	2019-10-29	Same as above	ERFN Trapper	Marten, Fisher and Wolverine: In recent memory, marten is much more commonly observed compared to fisher. Probably 9 or 10 out of 10 would be marten. In fact, last year ERFN Trapper caught 90 marten and no fisher.	Denison considered this in section: Existing Environment, Traditional Foods Diet	The context in which this comment was used within the Human Health and Safety section of the EIS serves as a local perspective, documented as coming from ERFN Trapper who attended a site visit in the year 2019. The record reference serves to highlight aspects of the traditional foods diet in relation to the existing environment.
19-LK-ERFNTrap-134.163	134	Site Visit	2019-10-29	Same as above	ERFN Trapper	Prey Species: In recent years, there are fewer rabbits (snowshoe hare) and bush chickens (grouse species).	Denison considered this in section: Existing Environment, Traditional Foods Diet	The context in which this comment was used within the Human Health and Safety section of the EIS serves as a local perspective, documented as coming from ERFN Trapper who attended a site visit in the year 2019. The record reference serves to highlight aspects of the traditional foods diet in relation to the existing environment.
19-LK-ERFNTrap-134.164	134	Site Visit	2019-10-29	Same as above	ERFN Trapper	Prey Species: Also, way less ptarmigan in winter. Less mallards and Canada geese, more surf Scoters (Melanitta perspicillata).	Denison considered this in section: Existing Environment, Traditional Foods Diet	The context in which this comment was used within the Human Health and Safety section of the EIS serves as a local perspective, documented as coming from ERFN Trapper who attended a site visit in the year 2019. The record reference serves to highlight aspects of the traditional foods diet in relation to the existing environment.
19-LK-ERFNTrap-134.166	134	Site Visit	2019-10-29	Same as above	ERFN Trapper	Birds: There are fewer loons on Cree Lake even though the number of fish caught here remains unchanged. There are still loons at Russell Lake. Russell Lake also has a growing population of Red Throated Loons (Gavia stellata).	Denison considered this in section: Existing Environment, Traditional Foods Diet	The context in which this comment was used within the Human Health and Safety section of the EIS serves as a local perspective, documented as coming from ERFN Trapper who attended a site visit in the year 2019. The record reference serves to highlight aspects of the traditional foods diet in relation to the existing environment.
19-LK-ERFNTrap-134.255	134	Site Visit	2019-10-29	Same as above	ERFN Trapper	Russell is one lake where I commercially fish. How will this effluent impact the water quality, fish health? Will I be able to sell fish	Denison considered this in section: Existing Environment, Baseline Monitoring Data	The context in which this comment was used within the Human Health and Safety section of the EIS serves as a local perspective, documented as coming from ERFN Trapper who attended a site visit in the year 2019. The record reference serves to highlight dialogue

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments (From Interested Party)	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
						from here? If there is going to water pollution, I just want to know.		surrounding local fisheries in relation to baseline monitoring data. Water quality in Whitefish Lake and, by extension, downstream of Whitefish Lake will meet appropriate benchmarks for the protection of aquatic life in consideration of a small mixing zone in the lake. Following Decommissioning and the restoration of drainage patterns that are similar to pre-mining conditions, water quality is expected to meet appropriate benchmarks for the protection of aquatic life in Whitefish Lake and downstream. This includes Russell Lake of which the Icelander River system is associated. Denison has completed an environment assessment to understand Project impacts on the environment. The assessment considers potential impacts to traditional and other land use activities, fishing and water quality. Denison additionally completed a human health risk assessment. Denison has determined that there will be no significant impacts as a result of Project activities.
21-EN-ERFNSUR-456.21	456	Survey	2021-04-09	As part of engagement activities for English River First Nation, Denison prepared and shared an online survey which included information about Denison, the Wheeler River Project, and posed validation questions about the Valued Components being assessed as part of the environmental assessment process. A total of 23 responses were received. The information related to the Valued Components was incorporated into the assessment and questions asked on the surveys was incorporated into the overall engagement database.	English River First Nation	Denison Question: Based on what you know so far about the Wheeler Project, what aspects of the project could be challenging or cause concern for your community? Response: Health and well-being of humans and wildlife.	Denison considered this in section: Residual Effects Evaluation, Summary of Human Health Risk Assessment, Human Receptors Selection Characterization	The context in which this comment was used within the Human Health section of the EIS serves as a local perspective, documented as coming from a member of English River First Nation who completed a survey in the year 2021. The record reference serves to highlight an emphasis on human health from within the engagement database. Denison has completed an environmental assessment to understand Project impacts on the environment. The assessment considers potential impacts to humans and wildlife. Denison has determined that there will be no significant impacts as a result of Project activities.
21-EN-ERFNSUR-456.22	456	Survey	2021-04-09	Same as above	English River First Nation	Denison Question: Based on what you know so far about the Wheeler Project, what aspects of the project could be challenging or cause concern for your community? Response: Health	Denison considered this in section: Residual Effects Evaluation, Summary of Human Health Risk Assessment, Human Receptors Selection Characterization	The context in which this comment was used within the Human Health section of the EIS serves as a local perspective, documented as coming from a member of English River First Nation who completed a survey in the year 2021. The record reference serves to highlight an emphasis on human health from within the engagement database. Denison has completed an environmental assessment to understand Project impacts on the environment. The assessment considers potential impacts to human health. Denison has determined that there will be no significant impacts as a result of Project activities.
22-EN-SUR-652.73	652	Survey	2022-06-03	As part of engagement activities for English River First Nation, Beauval, and Pinehouse, Denison prepared and shared, both online and as a hardcopy during Spring Engagement meetings, a survey that asked a series of	Unknown	Denison Question: What additional information would be helpful for you to	Denison considered this in section:	The context in which this comment was used within the Human Health section of the EIS serves as a local perspective, documented as coming from an individual from English River First Nation, Beauval, or Pinehouse,

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments (From Interested Party)	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
				questions relating to the results of the environmental assessment. A total of 39 surveys were entirely or partially completed.		understand the Project and its potential impacts to people and the environment? Response: Are water samples being taking for human consumption	Residual Effects Evaluation, Summary of Human Health Risk Assessment, Human Receptors Selection Characterization	who completed a survey in the year 2022. The record reference serves to highlight an emphasis on human health from within the engagement database. Denison has completed an environmental assessment to understand Project impacts on the environment. The assessment considers potential impacts to surface water, groundwater, and human health. Denison has determined that there will be no significant impacts as a result of Project activities. Monitoring will be implemented, per the Environmental Management System, in relation to regulatory requirements associated with the environment, including effluent monitoring and groundwater monitoring.

Denison Mines

Wheeler River Project

Final Environmental Impact Statement

November 2024

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WORKER DOSE ASSESSMENT

FOR THE WHEELER RIVER PROJECT

DRAFT REPORT PREPARED FOR:

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Ref. 20-2663
30 August 2023

Ecometrix | Environmental INTELLIGENCE

WORKER DOSE ASSESSMENT

FOR THE WHEELER RIVER PROJECT

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Reviewer

EXECUTIVE SUMMARY

The Wheeler River Project proposes the development of the high-grade Phoenix uranium deposit as an in-situ recovery (ISR) mining operation with on-site processing. This worker dose report provides technical detail regarding radiological doses to workers involved in the ISR operations, and supports the Human Health Assessment, which is part of the Wheeler River Environmental Assessment (EA).

The ISR operations involve a wellfield, where uranium is extracted from the ore body in a circulating lixiviant solution (mining solution), and the ISR Plant, where uranium is precipitated out of solution to make the yellowcake product. The fresh yellowcake will be dried and calcined, and then packaged for transport.

Prior to uranium precipitation, unwanted constituents, particularly iron (Fe) and radium (Ra), will be removed from solution by precipitation. The process precipitate sludge will contain enough uranium to be considered an asset and it is expected to be sent offsite for processing at an eligible licensed facility. Secondary options include offsite disposal, long term reclamation and storage in place on surface or re-slurry and injection below ground at the end of mining.

Other stored waste includes drill cuttings from the wellfield. Drill cuttings from the ore body will be segregated and stored at a special waste pad. The intent is to convey this ore material to a conventional uranium mill for processing, during operations and/or at the end of mining. As a secondary option, the material may be contained and reclaimed on site for long term storage.

Workers engaged in the operation of the Wheeler River Project will be occupationally exposed to radiation sources in several work areas in the process of drilling, lixiviant recovery and processing to yellowcake. Expected exposure pathways are through inhalation of dust and radon, as well as external exposure to gamma radiation from process solids and liquids containing radionuclides of the U-238 decay chain.

Radon (and short-lived progeny) are of primary concern at the front end of the ISR process, where solutions and precipitates bearing Ra-226 and daughter Rn-222 are present. Gaseous Rn-222 grows in rapidly from decay of Ra-226. When lixiviant is initially brought from the ore body to the land surface, Rn-222 gas is supersaturated in the solution, and will off-gas rapidly when exposed to air. Venting is undertaken initially to facilitate off-gassing to the open atmosphere. Within the ISR plant, Rn-222 in solution is supported by ingrowth from Ra-226, and Rn-222 gas can partition from open solutions or precipitates to indoor air.

Long-lived radioactive dust is of primary concern at the back end of the ISR process, since the process is wet until the yellowcake product (uranium oxides) is precipitated out of solution and dried. The long-lived species of concern at that point are U-238 and U-234. Both species can be inhaled from air in drying and packaging areas.

Ore dust is also of potential concern when handling ore material that is subject to drying. The drilling process is wet, but cores may become dry. In ore material, all the radionuclides of the U-238 series are present, and all may contribute to worker dose if dust is inhaled.

External gamma exposure is of potential concern throughout the ISR process, when workers spend time in close proximity to a source, particularly a large volume with high concentrations of U-238 series radionuclides. Container materials may provide shielding and thereby reduce the radiation dose.

Doses to workers at the Wheeler River Project are expected to be within the annual dose limit of 20 mSv/a (as a 5-year average) for nuclear energy workers (NEWs). Uranium dust levels in the drying and packaging/loading areas should be monitored and kept as low as reasonably achievable (ALARA). Equipment sources of dust will be enclosed under negative pressure.

Dust inhalation is also a potentially significant component of dose at the core shack. At this location, dust levels will be monitored, and time in the shack will be managed to control dose from inhalation of ore dust. it may be possible to increase air exchange in the core shack, above the planned 6 exchanges per hour, should this be necessary. This would help also with radon exposure in the core shack.

For external radiation exposure, the most significant sources are ore cuttings in drums on the wellfield and totes of filter cake in the process precipitate removal area. Doses from external sources can be most effectively reduced by minimizing time at close distance. In the first case of drums on the wellfield, increasing distance to the drums is a readily available option. For exposure to totes of filter cake in the ISR plant, external dose can be minimized by managing the quantity of filter cake in the work area, as well as worker proximity.

External doses from ore cuttings stored at the special waste pad were assumed to be mitigated by a berm around the pad, which provides shielding. However, this area is a potentially significant source of external dose, and work inside the berm should be minimized.

In general, it will be necessary to manage work sequence and schedule to avoid prolonged exposures close to identified sources, especially those identified as being significant to worker dose. Doses can be most effectively reduced by reducing exposure times and maximizing distances from the source, as well as by use of protective shielding.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 Introduction

1.1 Wheeler River Project

The Wheeler River Project proposes the development of the high-grade Phoenix uranium deposit as an in-situ recovery (ISR) mining operation with on-site processing. Denison Mines Corp. (Denison) is the operator of the Wheeler River Joint Venture and holds a 90% interest (directly or through its subsidiaries). JCU (Canada) Exploration Company Ltd. owns the remaining 10% of the joint venture. As of August 3, 2021, Denison acquired 50% of JCU. The Project is located approximately 35 km north-northeast of Cameco's Key Lake Operation and 35 km southwest of Cameco's McArthur River Operation in the eastern portion of the Athabasca Basin region in northern Saskatchewan.

Denison has prepared the Wheeler River Environmental Assessment (EA) to evaluate the potential effects of the Project on the environment and human health. This worker dose report provides technical detail regarding radiological doses to workers involved in the ISR operations, and supports the Human Health Assessment, which is part of the EA.

The ISR operations involve a wellfield, where uranium is extracted from the ore body in a circulating lixiviant solution (mining solution), and the ISR Plant, where uranium is precipitated out of solution to make the yellowcake product. The fresh yellowcake will be dried and potentially calcined, and then packaged for transport. Figure 1.1 shows a schematic overview of the process.

Prior to uranium precipitation, unwanted constituents, particularly iron (Fe) and radium (Ra), will be removed from solution by precipitation. The process precipitate sludge will contain enough uranium to be considered an asset and is it expected to be sent offsite for processing at an eligible licensed facility. Secondary options include offsite disposal, long term reclamation and storage in place on surface or re-slurry and injection below ground at the end of mining.

Other stored waste includes drill cuttings from the wellfield. Drill cuttings from the ore body will be segregated and stored at a special waste pad. The intent is to convey this ore material to a conventional uranium mill for processing, during operations and/or at the end of mining. As a secondary option, the material may be contained and reclaimed on site for long term storage.

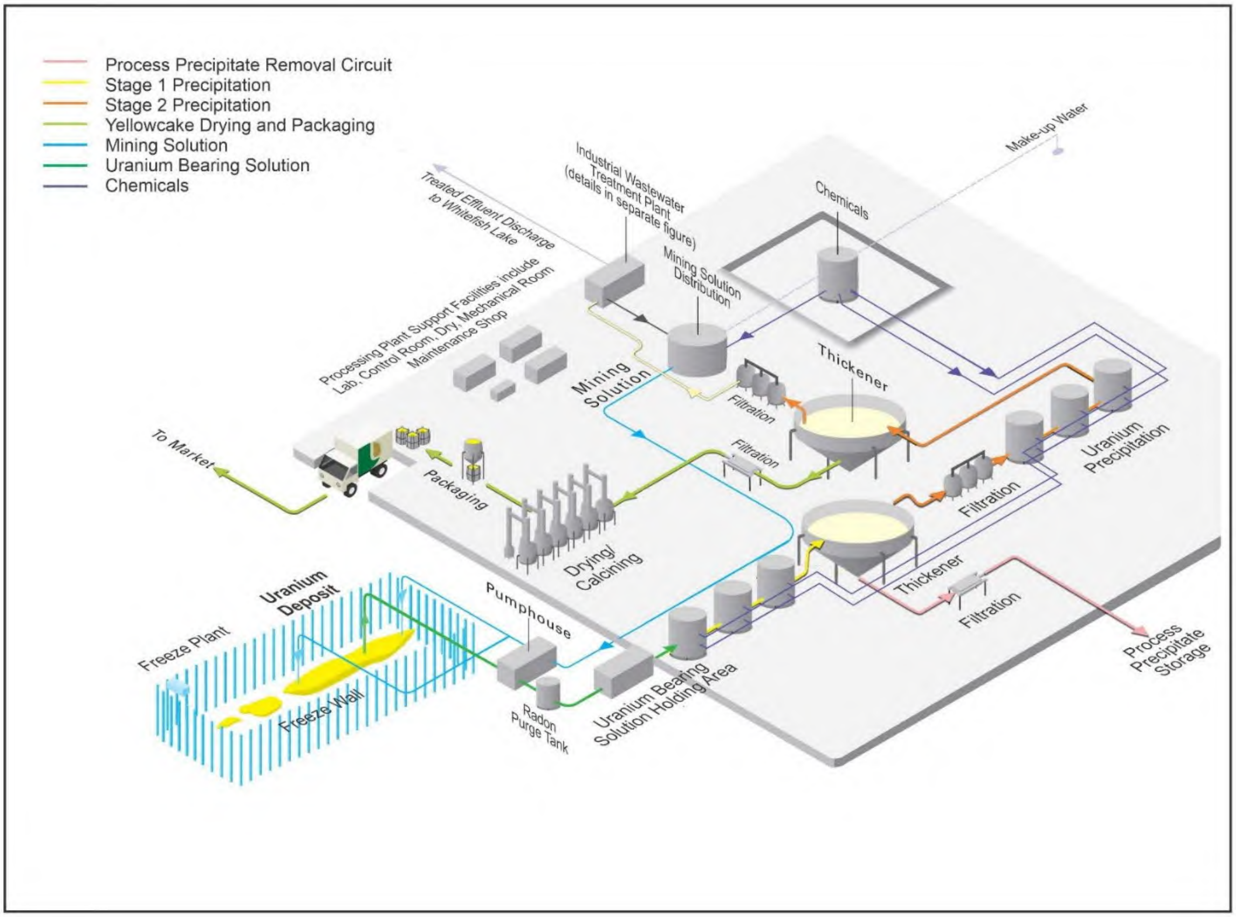


Figure 1.1: Schematic Overview of the ISR Process

1.2 Worker Component of Human Health Assessment

The Human Health component of the EA will address radiological and non-radiological exposures to members of the public, and to workers involved in the ISR process.

This worker dose report specifically addresses the radiological dose to workers, and will provide this information to the Human Health component of the EA. In addition, the worker dose information will inform the development of the Radiation Protection Plan, which will be prepared as a mitigation measure in order to control worker exposure and dose.

Information on the Project operations and work activities was provided by Denison. Based on this, EcoMetrix identified important work areas, sources and exposure pathways by which workers are likely to receive radiation doses, and requested from Denison detailed information needed to develop radiation exposure scenarios for each job category. The information, such as radionuclide concentrations in source materials, source shapes and volumes, container materials, building volumes and air exchange rates, and worker time spent near sources, was provided by Denison and outlined by Ecometrix in a memo (Ecometrix, 2023), for confirmation by Denison, and is described in Section 3, below. EcoMetrix then applied standard methodology to calculate worker doses, as described in Section 4, presented dose results and discussed radiation protection strategies.

2.0 Regulatory Context

The EA for the Project is subject to federal and provincial approval under the *Canadian Environmental Assessment Act 2012*. The Canadian Nuclear Safety Commission (CNSC) is the responsible authority for the environmental assessment, since the Project will be regulated under the *Nuclear Safety and Control Act* (NSCA). Following EA approval, the Project will be subject to licensing under the NSCA, and the CNSC will be the regulatory body.

The *Radiation Protection Regulations* under the NSCA outline the regulatory requirements with respect to control of radiation doses to both workers and members of the public. Workers subject to radiation exposure from the Project will be designated as Nuclear Energy Workers (NEWs) and as such their radiation doses will be monitored and controlled so as not to exceed radiation dose limits for workers. These dose limits are:

- 50 mSv/a annual effective dose in any year
- 100 mSv as a 5-year effective dose (implies 20 mSv/a average annual effective dose)
- 50 mSv/a equivalent dose to lens of eye
- 500 mSv/a equivalent dose to skin

For any NEW who is pregnant, the effective dose limit is lowered to 4 mSv/a for the balance of pregnancy, after the licensee has been informed, and doses must be managed accordingly.

In uranium mining, the main sources of radiation dose include:

- External gamma radiation, received while in proximity to radioactive sources
- Long-lived radioactive dust (U-238, U-234, Th-230, Ra-226, Pb-210, Po-210)
- Radon (Rn-222) and short-lived progeny (Po-218, Pb-214, Bi-214, Po-214)

The *Radiation Protection Regulations* require monitoring and control of radon exposure, as well as total effective dose and equivalent dose. While radon concentration limits are not specified in the regulation, other workplace standards may be considered relevant. Health Canada (2014) guidelines call for a Radiation Protection Program if annual average radon in the workplace exceeds 800 Bq/m^3 and specify that the annual average should not exceed 3,000 Bq/m^3.

3.0 Worker Exposure Situations

3.1 Radionuclides and Exposure Pathways

The primary radionuclides that workers may be exposed to include radionuclides of the U-238 decay chain, including radon and short-lived progeny.

Workers engaged in the operation of the Wheeler River Project will be occupationally exposed to radiation sources in several work areas in the process of drilling, lixiviant (mining solution) recovery and processing to yellowcake. Expected exposure pathways are through inhalation of dust and radon, as well as external exposure to gamma radiation from process solids and liquids containing radionuclides of the U-238 decay chain.

Radon (and short-lived progeny) are of primary concern at the front end of the ISR process, where solutions and precipitates bearing Ra-226 and daughter Rn-222 are present. Gaseous Rn-222 grows in rapidly from decay of Ra-226. When lixiviant is initially brought from the ore body to the land surface, Rn-222 gas is supersaturated in the solution, and will off-gas rapidly when exposed to air. Venting is undertaken initially to facilitate off-gassing to the open atmosphere. Within the ISR plant, Rn-222 in solution is supported by ingrowth from Ra-226, and Rn-222 gas can partition from open solutions or precipitates to indoor air.

The short-lived progeny of Rn-222, specifically Po-218, Pb-214, Bi-214 and Po-214, grow in rapidly from the airborne radon, and are more important to dose than radon. Both radon and short-lived progeny can be inhaled from air and contribute to worker dose.

Long-lived radioactive dust is of primary concern at the back end of the ISR process, since the process is wet until the yellowcake product (uranium oxides) is precipitated out of solution and dried. The long-lived species of concern at that point are U-238 and U-234. The uranium mass is almost entirely U-238; on an activity basis, U-238 and U-234 contribute equal activity. Both species can be inhaled from air in drying and packaging areas.

Ore dust is also of potential concern when handling ore material that is subject to drying. The drilling process is wet, but cores may become dry. In ore material, all the radionuclides of the U-238 series are present, and all may contribute to worker dose if dust is inhaled.

External gamma exposure is of potential concern throughout the ISR process, when workers spend time in close proximity to a source, particularly a large volume with high concentrations of U-238 series radionuclides. Container materials may provide shielding and thereby reduce the radiation dose.

3.2 Work Areas and Radiation Sources

Occupational exposure is expected to occur during multiple stages of the ISR process. The following locations and associated sources and worker functions are considered in this assessment:

- Wellfield: Drillers on the wellfield will be exposed to radiation from ore cuttings stored in drums at the well head. Wellfield operators/workers will be exposed to radiation from uranium bearing solution (UBS) in pipes and at the pumphouse and at the UBS storage pond. In addition, wellfield operators may be exposed to radiation from process precipitate slurry in piping at the disposal wellfield, in the event that this material is injected underground (not the preferred option). Both drillers and wellfield operators will be exposed to low levels of radon in outdoor air due to venting at the wellfield, from piping and from the UBS pond.

- The ISR plant consists of 5 areas that each have multiple sources for occupational radiation exposure, as follows:

    - Plant operators/workers in the process precipitate removal area will be exposed to radiation from the UBS feed tank and the process precipitate thickener. Additionally, it is expected that up to three totes of filter cake will be intermittently stored in this area before it is taken to the Process Precipitate pond. Plant operators/workers in the process precipitate removal will be exposed to radon arising from several sources - the open solution in the thickener, and the filter cake.

    - During the yellowcake precipitation, plant operators/workers in this area will be exposed to radiation from the precipitation tank and the yellowcake thickener. Additionally, there will be yellowcake in the conveyor that transports yellowcake to the drying area. Plant operators/workers in the yellowcake precipitation area will be exposed to radon arising from the open solution in the thickener.

    - The water treatment process involves three clarifiers which will be sources of radiation exposure for plant operators/workers in the water treatment area. Precipitated solids from first stage treatment will be conveyed to the Process Precipitate pond; second stage solids will be conveyed to the gypsum pond. Plant operators/workers in the water treatment area will be exposed to radon arising from the open solution in the clarifiers.

    - In the drying area plant operators/maintenance workers will be exposed to radiation from yellowcake in the drier and in the possible calciner. In addition, they will be potentially exposed to radioactive dust in the air from the dried yellowcake product. Equipment sources of dust will be enclosed under negative pressure.

    - In the packaging area plant operators/workers will be exposed to radiation from drums of yellowcake product in the loading bay. In addition, they will be potentially exposed to radioactive dust in the air from the dried yellowcake product. Equipment sources of dust will be enclosed under negative pressure.

- Several waste pads and ponds on site are considered as sources of radiation exposure for equipment operators. These include the special waste pad for drill cuttings from the ore zone, and the Process Precipitate Pond. Equipment operators in these areas will also be exposed to radon in outdoor air from various sources, including the wellfield and the Process Precipitate pond.

- The core shack will hold up to 3 cores that will constitute a source of radiation exposure for geologists and geotech loggers working in this area. In addition, the cores will be a source of both radioactive dust and radon to the air in the core shack, resulting in exposures to the workers in this area.

A summary of all exposure situations is presented in Table 3.1.

Table 3.1: Exposure Locations and Sources

<table>
<tr><th>Location</th><th>Work Area</th><th>Source</th><th>Worker Function</th></tr>
<tr><td rowspan="4">Wellfield</td><td>Wellfield drilling</td><td>Cuttings in drum</td><td>Driller 1</td></tr>
<tr><td>Pump houses</td><td>UBS in pump house piping</td><td>Wellfield Operator 1</td></tr>
<tr><td>UBS Pond</td><td>UBS in storage pond</td><td>Wellfield Operator 1</td></tr>
<tr><td>Wellfield piping</td><td>UBS in piping</td><td>Wellfield Operator 2 [a]</td></tr>
<tr><td rowspan="9">ISR Plant</td><td rowspan="3">Process precipitate removal Area</td><td>UBS feed tank</td><td rowspan="3">Plant Operator 1 [a]</td></tr>
<tr><td>Totes of filter cake</td></tr>
<tr><td>Process precipitate thickener</td></tr>
<tr><td rowspan="3">Yellowcake Precipitation Area</td><td>Yellowcake precipitation tank</td><td rowspan="3">Plant Operator 2 [a]</td></tr>
<tr><td>Yellowcake conveyor</td></tr>
<tr><td>Yellowcake thickener</td></tr>
<tr><td>Water Treatment Area</td><td>WTP clarifier</td><td>Plant Operator 3 [a]</td></tr>
<tr><td>Drying Area</td><td>Yellowcake</td><td>Plant Operator 4 [a]</td></tr>
<tr><td>Packaging Loading Area</td><td>Yellowcake</td><td>Plant Operator 5 [a]</td></tr>
<tr><td rowspan="3">Site Ponds Pads</td><td>Special Waste Pad</td><td>Drill cuttings</td><td>Equipment Operator 1</td></tr>
<tr><td>Industrial Landfill</td><td>none</td><td>Equipment Operator 1</td></tr>
<tr><td>Process Precipitate Pond</td><td>Process precipitate</td><td>Equipment Operator 1</td></tr>
<tr><td>Site infrastructure</td><td>Core Shack</td><td>3 cores</td><td>Geologist/Geotech Loggers</td></tr>
</table>

(a) Operator and Maintenance worker have the same exposure characteristics

3.3 Exposure Scenarios and Assumptions

3.3.1 Inhalation Scenarios

Workers at the Wheeler River Project may be exposed to radionuclides through inhalation of dust containing U-238 and its daughters, which can be produced when ore or product is handled. Rn-222 is a gaseous daughter of Ra-226; it will quickly dissipate outdoors, but can become a radiological hazard indoors, mainly due to ingrowth of short-lived progeny.

3.3.1.1 Exposure to Uranium Dust in Air

Radionuclide concentrations in dust and air, as well as worker occupancy in each exposure area, are summarized in Table 3.2. Atmospheric modelling results were used for uranium dust concentrations in outdoor areas, which arise mainly from stacks at the ISR plant (EIS Appendix 6-A). Concentrations of radionuclides in dust for indoor locations were estimated as described in this section.

Table 3.2: Concentrations in Dust and Occupancy in Work Area for the Indoor and Outdoor Dust Inhalation Scenarios

Work Area	Worker	Respirable Dust in Air (kg/m³)	U-238 in Dust (Bq/kg)	Ra-226 in Dust (Bq/kg)	U-238 in Air (Bq/m³)	Daily Occupancy h/d	Active months per year [d]
Wellfield	Driller 1	-	-		9.49E-04[a]	11	8
Wellfield	Wellfield Operator 1, 2	-	-		9.49E-04[a]	8	12
Process Precipitate Removal Area	Plant Operator 1	-	-		3.41E-03[a]	8	12
Yellowcake Precip Area	Plant Operator 2	-	-		3.41E-03[a]	8	12
Water Treatment Area	Plant Operator 3	-	-		3.41E-03[a]	8	12
Drying Area	Plant Operator 4	4.00E-07	9.74E+06		3.90E+00[b]	4	12
Packaging Loading Area	Plant Operator 5	4.00E-07	9.74E+06		3.90E+00[b]	4	12
Special Waste Pad	Equipment Operator 1	-	-		6.83E-03[a]	2	12
Process Precipitate Pond	Equipment Operator 1	-	-		9.95E-04[a]	4	12
Industrial Landfill	Equipment Operator 1	-	-		4.25E-04[a]	3	12
Core Shack	Geologist/ Geotech Logger	6.75E-08	2.99E+06	2.06E+06	2.02E-01[c]	11	6

(a) U-238 (Bq/m³) in air calculated by IEC (EIS Appendix 6-A) µg/m³ in outdoor air at each location, operations phase, with calciner

(b) U-238 in air shown for drying and packaging areas is an ambient concentration, based on design value for dust in the main room of the drying area (0.5 mg/m³ total)

(c) U-238 in air for core shack based on an administrative level for respirable dust equal to ¼ of the ACGIH Threshold Limit Value (TLV); U-238 concentration in dust from ore assays by R and D Enterprises (2018)

(d) Workers are assumed to work 20 days per month

In the ISR plant, a dust concentration for the main room of the drying area was obtained as a conservative design estimate (0.5 mg/m^3 total), although the drier and calciner will be enclosed under negative pressure. It is expected that 80% by mass will be of particle sizes smaller than 10 µm and, as such, respirable (EPA, 1980), resulting in a respirable dust in air concentration of 0.4 mg/m^3. The dust was assumed to be UO_4, and the U concentration (all U-238 by mass) was estimated from the atomic weights as 7.88E+05 mgU/kg. The activity concentration of U-238 was calculated as 9.74E+06 Bq/kg using a specific activity of 12.356 Bq/mg U, and U-234 was assumed to be present in secular equilibrium. Workers in the packaging/loading area were assumed to experience the same concentrations as workers in the drying area.

In the core shack, dust was assumed to be uranium ore. Dust levels in the shack will be maintained below ¼ of the ACGIH Threshold Limit Value (TLV) of 0.27 mg/m^3 for respirable dust (Verma et al., 2015). The concentration of uranium per unit mass in ore was taken from pilot studies that found uranium concentrations in ore heads to be 2.42E+05 mgU/kg (R and D Enterprises, 2018). The activity concentration was calculated using a specific activity of 12.356 Bq/mg U. The Ra-226 concentration was also measured in the aforementioned pilot studies.

For exposure to ore dust in the core shack, progeny were considered to be in secular equilibrium with U-238 and Ra-226. For U-238, this includes equal concentrations of Th-234, U-234 and Th-230. For Ra-226, the progeny included are Pb-214, Bi-214, Pb-210, Bi-210, Po-210. Radon is considered separately in the following section.

3.3.1.2 Estimation of Radon in Air

Rn-222 concentrations in air, as well as time spent by workers in each considered area, are summarized in Table 3.3. Radon concentrations in outdoor work areas were taken from atmospheric modelling results (EIS Appendix 6-A). Radon concentrations were estimated for indoor work areas as described in this section.

Table 3.3: Concentrations of Radon and Occupancy in Work Area for the Indoor and Outdoor Radon Inhalation Scenarios

Work Area	Worker	Source	Rn-222 in Air (Bq/m³)	Daily Occupancy h/d	Active months per year [b]
Wellfield	Driller 1	Outdoor	6.75E+01[a]	11	8
Wellfield	Wellfield Operator 1, 2	Outdoor	6.75E+01[a]	8	12
Process Precipitate Removal Area	Plant Operator 1	Outdoor	1.17E+02[a]	8	12
		Cake	2.72E+01		
		Thickener	7.35E+02		
Yellowcake Precip Area	Plant Operator 2	Outdoor	1.17E+02[a]	8	12
		Thickener	4.96E+02		
Water Treatment Area	Plant Operator 3	Outdoor	1.17E+02[a]	8	12
		Clarifier	1.28E+02		
Drying Area	Plant Operator 4	Outdoor	1.17E+02[a]	4	12
Packaging Loading Area	Plant Operator 5	Outdoor	1.17E+02[a]	4	12
Special Waste Pad	Equipment Operator 1	Outdoor	8.82E+02[a]	2	12
Process Precipitate Pond	Equipment Operator 1	Outdoor	9.03E+01[a]	4	12
Industrial Landfill	Equipment Operator 1	Outdoor	2.97E+01[a]	3	12
Core Shack	Geologist/Geotech Logger	Outdoor	6.75E+01[a]	11	6
		Cores	1.18E+03		

(a) Rn-222 (Bq/m³) in air taken from IEC (2022) value in outdoor air at each location, operations phase, with calciner
(b) Workers are assumed to work 20 days per month

Two work areas in the ISR Plant are of particular interest with respect to radon partitioning from the circulating uranium bearing solution (UBS) to the indoor air: the Process Precipitate Removal Area and the Yellowcake Precipitation Area, both areas where the solution passes through a thickener that is open to air. In the Process Precipitate Removal Area there is also process precipitate cake that can partition radon to air.

The WTP work area is also of interest with respect to radon partitioning to air, as there will be residual radon in the water being treated, and this water will be open to air in the clarifiers.

The radon concentration in each work area as a result of partitioning from the uranium bearing solution was estimated based on the USNRC (1999) equation for radon transfer from household water to indoor air (USNRC, 1999), as follows:

$$TC = \frac{C_a}{C_w} = UR \times \frac{TE}{(ER \times V)}$$

Where:

TC = transfer coefficient (m^3/m^3)
C_a = radon (Rn-222) in air (Bq/m^3)
C_w = radon (Rn-222) in water (Bq/m^3)
UR = water use rate (m^3/h)
TE = transfer efficiency (unitless)
ER = air exchange rate (1/h)
V = air volume (m^3)

It was assumed that the Rn-222 concentration in water (UBS) entering the ISR plant equals the Ra-226 concentration in water (3,000 Bq/L). Solution arriving at the UBS Pond is expected to contain 3,700 Bq/L Rn-222 (IEC, 2022) but this would be reduced over the 7-day retention time, due to decay and volatilization, to a level supported by Ra-226. The water use rate was taken to be the process plant feed rate of UBS (30 m^3/h) (Denison Mines, 2021a). Transfer efficiency was taken to be 0.55 as recommended by the USNRC. The air exchange rate was the design value of 6 air exchanges per hour. The air volume used was the design volume of each work area – 11,232 m^3 for the Process Precipitate Removal Area, 7,488 m^3 for Yellowcake Precipitation Area, and 13,104 for the WTP Area (Ecometrix, 2022).

Denison completed pilot studies (Ecometrix, 2023), to determine that the maximum Ra-226 in uranium bearing solution entering the Process Precipitate Removal Area was 3,000 Bq/L (3.0E+06 Bq/m^3). After process precipitate removal, the maximum Ra-226 in the yellowcake precipitation tank solution was 3.2 Bq/L (3.2E+03 Bq/m^3). The maximum Ra-226 in the WTP was 0.4 Bq/L (4.0E+02 Bq/m^3). Based on this information, and accounting for Rn-222 loss through the ventilation system (6 air exchanges /h), the Rn-222 in solution will be in excess of that supported by Ra-226 downstream of the Process Precipitate Removal Area – 1,350 Bq/L (1.35E+06 Bq/m^3) in the Yellowcake Precipitation Area, and 610 Bq/L (6.1E+05 Bq/m^3) in the WTP Area. Based on these inputs, the Rn-222 in air was estimated to be 735 Bq/m^3 in the Process Precipitate Removal Area, 496 Bq/m^3 in the Yellowcake Precipitation Area, and 128 Bq/m^3 in the WTP Area.

In the Process Precipitate Removal Area, the precipitate cake produced by dewatering the process precipitates may be considered as an additional source of radon release to air. The process precipitate cake taken from the filter press will be bagged and transported from the ISR Plant to the Process Precipitate Pond. The amount of process precipitate in the Process Precipitate Removal Area at any time will be up to 3 totes (1m height, 1m diameter). The IAEA provides radon exhalation rates ($Bq/m^2/s$) for thick NORM residues (>2m thick) as a function of Ra-226 content and % saturation (IAEA, 2013). These rates are conservative for a 1m thickness. Assuming a 30% saturation, the radon exhalation rate is estimated at 0.9 $Bq/m^2/s$ per Bq/g of Ra-226. The radon concentration in air from process precipitate cake can be calculated as:

$$C_a = C_s \times ExRate \times \frac{SA}{(ER \times V)}$$

Where:

C_a = Radon (Rn-222) in air (Bq/m^3)
C_s = Ra-226 in cake (Bq/g fw)
ExRate = exhalation rate (Bq/m^2/s)
SA = open surface area of cake (m^2)
ER = air exchange rate (1/s)
V = air volume (m^3)

From the above-mentioned Denison pilot studies, the Ra-226 in process precipitate solids is expected to be 300 Bq/g dw. The ratio of dry weight to fresh weight after dewatering is expected to be 0.8, so the fresh weight concentration of Ra-226 is 240 Bq/g fw. The exhalation rate was 0.9 Bq/m^2/s as discussed above. The open surface area for 3 totes of process precipitate cake was 2.355 m^2. The air exchange rate was the design value of 6 air exchanges per hour, or 0.00167 per second. The air volume used was 11,232 m^3 as noted above. Based on these inputs, the Rn-222 in air from process precipitate cake in the Process precipitate Removal Area was estimated to be 27.2 Bq/m^3, which is a very small addition to the Rn-222 in air arising from the thickener.

The Core Shack is another work area where radon partitioning to air will be of concern. This concern relates to radon exhalation from core material that is taken from the ore zone.

The Core Shack is a small narrow structure (40' long, 8' wide and 8' high). It will hold up to 3 cores at a time, each 4m long and 8cm in diameter, for examination by the geologist or geotech logger. Each core is housed in a core box, in three segments, with bottom and side walls. The source surface area was estimated as 3 x 0.08m x 4m = 0.96 m^2. Radon exhalation from core material was estimated using the IAEA exhalation rate for thick NORM residues, with the suggested adjustment for thin layers (IAEA, 2013). Assuming a 10% saturation, and a 0.08 m layer thickness, the thick layer exhalation rate of 1.2 Bq/m^2/s per Bq/g of Ra-226 was adjusted by tanh[sqrt(λ/D) z], with λ=2.1E-6 s^{-1}, D=3.0E-6 m^2/s and z=0.08m, giving an estimated exhalation rate of 0.08 Bq/m^2/s per Bq/g of Ra-226.

From pilot studies (R and D Enterprises, 2018), the Ra-226 in ore solids was taken to be 2,061 Bq/g dw. The ratio of dry weight to fresh weight was taken to be 0.9 (dry, but not bone dry), so the fresh weight concentration of Ra-226 was 1,855 Bq/g fw. The exhalation rate was therefore 0.08 x 1,855 Bq/g x 0.96 m^2 = 142.5 Bq/s. The air exchange rate was the design value of 6 air exchanges per hour, or 0.001667 volumes per second. The air volume used was 72.5 m^3 (12.2m x 2.44m x 2.44m). Based on these inputs, the Rn-222 in air from cores in the Core Shack was estimated to be 142.5 Bq/s / 0.1208 m^3/s = 1,180 Bq/m^3.

3.3.2 External Exposure

3.3.2.1 Radionuclide Concentrations

External exposure of workers is dependent on the chemistry of the radiation source. Five source configurations were identified for external exposure of workers:

Ore: Concentration of U-238 and Ra-226 in uranium ore were taken from pilot studies (R and D Enterprises, 2018) and converted to activity concentrations as discussed in Section 3.3.1.1. The progeny are considered in secular equilibrium with U-238 and Ra-226 as summarized in Table 3.4. Fresh weight concentrations are calculated using a dw/fw ratio of 0.9 and 0.7 for uranium ore cores and uranium ore cuttings respectively.

Table 3.4: Concentrations of U-238 and Ra-226 and Progeny in Uranium Ore

Radionuclide	Ore (Bq/kg dw)	Progeny
U-238	2.99E+06	U-234, Th-234, Th 230
Ra-226	2.06E+06	Rn-222, Po-218, Pb-214, Bi-214, Po-214, Pb-210, Bi-210, Po-210

Uranium Bearing Solution (UBS): The chemical composition of UBS was investigated in pilot tests and is summarized in Table 3.5. The daughters are considered to be in secular equilibrium with the parent. An exception to this is Th-234 for which the same activity concentration as Th-230 is assumed, based on similar chemical behaviour in solution.

Table 3.5: Measured Concentrations and Progeny of Radionuclides in the UBS Entering the ISR Plant

Radionuclide	UBS Bq/L	Progeny
Th-232[a]	1.20E+01	
U-238	4.50E+05	U-234
Ra-228[a]	5.00E+00	Ac-228, Th-228, Ra-224, Rn-220, Po-216, Pb212, Bi-212; 64.06% Po-212; 35.94% Tl-208
Th-230	2.20E+05	
Ra-226	3.00E+03	
Rn-222	3.00E+03	Po-218, Pb-214, Bi-214, Po-214
Pb-210	1.70E+03	Bi-210, Po-210

(a) The Th-232 decay series is included in the external dose calculations, however its contribution to external dose is not significant compared to the contribution from the U-238 series.

Process precipitate solids: The chemical composition of the process precipitate solids from pilot testing is summarized in Table 3.6. The daughters are considered to be in secular equilibrium with the parent. An exception to this is Th-234 for which the same activity concentration as Th-230 is assumed. Fresh weight concentrations are calculated using a dw/fw ratio of 0.8, 0.5 and 0.3 for cake, sludge and slurry respectively. Rn-222 and short-lived progeny are assumed to be present in these media at the Ra-226 concentration. The Plant Operator has radiation exposure from slurry in the thickener, and from process precipitate cake. The Equipment Operator has radiation exposure from sludge at the Process Precipitate Pond.

Table 3.6: Measured Concentrations and Progeny of Radionuclides in the Process Precipitate Solids

Radionuclide	Process precipitate Solids (Bq/kg dw)	Process precipitate Pond Solids[b] (Bq/kg dw)	Progeny
Th-232[a]	2.60E+02	2.10E+02	
U-238	2.90E+05	2.33E+05	U-234
Ra-228[a]	2.00E+03	1.72E+03	Ac-228, Th-228, Ra-224, Rn-220, Po-216, Pb212, Bi-212; 64.06% Po-212; 35.94% Tl-208
Th-230	1.30E+06	1.09E+06	
Ra-226	3.00E+05	2.40E+05	Rn-222, Po-218, Pb-214, Bi-214, Po-214
Pb-210	7.00E+04	5.72E+04	Bi-210, Po-210

(a) The Th-232 decay series is included in the external dose calculations, however its contribution to external dose is not significant compared to the contribution from the U-238 series.
(b) The process precipitate solids will be mixed 80:20 with gypsum solids in the Process Precipitate Pond and therefore have lower concentrations of radionuclides in both U-238 and Th-232 series.

Yellowcake Precipitation Tank Solution: Radionuclide concentrations in the yellowcake precipitation tank as determined in pilot testing are summarized in Table 3.7. The daughters are considered to be in secular equilibrium with the parent. An exception to this is Th-234 for which the same activity concentration as Th-230 is assumed.

Table 3.7: Measured Concentrations and Progeny of Radionuclides in the Yellowcake Precipitation Tank

Radionuclide	Yellowcake Precipitation Tank Solution Bq/L	Progeny
Th-232[a]	1.00E+01	
U-238	1.62E+05	U-234
Ra-228[a]	2.00E+00	Ac-228, Th-228, Ra-224, Rn-220, Po-216, Pb212, Bi-212; 64.06% Po-212; 35.94% Tl-208
Th-230	1.83E+04	
Ra-226	3.20E+00	
Rn-222	1.35E+03[b]	Po-218, Pb-214, Bi-214, Po-214
Pb-210	6.00E+01	Bi-210, Po-210

(a) The Th-232 decay series is included in the external dose calculations, however its contribution to external dose is not significant compared to the contribution from the U-238 series.

(b) Rn-222 was calculated to account for loss through the ventilation system in the process precipitate area.

Uranium Peroxide: Uranium peroxide is assumed to contain U-238 with a concentration of 9.74E+06 Bq/kg (dw) as discussed in Section 3.3.1.1. The only progeny included in the dose calculations is U-234 in secular equilibrium. Fresh weight concentrations are determined with a dw/fw ratio of 0.8 and 0.3 for cake in the yellowcake conveyor and slurry in the yellowcake thickener respectively. Yellowcake in the drying area is assumed to be almost dry, with a dw/fw ratio of 0.9, and completely dry in the packaging area, with a dw/fw ratio of 1 when packaged.

Water Treatment Plant Solids: Radionuclide concentrations in the 1st stage clarifier solids as determined in pilot testing are summarized in Table 3.8. Progeny are considered to be in secular equilibrium with the parent. An exception to this is Th-234 for which the same activity concentration as Th-230 is assumed. _Fresh weight concentrations are calculated using a dw/fw ratio of 0.3 for slurry. Rn-222 and short-lived progeny are estimated to be present in the slurry at 6.1E+02 Bq/L, accounting for loss through the ventilation system in the Yellowcake Precipitation Area. The WTP Operator receives radiation exposure from slurry in the clarifier.

Table 3.8: Measured Concentrations and Progeny of Radionuclides in the WTP Solids

Radionuclide	Waste Treatment Solids (Bq/kg dw)	Progeny
Th-232[a]	5.00E+00	
U-238	5.70E+00	U-234
Ra-228[a]	9.00E+01	Ac-228, Th-228, Ra-224, Rn-220, Po-216, Pb212, Bi-212; 64.06% Po-212; 35.94% Tl-208
Th-230	4.00E+04	
Ra-226	2.00E+02	Rn-222, Po-218, Pb-214, Bi-214, Po-214
Pb-210	1.40E+03	Bi-210, Po-210

The 1st stage solids will be sent directly to the Precipitate Pond, as a slurry, without dewatering. Any exposures arising from these solids at the Precipitate Pond will be bounded by the calculated exposure from process precipitate solids at that location. The 2nd stage solids are of relatively low activity and will be sent directly to the Gypsum Pond, without dewatering.

The WTP liquid as determined in pilot testing was not used in calculation of WTP Operator exposure. The bounding exposure scenario was considered to be from slurry in the clarifier.

3.3.2.2 Exposure Times

Exposure times for the external exposure scenarios are summarized in Table 3.9. In the ISR Plant one plant operator will be assigned to each of the five areas: process precipitate removal, yellowcake precipitation, water treatment, drying, and loading. In the process precipitate removal, yellowcake precipitation, and water treatment areas, the operators are assumed to split their time equally between the various sources in each area.

Table 3.9: Exposure Factors for External Exposures.

Location	Source [a]	Worker Function	h/d in area	h/d at 1 m	h/d at 5 m	h/d at 10 m	active months per year
Wellfield	Cuttings in Drum	Driller 1	11	2	4	5	8
	UBS Solution in pump house piping	Wellfield Operator 1	4	2	1	1	12
	UBS solution in storage pond	Wellfield Operator 1	4	2	1	1	12
	UBS Solution in piping	Wellfield Operator 2	8	4	2	2	12
ISR Plant	UBS feed tank Totes of filter cake Process precipitate Thickener	Plant Operator 1	8	6	1	1	12
	Yellowcake precipitation tank Yellowcake conveyor Yellowcake Thickener	Plant Operator 2	8	6	1	1	12
	WTP Clarifier	Plant Operator 3	8	6	1	1	12
	Drying Area, Dryer Drying Area, Calciner	Plant Operator 4	4	0	3	1	12
	Packaging/Loading Area	Plant Operator 5	4	0	3	1	12
Site Ponds Pads	Special Waste Pad	Equipment Operator 1	2	0	2	0	12
	none	Equipment Operator 1	3	0	2	1	12
	Process precipitate Pond	Equipment Operator 1	4	0	3	1	12
Core Shack	3 cores	Geologist/Geotech Loggers	11	2	8	1	6

(a) When there are several sources in one work area, the worker is assumed to divide his time roughly equally among those sources (see Appendix Table A.3).

3.3.2.3 External Exposure Geometries and Shielding

Table 3.10 to Table 3 12 summarize the exposure geometries assumed to apply to workers in the different exposure situations. The tables also include illustrative sketches from the setup in MicroShield reflecting any simplifications to conform with input requirements for the program. In all cases, the source material is modelled as the custom material "soil" with densities reflecting the dw/fw used to calculate the activity concentration discussed in Section 3.3.2.1. The shielding for each exposure situation is noted. Stainless steel shielding is modelled as iron in MicroShield with a material density of 7.82 g/cm^3. HDPE piping is modelled as polyethylene with a material density of 0.93 g/cm^3 (PNNL, 2006).

All receptors, represented by exposure points in MicroShield, are positioned at 1 m above ground. For horizontal geometries the exposure height is conservatively assumed to be at the same level as the source. The modelled distances from the source are 1, 5 and 10 m in accordance with the occupancy information presented in Table 3.9.

Table 3.10: Geometries for External Exposure Scenarios Modelled in MicroShield for Sources in the Wellfield

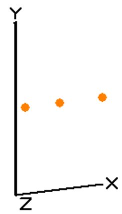
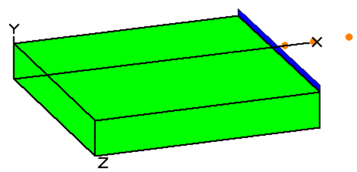
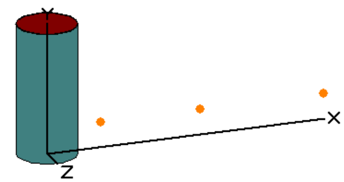
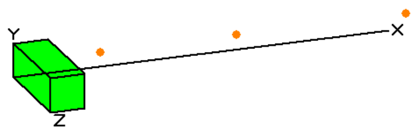
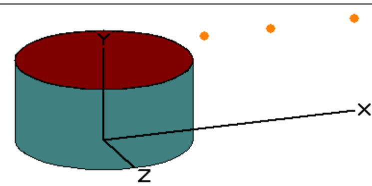
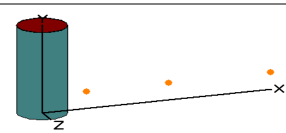
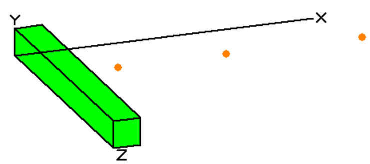
Source	Geometry	Source Type	MicroShield Geometry	Volume (m^3)	Shielding Thickness (mm)	Shielding material	Source form	Density (kg/m^3)
Cuttings in drum	Height: 0.89m, diameter: 0.58m	Ore		2.35E-01	1.20	Steel	Sludge	2.60E+03
Vertical Pipes in Pump House	Vertical pipes on both side walls, width 2.5m, height 2.7m	UBS Feed		1.35E+00	15.5	Polyethylene	Liquid	1.00E+03
Horizontal Pipe in Wellfield piping	Horizontal pipe, 1.2 above grade	UBS Feed		6.28E-01	15.50	Polyethylene	Liquid	1.00E+03
UBS Pond	Dimensions: 1.5m x 59m x 59m	UBS Feed		5.22E+03	6.35	Steel	Liquid	1.00E+03

Table 3.11: Geometries for External Exposure Scenarios Modelled in MicroShield for Sources in the ISR Plant

Source	Geometry	Source Type	MicroShield Geometry	Volume (m^3)	Shielding Thickness (mm)	Shielding material	Source form	Density (kg/m^3)
UBS Feed Tank	Height: 5.2m, diameter: 3.3m	UBS Feed		4.45E+01	6.35	Steel	Liquid	1.00E+03
Totes of Filter Cake	3 totes of filter cake, each 1m height, 1m diameter	Process Precipitates		3.00E+00	6.35	PET	Cake	1.88E+03
Process precipitate Thickener	Height: 5m, Diameter: 10m, drum 1.7m above the floor	Process Precipitates		3.93E+02	6.35	Steel	Slurry	1.30E+03
Precipitation Tank	Height:5.2m, Diameter: 3.3m	Yellowcake Precipitation Solution		4.45E+01	6.35	Steel	Liquid	1.00E+03
Yellowcake in Screw conveyor	Height: 1m, Length: 10m, Width: 1m	UO_4		1.00E+01	6.35	Steel	Cake	2.40E+03

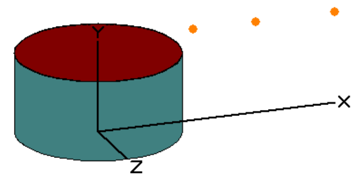
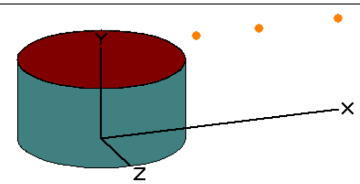
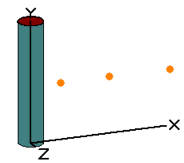
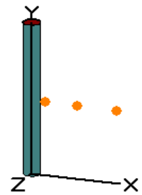
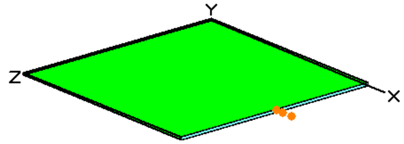
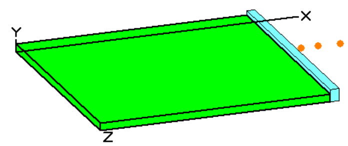
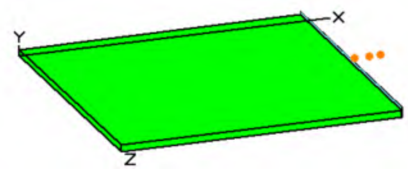
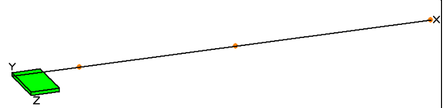
Source	Geometry	Source Type	MicroShield Geometry	Volume (m^3)	Shielding Thickness (mm)	Shielding material	Source form	Density (kg/m^3)
Yellowcake Thickener	Height: 5m, Diameter: 10m, drum 1.7m above the floor	UO_4		3.93E+02	6.35	Steel	Slurry	1.30E+03
WTP Clarifier	Height: 5m, Diameter: 10m, drum 1.7m above the floor	NA		3.93E+02	6.35	Steel	Slurry	1.00E+03
Dryer	Horizontal cylinder, Length: 10m Diameter: 2m	UO_4		3.14E+01	6.35	Steel	powder	2.03E+03
Calciner	Horizontal cylinder, Length: 20m Diameter: 2m	UO_4		6.28E+01	6.35	Steel	powder	2.03E+03
Drum Storage	350 barrels on a pad, each height: 0.89m, diameter: 0.58m	UO_4		1.08E+02	1.20	Steel	powder	1.71E+03

Table 3 12: Geometries for External Exposure Scenarios Modelled in MicroShield for Sources in the Site Ponds/Pads and Other Site Infrastructure

Source	Geometry	Source Type	MicroShield Geometry	Volume (m^3)	Shielding Thickness (mm)	Shielding material	Source form	Density (kg/m^3)
Special Waste Pad	Pad with dimensions: width 53m x length 53m, height: 1.8m, Berm 2m wide	Ore		5.06E+03	2000	Sandy soil	sludge	2.60E+03
Process precipitate pond	Dimensions 150m x 150m x 2.3m	Process Precipitates		5.18E+04	6.35	Steel	sludge	1.60E+03
Cores in Shack	3 cores in core boxes, each 0.08m diameter, length 4m, each cut in 3 pieces	Ore		7.72E-02		none	cylindrical solids	3.36E+03

4.0 Dose Calculation Methodology

4.1 Worker Dose from Dust Inhalation

Internal dose from inhalation of radioactive materials is related to the concentration in air through the transfer parameter P(i)19 for transfer from air to dose in CSA N288.1-20 (CSA, 2020).

$$P(i)19 = I \cdot DCF_i \cdot OF_i$$

Where:

I = inhalation rate ($m^3 \cdot a^{-1}$)
DCF_i =dose coefficient for inhalation ($Sv \cdot Bq^{-1}$)
OF_i = occupancy factor, or fraction of time an individual is exposed to the inhalation hazard (unitless)

Based on ICRP 119 (ICRP, 2012) the inhalation rate used for workers is 1.2 m^3/h. The dose coefficients for inhalation are those specified in ICRP Publication 137 as appropriate for occupational intakes of radionuclides in uranium ore (ICRP, 2017). Selected DCFs were for activity median aerodynamic diameter (AMAD of 5μm and the lung absorption type M, as indicated in ICRP 137 to be appropriate for uranium ore dust (ICRP, 2017).

The effective dose from inhalation is expressed as:

$$D(i) = P(i)19 \cdot A$$

Where:

A = activity of the dust (Bq/m^3)

4.2 Worker Dose from Radon

Dose from Rn-222 inhalation is calculated using the equilibrium fraction method in CSA N288.6-12 (CSA, 2020). For a given concentration of radon, the dose is dependent on the degree of equilibrium (F) between the radon and the short-lived radioactive decay products. The value of F is estimated at 0.18 for indoor work areas, based on 6 air exchanges/hour (10 min air residence time), and at 0.1 for outdoor locations, assuming a 5 min air travel time (Health Canada, 2010). The equation for the calculation of dose (mSv/a) from indoor radon and progeny for workers is:

$$Dose_{Rn} = C_{Rn} \cdot (3700\ Bq \cdot m^{-3})^{-1} \cdot F \cdot (ET \cdot (170h)^{-1}) \cdot 5\ mSv$$

Where:

C_{Rn}= concentration of radon in air (Bq/m^3)
F =degree of equilibrium between radon and decay products (unitless)

ET = exposure time (h/a)

4.3 Worker Dose from Gamma Radiation

All external dose calculations were done in the Computer Code "MicroShield Pro" (Version 13). MicroShield is a comprehensive photon/gamma ray shielding and dose assessment program that is widely used for a number of radiation science applications, e.g. designing shields and estimating source strength from radiation measurements. The dosimetric properties of U-238 and Th-232 decay series radionuclides are included in the database library of MicroShield. The DCF associated with any worker exposure condition depends on the geometry of the radiation source (size and shape), the distance of the worker from the source, and on the nature of any shielding between the worker and the source. MicroShield incorporates solution algorithms for various source geometries and the DCFs are calculated based on the decay energies of each radionuclide including buildup in the source.

The fundamental result of point kernel integration is the photon fluence rate (photons/cm^2/s) at the dose point for each energy in each case. This is multiplied by the energy to achieve the energy fluence rate, MeV/cm^2/sec. The photon fluence rate is then converted by MicroShield to units of exposure, energy absorption in air (mGy/h), and effective dose (mSv/h). Conversion tables in ICRP Publication 116 (ICRP, 2012) are used to convert to effective dose (mSv/h) and organ equivalent dose (mSv/a). For the purposes of this report only the effective dose and the equivalent dose to the lens of the eye will be reported. In calculating the effective dose, the MicroShield output includes results for all orientations of the receptor in accordance with geometries provided by ICRP 116. Conservatively, the geometry resulting in the highest effective dose is selected. This is typically the antero-posterior or lateral geometry. For equivalent dose to the lens of the eye the geometry resulting in the largest dose is, in most cases, the right and left lateral geometry. The exposure cases were set up in MicroShield as described in Section 3.3.2.3. The appropriate number of integration slices for the point kernel calculations were selected through a sensitivity analysis.

5.0 Worker Dose Estimates

Predicted doses for the selected exposed workers at the Wheeler River Project are presented in Sections 5.1 to 5.4.

5.1 Dose from Dust Inhalation

Inhalation of U dust will result in appreciable effective dose to workers only in the drying area and in the packaging/loading area of the ISR plant (both 11.7 mSv/a) and in the core shack (6.65 mSv/a). Doses in all considered locations are presented in Table 5.1.

Table 5.1: Internal Annual Dose from Dust Inhalation

Work Area	Worker	Effective Dose from Inhalation U-238$^+$ (mSv/a)	Effective Dose from Inhalation Ra-226$^+$ (mSv/a)	Total Effective Dose (mSv/a)
Wellfield	Driller 1	5.21E-03	-	5.21E-03[a]
Wellfield	Wellfield Operator 1, 2	5.68E-03	-	5.68E-03[a]
Process Precipitate Removal Area	Plant Operator 1	2.04E-02	-	2.04E-02[a]
Yellowcake Precip Area	Plant Operator 2	2.04E-02	-	2.04E-02[a]
Water Treatment Area	Plant Operator 3	2.04E-02	-	2.04E-02[a]
Drying Area	Plant Operator 4	1.17E+01	-	1.17E+01[b]
Packaging Loading Area	Plant Operator 5	1.17E+01	-	1.17E+01[b]
Special Waste Pad	Equipment Operator 1	1.02E-02	-	1.02E-02[ac]
Process Precipitate Pond	Equipment Operator 1	2.98E-03	-	2.98E-03[ac]
Industrial Landfill	Equipment Operator 1	9.54E-04	-	9.54E-04[ac]
Core Shack	Geologist/ Geotech Logger	5.63E+00	1.02E+00	6.65E-00[d]

(a) Based on outdoor concentration of U dust from IEC (EIS Appendix 6-A); U-238$^+$ DCF 2.60E-06 Sv/Bq from ICRP 137 includes U-238+U-234
(b) Based on indoor concentration of U dust, which dominates; U-238$^+$ DCF 2.60E-06 Sv/Bq from ICRP 137 includes U-238+U-234
(c) Equipment Operator 1 frequents 3 locations; the 3 doses must be added for this worker
(d) Based on indoor concentration of ore dust, which dominates; U-238$^+$ DCF 2.08E-05 Sv/Bq from ICRP 137 includes the entire U-238 series; doses shown for U-238$^+$ and Ra-226$^+$ reflect the portions from U-238 to Th-230, and from Ra-226 to Po-210, respectively.

5.2 Dose from Radon Inhalation

Inhalation of Rn-222 and its short-lived progeny in air will result in appreciable effective dose to workers in ISR plant areas with open solution (2.27, 1.54 and 0.53 mSv/a in process precipitate removal, Yellowcake Precipitation, and Water Treatment, respectively), at the waste pad/ponds (0.42 mSv/a) and in the core shack (2.3 mSv/a). High radon concentrations in the core shack are due in part to the small volume of the room. Doses in all considered locations are presented in Table 5.2.

Table 5.2: Internal Annual Dose from Radon Inhalation

Work Area	Worker	Source	Dose from Radon in Air (mSv/a)	Total Radon Dose for Worker (mSv/a)
Wellfield	Driller 1	Outdoor	9.44E-02[a]	9.44E-02
Wellfield	Wellfield Operator 1, 2	Outdoor	1.03E-01[a]	1.03E-01
Process precipitate Removal Area	Plant Operator 1	Outdoor	1.78E-01[a]	2.27E+00
		Cake	7.47E-02[b]	
		Thickener	2.02E+00[b]	
Yellowcake Precip Area	Plant Operator 2	Outdoor	1.78E-01[a]	1.54E+00
		Thickener	1.36E+00[b]	
Water Treatment Area	Plant Operator 3	Outdoor	1.78E-01[a]	5.30E-01
		Clarifier	3.52E-01[b]	
Drying Area	Plant Operator 4	Outdoor	8.89E-02[a]	8.89E-02
Packaging Loading Area	Plant Operator 5	Outdoor	8.89E-02[a]	8.89E-02
Special Waste Pad	Equipment Operator 1	Outdoor	3.37E-01[a]	4.23E-01
Process precipitate pond	Equipment Operator 1	Outdoor	6.89E-02[a]	
Industrial Landfill	Equipment Operator 1	Outdoor	1.70E-02[a]	
Core Shack	Geologist/	Outdoor	7.08E-02[a]	2.30E+00
	Geotech Logger	Cores	2.23E+00[b]	

(a) Based on outdoor concentration of radon from IEC (EIS Appendix 6-A)
(b) Based on an indoor source of radon to indoor air

5.3 Dose from External Exposure

External exposure to gamma radiation from sources in the work area will result in effective dose to workers above 1 mSv/a for Driller 1 in the wellfield (10.16 mSv/a), Plant Operator 1 in the Process Precipitate Removal Area (12.59 mSv/a), Plant Operator 3 in the Water Treatment Area (1.7 mSv/a), Equipment Operator 1 at the waste pad/ponds (5.68 mSv/a) and the Geologist/Geotech Logger in the Core Shack (2.02 mSv/a). External dose for Equipment

Operator 1 at the Special Waste Pad is mitigated by a berm, which provides shielding. Low external dose here depends on the berm.

Doses to the lens of the eye are generally higher by 40% to 60% depending on the exposure geometry. For the above-mentioned workers, the dose to lens of the eye is: Driller 1 (16.4 mSv/a), Plant Operator 1 (20.4 mSv/a), Plant Operator 3 (2.61 mSv/a), Equipment Operator 1 (9.33 mSv/a) and Geologist/Geotech Logger (3.25 mSv/a).

Table 5.3: Effective Dose and Equivalent Dose to the Lens of the Eye for Workers from External Exposure

			By Exposure Scenario		By Worker	
Work Area	**Worker**	**Source**	**External Dose (mSv/a)**	**Dose to Lens of Eye (mSv/a)**	**External Dose (mSv/a)**	**Dose to Lens of Eye (mSv/a)**
Wellfield	Driller 1	Cuttings	10.16	16.40	10.16	16.40
Wellfield	Wellfield Operator 2	Piping	0.05	0.07	0.05	0.07
	Wellfield Operator 1	Pump House Piping	0.24	0.34	0.53	0.81
		UBS Pond	0.29	0.47		
Process Precipitate Removal Area	Plant Operator 1	Feed Tank	0.24	0.39	12.59	20.40
		Cake	8.19	13.15		
		Thickener	4.16	6.86		
Yellowcake Precip Area	Plant Operator 2	Precip Tank	0.08	0.13	0.10	0.15
		Cake	0.02	0.02		
		Thickener	0.001	0.001		
Water Treatment Area	Plant Operator 3	Clarifier	1.70	2.61	1.70	2.61
Drying Area	Plant Operator 4	Dryer	0.002	0.002	0.004	0.004
		Calciner	0.002	0.002		
Packaging Loading Area	Plant Operator 5	Drums	0.009	0.009	0.009	0.009
Special Waste Pad	Equipment Operator 1	Waste Pad	<0.0001[a]	0.0001[a]	5.68	9.33
Process Precipitate Pond	Equipment Operator 1	Waste Pond	5.68	9.33		
Industrial landfill	Equipment Operator 1	No source	0.000	0.000		
Core Shack	Geologist/ Geotech Logger	Cores	2.02	3.25	2.02	3.25

(a) Dose to Equipment Operator 1 at the Special Waste Pad is mitigated by a 2m wide berm, which provides shielding.

5.4 Total Dose from all Exposures

The total dose from internal as well as external exposure to radioactive material is presented in Table 5.4. Predicted doses range from 0.16 mSv/a for the Wellfield Operator 2 to 14.88 mSv/a for the Plant Operator 1 working in the Process Precipitate Removal Area. In most cases, external radiation is the largest contributor to dose. Radon is most important for Wellfield Operator 2 (although total dose here is low) and for Plant Operator 2 in the Yellowcake Precipitation area. Dust inhalation is the dominant contributor to dose in the Drying and Packaging/Loading areas, and in the Core Shack. All worker doses are expected to be maintained below the average annual dose limit of 20 mSv/a for NEWs.

Table 5.4: Total Dose from Internal and External Pathways for Workers

Work Area	Worker	Internal Dose (mSv/a)		External Dose (mSv/a)	Total Effective Dose (mSv/a)
		Dust	Radon		
Wellfield	Driller 1	5.21E-03	9.44E-02	10.16	10.26
Wellfield	Wellfield Operator 2	5.68E-03	1.03E-01	0.05	0.16
	Wellfield Operator 1	5.68E-03	1.03E-01	0.53	0.64
Process Precipitate Removal Area	Plant Operator 1	2.04E-02	2.27E+00	12.59	14.88
Yellowcake Precip Area	Plant Operator 2	2.04E-02	1.54E+00	0.10	1.66
Water Treatment Area	Plant Operator 3	2.04E-02	5.30E-01	1.70	2.25
Drying Area	Plant Operator 4	1.17E+01[a]	8.92E-02	0.004	11.77
Packaging Loading Area	Plant Operator 5	1.17E+01[a]	8.92E-02	0.009	11.78
Special Waste Pad	Equipment Operator 1	1.02E-02	3.37E-01	- [b]	
Process precipitate Pond	Equipment Operator 1	2.98E-03	6.89E-02	5.68	6.11
Industrial Landfill	Equipment Operator 1	9.54E-04	1.70E-02	-	
Core Shack	Geologist/	6.65E+00[a]	2.30E+00	2.02	10.97
	Geotech Logger				

(a) Dust exposures in work area to be monitored and kept ALARA
(b) External dose mitigated by a berm around the Special Waste Pad, which provides shielding

The actual exposure geometries and shielding factors which will be experienced at the Wheeler River Project Site will be variable, making the predictions made here somewhat uncertain. This is especially true for workers in the ISR plant which are expected to be mobile between different sources of exposure, with various shielding characteristics. Nonetheless, the assumptions made in dose modelling are relatively conservative, and both area monitoring (dust, radon) and individual monitoring of external doses will be carried out, allowing for tracking of worker doses, and ongoing adjustment to minimize doses.

6.0 Radiation Protection Strategies

Doses to workers at the Wheeler River Project are expected to be maintained below the average annual dose limit of 20 mSv/a for NEWs. Several mitigations have been assumed and will be important in keeping doses ALARA. For the drying and packaging/loading areas of the ISR Plant, the engineering controls will include negative pressure enclosures around source equipment and exhaust, as well as ventilation controls in the main rooms (beyond enclosures). Administrative controls will include area and individual monitoring and time-exposure management. Actual dust levels will be confirmed during the commissioning phase and the control system will be optimized to ensure that doses are ALARA.

Powered Air Purifying Respirators (PAPR) should be available in these areas in case of need for any non-routine work that may involve high dust exposures. However, PAPR is a control of last resort. Under the Radiation Protection Program, a radiation work permit process will be in place for any non-routine work that may involve unusually high exposures, ensuring that risks are assessed and exposure controls are optimized in accordance with the ALARA principle. Dust inhalation is also a potentially significant component of dose at the core shack. An administrative level of respirable dust equal to ¼ of the ACGIH TLV of 0.27 mg/m^3 has been assumed. Again, dust levels will be confirmed during the commissioning phase and the control systems will be optimized to ensure that doses are ALARA. It may be possible to increase air exchange in the core shack, above the planned 6 exchanges per hour, should this be necessary. This would help also with radon exposure in the core shack.

For external radiation exposure the most significant sources are ore cuttings in drums on the wellfield and totes of filter cake in the Process Precipitate Removal Area. Doses from external sources can be most effectively reduced by maximizing distances or minimizing time at close distance. In the first case of drums on the wellfield, increasing distance to the drums is a readily available option. For exposure to totes of filter cake in the ISR plant, it was assumed that 3 totes will be in the area simultaneously at all times. The external dose from this source could be minimized by managing the quantity of filter cake in the work area, as well as worker proximity.

External doses from ore cuttings at the Special Waste Pad were assumed to be mitigated by a berm around the pad, which provides shielding. However, this area is a potentially significant source of external dose, and work inside the berm should be minimized.

In general, it will be necessary to manage work sequence and schedule to avoid prolonged exposures to the identified sources, especially those identified as being significant to worker dose. Doses can be most effectively reduced by reducing exposure times and maximizing distances from the source, as well as by use of protective shielding.

7.0 References

CSA (Canadian Standards Association), 2020. Guidelines for modelling radionuclide environmental transport, fate, and exposure associated with the normal operation of nuclear facilities. Report No. CSA N288.1-20.

Denison Mines, 2021a. Design Basis Document. March.

Denison Mines, 2021b. Technical Communication on Source Characteristics. July.

Ecometrix (Ecometrix Incorporated), 2023. Assumptions used in Worker Dose Calculations for the Wheeler River Project. Technical Memorandum to Denison Mines.

Health Canada, 2010. Federal Contaminated Site Risk Assessment in Canada, Part VI: Guidance on Human Health Detailed Quantitative Radiological Risk Assessment (DQRARAD).

Health Canada, 2014. Canadian Guidelines for the Management of Naturally Occurring Radioactive Materials (NORM). Canadian NORM Working Group of the Federal Provincial Territorial Radiation Protection Committee. Revised 2011.

IAEA (International Atomic Energy Agency), 2013. Measurement and Calculation of Radon Releases from Norm Residues. Report No. Technical Report Series No 474.

ICRP (International Commission on Radiological Protection), 2012. Compendium of Dose Coefficients based on ICRP Publication 60. Report No. ICRP Publication 119. Ann. ICRP 41(Suppl.).

ICRP (International Commission on Radiological Protection), 2017. Occupational Intakes of Radionuclides: Part 3. Report No. Part 3. ICRP Publication 137. Ann. ICRP 46(3/4).

PNNL (Pacific Northwest National Laboratory), 2006. Compendium of Material Composition Data for Radiation Transport Modeling. Report No. PNNL-15870.

R and D Enterprises (R and D Enterprises Inc.), 2018. Agitation and Column Leach Testing of Wheeler River Project Ores to Support In-Situ Uranium Recovery.

USNRC (National Research Council (US) Committee on Risk Assessment of Exposure to Radon in Drinking Water), 1999. Risk Assessment of Radon in Drinking Water.

Appendix A Example Calculations

Table A.1: Dust Inhalation Dose Calculation

Work Area	Worker	U-238 in Air (Bq/m³)	Exposure Time (h/a)	DCF (Sv/Bq)	Total Effective Dose (mSv/a)
Wellfield	Driller 1	9.49E-04	1760	2.60E-06	5.21E-03
Wellfield	Wellfield Operator 1, 2	9.49E-04	1920	2.60E-06	5.68E-03
Process Precipitate Removal Area	Plant Operator 1	3.41E-03	1920	2.60E-06	2.04E-02
Yellowcake Precip Area	Plant Operator 2	3.41E-03	1920	2.60E-06	2.04E-02
Water Treatment Area	Plant Operator 3	3.41E-03	1920	2.60E-06	2.04E-02
Drying Area	Plant Operator 4	3.90E+00	960	2.60E-06	1.17E+01
Packaging Loading Area	Plant Operator 5	3.90E+00	960	2.60E-06	1.17E+01
Special Waste Pad	Equipment Operator 1	6.83E-03	480	2.60E-06	1.02E-02
Process precipitate pond	Equipment Operator 1	9.95E-04	960	2.60E-06	2.98E-03
Industrial Landfill	Equipment Operator 1	4.25E-04	720	2.60E-06	9.54E-04
Core Shack	Geologist/ Geotech Logger	2.02E-01	1320	2.08E-05	6.65E+00

Total Effective Dose (mSv/a) = Cair (Bq/m^3) x I (m^3/h) x ET (h/a) x DCF (Sv/Bq) x 1000 (mSv/Sv)

Notes:
Concentrations from indoor sources for Drying/Packaging and Core Shack
Concentration in Drying/Packaging is respirable activity based on a design value for dust in the main room of the drying area (0.5 mg/m^3 total)
DCFs (Sv/Bq) from ICRP 137: U238+U234 (2.60E-6); U238 to Po-210 (2.08E-5)
Inhalation Rate (I) from ICRP 119 is 1.2 m^3/h

Table A.2: Radon Dose Calculation

Work Area	Worker	Source	Radon in Air (Bq/m³)	Exposure Time (h/a)	Equilibrium Factor F	Radon Dose (mSv/a)	Total (mSv/a)
Wellfield	Driller 1	Outdoor	6.75E+01	1760	0.10	9.44E-02	9.44E-02
Wellfield	Wellfield Operator 1, 2	Outdoor	6.75E+01	1920	0.10	1.03E-01	1.03E-01
Process Precipitate Removal Area	Plant Operator 1	Outdoor	1.17E+02	1920	0.10	1.78E-01	2.27E+00
		Cake	2.72E+01	1920	0.18	7.47E-02	
		Thickener	7.35E+02	1920	0.18	2.02E+00	
Yellowcake Precip Area	Plant Operator 2	Outdoor	1.17E+02	1920	0.10	1.78E-01	1.54E+00
		Thickener	4.96E+02	1920	0.18	1.36E+00	
Water Treatment Area	Plant Operator 3	Outdoor	1.17E+02	1920	0.10	1.78E-01	5.30E-01
		Clarifier	1.28E+02	1920	0.18	3.52E-01	
Drying Area	Plant Operator 4	Outdoor	1.17E+02	960	0.10	8.89E-02	8.89E-02
Packaging Loading Area	Plant Operator 5	Outdoor	1.17E+02	960	0.10	8.89E-02	8.89E-02
Special Waste Pad	Equipment Operator 1	Outdoor	8.82E+02	480	0.10	3.37E-01	4.23E-01
Process Precipitate Pond	Equipment Operator 1	Outdoor	9.03E+01	960	0.10	6.89E-02	
Industrial Landfill	Equipment Operator 1	Outdoor	2.97E+01	720	0.10	1.70E-02	
Core Shack	Geologist/ Geotech Logger	Outdoor	6.75E+01	1320	0.10	7.08E-02	2.30E+00
		Cores	1.18E+03	1320	0.18	2.23E+00	

Radon Dose (mSv/a) = (Cair (Bq/m^3) / 3700 Bq/m^3 per WL) x F x (ET (h/a) / 170 h per WL) * 5 (mSv/a per WL)

Table A.3: External Dose Calculation

			Exposure Time (h/d) at:			Max Effective Dose (mSv/h)			Max Lens Dose (mSv/h)				By Exposure Scenario	
Work Area	Worker	Source	1m	5m	10m	1m	5m	10m	1m	5m	10m	Exp Days (d/a)	External Dose (mSv/a)	Dose to Lens of Eye (mSv/a)
Wellfield	Driller 1	Cuttings	2	4	5	2.68E-02	1.86E-03	4.84E-04	4.33E-02	3.01E-03	7.82E-04	160	10.16	16.40
Wellfield	Wellfield Operator 2	Piping	4	2	2	4.91E-05	9.10E-06	3.40E-06	6.85E-05	1.26E-05	4.68E-06	240	0.05	0.07
	Wellfield Operator 1	Pump House Piping	2	1	1	4.74E-04	4.13E-05	1.08E-05	6.74E-04	5.81E-05	1.52E-05	240	0.24	0.34
		UBS Pond	2	1	1	4.63E-04	1.80E-04	8.75E-05	7.59E-04	2.94E-04	1.43E-04	240	0.29	0.47
Precipitate Removal Area	Plant Operator 1	Feed Tank	2.2	0.33	0.33	4.35E-04	8.51E-05	2.82E-05	7.13E-04	1.39E-04	4.60E-05	240	0.24	0.39
		Cake	1.6	0.33	0.33	2.08E-02	1.92E-03	5.06E-04	3.34E-02	3.09E-03	8.14E-04	240	8.19	13.15
		Thickener	2.2	0.33	0.33	7.17E-03	3.26E-03	1.43E-03	1.18E-02	5.34E-03	2.34E-03	240	4.16	6.86
Yellowcake Precip Area	Plant Operator 2	Precip Tank	2	0.33	0.33	1.63E-04	3.18E-05	1.05E-05	2.65E-04	5.17E-05	1.71E-05	240	0.08	0.13
		Cake	2	0.33	0.33	3.69E-05	7.89E-06	2.50E-06	3.69E-05	7.89E-06	2.50E-06	240	0.02	0.02
		Thickener	2	0.33	0.33	2.33E-06	1.87E-06	8.74E-07	2.33E-06	1.87E-06	8.74E-07	240	0.001	0.001
Water Treatment Area	Plant Operator 3	Clarifier	6	1	1	1.06E-03	5.03E-04	2.22E-04	1.63E-03	7.51E-04	3.30E-04	240	1.70	2.61
Drying Area	Plant Operator 4	Dryer	0	1.5	0.5	9.12E-06	4.37E-06	1.55E-06	1.51E-05	4.37E-06	1.55E-06	240	0.002	0.002
		Calciner	0	1.5	0.5	1.52E-05	5.10E-06	2.30E-06	1.52E-05	5.10E-06	2.30E-06	240	0.002	0.002
Packaging Loading Area	Plant Operator 5	Drums	0	3	1	5.91E-05	1.19E-05	3.79E-06	5.91E-05	1.19E-05	3.79E-06	240	0.009	0.009
Special Waste Pad	Equipment Operator 1	Waste Pad	0	2	0	1.02E-07	8.54E-08	5.86E-08	1.84E-07	1.55E-07	1.06E-07	240	4.10E-05	0.0001
Precipitate Pond	Equipment Operator 1	Waste Pond	0	3	1	1.49E-02	6.78E-03	3.31E-03	2.45E-02	1.12E-02	5.43E-03	240	5.68	9.33
Industrial Landfill	Equipment Operator 1	No source	0	3	0	-	-	-	-	-	-	240	0	0
Core Shack	Geologist/ Geotech Logger	Cores	2	8	1	6.59E-03	4.39E-04	1.12E-04	1.06E-02	7.09E-04	1.81E-04	120	2.02	3.25

External Dose (mSv/a) = [Σ ET (h/d) x Max Effective Dose (mSv/h)] x ED (d/a)
Dose to Lens (mSv/a) = [Σ ET (h/d) x Max Lens Dose (mSv/h)] x ED (d/a)

Notes:
Maximum dose rates at distance (mSv/h) are output from Microshield scenarios; highest value considering all possible orientations.
Skin dose was less than or equal to lens dose, depending on the scenario.

Denison Mines

Wheeler River Project

Final Environmental Impact Statement

November 2024

Powering
PEOPLE, PARTNERSHIPS AND PASSION.

Section 11: Engagement Database Summary Table – Indigenous Land and Resource Use

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments (From Interested Party)	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
17-EN-ERFN-104.2	104	Meeting	2017-03-03	Denison and the Lands Manager for the English River First Nation met to discuss the traditional territory boundaries of English River First Nation. The Lands Manager supplied a hard copy and electronic copy of the ERFN Traditional Land Use map.	English River First Nation	Medicine Stick – a form of medicinal plant is found at the north end of Cree Lake and the southeast end of the lake as well.	Denison considered this in section: Existing Environment, Contemporary Indigenous Land and Resource Use in the Region, English River / Patuanak	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming from a member of English River First Nation who attended a meeting in the year 2017. The record reference serves to describe contemporary Indigenous land and resource use in the region, in relation to English River / Patuanak.
17-EN-ERFN-104.4	104	Meeting	2017-03-03	Same as above	English River First Nation	In addition to persons trapping in the area, he has two brothers and a sister with cabins in the area.	Denison considered this in section: Existing Environment, Contemporary Indigenous Land and Resource Use in the Region, English River / Patuanak	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming from a member of English River First Nation who attended a meeting in the year 2017. The record reference serves to describe contemporary Indigenous land and resource use in the region, in relation to English River / Patuanak.
18-EN-VB-4.54	4	Workshop	2018-01-18	As part of the engagement program for the Wheeler River Project, Denison organized a workshop in Beauval for community members to attend. The workshop gathered community input in relation to road alignment options, treated effluent discharge locations, and mining methods.	Village of Beauval	Mining Method (ISR_DirectionalDrilling): Cons - Never been done for uranium; Drill bit will come back hot (radioactive); Reminds me of fracking – negative perception of the term; When will it be tested? When will it be proven? Safety would be one of the biggest concerns in either method. With either method you're breaking new ground.	Denison considered this in section: Assessment of Project Related Effects, Perceived Suitability of Land and Resources Therein, Perceived Suitability / Safe Use of Resources.	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming from an individual who attended a workshop in Beauval in the year 2018. The record reference serves to highlight an example of local perceptions toward the ISR mining method in terms of perceived suitability and safe use of resources in terms of Project related effects. Mining methods were evaluated through an increasingly rigorous process and considered factors such as: safety, environment, production rates, capital costs, operating costs, schedule, operational flexibility, and risk. ISR mining for uranium is a common mining method for uranium globally. Denison included the ISR method in the prefeasibility study and the feasibility field test, and this mining method was selected as the basis for the environmental assessment. Denison has completed an environment assessment to understand potential Project impacts on the environment. The assessment considers potential accidents and malfunctions. Denison has determined that there will be no significant impacts as a result of Project activities.
18-EN-ERFN-5.1	5	Workshop	2018-05-03	As part of the engagement program for the Wheeler River Project, Denison organized a workshop for ERFN at their Patuanak Reserve location for ERFN and Patuanak members to attend. The workshop aimed to gather community input in relation to road alignment options, treated effluent discharge locations, and mining methods. The meeting had been delayed many times, and was held in the Health Clinic because there was a regional power outage.	English River First Nation	I always come from the elders' perspective. Since 1906, the area where you're working has been Treaty 10 land. Those lands were the primary area of ERFN and contain burial sites and birth sites of ERFN members. The Dené name of the Wheeler River, Russell Lake and Cree Lake all come from the Denésuliné of English River. The elders have always expressed that it's a primary area of EFRN. One of our late elders was born north of there in 1922. Our traditional gathering place is there.	Denison considered this in section: Existing Environment, Contemporary Indigenous Land and Resource Use in the Region, English River / Patuanak	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming from a member of English River First Nation who attended a workshop in the year 2018. The record reference serves to describe contemporary Indigenous land and resource use in the region, in relation to English River / Patuanak.
18-EN-ERFN-5.3	5	Workshop	2018-05-03	Same as above	English River First Nation	For many years I've invited (the media) to come to our gathering on the Key Lake road, to showcase and impress on the	Denison considered this in section: Existing Environment, Contemporary Indigenous Land and	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming from a member of English River First Nation who attended a workshop in the year 2018. The record reference serves to describe

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments (From Interested Party)	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
						world that we're still using those areas. If you really want to work with us, you need to work with our council right from Day one.	Resource Use in the Region, English River / Patuanak	contemporary Indigenous land and resource use in the region, in relation to English River / Patuanak.
19-EN-HLFN-78.2	78	Meeting	2019-10-03	Denison staff attended and presented to the First Nation Chiefs of the Ya'thi Néné Lands and Resources Office, the Executive Board Members, and the staff, providing a detailed overview of the Wheeler River Project.	Black Lake First Nation, Fond du Lac First Nation, Hatchet Lake First Nation, Ya'thi Néné Land and Resource Office	An Elder [described] travelling from Hatchet Lake to Russell Lake, Highrock River and the Geike River. The area close to Russell Lake and Highrock River – we have historical connections here. The area along the Treaty 10/Treaty 8 boundary towards Cree Lake and Gieke River are areas Dene travelled around. Could you bring our Elders to the Wheeler area to get their input on land use and ask them questions? Could you give our Elders a site tour? You should consult with our Elders.	Denison considered this in section: Existing Environment, Contemporary Indigenous Land and Resource Use in the Region, Athabasca Denesųłiné Communities	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming from an Elder from one of Black Lake, Fond du Lac, or Hatchet Lake, who attended a meeting in the year 2019. The record reference serves to describe contemporary Indigenous land and resource use in the region, in relation to Athabasca Denesųłiné Communities. Denison understands the importance of engaging with local and Indigenous communities, residents, businesses, organizations, land users and the various regulatory authorities. Since 2016, Denison has been engaging with Interested Parties to support the development of positive relationships and a mutual commitment to collaboration. Denison has applied a variety of methods, one of which includes site tours, to support engagement activities throughout the engagement process and used different methods with various groups depending on requirements and preferences of the process. Documentation of all site tours that have occurred can be found in the Engagement section of the EIS.
19-EN-YNLR-84.1	84	Meeting	2019-06-18	Denison met with the Ya'thi Néné Lands and Resources Office regarding the Project Description for the Wheeler River Project and provided an overview of the Project, prior to the YNLR submitting comments on the Project Description.	Ya'thi Néné Land and Resource Office	Very positive and complimentary about the minimal environmental effects (no tailings, small volumes of waste rock) associated with ISR; how minimal the surface disturbance was and that the injection/recovery wells were not too high density.	Denison considered this in section: Assessment of Project Related Effects, Perceived Suitability of Land and Resources Therein, Perceived Suitability / Safe Use of Resources And in section: Mitigation Measures, Perceived Suitability of Lands and Resources Therein	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a perspective representing local interests, documented as coming from YNLR staff who attended a meeting in the year 2019. The record reference serves to describe the perceived suitability and safe use of resources in terms of Project related effects and mitigation measures.
19-LK-ERFNTrap-134.25	134	Site Visit	2019-10-29	Denison met with local land user and English River First Nation Trapper at the Wheeler River Project site location for a full-day to interview him regarding his knowledge of the area, including providing information and feedback on specifics pertaining to wildlife and wildlife movement patterns, fish and spawning areas, local lakes and lake names, recreational and commercial use, traditional food consumption, and specific aspects of the Wheeler River Project. ERFN Trapper provided his consent to Denison to use the information he provided in the environmental assessment. He reviewed the notes taken	ERFN Trapper	This [more cabins in the area] has affected me because there are more boats on the lakes. More boats on the lakes leads to more overfishing, anglers also cut access trails to lakes, access trails impact caribou by increasing wolf traffic.	Denison has considered this in section: Existing Environment, Contemporary Indigenous Land and Resource Use in the Region, English River First Nation / Patuanak	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming ERFN Trapper, who attended a site visit in the year 2019. The record reference serves to describe contemporary Indigenous land and resource use in the region, in relation to English River / Patuanak.

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments (From Interested Party)	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
				from the meeting, and provided his revisions / modifications to Denison on January 2, 2020.				
19-LK-ERFNTrap-134.66	134	Site Visit	2019-10-29	Same as above	ERFN Trapper	Denison Question: Does he eat anything off his trapline? Response: ERFN Trapper will consume small lynx, beaver and muskrat from his trapline but there are fewer around than in the past.	Denison has considered this in section: Existing Environment, Contemporary Indigenous Land and Resource Use in the Region, English River First Nation / Patuanak	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming ERFN Trapper, who attended a site visit in the year 2019. The record reference serves to describe contemporary Indigenous land and resource use in the region, in relation to English River / Patuanak.
19-LK-ERFNTrap-134.124	134	Site Visit	2019-10-29	Same as above	ERFN Trapper	Denison Question: Do you gather berries or any plants? If so, from what and from where. Response: I might eat some berries while I am walking around but I don't gather berries. I don't drink Labrador Tea.	Denison considered this in section: Existing Environment, Contemporary Indigenous Land and Resource Use in the Region, English River First Nation / Patuanak And in section: Assessment of Project Related Effects, Resource Availability for Harvesting Subsistence Resources, Terrestrial Resource Availability.	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming ERFN Trapper, who attended a site visit in the year 2019. The record reference serves to describe contemporary Indigenous land and resource use in the region, in relation to English River / Patuanak.
19-LK-ERFNTrap-134.138	134	Site Visit	2019-10-29	Same as above	ERFN Trapper	What fish species are collected for: Food – natives prefer jackfish, whitefish, trout; whites go for walleye; Ceremonial purposes – don't know of any; commercial purposes (e.g., bait fish) – mullet (white sucker) collected for bait; Walleye is the most valuable catch=> highest price per kilo at the fish plant	Denison considered this in section: Existing Environment, Contemporary Indigenous Land and Resource Use in the Region, English River First Nation / Patuanak	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming ERFN Trapper, who attended a site visit in the year 2019. The record reference serves to describe contemporary Indigenous land and resource use in the region, in relation to English River / Patuanak.
19-LK-ERFNTrap-134.158	134	Site Visit	2019-10-29	Same as above	ERFN Trapper	Caribou: Barren ground caribou were last seen in the north Cree Lake area around 1983. ERFN Trapper believes they no longer come as far south because of the large fires that have burned across the north. He felt these fires may have created a barrier in search of food.	Denison considered this in section: Assessment of Project Related Effects, Resource Availability for Harvesting Subsistence Resources, Terrestrial Resource Availability.	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming ERFN Trapper, who attended a site visit in the year 2019. The record is used in relation to potential project related effects in terms of terrestrial resource availability.
19-LK-ERFNTrap-134.172	134	Site Visit	2019-10-29	Same as above	ERFN Trapper	Moose: The area to the north of the Wheeler River Project regional study area (from maps) has generally been better for moose than the local project area. The area east and north of Three Mile Lake, and Omnia winter tracking transects #11 and 4 (see Omnia Terrestrial Baseline Report, Figure 2.5-1; and image included below). He sees more caribou and less moose. He believes this is a natural change and moose are moving further south.	Denison considered this in section: Existing Environment, Contemporary Indigenous Land and Resource Use in the Region, English River First Nation / Patuanak	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming ERFN Trapper, who attended a site visit in the year 2019. The record reference serves to describe contemporary Indigenous land and resource use in the region, in relation to English River / Patuanak.

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments (From Interested Party)	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
19-LK-ERFNTrap-134.174	134	Site Visit	2019-10-29	Same as above	ERFN Trapper	Caribou: He sees more caribou and less moose. When he goes out to check his traplines in the winter he sees caribou quite regularly. He also sees caribou in the summer.	Denison considered this in section: Existing Environment, Contemporary Indigenous Land and Resource Use in the Region, English River First Nation / Patuanak	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming ERFN Trapper, who attended a site visit in the year 2019. The record reference serves to describe contemporary Indigenous land and resource use in the region, in relation to English River / Patuanak.
19-LK-ERFNTrap-134.177	134	Site Visit	2019-10-29	Same as above	ERFN Trapper	Caribou: Identified area east of Highway 914 and NE of Russell Lake, sort of between Russell Lake and McDougall Lake as an area where caribou are commonly seen in the winter. There are tall trees here, some small hills with protected valley areas, and it seems sheltered. There is caribou moss in this area.	Denison considered this in section: Existing Environment, Contemporary Indigenous Land and Resource Use in the Region, English River First Nation / Patuanak	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming ERFN Trapper, who attended a site visit in the year 2019. The record reference serves to describe contemporary Indigenous land and resource use in the region, in relation to English River / Patuanak.
19-LK-ERFNTrap-134.224	134	Site Visit	2019-10-29	Same as above	ERFN Trapper	Denison Question: Can you comment on who is using the area (besides cabin owners), what they are doing, any access concerns, etc. Response: If the gate at Key Lake is removed or the road is redesigned to go around Key Lake allowing unimpeded access to the north, there would be lots of concerns about the increase in the number of people coming north into this area. However, many people can currently bypass the Key Lake gate and drive along the Fox Lake road. There is a bridge in place (near the south part of Fox Lake road) for access to a drilling camp and this bridge is over a fairly deep river. If this bridge came out, it would restrict access further north along the road. More people have quads these days.	Denison considered this in section: Cumulative Effects	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming ERFN Trapper, who attended a site visit in the year 2019. The record reference serves to describe contemporary Indigenous land and resource use in the region, in relation to English River / Patuanak.
19-LK-ERFNTrap-134.225	134	Site Visit	2019-10-29	Same as above	ERFN Trapper	ERFN Trapper prefers using trails that he has created for accessing fishing, trapping and hunting locations ERFN Trapper is not opposed to reducing the overall footprint in the area and closing off some access (this discussion was in the context of improving caribou habitat integrity). However, ERFN Trapper also noted that wolves, caribou and black bears use the trails/lines and wonders why we would decommission something they use. ERFN Trapper would be in favour of closing off or fully decommissioning the Fox Lake Road to general public travel. This includes pulling bridges and making stream	Denison considered this in section: Existing Environment, Contemporary Indigenous Land and Resource Use in the Region, English River First Nation / Patuanak	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming ERFN Trapper, who attended a site visit in the year 2019. The record reference serves to describe contemporary Indigenous land and resource use in the region, in relation to English River / Patuanak.

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments (From Interested Party)	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
						crossings impossible to pass through with a truck or ATV.		
19-LK-ERFNTrap-134.252	134	Site Visit	2019-10-29	Same as above	ERFN Trapper	My problem with these options is that all of these lakes flow towards Russell. Fish travel. If there are effects in one of the smaller lakes, like Whitefish Lake, fish can easily move from here downstream into Russell Lake. If you discharge water into Whitefish Lake, I would like to see someone drink water out of McGowan Lake.	Denison considered this in section: Assessment of Project Related Effects, Perceived Suitability of Land and Resources Therein, Perceived Suitability / Safe Use of Resources.	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming ERFN Trapper, who attended a site visit in the year 2019. The record reference serves to describe the perceived suitability and safe use of resources in terms of Project related effects. Denison has completed an environment assessment to understand Project impacts on the environment. The assessment considers potential impacts to traditional and other land use activities, fishing and water quality. Denison additionally completed a human health risk assessment. Denison has determined that there will be no significant impacts as a result of Project activities.
19-EN-VPL/ML9-135.4	135	Meeting	2019-02-01	Denison and Pinehouse leaders (Village, Kineepik Métis, and Pinehouse Business North) held a meeting, in which Denison provided an update on the Wheeler River Project, including the pending submission of the Project into the environmental assessment process.	Kineepik Métis Local #9, Village of Pinehouse Lake	Pinehouse would be looking for support from Denison in order to explain the ISR method to community at large given that it is new. He expects there will be a lot of questions about it.	Denison considered this in section: Mitigation Measures, Perceived Suitability of Lands and Resources Therein	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming from an individual who attended a meeting in Pinehouse in the year 2019. The record reference is used in the context of mitigation measures in relation to potential for the ISR mining method to influence the perceived suitability of lands and resources.
19-EN-ERFN-137.1	137	Meeting	2019-06-17	Denison and the Chief of the English River First Nation met to discuss the Wheeler River Project, including that the Project Description was currently undergoing a 30-day public review period. Also discussed were land use activities by ERFN members and other First Nations.	English River First Nation	Furblock N-18 and N-16 were amalgamated into management by English River First Nation a while back, under a co-management regime.	Denison considered this in section: Assessment of Project Related Effects, Lands / Waters Available for Traditional Practices, Availability / Accessibility of Land	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming from a member of English River Frist Nation, who attended a meeting in the year 2019. The record reference is used in relation to availability and accessibility of land in terms of the assessment of project related effects.
20-LK-LEASESUR-267.40	267	Survey	2020-02-01	Denison sent all known local cabin and lodge leaseholders a survey in the mail to be completed regarding their interests in Wheeler River. Denison received 6 responses from the survey, which has informed it's understanding of leaseholder uses in the area and interests regarding elements to be assessed as part of the environmental assessment.	Leaseholder, Wheeler River Lodge	Denison Question: What do you use your cabin or land for mostly? Response: Plant Harvesting / Collecting	Denison considered this in section: Assessment of Project Related Effects, Resource Availability for Harvesting Subsistence Resources, Terrestrial Resource Availability	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming from local leaseholder who completed a survey in the year 2020. The record reference serves to highlight gathering plants for food or subsistence purposes in relation to the assessment of project related effects in terms of terrestrial resource availability.
21-EN-SUR-446.69	446	Survey	2021-02-16	As part of engagement activities for the municipalities of Beauval, Ile a la Crosse and Pinehouse Lake, Denison prepared and shared an online	Village of Beauval, Village of Ile a la Crosse, Village of Pinehouse Lake	Denison Question: Based on what you know so far about the Wheeler Project, what aspects of the project could be challenging or cause concern for your community?	Denison considered this in section: Assessment of Project Related Effects, Resource Availability for Harvesting Subsistence Resources,	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming from an individual who completed a survey sent to residents of Beauval, Pinehouse, and Ile a la Crosse, in the year 2021. The record, which serves to highlight dialogue pertinent to the health and abundance of resources, is referenced in terms of the assessment of project related effects.

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments (From Interested Party)	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
				survey which included information about Denison, the Wheeler River Project, and posed validation questions about the Valued Components being assessed as part of the environmental assessment process. A total of 68 responses were received and 62 of the responses were considered complete, for a 91% completion rate. The information related to the Valued Components was incorporated into the assessment.		Response: The impact of mining on the natural habitat and the displacement of the animals that currently inhabit the proposed site.	Health and Abundance of Resources	Denison has completed an environment assessment to understand Project impacts on the environment. Denison has determined that there will be no significant impacts as a result of Project activities.
21-EN-SUR-446.76	446	Survey	2021-02-16	Same as above	Village of Beauval, Village of Ile a la Crosse, Village of Pinehouse Lake	Denison Question: Based on what you know so far about the Wheeler Project, what aspects of the project could be challenging or cause concern for your community? Response: Environment impact due to air quality and transportation of uranium	Denison considered this in section: Assessment of Project Related Effects, Perceived Suitability of Land and Resources Therein, Aesthetic Experience	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming from an individual who completed a survey sent to residents of Beauval, Pinehouse, and Ile a la Crosse, in the year 2021. The record reference serves to highlight a concern raised regarding air quality, which is used in relation aesthetic experience in terms of the perceived suitability of land and resources. Denison has completed an environment assessment to understand Project impacts on the environment. The assessment considers transportation and potential impacts to air quality. Denison has determined that there will be no significant impacts as a result of Project activities.
21-EN-ERFNSUR-456.40	456	Survey	2021-04-09	As part of engagement activities for English River First Nation, Denison prepared and shared an online survey which included information about Denison, the Wheeler River Project, and posed validation questions about the Valued Components being assessed as part of the environmental assessment process. A total of 23 responses were received. The information related to the Valued Components was incorporated into the assessment and questions asked on the surveys was incorporated into the overall engagement database.	English River First Nation	Denison Question: Why did you choose these valued components? Response: I wish traditional livelihood to continue by the future generations in these areas	Denison considered this in section: Scope of Assessment, Valued Component Selection	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming from a member of ERFN who completed a survey in the year 2021. The record reference serves to highlight a concern raised regarding air quality, which is used in relation aesthetic experience in terms of the perceived suitability of land and resources. The record reference serves to highlight an example of information related to the VCs that was incorporated into the assessment.
21-EN-ERFNSUR-456.42	456	Survey	2021-04-09	Same as above	English River First Nation	Denison Question: Why did you choose these valued components? Response: Cause I'm a hunter and I always use the land	Denison considered this in section: Scope of Assessment, Valued Component Selection.	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming from a member of ERFN who completed a survey in the year 2021. The record reference serves to highlight a concern raised regarding air quality, which is used in relation aesthetic experience in terms of the perceived suitability of land and resources. The record reference serves to highlight an example of information related to the VCs that was incorporated into the assessment.

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments (From Interested Party)	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
21-EN-ERFNSUR-456.44	456	Survey	2021-04-09	Same as above	English River First Nation	Denison Question: Why did you choose these valued components? Response: Community concerns and requirements for the future of our children's, grandchildren's, great grandchildren's connection to the land and utilization of renewable resources by future generations.	Denison considered this in section: Scope of Assessment, Valued Component Selection.	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming from a member of ERFN who completed a survey in the year 2021. The record reference serves to highlight a concern raised regarding air quality, which is used in relation aesthetic experience in terms of the perceived suitability of land and resources. The record reference serves to highlight an example of information related to the VCs that was incorporated into the assessment.
21-EN-ERFN-473.12	473	Advisory Committee Meeting	2021-06-17	Denison and the Nuhtsiye-kwi Benéne Committee (Ancestral Lands Committee) of English River First Nation held a meeting. During the meeting topics discussed were: concluding discussions related to the geotechnical permit for the Wheeler River Project for 2021, site access considerations (related to English River First Nation usage of the Fox Lake road), a report on a subsidence assessment report undertaken by Denison and requested by ERFN, and an overview of a pilot project being undertaken by Denison related to reclamation of linear features in and around the Wheeler River Project area.	Nuhtsiye-kwi Benéne Committee (Ancestral Lands Committee)	Denison Question: The lines that are cut, that essentially make a highway for the wolves to chase down caribou, has that been a concern? Response: We hunt around that Brown Lake area – we have seen wolf tracks but there is caribou there because of the green areas. We haven't been concerned about the wolves. Moose is more our mainstay.	Denison considered this in section: Existing Environment, Contemporary Indigenous Land and Resource Use in the Region, English River First Nation / Patuanak	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming from a member of English River First Nation and participant in the Nuhtsiye-kwi Benéne Committee (Ancestral Lands Committee) who attended an advisory committee meeting in the year 2021. The record reference serves to describe contemporary Indigenous land and resource use in the region, in relation to English River / Patuanak.
21-EN-ERFN-473.17	473	Advisory Committee Meeting	2021-06-17	Same as above	Nuhtsiye-kwi Benéne Committee (Ancestral Lands Committee)	Denison Question: The lines that are cut, that essentially make a highway for the wolves to chase down caribou, has that been a concern? Response: We hunt around that Brown Lake area – we have seen wolf tracks but there is caribou there because of the green areas. We haven't been concerned about the wolves. Moose is more our mainstay.	Denison considered this in section: Existing Environment, Contemporary Indigenous Land and Resource Use in the Region, English River First Nation / Patuanak	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming from a member of English River First Nation and participant in the Nuhtsiye-kwi Benéne Committee (Ancestral Lands Committee) who attended an advisory committee meeting in the year 2021. The record reference serves to describe contemporary Indigenous land and resource use in the region, in relation to English River / Patuanak.
21-EN-ERFN-473.18	473	Advisory Committee Meeting	2021-06-18	Same as above	Nuhtsiye-kwi Benéne Committee (Ancestral Lands Committee)	That's what we have in our freezer. Moose has the same concern and affect for ERFN – not just the government protected caribou. We want to know how moose would be impacted?	Denison considered this in section: Existing Environment, Contemporary Indigenous Land and Resource Use in the Region, English River First Nation / Patuanak	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming from a member of English River First Nation and participant in the Nuhtsiye-kwi Benéne Committee (Ancestral Lands Committee) who attended an advisory committee meeting in the year 2021. The record reference serves to describe contemporary Indigenous land and resource use in the region, in relation to English River / Patuanak. Denison has completed an environment assessment to understand Project impacts on the environment. Moose have been included as a key indicator as part of the assessment. Denison has determined that there will be no significant impacts as a result of Project activities.

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments (From Interested Party)	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
22-EN-SUR-652.53	652	Survey	2022-06-03	As part of engagement activities for English River First Nation, Beauval, and Pinehouse, Denison prepared and shared, both online and as a hardcopy during Spring Engagement meetings, a survey that asked a series of questions relating to the results of the environmental assessment. A total of 39 surveys were entirely or partially completed.	Unknown	Denison Question: Are there any topics of particular concern that Denison needs to pay special attention to? Response: Traditional cabins on land.	Denison considered this in section: Existing Environment, Contemporary Indigenous Land and Resource Use in the Region	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming from an individual from English River First Nation, Beauval, or Pinehouse who completed a survey in the year 2022. The record reference serves to describe the existing environment in terms of contemporary Indigenous land and resource use in the region. Denison has completed an environment assessment to understand Project impacts on the environment. Land/water available for traditional practices has been included as a key indicator as part of the assessment, which considers cabins and campsites. Denison has determined that there will be no significant impacts as a result of Project activities.

Section 11: Engagement Database Summary Table – Other Land and Resource Use

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments (From Interested Party)	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
18-EN-VPL-2.29	2	Workshop	2018-01-16	As part of the engagement program for the Wheeler River Project, Denison organized a workshop in Pinehouse Lake for community and Kineepik Métis members to attend. The workshop gathered community and student input in relation to road alignment options, treated effluent discharge locations, and mining methods.	Village of Pinehouse Lake	Mining Method (ISR): Pros - No mill, no tailings; Seems safer, more economical, and better than the other options; In theory, this option looks really good.	Denison considered this in section: Assessment of Project Related Effects, Suitability of Lands and Resources, Perceived Suitability of Resources for Safe Use	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming from an individual who attended a workshop in Pinehouse in the year 2018. The record reference serves to highlight an example of local perceptions toward the ISR mining method in terms of perceived suitability and safe use of resources in terms of Project related effects.
18-EN-VPL-2.30	2	Workshop	2018-01-16	Same as above	Village of Pinehouse Lake	Mining Method (ISR): Cons - Not enough information to understand the pros and cons of this option.	Denison considered this in section: Assessment of Project Related Effects, Suitability of Lands and Resources, Perceived Suitability of Resources for Safe Use	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming from an individual who attended a workshop in Pinehouse in the year 2018. The record reference serves to highlight an example of local perceptions toward the ISR mining method in terms of perceived suitability and safe use of resources in terms of Project related effects. Increasing familiarity of the ISR mining method is an important component of ongoing engagement work.
18-EN-VPL-2.59	2	Workshop	2018-01-16	Same as above	Village of Pinehouse Lake	We don't have full confidence in government. When's the tipping point where uranium mining has a stigma across the landscape? Everyone is concerned about uranium development. The mining industry carries 10% of the northern workforce and revenue stream. We still need forestry and tourism – where's the point where so much mining activity interferes with tourism development, based on general attitude? That was discussed 25 years ago; is it still being discussed, and when is that tipping point? There is no consideration in the E for the impact on other economies. Yours is a stand-alone statement for the impact of mining within a social development model. What happens when we can't have tourism in the areas you're in? I've never seen that element of a negative impact to tourism in any EA.	Denison considered this in section: Scope of the Assessment, Key Indicators and Measurable Parameters	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming from an individual who attended a workshop in Pinehouse in the year 2018. The record reference serves as an example which validates the selections made in terms of valued components. Denison has completed an environment assessment to understand Project impacts on the environment. Forestry and tourism are captured as components of land and resource use. Resource use is comprised of subsistence, commercial and recreation use of resources derived from the natural environment. Denison has determined that there will be no significant impacts as a result of Project activities.
19-LK-ERFNTrap-134.85	134	Site Visit	2019-10-29	Denison met with local land user and English River First Nation Trapper at the Wheeler River Project site location for a full-day to interview him regarding his knowledge of the area, including providing information and feedback on specifics pertaining to wildlife and wildlife movement patterns, fish and	ERFN Trapper	Sell gutted fish to the plant in Pinehouse. From there they go to Winnipeg, possibly Freshwater Fish Company.	Denison considered this in section: Existing Environment, Fishing, Commercial Fishing	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming from ERFN Trapper who attended a site visit in the year 2019. The record reference serves to describe the existing environment in terms of commercial fishing.

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments (From Interested Party)	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
				spawning areas, local lakes and lake names, recreational and commercial use, traditional food consumption, and specific aspects of the Wheeler River Project. ERFN Trapper provided his consent to Denison to use the information he provided in the environmental assessment. He reviewed the notes taken from the meeting, and provided his revisions / modifications to Denison on January 2, 2020.				
19-LK-ERFNTrap-134.161	134	Site Visit	2019-10-29	Same as above	ERFN Trapper	Marten, Fisher and Wolverine: Marten are typically caught during the winter months (Nov to April) using a tree mounted box with bait and a snap trap (conibear?)	Denison considered this in section: Existing Environment, Commercial Trapping	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming from ERFN Trapper who attended a site visit in the year 2019. The record reference serves to describe the existing environment in terms of commercial trapping.
19-LK-ERFNTrap-134.226	134	Site Visit	2019-10-29	Same as above	ERFN Trapper	If the gate at Key Lake is removed or the road is redesigned to go around Key Lake allowing unimpeded access to the north, there would be lots of concerns about the increase in the number of people coming north into this area. However, many people can currently bypass the Key Lake gate and drive along the Fox Lake road. There is a bridge in place (near the south part of Fox Lake road) for access to a drilling camp and this bridge is over a fairly deep river. If this bridge came out, it would restrict access further north along the road. More people have quads these days.	Denison considered this in section: Cumulative Effects And in section: Other Land and Resource Use Summary	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming from ERFN Trapper who attended a site visit in the year 2019. The record reference serves to highlight information within the engagement database that is pertinent to cumulative effects with respect to changes in access.
19-LK-ERFNTrap-134.255	134	Site Visit	2019-10-29	Same as above	ERFN Trapper	Russell is one lake where I commercially fish. How will this effluent impact the water quality, fish health? Will I be able to sell fish from here? If there is going to water pollution, I just want to know.	Denison considered this in section: Assessment of Project Related Effects, Suitability of Lands and Resources, Perceived Suitability of Resources for Safe Use	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming from ERFN Trapper who attended a site visit in the year 2019. The record reference serves to highlight dialogue related to the perceived suitable of resources for safe use. Denison has completed an environment assessment to understand Project impacts on the environment. The assessment considers potential impacts to traditional and other land use activities, fishing and water quality. Denison has additionally completed a human health risk assessment. Denison has determined that there will be no significant impacts as a result of Project activities.
19-EN-ERFN-137.1	137	Meeting	2019-06-17	Denison and the Chief of the English River First Nation met to discuss the Wheeler River Project, including that the Project Description	English River First Nation	Furblock N-18 and N-16 were amalgamated into management by English River First	Denison considered this in section:	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming from a member of

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments (From Interested Party)	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
				was currently undergoing a 30-day public review period. Also discussed were land use activities by ERFN members and other First Nations.		Nation a while back, under a co-management regime.	Assessment of Project Related Effects, Land Available to Practice Commercial and Recreational Land Use, Availability / Accessibility of Land	English River Frist Nation, who attended a meeting in the year 2019. The record reference is used in relation to availability and accessibility of land in terms of the assessment of project related effects.
19-EN-LEASE-138.1	138	Phone Call	2019-06-25	A cabin owner called Denison in response to a letter sent to him regarding the Wheeler River Project and the 30-day Project Description review period. The conversation focussed on the potential impact of removing the controlled access at Key Lake - which is not part of the Wheeler Project.	Leaseholder	His main concern is that the gate stays in place at Key Lake. He really likes the controlled access to the area north of Key. He is concerned that if the gate is removed and access north of Key Lake is no longer controlled, that his belongings will get stolen, cabin will get vandalized and slightly less concerned about lakes getting over fished. If the project requires the gate be removed, he would consider selling his cabin as he doesn't want to deal with the outfall.	Denison considered this in section: Cumulative Effects And in section: Other Land and Resource Use Summary	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming from a local leaseholder who took part in a phone call in the year 2019. The record reference serves to highlight information within the engagement database that is pertinent to cumulative effects with respect to changes in access. Restrictions on access to the site area would be controlled through two security gates. Denison understand that maintaining restricted access to the north (through Cameco's Key Lake gate) is a high priority for local Indigenous group and northern residents. Access road designs that have security gates are preferred and will make sure the Project site is safe and secure.
19-EN-ERFN-140.26	140	Site Visit	2019-08-28	Denison provided a site tour of the Wheeler River Project to the Chief of English River First Nation, along with three ERFN Councillors. Also on the tour was the local ERFN land user who resides near to the Wheeler River Project site location.	English River First Nation, ERFN Trapper	What will be the impact to water from the operation? Those freeze plants could affect the groundwater.	Denison considered this in section: Assessment of Project Related Effects, Suitability of Lands and Resources, Perceived Suitability of Resources for Safe Use	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming from a member of English River First Nation who attended a site visit in the year 2019.The record reference serves to highlight dialogue related to the perceived suitable of resources for safe use. The freeze wall will prevent groundwater flow in the area surrounding the ore body. The removal of the freeze wall will allow groundwater to re-establish its original flow path through the area.
19-EN-ERFN-140.27	140	Site Visit	2019-08-28	Same as above	English River First Nation, ERFN Trapper	What would be the impact on air?	Denison considered this in section: Assessment of Project Related Effects, Suitability of Lands and Resources, Aesthetic Experience	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming from a member of English River First Nation who attended a site visit in the year 2019. The record reference serves to highlight dialogue regarding air quality, which is used in relation aesthetic experience in terms of the perceived suitability of land and resources. Denison has completed an environmental assessment to understand Project impacts on the environment. The assessment considers potential impacts to air. Denison has determined that there will be no significant impacts as a result of Project activities.
19-EN-LODGE-141.1	141	Drop-in Visit/Casual Meeting	2019-08-08	The owner of the Wheeler River Lodge stopped in to the Denison office to speak to Denison regarding the Wheeler River Project in relation to the material sent by Denison to	Wheeler River Lodge	Concerned about access to the area and was wondering about changes to the current controls on Hwy 914 with the Key Lake gatehouse. He is concerned about vandalism.	Denison considered this in section: Cumulative Effects And in section:	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming from the owner of the Wheeler River Large, who took part in a casual meeting in

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments (From Interested Party)	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
				cabin owners about the Project Description 30-day review period. His focus was on maintaining the controlled access of the area north of Key Lake.		He can safely leave a truck and other equipment on the shore of Russell Lake near Hwy 914 unattended for a week or longer and has had no issues with vandalism or theft. If Wheeler changes the public's access to the area, he is concerned about leaving his belongings unattended and also potential for vandalism from his lodge. Which is further downstream from Russell on the Wheeler River.	Other Land and Resource Use Summary	the year 2019. The record reference serves to highlight information within the engagement database that is pertinent to cumulative effects with respect to changes in access. The Project does not propose any changes to the current access to Highway 914 north of Cameco's Key Lake Operation gate.
20-LK-LEASESUR-267.58 20-LK-LEASESUR-267.62	267	Survey	2020-02-01	Denison sent all known local cabin and lodge leaseholders a survey in the mail to be completed regarding their interests in Wheeler River. Denison received 6 responses from the survey, which has informed it's understanding of leaseholder uses in the area and interests regarding elements to be assessed as part of the environmental assessment.	Leaseholder, Wheeler River Lodge	I am concerned with how Denison will access their mine on the same road as Cameco uses from the Key Lake mine to McArthur. Presently, Cameco has gates which restrict access to that section of road. If these gates are to be removed or altered by Denison so that everyone has access to the section of road between Key Lake and McArthur that would be disastrous to the region. The theft, vandalism and crime would increase astronomically and the region would lose its remoteness, tranquility and quality of fishing and a lot more.	Denison considered this in section: Existing Environment, Fishing, Recreational Fishing In section: Cumulative Effects And in section: Other Land and Resource Use Summary	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming from local leaseholder who completed a survey in the year 2020. The record reference serves to describe the existing environment in terms of recreational fishing and serves to highlight information within the engagement database that is pertinent to cumulative effects with respect to changes in access. Access restrictions north of the Key Lake gate mean that use is restricted to lease holders (e.g., cabin owners) and select Indigenous communities. The Project does not propose any changes to the current access to Highway 914 north of Cameco's Key Lake Operation gate. Denison has completed an environment assessment to understand Project impacts on the environment. The assessment considers potential impacts to traditional and other land use activities, including fishing. Denison has determined that there will be no significant impacts as a result of Project activities.
20-LK-LEASESUR-267.74	267	Survey	2020-02-01	Same as above	Leaseholder, Wheeler River Lodge	Denison Question: What issues or concerns are of particular interest to you? What do you feel should be considered in the Project Environmental Impact Assessment? Response: Access to fish resources.	Denison considered this in section: Existing Environment, Fishing, Recreational Fishing	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming from local leaseholder who completed a survey in the year 2020. The record reference serves to describe the existing environment in terms of recreational fishing. Denison has completed an environment assessment to understand Project impacts on the environment. The assessment considers access to fish resources for both commercial and recreational purposes. Denison has determined that there will be no significant impacts as a result of Project activities.
20-LK-LEASESUR-267.99 20-LK-LEASESUR-267.100	267	Survey	2020-02-01	Same as above	Leaseholder, Wheeler River Lodge	Denison Question: What issues or concerns are of particular interest to you? What do you feel should be considered in the Project Environmental Impact Assessment? Response: Changes in traffic.	Denison considered this in section: Assessment of Project Related Effects, Suitability of Lands and Resources, Aesthetic Experience	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming from local leaseholder who completed a survey in the year 2020. The record reference provides context in relation to the aesthetic

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments (From Interested Party)	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
20-LK-LEASESUR-267.101 20-LK-LODGESUR-267.102 20-LK-LEASESUR-267.103 20-LK-LEASESUR-267.104								experience in terms of the assessment of project related effects. Denison has completed an environment assessment to understand Project impacts on the environment. The assessment considers changes in traffic volume. While it is expected that traffic north of the Key Lake gatehouse will increase by 23% during construction and 30% during operation, proven mitigation options are planned to reduce the risk of increased traffic. Denison has determined that there will be no significant impacts as a result of Project activities.
20-LK-LEASE-328.10	328	Meeting	2020-01-31	Denison staff met with a local leaseholder / cabin owner to discuss the Wheeler River Project.	Leaseholder	He said he can sometimes hear noise from drilling activities at his cabin. Although he wasn't particularly concerned about noise from Wheeler if it goes ahead.	Denison considered this in section: Assessment of Project Related Effects, Suitability of Lands and Resources, Aesthetic Experience	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming from a member of local leaseholder who attended a meeting in the year 2020. The record reference provides context in relation to the aesthetic experience in terms of the assessment of project related effects.
20-LK-LEASE-328.11	328	Meeting	2020-01-31	Same as above	Leaseholder	One of his main concerns were about the treated effluent being released to Whitefish Lake which flows into McGowan Lake ("his lake").	Denison considered this in section: Assessment of Project Related Effects, Suitability of Lands and Resources, Perceived Suitability of Resources for Safe Use	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming from a member of local leaseholder who attended a meeting in the year 2020. The record reference serves to highlight dialogue related to the perceived suitable of resources for safe use. Denison has completed an environment assessment to understand Project impacts on the environment. The assessment considers potential impacts to surface water quality and quantity. Denison has determined that there will be no significant impacts as a result of Project activities.
20-LK-LEASE-328.14	328	Meeting	2020-01-31	Same as above	Leaseholder	Another one of his concerns was potential for overfishing on McGowan Lake by Denison staff if the Project goes ahead.	Denison considered this in section: Assessment of Project Related Effects, Suitability of Lands and Resources, Aesthetic Experience	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming from a member of local leaseholder who attended a meeting in the year 2020. The record reference serves to highlight dialogue related to the perceived suitable of resources for safe use. Denison has completed an environment assessment to understand Project impacts on the environment. The assessment considers potential impacts aquatic resource, and land and resource use. Denison has determined that there will be no significant impacts as a result of Project activities.
21-EN-YOUTH-445.5	445	Virtual Meeting	2021-02-10	Denison provided a virtual presentation to the high schools in Ile a la Crosse, Beauval and Pinehouse about the Wheeler River	Village of Ile a la Crosse, Village of Pinehouse Lake,	Wondering how the freeze wall will work based on the difficulties that Cigar Lake had?	Denison considered this in section:	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming from an individual that

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments (From Interested Party)	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
				Project. Included in the discussion was an overview on the Valued Components for the Wheeler River Project, with a request to provide feedback to Denison via an online survey with specific questions pertaining to Valued Components.	Village of Beauval, Denison		Assessment of Project Related Effects, Suitability of Lands and Resources, Perceived Suitability of Resources for Safe Use.	attended a virtual high school presentation for Ile a la Crosse, Pinehouse, and Beauval, in the year 2021. The record reference serves to highlight dialogue related to the perceived suitable of resources for safe use. The freeze wall is intended for tertiary containment of mining solution to support a defence in depth strategy as additional, site-specific data is obtained on hydraulic containment. The freeze wall around the mining area will extend from the surface to the basement rock, isolating the mining area from regional groundwater. The freeze wall is expected to be a minimum of 10 m thick, be installed 25m away from the uranium deposit, and extend 30 m into the basement rock. Data from the groundwater monitoring network installed in and around the wellfield and freeze wall will make sure the freeze wall is meeting design specifications.
21-EN-SUR-446.18	446	Survey	2021-02-16	As part of engagement activities for the municipalities of Beauval, Ile a la Crosse and Pinehouse Lake, Denison prepared and shared an online survey which included information about Denison, the Wheeler River Project, and posed validation questions about the Valued Components being assessed as part of the environmental assessment process. A total of 68 responses were received and 62 of the responses were considered complete, for a 91% completion rate. The information related to the Valued Components was incorporated into the assessment and questions asked on the surveys was incorporated into the overall engagement database.	Village of Beauval, Village of Ile a la Crosse, Village of Pinehouse Lake	Denison Question: Why did you choose these valued components? Response: We are given a lot of assurances about how environmentally safe this energy source can be it still has a LARGE impact on the land. I feel that the land and water are our best resources and in the not too distant future they will be incredibly valuable. Compromising them seems dangerous.	Denison considered this in section: Scope of the Assessment, Valued Component Selection	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming from a member of Beauval, Ile a La Crosse, or Pinehouse, who completed a survey in the year 2021. The record reference serves as an example which validates the selections made in terms of valued components.
21-EN-SUR-446.29	446	Survey	2021-02-16	Same as above	Village of Beauval, Village of Ile a la Crosse, Village of Pinehouse Lake	Denison Question: Why did you choose these valued components? Response: All of them are reasonable and none should be bypassed.	Denison considered this in section: Scope of the Assessment, Valued Component Selection	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming from a member of Beauval, Ile a La Crosse, or Pinehouse, who completed a survey in the year 2021. The record reference serves as an example which validates the selections made in terms of valued components.

Section 11: Engagement Database Summary Table – Heritage Resources

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments (From Interested Party)	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
21-EN-ERFN-591.1	591	Virtual Meeting	2021-10-14	Denison met with the English River First Nation Chief and Council, along with members of the Nuhtsiye-kwi Benéne Committee to provide an overview of the 2022 Exploration Activities, the report from the ERFN Environment & Cultural Monitor, an overview of the 2021 and planned 2022 activities for Wheeler River, and information related to heritage management planning for the Wheeler River Project.	English River First Nation, Nuhtsiye-kwi Benéne Committee (Ancestral Lands Committee)	Artifacts become property of the Crown? That doesn't seem right, that the Nation doesn't get to keep the artifact.	Denison considered this in section: Influence of Indigenous Knowledge, Local Knowledge, and Engagement on the Assessment. And in section: Mitigation Measures	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming from a member of English River First Nation who attended a virtual meeting in the year 2021. The Heritage Resource Management Plan (HRMP) was informed by engagement with English River First Nation, who recommended that the HRMP should include a mechanism to involve Indigenous communities where appropriate. The HRMP outlines mechanisms for Indigenous engagement including the communities, implementation of appropriate cultural protocols, the potential for storage of artifacts outside of the Royal Saskatchewan Museum, and the inclusion of Indigenous field assistants when possible. See Appendix 11-B for the HRMP.
21-EN-ERFN-591.2	591	Virtual Meeting	2021-10-14	Same as above	English River First Nation, Nuhtsiye-kwi Benéne Committee (Ancestral Lands Committee)	What's the process for repatriation?	Denison considered this in section: Influence of Indigenous Knowledge, Local Knowledge, and Engagement on the Assessment. And in section: Mitigation Measures	The context in which this comment was used within the Land and Resource Use section of the EIS serves as a local perspective, documented as coming from a member of English River First Nation who attended a virtual meeting in the year 2021. The Heritage Resource Management Plan (HRMP) was informed by engagement with English River First Nation, who recommended that the HRMP should include a mechanism to involve Indigenous communities where appropriate. The HRMP outlines mechanisms for Indigenous engagement including the communities, implementation of appropriate cultural protocols, the potential for storage of artifacts outside of the Royal Saskatchewan Museum, and the inclusion of Indigenous field assistants when possible. See Appendix 11-B for the HRMP.

Denison Mines

Wheeler River Project

Final Environmental Impact Statement

November 2024

Powering PEOPLE, PARTNERSHIPS AND PASSION.

Denison Mines Corporation
Wheeler River Uranium Project
Heritage Resources Management Plan

Report

Prepared by:

Canada North Environmental Services
Saskatoon, Saskatchewan

Prepared for:

Denison Mines Corporation
Saskatoon, Saskatchewan

Project No. 3402

August 2022

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

PROJECT CREDITS

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1.0 INTRODUCTION

The Wheeler River Uranium Project (the Project) is an advanced exploration project owned by Denison Mines Corp. (Denison) at 90% and JCU (Canada) Exploration Company Ltd. (JCU) at 10%. Exploration activities began in the late 1970s. Denison became the operator of the joint venture in 2004. Denison completed the *Prefeasibility Study Report* for the Project in 2018 and the *Provincial Technical Proposal and Federal Project Description* in 2019. A joint federal-provincial Environmental Impact Assessment (EIA) will be conducted; thus, a single Environmental Impact Statement (EIS) will be submitted to both the Saskatchewan MOE's Environmental Assessment and Stewardship branch and the Canadian Nuclear Safety Commission (CNSC).

This Heritage Resources Management Plan (HRMP) has been developed to guide Denison if archaeological artifacts, features, or human remains (and suspected human remains) are identified within the Project development footprint during all stages of the Project. As Heritage Resources have been identified within the Project area during previous Heritage Resource Impact Assessments (HRIAs) and Indigenous Knowledge (including Traditional Land Use Studies) show past and continued use of the Project area, it suggests that there is further potential to find Heritage Resources during future activities.

As Heritage Resources have been identified within the Project area during previous Heritage Resource Impact Assessments (HRIAs) and Indigenous Knowledge (including Traditional Land Use Studies) show past and continued use of the Project area, it suggests that there is further potential to find Heritage Resources during future activities. The HRMP will serve as a guide to follow if archaeological artifacts, features, or human remains (and suspected human remains) are identified within the Project development footprint during all stages of the Project. Despite best efforts, unidentified Heritage Resources may be in located within the Project and may be unintentionally disturbed and discovered during activities associated with the Project, such as during construction. Heritage Resources are not only protected under provincial legislation but are non-renewable and are important for the scientific reconstruction of ancient and past lifeways. This report includes the regulatory context, the project background, the archaeological background that will inform the HRMP.

2.0 REGULATORY CONTEXT

Heritage Resources in Saskatchewan are Provincially legislated and protected under *The Heritage Property Act* (Government of Saskatchewan 1980) and all Heritage Resources identified on public, provincially owned, or private land, fall under its protection. Federal lands (including national parks, national historic sites, and First Nations reserve lands) are regulated by the Federal Government and are, therefore, outside of the jurisdiction of *The Heritage Property Act*. Legislation in Saskatchewan will be discussed below. For the purposes of the HRMP, the following definitions as outlined in *The Heritage Property Act* will be used (Government of Saskatchewan 1980; GS 2003):

- Heritage Property: any archaeological object, any palaeontological object, any property that is of interest for its architectural, historical, cultural, environmental, archaeological, palaeontological, aesthetic or scientific value, and any site where any object or property mentioned above is or may reasonably be expected to be found.
- Archaeological object: any object showing evidence of manufacture, alteration or use by humans that is found in or taken from land in Saskatchewan and that is of a value for the information that it may give on prehistoric or early historic human activity in Saskatchewan.
- Paleontological object: a fossil of a vertebrate animal or a macroscopic fossil of an invertebrate animal or plant that lived in the geological past, but does not include:
    - A fossil fuel or fossiliferous rock intended for industrial use; or
    - Any form in addition to those mentioned in subclause (a), of a preserved remain or trace of a multicellular organism that may be prescribed in the regulations.
- Site: any parcel of land or remains of any building or structure.

2.1 Heritage Property Act

In Saskatchewan, Heritage Resources include Precontact period and Historic period archaeological sites, built heritage sites and structures of historical and/or architectural interest, and paleontological sites. According to Section 5(63) (1), if an operation or activity may result in the alteration, damage, or destruction of heritage property than the person/company may have to:

- carry out an impact assessment to determine the effect of the proposed operation or activity on the heritage property,
- prepare and submit a report to the government summarizing the assessment, and
- undertake any salvage, preservation or protective measures that the minister may require (Government of Saskatchewan 1980).

The third bullet listed above is especially important in regards to the HRMP. These investigations must be carried out by qualified personnel who have been issued an Archaeological Resource Investigation Permit or a Palaeontological Resources Investigation Permit by the Heritage Conservation Branch. The permit holder is responsible for the completion of the assessment, the reporting, and the delivery of artifacts to the Royal Saskatchewan Museum (RSM). All artifacts must be stored at the RSM unless other arrangements are made with the RSM.

In Saskatchewan, both palaeontological and archaeological objects are the property of the Crown (Government of Saskatchewan 1980). If an object was collected prior to November 28th, 1980, then the person should register the object with the government, and the person may be able to maintain ownership of the object (Government of Saskatchewan 1980 Section 5[66.2]). It is illegal to sell, buy, trade, etc. any heritage object found on or taken from land in Saskatchewan (Government of Saskatchewan Section 5 (7)). Any person who identifies a heritage object or site without a permit has 15 days to notify the Government (Government of Saskatchewan 1980 Section 5[71]). This will be discussed under the Chance Finds policy outlined in the HRMP (see section 5.2.2).

Sites of Special Nature (SSN) are offered explicit protection under Section 64 of *The Heritage Property Act* (Government of Saskatchewan 1980). SSN include pictographs, petroglyphs, human skeletal material, burial object, burial place or mound, boulder effigy or medicine wheel (Government of Saskatchewan 1980 Section 5[64]). These sites cannot be altered or moved, and in general must be avoided by development. Additional measures have been outlined in The Archaeological Burial Management Policy in regard to human remains (GS 2003).

2.2 The Archaeological Burial Management Policy

Archaeological burials (including burials, burial places, burial mounds and human skeletal materials) are human remains that are not located in cemeteries recognized under *The Cemeteries Act* and are not under the jurisdiction of criminal investigations (GS 2010).

The Archaeological Burial Management Policy has four steps (GS 2010):

- Discovery and Notification
  - Upon identification of human remains all work must immediately be stopped in the vicinity of the discovery.
  - Unless the burial is in a clear archeological context (i.e. with artifacts) the RCMP (or other appropriate law enforcement) must be notified.
  - The Heritage Resources Branch shall be notified.
- Assessment
  - Within 48 hours it will be determined if the human remains are a police matter or an archaeological matter.
  - If the remains are archaeological then the cultural affiliation must be determined and all applicable interest groups will be advised of the discovery and consulted.
- Preservation or Removal
  - It will be determined if the burial should be removed and relocated (often due to risk of imminent destruction) or preserved in situ.
- Final Disposition
  - If the burial must be removed from its original location the final step will be reburial in an appropriate location in consultation with the appropriate interest groups.

If suspected human remains are identified, the above steps must be followed until their identification is confirmed.

2.3 Heritage Resource Review

Heritage Resource Reviews (HRRs) are completed by the Heritage Conservation Branch (HCB) for proposed projects that are likely to affect Heritage Resources. The HCB has identified two primary triggers for determining if a Heritage Resource Impact Assessment (HRIA) is required for a project (per section 63 of *The Heritage Property Act*) (Government of Saskatchewan 1980). An area is considered heritage sensitive based on the presence of known Heritage Resources and the potential for new Heritage Resources to be discovered. The extent of previous land disturbance and nature and scope of the project are also taken into consideration. Additional screening criteria for northern Saskatchewan (northern parklands and boreal forest) to determine heritage potential, include (GS 2008):

- within 500 m of a Site of a Special Nature (SSN) (per. S. 64 of *The Heritage Property Act*), or other previously recorded site(s), unless the site has been determined to have low interpretive value;
- along dry, upland margins of a major bog or fen;
- within 250 m of watercourses or lakes;
- within 50 m of historic trails;
- within 250 m of strandlines; and
- on escarpments (defined by two or more contour intervals within 200 m), prominent uplands, and hills/ridges (including eskers) within 500 m of a water source.

Developments affecting areas of moderate to high potential will likely require the completion of an HRIA prior to construction. Eskers are especially important in Northern Saskatchewan as they have been interpreted by the HCB as being important travel routes for Precontact period people across a challenging landscape. An esker is defined as long ridge of gravel and other material deposited by a meltwater channel during glaciation (GS 2017). Several prominent eskers are located in the vicinity of the Project.

Additionally, the HCB has developed guidelines around exploration in northern Saskatchewan to help determine if a project requires an HRR (GS 2017). Exploration activities located within 100 m of a waterbody or watercourse, a known heritage site, or on an esker require an HRR if they will disturb the mineral soils (i.e., soil below the leaf cover/organic duff). Activities that will cause disturbances to the mineral soil include:

- surface blading;
- stump removal; and
- grading.

Developments including permanent and temporary roads, new work camps, staging areas, and drill pads are likely to affect the mineral soil and would require an HRR. Activities that do not affect the mineral soil are unlikely to negatively affect heritage sites. These activities will not normally require an HRR and include:

- line cutting;
- mulching vegetation;
- geophysical survey;
- new work camps, roads, staging areas, drill pads, etc. constructed in areas that have been previously disturbed by development;
- new work camps, roads, staging areas, drill pads etc. constructed in areas that are more than 100 m from a watercourse or waterbody (except if located on an esker);
- drilling during frozen ground conditions or from drill pads located on a frozen lake; and
- any activity that will disturb less than 26 m^2 of mineral soil.

Denison followed all regulatory procedures as outlined above and submitted the Project to the HCB for review in 2017 and 2019. The results of the HRRs and the subsequent HRIAs are detailed in section 4.2.2.

3.0 PROJECT BACKGROUND

The Project is a proposed uranium mine and processing plant located in northern Saskatchewan, approximately 35 km north-northeast of Cameco Corporation's Key Lake Operation (Figure 1 and Figure 2). For the development of the Phoenix uranium deposit, Denison is planning on using ISR mining with on-site processing. Supporting components for the Project include the construction, operation, and decommissioning of a 7-km access road from Highway 914, an accommodation complex, operations centre, airstrip, a 5-km long road from site to the airstrip, site access roads, lined pads for storage of impurities from the processing plant and mineralized drill cuttings from the wellfield development, water treatment ponds, and potable, sewage, and wastewater treatment plants.

Any activity that affects the ground surface may negatively affect Heritage Resources. As such, all ground disturbance activities associated with the construction and operation of the Project should be considered potentially harmful to Heritage Resources and the HRMP will be consulted.

3.1 Environment

The Project is located in the Athabasca Basin of northern Saskatchewan. The Athabasca Basin is the world's leading source of high-grade uranium. The Athabasca Basin covers approximately 100,000 km^2 extending from just south of Lake Athabasca in the west to just east of Wollaston Lake.

The Project is located in the Wheeler Upland Landscaper Area of the Athabasca Plain Ecoregion (Acton et al. 1998). The most important factor in creating this physical landscape area is glaciation. This region is characterized by drumlinoid moraine that is largely covered by hummocky glaciofluvial outwash. The hummocky terrain creates well drained uplands and areas of small, poorly drained swales and flats. Eskers cross the region from northeast to southwest. Some of these eskers are more than 100 km long. These eskers would have provided Precontact period groups with effective travel routes through a rough and challenging landscape. Drainage in this region is weakly developed and water flows from lake to lake through small creeks. This area would have been deglaciated approximately 8,500 years before present (B.P.), providing a baseline for the earliest human habitation of the area (Dyke 2004).

The area is prone to forest fires and most of the area is in some state of regeneration (Acton et al. 1998). The uplands are dominated by jack pine and black spruce with an understory of lichen, Canada blueberry, and green alder. Low lying areas are dominated by bogs that may have black spruce, white birch, and willow, depending on the stage of regeneration.

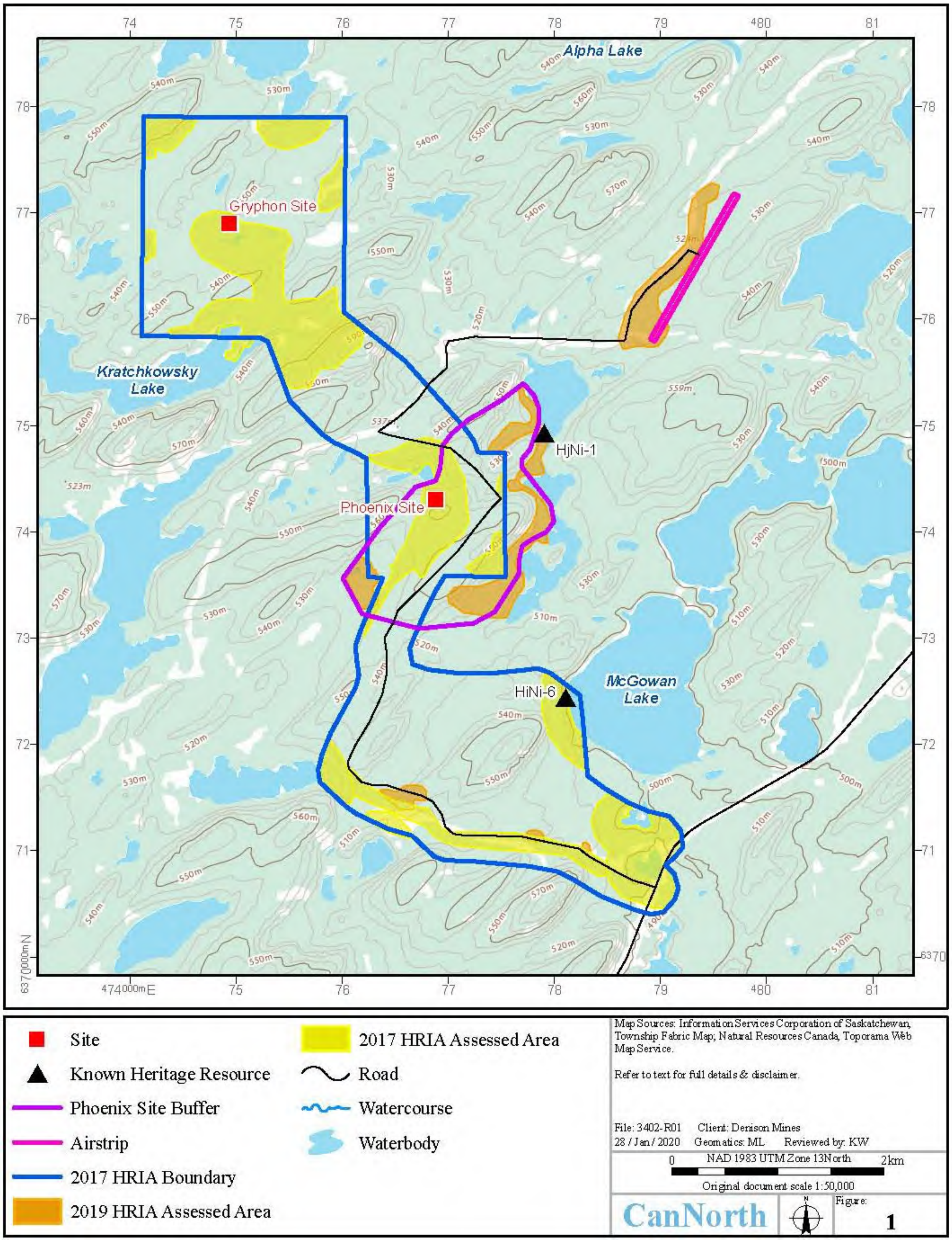


Figure 1. Heritage Resources near the Wheeler River Project

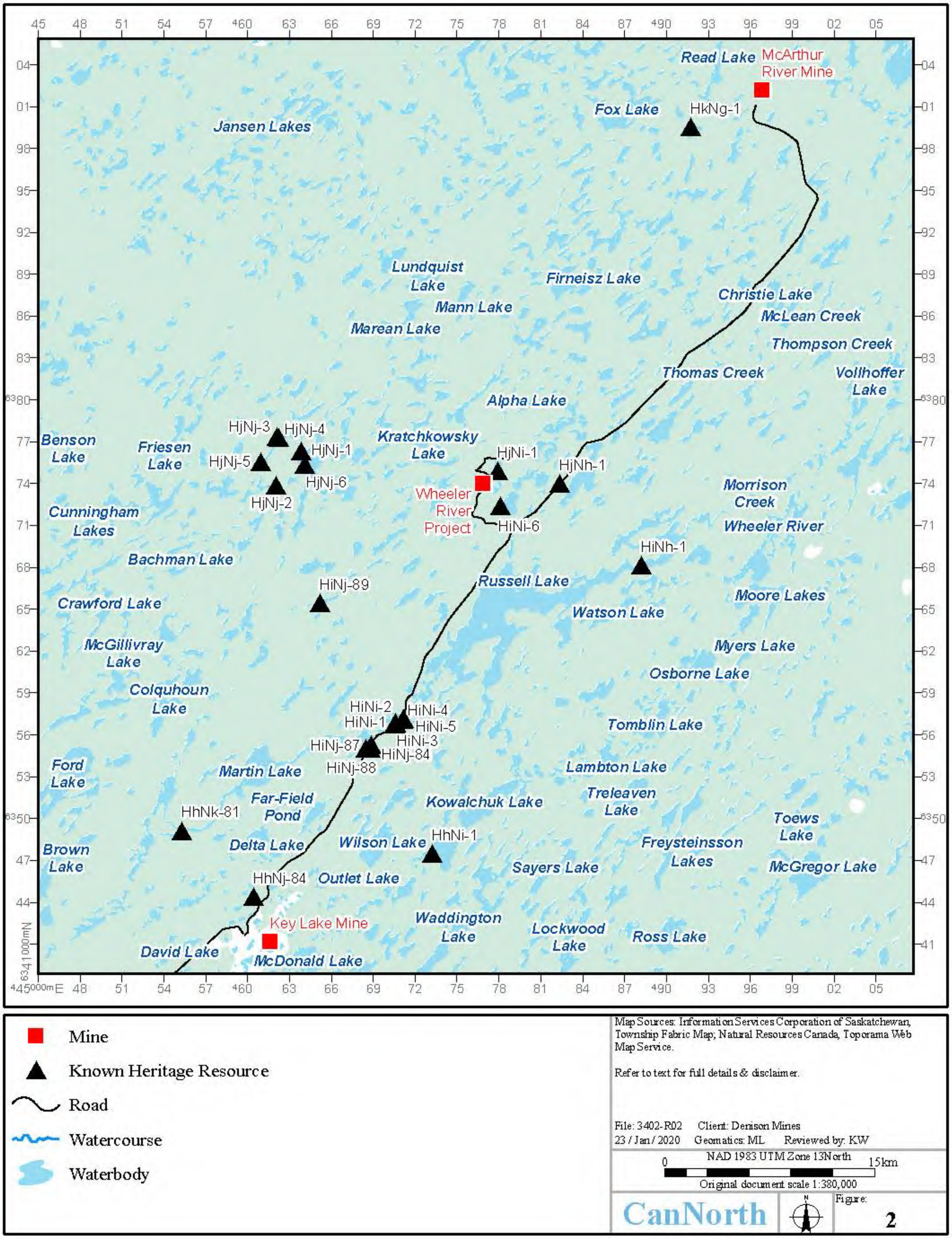


Figure 2. Heritage Resources associated with Mining Projects.

4.0 ARCHAEOLOGICAL AND HISTORICAL BACKGROUND

4.1 Culture History

In general, the culture histories, ancient land-use patterns, and ancient lifeways of northern Saskatchewan, including the Project area, are poorly understood because of the many problems associated with boreal forest archaeology. These problems include poor organic preservation, a lack of stratified sites and a paucity of archaeological work conducted in the north (Wright 1972; Hamilton 1988; Reid 1988; Ives 1993; Meyer 1995). Present knowledge of this area borrows heavily from archaeological research conducted in adjacent areas such as northeastern Alberta, Northwest Territories, Nunavut, northwestern Manitoba, and the more southern Northern Plains regions of the Prairie Provinces and northern United States. No culturally or temporally diagnostic archaeological materials have been discovered in the Project area, and the following discussion of the culture history, ancient land-use patterns, and lifeways of northern Saskatchewan should be seen as a temporary guide of current research until our knowledge base is broadened from future archaeological research in this region.

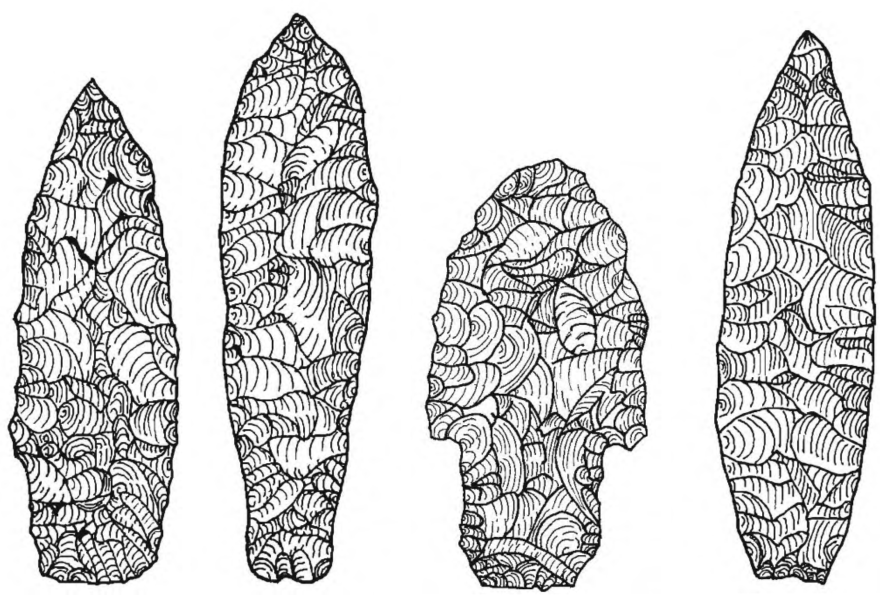
Deglaciation and draining of the associate proglacial lakes in the Project area would have been necessary in the Project area. The Project area would have been deglaciated approximately 8,500 years before present (B.P.), providing a baseline for the earliest human habitation of the area (Dyke 2004). In general, the culture history of northern Saskatchewan can be divided into four temporal periods (from earliest to latest): the Early Precontact period (9,500 to 7,500 B.P.); the Middle Precontact period (7,500 to 1,000 B.P.); the Woodland period (1,000 to 170 B.P.); and the Contact period, which commenced with arrival of early explorers and fur traders into the region approximately 170 years ago.

4.1.1 Early Precontact period (10,000 to 7,500 B.P.)

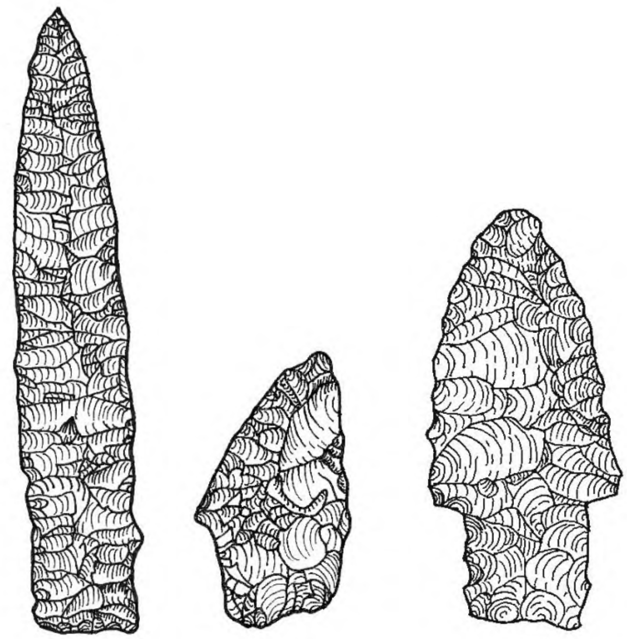
Environmental conditions at the beginning of this period would have been harsher than present conditions, supporting tundra-like vegetation and large fauna, including extinct species such as mammoth, horse, camel, elk, caribou, musk oxen, and early bison species (MacDonald and McLeod 1996; Meyer and Russell 2007). During this period, the Project area would likely have been occupied by small bands of mobile hunter gathers that would have depended on the available plant and faunal resources of the area shortly after deglaciation ~8,500 B.P.

Diagnostic artifacts of the Early Precontact period found in northern Saskatchewan include projectile points and tools from the Agate Basin complex (10,500 to 9500 B.P.), Goshen-Plainview complex (9,500 to 9,000 B.P.), Alberta complex (9,500 to 9,000 B.P.), Cody complex (8,800 to 8,400 B.P.), Hell Gap complex (10,000 to 9,500 B.P.), and Angostura complex (8,400 to 7,500) (Millar 1997; Meyer 1999; Amundson and Meyer 2003). The majority of these projectile points and tools have been discovered on the surface or have been excavated from an un-dateable context; however, an exception is a lanceolate point resembling the Angostura projectile point style excavated from the St. Louis site (FfNk-7), an archaeological site near the Town of St. Louis, Saskatchewan. Bone associated with this projectile point produced a date of 7,810 B.P. (Amundson and Meyer 2003).

Evidence of the Early Precontact period has not been found in the Project area or even nearby. Two Early period archaeological sites nearest to the Project area are GkNg-1, which is located along the Churchill River near Misinipe, Saskatchewan, and is represented by a projectile point resembling the Northern Plano / Angostura point style (~8,400 to 7,500 B.P), and the Old Beach site located near Buffalo Narrows, Saskatchewan, where a projectile point resembling the Alberta point style was discovered (9,500 to 9,000 B.P.).



Agate Basin, Hell Gap, Alberta, and Angostura projectile points.

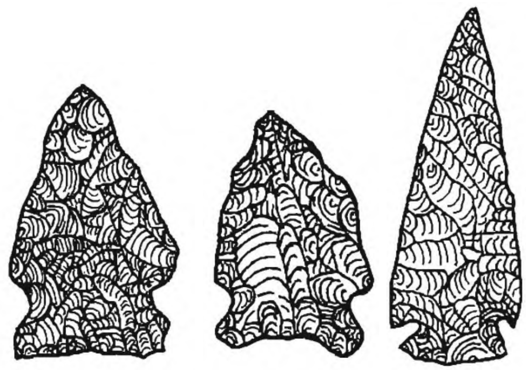


Cody complex: Eden projectile point, Cody knife, and Scottsbluff projectile point.

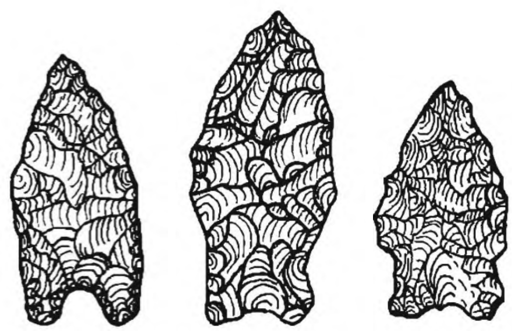
4.1.2 Middle Precontact period (7,500 to 1,000 B.P.)

At approximately 7,500 B.P., a relatively hot and dry period known as the Hypsithermal caused a northern expansion of the Aspen Parklands, plains grasslands, plains bison, and subsequent plains/bison adapted people into portions of the southern zone of northern Saskatchewan (Johnson 1989; Ritchie 1989; Meyer 1999). Projectile points found in northern Saskatchewan from this period are indistinguishable from ones found in southern Saskatchewan; however, unlike the specialized bison hunting strategies used in southern Saskatchewan, people in the southern zone of northern Saskatchewan developed their own unique, more generalized, hunter-gatherer strategies (FMA 1992).

The Mummy Cave/Early Side-notched culture (7,500 to 5,000 B.P.) represents the earliest Middle Precontact period archaeological group to occupy this region (Meyer 1999). Projectile points of this style have been found at Lac La Loche (Steer 1977; Meyer 1995), the Near Norbert archaeological site (GlNp-1), located at the confluence of the Norbert and Haultain rivers (Meyer 1999) and at Brabant Lake (Pentney 2002). Archaeological groups that followed the Mummy Cave/Early Side-notched culture include the Oxbow culture (4,700 to 3,800 B.P.), the McKean culture (4,100 to 3,100 B.P.), and the Pelican Lake culture (3,300 to 2,000 B.P.). Projectile points affiliated with these archaeological cultures have been found throughout the southern zone of northern Saskatchewan (Gryba 1974; Steer 1977; Hanna 1982; Meyer 1995; Millar 1997; Markowski and Wolfe 2013).

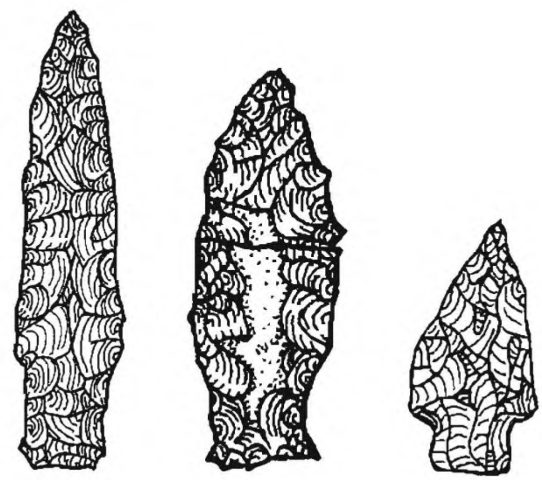


Mummy Cave, Oxbow, and Pelican Lake projectile points.



McKean Complex: McKean, Duncan, and Hanna projectile points.

In addition to the influence of plains-adapted archaeological cultures from the south, the southern zone of northern Saskatchewan was also influenced by barrenland adapted cultures from the north. The Taltheilei culture is typically divided into the Early period (2,600 to 2,100 B.P), Middle period (2,100 to 1,500 B.P.), and Late period (1,200 to Historic Period) (Gordon 1996; Meyer 1999) (Appendix C). It is believed that the Taltheilei archaeological culture represents ancestral Dené who continue to live and hunt in northern Saskatchewan (Noble 1971; Meyer 1999). Taltheilei projectile points have been discovered throughout the upper Churchill River basin and in Alberta, including the Primrose Weapons Range and the Cold Lake area (FMA 1992; Meyer 1995; Millar 1997). Taltheilei people used a strategy of following migratory barrenground caribou from their winter range north of the Thelon River and Beverly Lake in Nunavut to their summer range in northern Saskatchewan (Gordon 1996; Meyer 1999). The presence of Taltheilei archaeological sites as well as oral histories from the southern zone suggests that the southernmost range of barrenland caribou during this time was much further south than it is at present (Holland and Kkailther 2003; Millar 2009; Korejbo 2011).

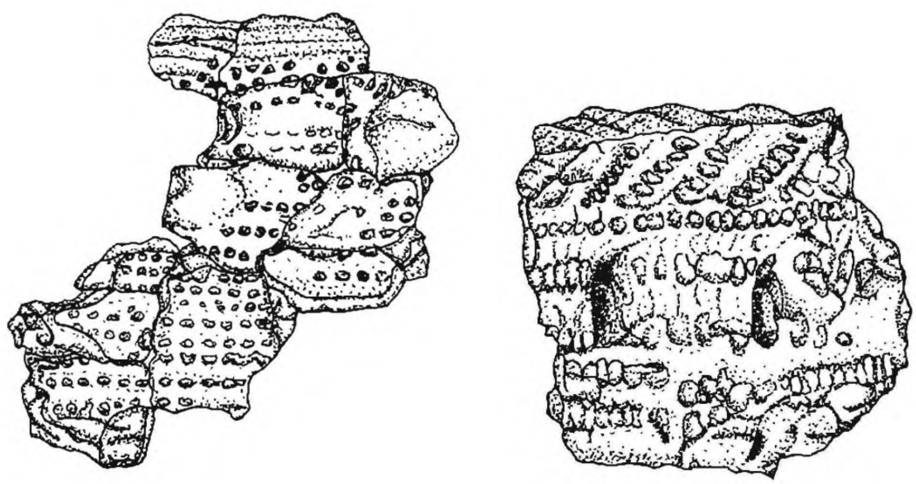


Early, Middle, and Late Taltheilei projectile points.

4.1.3 The Woodland period (1,000 to 170 B.P.)

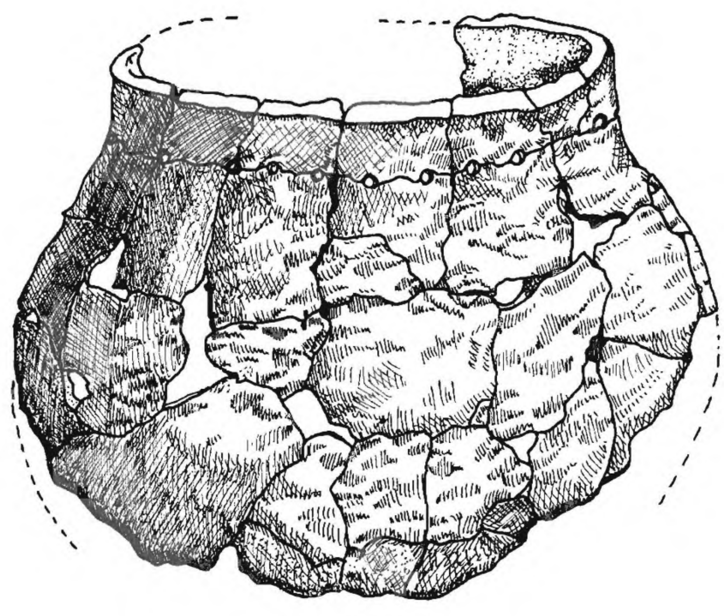
The Woodland period is generally divided into Early, Middle, and Late periods. Previous archaeological cultures throughout the Early Precontact period and Middle Precontact period are defined by diagnostic projectile points, whereas Woodland period groups are defined by pottery styles. Early Woodland period groups first appear approximately 2,500 years B.P. in the eastern United States, but do not appear to be present in Saskatchewan (Meyer 1999).

The earliest Woodland period group in northern Saskatchewan is defined by a Middle Woodland period group known as Laurel. In Saskatchewan, Laurel sites have been recorded along the Sturgeon Weir, Churchill, and Reindeer rivers (Meyer 1999). Although a precise time period of occupation remains unknown, a Laurel pottery sherd from the Spruce Rapids site on Amisk Lake has been dated to approximately 1,000 years B.P. The River House complex (1,220 to 850 B.P.), contemporaneous with later expressions of Laurel, was an archaeological culture that was present along the lower North Saskatchewan River valley and east and southeast into west-central Manitoba (Meyer 1999; Meyer et al. 2008). A third archaeological group known as the Blackduck culture (1,000 to 650 B.P.) was also present in northern Saskatchewan during the Laurel and River House occupations (Meyer 1999).



Laurel and Blackduck pottery sherds.

The Selkirk culture (700 to 300 B.P.) is considered a Late Woodland period group (Young 2006). Selkirk pottery styles recovered from the southern edge of the boreal forest and in the Buffalo Narrows region provide evidence for interactions and influences from plains groups in southern Saskatchewan (Meyer 1999). Selkirk likely signals the introduction of a distinct group of people from the eastern woodlands (Young 2006). A Selkirk composite pottery sherd recovered from the northern extent of Lac La Loche indicates a possible ethnic boundary between the Athabasca River drainage and the Churchill River drainage during the Late Woodland period (Korejbo 2011). In addition, rock paintings in northern Saskatchewan are also believed to have been made by the Algonquian speaking Selkirk culture throughout the Woodland Period (Meyer 1999; Jones 2006). It is believed that the Selkirk archaeological culture represents Algonquian-speaking people, who are ancestral to the Cree (Meyer and Russell 1987).



Selkirk pottery.

4.1.4 The Contact period: The Fur Trade

The Contact period in western Canada began with the arrival of early explorers and fur traders from the coasts of Hudson Bay. The first permanent inland trading post was established at Churchill, Manitoba, in 1717, nearly 100 years following the arrival of European goods, by William Steward of the Hudson's Bay Company (HBC) (SRC 1983). The Historic period in the southern zone begins as early as the earliest reconnaissance exploration into what is now eastern Saskatchewan by Henry Kelsey via the Red Deer River in 1691 (Russell 1999a). The Dené of northern Saskatchewan were perhaps the earliest group in Saskatchewan to be affected by the fur trade. David Meyer (SRC 1983a) suggests that the Dené likely obtained European goods as early as the 1620s. Although no inland trading posts had been established at this time, European goods made their way inland as a result of fur traders wintering and trading along Hudson Bay.

Trading posts were established in the southern zone of northern Saskatchewan following the establishment of trading posts along the Saskatchewan River during a period of intense competition among fur trade companies. Among the first trading posts in the southern zone of northern Saskatchewan was Fort St. Louis I established by French traders (1753-1757) near the present day James Smith Reserve (Russell and Meyer 1999). The establishment of

Cumberland House by the Hudson's Bay Company (HBC) in 1774 opened up trading activities in the southern zone of northern Saskatchewan. The Sturgeon Weir River and the Churchill River became crucial travel routes to access trading posts established in the Athabasca region (Russell and Meyer 1999). Fur trade explorers, including Peter Pond in 1778-1779, David Thompson in 1798-1799, and Peter Fidler in 1790-1792 travelled along the Sturgeon Weir River (Russell and Meyer 1999). Later expeditions that travelled along the Sturgeon Weir River include John Franklin in 1819-1822, J.B. Tyrell in 1894, and William McInnes in 1910 (Russell 1999b; Russell 2006).

4.2 Archaeological Background

The HCB's archaeological site database was consulted to determine the type and number of known sites recorded near the Project. In addition, the extent of previous archaeological work in the area was reviewed (Figure 2). Given the remote location of the Project, the record of archaeological sites is quite slim. This paucity of archaeological sites does not mean that there are not archaeological sites in the region but rather reflects the lack of archaeological research. The majority of the archaeological sites found in the region were identified in relation to resource development. In general, known archaeological sites in the north are clustered around mines or along roadways, reflecting the development pattern in the area and not the settlement patterns of past peoples.

In addition to the remote nature of the area, archaeological research is hampered by additional factors: a lack of stratified sites and a lack of organic materials. There has been little to no soil deposition in the project area since the advent of human occupation, and therefore, sites in the region do not exhibit distinct occupation layers (Meyer 1979). Stratification allows archaeologists to examine chronological changes at a site and to examine large-scale archaeological patterns in a regional and chronological context. Archaeologists also rely on carbon dating to date sites. However, the acidic soil in the region hampers preservation of organic materials in an archaeological site and organics (i.e., bones) are rarely found in the boreal forest. Therefore, the only way to reliably date sites in the region is through the use of diagnostic artifacts (Meyer 1979).

4.2.1 Previous Archaeological Research

Archaeological research in the Project area did not begin until the 1960s when archaeologists from the Saskatchewan Museum of Natural History (now the Royal

Saskatchewan Museum [RSM]) briefly visited Cree Lake in 1964 (approximately 40 km east of the Project). The first, large-scale archaeological research project in the area was conducted in 1978 by Dr. David Meyer in the Key Lake-Zimmer Lake region as part of the Environmental Impact Statement (EIS) for the proposed Key Lake Project (now the Key Lake Mine). The Key Lake Mine is located approximately 35 km south of the Project. During the multi-year project, Meyer identified and recorded 76 sites and 9 find areas (Meyer 1979). This project formed the baseline for all archeological research in the area and is still considered the single most important archaeological survey in the area to date.

4.2.2 Denison Baseline Heritage Resource Impact Assessment

Two HRIAs have been completed for the Project in 2017 and 2019 (Figure 1). The Project was submitted to the Heritage Conservation Branch (HCB) in 2017 and 2019 and HRRs were completed. The HRRs determined that portions of the project were located on heritage sensitive terrain and HRIAs were required.

A baseline HRIA was completed in 2017 under Archaeological Investigation Permit No. 17-091 (Golder 2017). A preliminary project footprint was initially reviewed by the HCB, and it was determined that portions of the project were located in heritage sensitive terrain (i.e., previously undisturbed, hilly terrain with prominent uplands in close proximity to permanent water sources) and an HRIA was required (HCB File No. 16-2102). A baseline HRIA was completed during the summer of 2017 under Archaeological Investigation Permit No. 17-091. The goal of baseline field assessments is to help to determine the nature of archaeological sites, the types of landforms in which sites are located, and the characteristics of artifacts that may be found within the baseline study area. This survey investigated several proposed access roads for the Project and approximately 393 ha were surveyed by archaeologists and a local assistant from the English River First Nation. The survey utilized pedestrian survey (walking and looking for visible evidence of past human behavior), the inspection of areas where soil and sediment were exposed (i.e., natural and mechanical disturbances to the soil), and the excavation of 258 shovel probes (approximately 40 cm by 40 cm, 40 cm deep holes dug by hand and sorted through by hand), and 5 shovel tests (approximately 50 cm by 50 cm, 40 cm deep holes dug by hand and sorted through a ¼” mesh screen).

A single site, HiNi-6, was identified after one flake (fragment of stone produced as a result of stone tool manufacture) was found in a shovel test on a terrace overlooking McGowan

Lake (Figure 1). The site is located near, but not in conflict with, the proposed access road for the Phoenix Site. The artifact was identified approximately 15 cm below the surface (dbs). Further shovel tests were excavated in order to assess the size, nature, and significance of the site, however, no further artifacts or Heritage Resources were discovered during the assessment. HiNi-6 is summarized below in section 3.2.2.1. Based on the results of the HRIA, the HCB determined that HiNi-6 was of limited interpretive value, and there were no concerns with the development proceeding as planned within the surveyed areas (HCB File No. 16-2102, December 14th, 2017). Regulatory approval as per section 63 of *The Heritage Property Act* (Government of Saskatchewan 1980) was granted for the Project (HCB File No. 16-2102, December 14, 2017). Furthermore, Denison will not be developing the proposed access road adjacent to HiNi-6 and the site will not be affected.

The project footprint was refined in 2019 and was resubmitted to the HCB for their review. The majority of the refined footprint overlapped with the footprint that was reviewed in 2017; however, the HCB determined that several areas of the refined footprint would have the potential to affect heritage sensitive terrain that had not been previously surveyed during the 2017 fieldwork and an HRIA was required. Approximately 284 ha were surveyed in the Phoenix Project buffer area, as well as additional areas along the previously assessed access roads, and near the air strip (Permit No. 19-065; Golder 2020).

The survey was completed by archaeologists and a local assistant from the English River First Nation utilizing pedestrian survey, the inspection of areas where soil and sediment were exposed, and the excavation of 212 shovel probes and 5 shovel tests. A single archaeological site, HjNi-1, was identified just outside the Phoenix buffer area after a single flake single flake was identified on the surface of an existing road that overlooks the confluence of a lake and a creek (Figure 1). To assess the site, the road was further examined for additional artifacts and additional shovel tests were excavated near the road, however, no additional artifacts or Heritage Resources were identified during the assessment. HjNi-1 is summarized below in section 3.2.2.2. Based on the results of the HRIA, the HCB determined that HjNi-1 was of limited interpretive value, and there were no concerns with the development proceeding as planned within the surveyed areas. Regulatory approval as per section 63 of *The Heritage Property Act* (Government of Saskatchewan 1980) was granted for the Project (HCB File No. 19-933 February 12th, 2020).

4.2.3 Known Heritage

In total, 16 archaeological sites have been identified with a 20-km radius around the project area (the Regional Study Area). Of the 16 sites, 15 were identified during heritage and environmental surveys for mining industry projects. The remaining site was identified by a local informant. The sites consist of artifact finds (n=10), artifact scatters (n=4), an artifact/feature combination (n=1), and a multiple feature site (n=1). Six of the sites could not be assigned a cultural or temporal affiliation. Nine of the sites are Precontact period sites and the last site is a Historic First Nation Site. Diagnostic artifacts were not identified at the sites to allow for a more specific cultural affiliation.

Table 1. Known archaeological sites within a **20-**kilometre radius of the project area.

Borden No.	Site Type	Cultural Affiliation	Permit No.
HiNh-1	Artifact/Feature Combination	Unknown	03-000
HiNi-1	Artifact Find	Unknown Precontact	78-000
HiNi-2	Artifact Find	Unknown Precontact	78-000
HiNi-3	Multiple Features	Historic First Nation	78-000
HiNi-4	Artifact Scatter	Unknown Precontact	90-037
HiNi-5	Artifact Find	Unknown Precontact	99-072
HiNi-6	Artifact Find	Unknown Precontact	17-091
HiNj-89	Artifact Find	Unknown Precontact	11-000
HjNh-1	Artifact Find	Unknown	93-058
HjNi-1	Artifact Find	Unknown Precontact	19-065
HjNj-1	Artifact Find	Unknown	07-183
HjNj-2	Artifact Scatter	Unknown Precontact	07-183
HjNj-3	Artifact Scatter	Unknown	07-183
HjNj-4	Artifact Find	Unknown	07-183
HjNj-5	Artifact Find	Unknown	07-183
HjNj-6	Artifact Scatter	Unknown Precontact	10-187

Two sites, HiNi-6 and HjNi-1 were identified during HRIAs conducted for the Project and are discussed below.

4.2.3.1 HiNi-6

HiNi-6 was identified during a baseline HRIA for Denison under Archaeological Resource Investigation Permit No. 17-091 (Golder 2017). The site is a Precontact period artifact find located on a terrace edge that overlooks a lake to the east. The terrace is flat, with undulating terrain and a small drainage to the west, and a steep slope down to a sandy beach along the lake to the east.

A single large, grey secondary flake was identified in a shovel test. The flake exhibited retouching along the concave edge. Four additional shovel tests were excavated adjacent to the positive shovel test. No additional artifacts were identified. Given the low density of artifacts, it was determined that the site had limited interpretive value, and no further work was required at the site.

4.2.3.2 HjNi-1

HhiNi-1 was identified during a HRIA of the Phoenix buffer area under Archaeological Resource Investigation Permit No. 19-065 (Golder 2020). The site is a Precontact period artifact find identified on the surface of an access road. Terrain in the area consists of flat forested uplands with a rock escarpment to the east. The confluence of a creek and a lake is located just north of the site.

A single quarzitic sandstone flake was identified. Subsurface exposures along the access road were examined and five shovel tests were excavated along the boundaries of the area disturbed by the access road. No additional artifacts or paleosols were identified in the shovel tests. Given the low density of artifacts, it was determined that the site had limited interpretive value, and no further work was required at the site.

5.0 HERITAGE RESOURCES MANAGEMENT POLICY

The following section outlines the HRMP developed for the Project. The legislation outlined above, the HCB's guidelines for mining and forestry work, the results of past HRIAs completed for the Project, previous archaeologic research, and the heritage potential of the area have been taken into consideration when developing this policy. The HRMP consists of a chance find procedure and then outlines the management of Heritage Resources should they be identified during the life of the project. The HRMP also identifies activities which may require submission to the HCB for further review.

This HRMP will be considered a living document and will be updated as needed. These updates may include concerns and suggestions from Indigenous Communities, updated heritage requirements from the HCB, changes to methodology, and the recording of additional archaeological sites within the Project area.

5.1 Chance Finds Procedure

The following steps and procedures should be followed in the case of any incidental or chance find, including archaeological or palaeontological sites, or human remains. For the purpose of this proposed procedure, a "Designated Person" is someone involved in the Project (e.g., Denison supervisor) and assigned responsibility for the protection of the find and the steps going forward, and an "Indigenous Community" is any Indigenous Community who Denison commits to engage in the event of a chance find.

1. If a chance find is suspected, all activity in the area of the discovery site is to stop immediately and the steps below are to be followed:

    a. All artifacts and features will be left in the same position in which they were discovered, and no objects will be removed from the location.
    b. A supervisor or the Designated Person must be informed immediately.
    c. Denison will isolate and protect the area by establishing a temporary buffer of 30 m around the discovery (i.e., staking, flagging, snow fencing, etc.) to prevent further disturbances in the area.
    d. The Designated Person will provide the following information to the HCB or a qualified archaeologist for evaluation: the GPS location of the discovery and photographs of the site location, identified artifacts, objects, or soil discolourations.

e. The Designated Person will inform the Indigenous Communities of the find, and provide updates of any relevant changes, decisions, or new information.
f. The professional archaeologist will work with Denison and the Designated Person to assess the significance of the discovery through surface inspection and ensure adequate protection measures are in place for the discovery. These protection measures will be communicated by the Designated Person to the Indigenous Communities.
g. If the archaeologist, in consultation with the Designated Person, determines that the object is archaeological in nature, the Designated Person will inform the Indigenous Communities and the steps outlined below will be followed.
h. If the object or feature is not archaeological in nature, then the work may proceed as planned.

2. Should a staff member encounter a suspected archaeological find during their leisure time (e.g., walking along a path or a beach) they will inform Denison who will commence the chance finds procedure outlined above.

3. If the object has been determined to be human remains, or if they are suspected to be human remains, the RCMP, the coroner, and the HCB must be contacted immediately, as per the Archaeological Burial Management Policy (2010) and under the authority of *The Heritage Property Act* (Government of Saskatchewan 1980).
    a. The Designated Person will promptly communicate with the Indigenous Communities, and shall provide updates of any relevant changes, decisions, or new information.
    b. If the remains are modern, requirements from the RCMP must be followed.
    c. If the remains are determined to be archaeological, then the HCB and Indigenous Communities will be consulted to determine how to proceed.

4. If the object is archaeological in nature, but not human remains, the archaeologist will contact the HCB and will obtain an Archaeological Resources Investigation Permit if necessary.
    a. The professional archaeologist, in consultation with the HCB, will conduct a HRIA in accordance with all site health and safety protocols and the regulatory requirements of *The Heritage Property Act* (Government of Saskatchewan 1980).

5. The results of the HRIA will be discussed with Denison, the HCB, the Designated Person, and the Indigenous Communities.
    a. Recommendations for protecting the archaeological site, the archaeological object, and mitigation measures will be determined in consultation with these above communities.

6. The archaeologist will work with Denison and the Designated Person to prepare written instructions for recommencement of work in the area, which will become part of the clearance recommendations in the HRIA permit report.
7. The archaeologist will prepare a draft of a HRIA permit report and a Saskatchewan Archaeological Resource Record (SARR) form to obtain regulatory approval for the Project for submission to Denison, the Designated Person, Indigenous Communities, and the HCB.
    a. Following approval of the HRIA permit draft report, final submission to the HCB, and regulatory approval, final copies will be provided to Denison, the Designated Person, and the Indigenous Communities.

8. Preservation of archaeological objects will follow requirements as outlined by the HCB, the RSM, and the Indigenous Communities, including the agreed upon cultural protocols.

5.1.1 Staff Education

All staff working at the Project should be informed of the possibility that they could encounter archaeological resources during their work/leisure time and the proper procedure to follow in the case of a chance find. This could be facilitated by a short archaeological education section in the employee orientation, outlining the types of sites and artifacts that could be encountered in the area, as well as what to do when a potential artifact or site is found.

5.2 Heritage Resources Impact Assessment

As explained above, if the chance find is deemed to be an archaeological site, then a HRIA is required, and a qualified archaeologist must complete the assessment. The archaeologist will apply for an Archaeological Resource Investigation Permit (Permit) from the HCB. It takes a minimum of two business days to receive a Permit; however, the amount of time required to receive a Permit from the HCB is dependent on their current workload and may take up to one week or longer. The HRIA fieldwork will be completed following the requirements outlined in the Heritage Resource Review (HRR) as well as any additional requirements from the HCB (if any) following the receipt of the Permit. The HCB may also add additional requirements during this stage of the process if they deem necessary. A SARR form is completed and submitted to the HCB to register the find as an archaeological site if a new site is identified, or if a known site is investigated further. A report outlining the results of the HRIA fieldwork will be completed and will include archaeological resource management recommendations to the HCB. Recommendations can include full heritage clearance, or conditional heritage clearance based on avoidance of the archaeological resource(s) (preferred), or that further archaeological investigations are completed to mitigate the affects of the project to archaeological resources. These recommendations will be discussed in management options. The HCB will issue a formal clearance letter granting either full heritage clearance for the Project to proceed, or conditional heritage clearance following the review and receipt of the final report.

5.3 Management of Heritage Resources

Heritage Resources can be managed in several ways including avoidance (preferred), mitigation, post-impact assessments, and altered work practices. In many cases a combination of management practices is utilized. SSN are offered additional protection and avoidance may be considered the only option. Each Heritage Resource should be considered unique as should the specific management of each resource. Management options will be discussed by the archaeologist and the HCB, in consultation with Denison. Management options will also be presented to the applicable Indigenous Communities for feedback and discussion regarding management of the resource and to ensure that the proper cultural protocols are being followed. Additionally, the management of Heritage Resources will include consultation with Indigenous communities and the submission of any new development to the HCB for review. Management options are discussed below.

5.3.1 Consultation with Indigenous Communities

The appropriate Indigenous Communities should be consulted prior to archaeological fieldwork regarding Heritage Resources and to determine what the proper cultural protocol would be if Heritage Resources are discovered. Protocols should be discussed regarding the initial discovery of the heritage resource, potential mitigation of the heritage resource, and the curation of the resource. Indigenous Communities may have preferences regarding how the HRIA is conducted, for example, they may ask that tobacco be placed in shovel tests where artifacts are identified, for an elder to bless artifacts, or they may request that artifacts are stored in a specific manner (e.g., with sage or tobacco). These protocols should be followed if possible; however, it should be noted that some protocols may affect future curation of Heritage Resources, and that it may be necessary to discuss these protocols with the HCB, RSM, or the Canadian Conservation Institute (CCI).

It is understood that many Indigenous Communities have an interest in repatriating artifacts to their traditional territories. The RSM does have a repatriation and shared stewardship policy and can be contacted by interested Indigenous Communities to discuss the long-term storage and repatriation of artifacts (RSM 2020). These discussions may include storage requirements from the RSM to ensure the stability of the artifacts and legal procedures that will need to be followed to allow for the permanent storage of artifacts outside of RSM properties.

5.3.2 Avoidance

Avoidance or partial avoidance of Heritage Resources through route or project location alterations are often the preferred method of management as other management methods (e.g., mitigative excavations) result in the destruction of the heritage resource. Avoidance may entail moving portions of the project (e.g., altering road alignments) to avoid Heritage Resources or changing construction processes to minimize ground disturbance (e.g., completing vegetation clearing in frozen conditions, boring pipelines/culverts). Avoidance buffers around sites can range from as small as 5 m to as large as 250 m (e.g., for SSN), but are more commonly approximately 25 m. Buffers around heritage sites will be established in consultation with the HCB. If construction plans are altered and the site can no longer be avoided, the HCB must be informed, and other management strategies will need to be employed. In the case of SSN, avoidance is recommended unless there is no other option.

5.3.3 Mitigation

Mitigation may be a viable option if Heritage Resources cannot be avoided. Two common forms of mitigation include intensive and detailed systematic shovel testing and archaeological excavation. These mitigative options generally follow a progression of archaeological investigations and will be discussed further in the paragraphs below.

The mitigation of a heritage resource can also occur through simple assessment during a HRIA. During these assessments, it may be determined that further archaeological investigations would be unlikely to result in the recovery of significant interpretive/scientific data, and no further work would be recommended. If the results of simple assessment suggest that the site is more significant and that further archaeological investigations would likely result in the recovery of significant interpretive data, then a higher level of assessment may be recommended.

A further level of assessment would involve a more detailed systematic and intensive shovel testing assessment program to further determine the extent, nature, and significance of the Heritage Resources at the site. This level of assessment may be determined and conducted during the initial HRIA assessment, or it may be determined later on by the HCB. If sufficient testing is required at a site, and the results suggest that further investigations are unlikely to result in the recovery of significant interpretive/scientific data, it might be recommended that further work is not needed at the site. However, the results of the testing, as well as any recommendations, will need to be presented to, and approved by the HCB. The HCB may require a further stage of work based on the results. If the results of the detailed systematic and intensive shovel testing program identifies that the site is significant, or if any artifact concentrations or features are present that might contain important interpretive data, a further level of archaeological investigations (usually mitigative excavations) will likely be recommended.

Although the excavation of an archaeological site is inherently destructive, when done in a controlled manner, meaningful data can be gathered to contribute to the overall knowledge of past peoples in the Project area. Mitigative excavations require a mitigation permit from the HCB and the methodology for the excavation should be discussed with the HCB prior to conducting the fieldwork. Excavations often go through several stages with additional excavations required based on results (i.e., if the known significance/extent of the site is increased during excavations, more excavations/investigations may be required). The site and any finds are recorded in detail throughout the excavation process. Any artifacts/ecofacts discovered will be taken to a lab to be analysed and recorded in detail, and may be submitted for further analysis (e.g., radiocarbon dating, blood residue analysis, thermoluminescence dating, etc.). Any additional requirements for analysis should be discussed with the HCB. The results of the excavations are summarized in a report that is submitted to the HCB for approval. Final approval of the mitigations will be made by the HCB. Any formal heritage clearances will be issued by the HCB following their approval and receipt of the final report.

Finally, at any point in the assessment process, the HCB may recommend construction monitoring. Construction monitoring involves a qualified archaeologist observing construction and continually inspecting disturbances created during construction. The archaeologist may stop construction at any point to examine potential artifacts. If an artifact is identified, the archaeologist will assess and record the artifact so that construction can continue. Construction monitoring can occur in both frozen and unfrozen conditions. The results of the construction monitoring are summarized in a report that is submitted to the HCB for approval. Final approval of the construction monitoring will be made by the HCB. Any formal heritage clearances will be issued by the HCB following their approval and receipt of the final report.

5.3.4 Altered Work Practices

Potential effects to sites can often be mitigated by adjusting the timing and approach to construction. This may include scheduling vegetation clearing during frozen conditions to reduce effects to the soil or using rig matting to avoid rutting up areas with sites, etc.

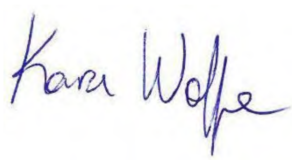
5.3.5 Additional Heritage Resource Reviews

Any new developments during the operational life of the mine that might affect Heritage Resource should be submitted to the HCB for an HRR. Changes to the project may include the expansion of the Project footprint or the addition of new infrastructure (e.g., roads). If the proposed developments are within the areas addressed during the baseline HRIAs conducted in 2017 and 2019, additional work may not be required; however, submission is still recommended.

6.0 CLOSURE

If you have any questions or require additional information regarding this HRIA, please contact the undersigned.

Sincerely,



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7.0 LITERATURE CITED

Acton, D.F., G.A. Padbury, and C.T. Stushnoff. 1998. The ecoregions of Saskatchewan. Canadian Plains Research Center, University of Regina, Regina.

Amundson, L.J., and D. Meyer. 2003. Late-plano occupation at the St. Louis site (FfNk-7), central Saskatchewan. Current Research in the Pleistocene 20:1-2.

Dyke, A.S. 2004. An outline for North American deglaciation with emphasis on central and northern Canada. *In* Quaternary glaciations – extent and chronology, part II, Vol 2. J. Ehlers and P.L. Gibbard (eds.). Elsevier Science and Technology Books, San Diego, California. pp. 373-424

Fedirchuk McCullough & Associates (FMA). 1992. The Duckett site: ten thousand years of prehistory on the shores of Ethel Lake, Alberta. Fedirchuk McCullough & Associates Ltd. Submitted to Esso Resources Canada Limited, Permit 86-034, final Report on file with the Heritage Resources Management Branch, Alberta Community Development, Edmonton, Alberta.

Gordon, B. 1976. Of men and herds in barrenland prehistory. Archaeological Survey of Canada, Mercury Series Paper 28. Canadian Museum of Civilization, Hull, Quebec.

Gordon, B.C. 1996. People of sunlight: people of starlight: barrenland archaeology in the Northwest Territories of Canada. Archaeological Survey of Canada, Mercury Series, Paper 154. Canadian Museum of Civilization, Hull, Quebec.

Golder Associates Ltd. (Golder). 2017. Denison Mines Corporation Wheeler River project heritage baseline study. Permit No. 17-091. Final report on file Heritage Conservation Branch, Regina.

Golder Associates Ltd. (Golder). 2020. Denison Mines Corporation Wheeler River project Heritage Resources Impact Assessment. Permit No. 19-065. Final report on file Heritage Conservation Branch, Regina.

Government of Saskatchewan. 1980. The Heritage Property Act, being Chapter H-2.2 of the Statutes of Saskatchewan, 1979-1980 (effective June 28, 1980) as amended by the Statutes of Saskatchewan, 1980-81, c. 76 and 83; 1982-83, c. 35; 1983, c.977; 1983-84, c. 39 and 49; 1988-89, c.55; 1989-90, c. 15 and 54; 1993, c.26; 1996, c.32; 1998, c. P.-42.7; 2000, c.L-5.1; 2001, c.20; 2002, c.C-11.1; 2005, c.M-36.1; 2007, c.P-13.2; 2010, c.N-5.2 and c.21; 2013, C.27; and 2014, c.E-13.1. 2014. The Queen's Printer. Regina, Saskatchewan. Website: www.qp.gov.sk.ca/documents/English/Statutes/Statutes/H2-2.pdf. Accessed April 18th, 2022.

Government of Saskatchewan (GS). 2008. Heritage Resource Impact Assessment and mitigation for forestry operations in Saskatchewan. The Queen's Printer. Regina, Saskatchewan. Website https://www.saskatchewan.ca/residents/parks-culture-heritage-and-sport/heritage-conservation-and-commemoration/archaeology/submit-your-land-and-resource-proposal-for-a-heritage-review. Accessed January 17th, 2020.

Government of Saskatchewan (GS). 2010. Archaeological burial management policy (effective January 1, 2003). The Queen's Printer. Regina, Saskatchewan. Website: https://publications.saskatchewan.ca/api/v1/products/84405/formats/97822/download. Accessed January 17th, 2020.

Government of Saskatchewan (GS). 2017. Heritage resources review and assessment guidelines for northern exploration. The Queen's Printer. Regina, Saskatchewan. Website: https://publications.saskatchewan.ca/api/v1/products/88953/formats/105684/download. Accessed January 17th, 2020.

Gryba, E.M. 1974. Final report of the 1973 archaeological survey of Prince Albert National Park: findings and recommendations. The Manuscript Report Series No. 319. Parks Canada, Department of Indian and Northern Affairs, Ottawa, Ontario.

Hamilton, S. 1988. The concept of cultural edge in the boreal forest of Manitoba and north western Ontario. *In* Boreal forest and sub-Arctic archaeology. C.S. Reid (ed.). Occasional Publications of the London Chapter No. 6, Ontario Archaeological Society Inc., London, Ontario. pp. 37-71.

Hanna, M.G. 1982. Report on reconnaissance survey of highway 21 and 155 and assessment and mitigation of HcOi-1, Old Airport Site. Under HRIA/M Permit No. 82 and 82-40, prepared for Saskatchewan Department of Highways and Transportation, North Battleford District. Final report on file with Saskatchewan Heritage Conservation Branch, Regina, Saskatchewan.

Heritage Conservation Branch (HCB). 2017. Heritage Resource Impact Assessment Review, December 14th, 2017 (Permit 17-091). HCB File No. 16-2102. Letter on file at the Heritage Resource Branch, Regina, Saskatchewan.

Heritage Conservation Branch (HCB). 2020. Heritage Resource Review Results, February 12th, 2020 (Permit 19-065). HCB File No. 19-993. Letter on file at the Heritage Resource Branch, Regina, Saskatchewan.

Holland, L., and M. Kkailther. 2003. They will have our words: the Dené elders project, volume 2. Holland Dalby Educational Consulting, LaRonge, Saskatchewan.

Ives, J.W. 1993. The ten thousand years before the fur trade in northeastern Alberta. *In* The uncovered past: roots of northern Alberta societies. P.A. McCormack and G.R. Ironside (eds.). Canadian Circumpolar Institute, University of Alberta, Edmonton. pp. 5-31.

Johnson, R.H. 1989. Relict grassland in northern Saskatchewan: a phytogeographic study in the Clearwater River Valley. Unpublished M.S. thesis, Department of Geography, University of Saskatchewan, Saskatoon, Saskatchewan.

Jones, T.E.H. 2006. The Aboriginal rock paintings of the Churchill River. Saskatchewan Archaeological Society, Saskatoon, Saskatchewan.

Korejbo, A.J. 2011. An archaeological survey in the Clearwater River Provincial Park, Saskatchewan; insights into the archaeology of the boreal forest of northwestern Saskatchewan. Unpublished M.A. thesis, Department of Archaeology and Anthropology, University of Saskatchewan, Saskatoon, Saskatchewan.

Markowski, M., and K. Wolfe. 2013. River valley tributaries and archaeological site discovery in sand dune environments. Saskatchewan Archaeological Society Newsletter 34(1):20-25.

MacDonald, G.M., and T.K. McLeod. 1996. The Holocene closing of the 'ice-free' corridor: a biogeographical perspective. Quaternary International 32:87-95.

Meyer, D. 1979. Archaeology in Key Lake Project, Environmental Impact Statement. Beak Consultants, Ltd. Calgary. Final report on file Heritage Conservation Branch, Regina.

Meyer, D. 1995. Churchill River archaeology in Saskatchewan: how much do we know? *In* The Churchill: A Canadian heritage river, proceedings from the conference, Saskatoon. March 8 – 10, 1995. Canadian Heritage Rivers System, Gatineau, Quebec. pp. 52-59.

Meyer, D. 1999. Precontact archaeology of northern Saskatchewan. *In* Atlas of Saskatchewan. K.I. Fung (ed.) University of Saskatchewan, Saskatoon, Saskatchewan. pp. 23-24.

Meyer, D., P. McKeand, J.M. Quigg, and G. Wowchuk. 2008. The river house complex: middle woodland on the northwestern periphery. Canadian Journal of Archaeology 32:43-76.

Meyer, D., and D.R. Russell. 1987. The Selkirk composite of central Canada: a reconsideration. Arctic Anthropology 24(2):1-31.

Meyer, D., and D.R. Russell. 2007. Aboriginal peoples from the Ice Age to 1870. *In* Saskatchewan: geographic perspectives. B.D. Thraves, M.L. Lewry, J.E. Dale, and H. Schlichtmann (eds.). Canadian Plains Research Centre, Regina. pp. 101-118

Millar, J.F.V. 1997. The prehistory of the upper Churchill River Basin, Saskatchewan, Canada. British Archaeological Reports International Series 668, John and Erica Hedges, Oxford, England.

Millar, M. 2009. Dené Honü: stories from the people. Birch Narrows Dené Nation, Turnor Lake, Saskatchewan.

Noble, W.C. 1971. Archaeological surveys and sequences in central district of Mackenzie, N.W.T. Arctic Anthropology 8(1):102-135.

Pentney, S.P. 2002. The archaeology of Brabant Lake. Unpublished M.A. thesis, Department of Archaeology, University of Saskatchewan, Saskatoon, Saskatchewan.

Reid, C.S. 1988. Some ideas concerning the formulation of research designs and excavation methodologies on boreal forest habitation sites. Midcontinental Journal of Archaeology. 13(52):187-221.

Ritchie, J.C. 1989. History of the boreal forests in Canada. *In* Quaternary geology of Canada and Greenland. R.J. Fulton 9ed.). Geological Survey of Canada, Ottawa. pp. 508-512.

Royal Saskatchewan Museum (RSM) 2020. Repatriation and shared stewardship. Website: https://royalsaskmuseum.ca/rsm/research/indigenous-studies. Accessed February 14th, 2020.

Russell, D. 1999a. Organized expeditions 1819-1910. *In* Atlas of Saskatchewan. K.I. Fung (ed.). University of Saskatchewan, Saskatoon, Saskatchewan. pp. 36-37.

Russell, D. 1999b. Fur trade journeys 1691-1808. *In* Atlas of Saskatchewan. K.I. Fung (ed.). University of Saskatchewan, Saskatoon, Saskatchewan. pp. 31-32.

Russell, D. 2006. Explorers. *In* The encyclopedia of Saskatchewan. Canadian Plains Research Center, University of Regina, Regina, Saskatchewan. pp. 310-311.

Russell, D., and D. Meyer. 1999. The history of fur trade ca. 1662 – post 1821. *In* Atlas of Saskatchewan. K.I. Fung (ed.). University of Saskatchewan, Saskatoon, Saskatchewan. pp. 33-35.

Saskatchewan Research Council (SRC). 1983. Heritage Resources Impact Assessment for Stony Rapids community and resource access road, Permit No. 82:020. Report prepared for Department of Northern Saskatchewan and McLaren Plansearch. Final report on file with the Heritage Conservation Branch, Regina, Saskatchewan.

Steer, D. 1977. The history and archaeology of a North West Company Trading Post and a Hudson's Bay Company transport depot, Lac La Loche, Saskatchewan. The Manuscript Report Series No. 280. Parks Canada, Department of Indian and Northern Affairs, Ottawa, Ontario.

Wright, J.V. 1972. The Shield Archaic. National Museum of Man, Publications in Archaeology, No. 3. National Museums of Canada, Ottawa, Ontario.

Young, P.S. 2006. An analysis of Late Woodland ceramics from Peter Pond Lake, Saskatchewan. Unpublished M.A. thesis, Department of Archaeology, University of Saskatchewan, Saskatoon, Saskatchewan.

8.0 MAP SOURCES AND DISCLAIMERS

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FlySask aerial photograpic imagery. Saskatchewan Geospatial Imagery Collaborative (SGIC). 2019. FlySask 60cm orthoimages 2008-2011. Web Map Server: https://www.flysask2.ca/ cubewerx/htcubeserv?.

Heritage resources. Government of Saskatchewan Ministry of Parks Culture and Sport-Heritage and Conservation Branch. 2019.

Provincial boundary. Information Services Corporation of Saskatchewan. 2019. "Saskatchewan Administrative Boundary Overlays." Reproduced with the permission of Information Services Corporation.

Rivers. ©Department of Natural Resources Canada. 2004. "North American Atlas – Hydrography." 1:10,000,000. Contains information licensed under the Open Government License – Canada http://open.canada.ca/en/open-government-licence-canada.

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Road network. Saskatchewan Ministry of Highways & Infrastructure. 2014. "Saskatchewan Road Network Database 2014 (SURN14)."

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Denison Mines

Wheeler River Project

Final Environmental Impact Statement

November 2024

Powering PEOPLE, PARTNERSHIPS AND PASSION.

November 2017

Permit No. 17-091

Denison Mines Corporation

Wheeler River Project
Heritage Baseline Study

REPORT

Submitted to:

Peter Longo
Denison Mines Corporation
230 22nd St. East, Suite 200
Saskatoon, SK S7K 0E9

Report Number: 1660579/P100

Distribution:

1 Copy - Denison Mines Corporation, Saskatoon, Saskatchewan (+1 CD)
1 Copy - Heritage Conservation Branch, Regina, Saskatchewan (+1 CD)
1 Copy - Royal Saskatchewan Museum, Regina, Saskatchewan (+1 CD)
1 Copy - Golder Associates Ltd., Saskatoon, Saskatchewan

Golder Associates

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Permit Holder...Tam Huynh, M.A.

Report Author ....Tam Huynh, M.A.

....Jennifer Rychlo, M.A

Field Investigator ....Tam Huynh, M.A.

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....Joey George, English River First Nation

Technical Assistance ....Lisa Stuart

....Justin Sikorsky

....Jenn Boehr

Executive Summary

Golder Associates Ltd. conducted a Heritage Resources Baseline study for Denison Mines Corporation's Wheeler River Project in northern Saskatchewan. The project was submitted to the Heritage Conservation Branch (Ministry of Parks, Culture and Sport) for heritage screening and it was determined that portions of the proposed infrastructure sites and access road corridors will impact hilly terrain and prominent uplands that are in proximity to permanent water sources.

The Heritage Resources Baseline study was initiated on July 5, 2017 by Golder Associated Ltd. under Archaeological Resource Investigation Permit 17-091. Heritage sensitive areas were assessed through a combination of pedestrian reconnaissance and visual inspection field programs, complimented by the excavation of 258 shovel probes and 5 shovel tests. The assessment resulted in the identification of HiNi-6, an Artifact Find site of an unknown Precontact cultural affiliation that was identified on the western terrace of a lake adjacent to the Phoenix 2 access road option. The site has limited interpretive potential and there are no further concerns attached to the site in the context of the current study. No additional heritage concerns were identified during the course of the remainder of the assessment.

It is recommended that a Section 63 approval be issued for the project. This Final Report fulfils the permitting requirements necessary for the completion of this Heritage Resources Impact Assessment.

Table of Contents

TABLES

FIGURES

PHOTOS

APPENDICES

APPENDIX A
Glossary of Technical Terms

APPENDIX B
Shovel Probes and Tests

APPENDIX C
HiNi-6 Artifact Catalogue

APPENDIX D
Map Showing Traditional Territory of the English River First Nation

1.0 INTRODUCTION

Denison Mines Corporation (Denison) is conducting baseline studies for the proposed Wheeler River Project (the Project) in northern Saskatchewan. The Project is located approximately 35 kilometres (km) northeast of Cameco Corporation's (Cameco) Key Lake Operations and 35 km southwest of Cameco's McArthur River Operation. The Project is situated along the eastern edge of the Athabasca Basin and is an advanced exploration stage uranium Project. When operational, the Project will consist of infrastructure required to mine the Gryphon and Phoenix deposits as a single underground mine, with milling of ore taking place off-site at an existing facility. Access to the proposed mining operations will be provided by an access road that will connect the operation to Highway 914. The right-of-way (ROW) for the access road has not been established and Denison is considering several options. The proposed options are 500 metres (m) wide and the access road will be contained within the corridor (Figure 1).

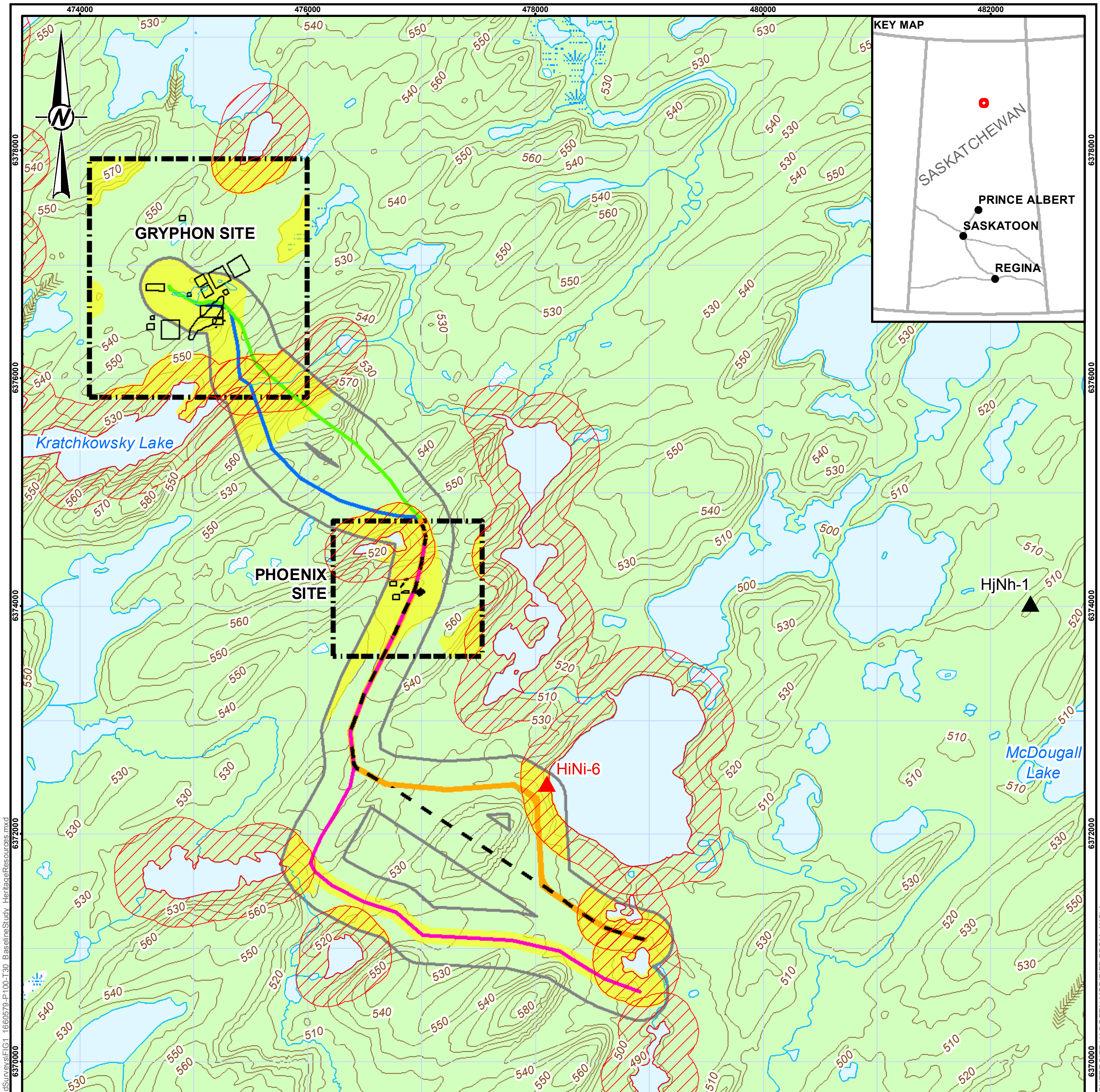
The Project was submitted to the Heritage Conservation Branch (Ministry of Parks, Culture and Sport) for heritage screening and it was determined that portions of the proposed infrastructure and access road options will impact hilly terrain and prominent uplands located within heritage sensitive areas (Heritage Conservation Branch File No. 16-2102; Table 1). Accordingly, a Heritage Resource Impact Assessment (HRIA) requirement was attached to the Project, pursuant to Section 63 of *The Heritage Property Act* (1979-80). The HRIA was restricted to the heritage sensitive areas within the 500 m wide corridors. The determination of heritage sensitive areas is further discussed under Section 4.1.1.

Table 1: Wheeler River Project Details

Project Component	Option	Total Length (km)	Heritage Sensitivities
Access Road	Phoenix 1	5.31	■ Portions of Access Road Options and Infrastructure sites in heritage sensitive terrain. ■ Potential to impact heritage resources.
	Phoenix 2	5.77	
	Phoenix 3	6.47	
	Gryphon 1	3.37	
	Gryphon 2	3.10	
Infrastructure	Phoenix Site	1.31 x 1.19	
	Gryphon Site	1.91 x 2.10	

m = metre; km = kilometre.

The HRIA was initiated on July 5, 2017, under Archaeological Resource Investigation Permit No. 17-091 issued to Tam Huynh (Archaeologist, Golder Associates Ltd [Golder]) to identify, record, and assess any heritage resources that may be impacted by the proposed project. This report contains the results of the HRIA. Section 2 describes the potential impacts and local environment for the Project. Section 3 will provide an overview of previous archaeological research. The methods and results of the assessment will be contained in Section 4 while a summary of the HRIA and associated recommendations will be contained in Section 5. A glossary of technical terms is located in Appendix A, shovel probe and test locations are contained in Appendix B and an artifact catalogue is contained in Appendix C. A map showing the Traditional Territory of the English River First Nation is contained in Appendix D.



LEGEND

- ELEVATION CONTOUR
- ESKER
- WATERCOURSE
- INTERMITTENT WATERBODY
- WATERBODY
- WETLAND
- WOODED AREA
- KNOWN HERITAGE RESOURCE
- NEW HERITAGE RESOURCE
- PHOENIX-3
- GRYPHON-1
- GRYPHON-2
- ACCESS ROAD OPTION CORRIDOR BOUNDARY
- ASSESSED AREA
- PROPOSED INFRASTRUCTURE
- PROPOSED INFRASTRUCTURE HERITAGE SURVEY AREA
- SELECTED WATER 250m BUFFER

ACCESS ROAD OPTIONS

- PHOENIX-1
- PHOENIX-2

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REFERENCE(S)
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2. HERITAGE RESOURCES OBTAINED FROM HERITAGE CONSERVATION BRANCH, MINISTRY OF PARKS, CULTURE AND SPORT, 2017.
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PROJECTION: UTM ZONE 13 DATUM: NAD 83

CLIENT
DENISON MINES CORPORATION

PROJECT
WHEELER RIVER PROJECT HERITAGE BASELINE STUDY

TITLE
LOCATION OF BASELINE STUDY AND HERITAGE RESOURCES

CONSULTANT

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PREPARED	SBM/LMS
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APPROVED	BN

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2.0 PROJECT SPECIFIC DETAILS AND ENVIRONMENT

2.1 Potential Impacts

The developments of the infrastructure and access roads required to mine the Gryphon and Phoenix uranium deposits all have the potential to impact heritage resources located within the Study Area, if present. Heavy vehicular traffic can impact surface features. In boreal forest environments where soil development is limited, heritage resources typically occur at or near the ground surface and can be easily disturbed. Surface features such as cabins or hearths could be damaged or destroyed by clearing, heavy machinery traffic and equipment. Disturbance to subsoils and sediments through compression and removal could also negatively impact buried Precontact sites such as campsites, lithic reduction areas, or human burials. In buried sites such as these, context is important and the value of the archaeological resource may be significantly reduced once it has been impacted. Impacts to heritage resources are permanent and irreversible.

2.2 Local Environment

The Project is located within the Wheeler Upland Ecodistrict of the Athabasca Plain Ecoregion of Saskatchewan. This Ecodistrict represents a large area extending from Creek Lake to Hatchet and Wollaston Lakes and primarily consists of drumlinoid moraine landscapes covered in undulating glaciofluvial outwash deposits (Acton et al. 1998). Prominent eskers, some extending 100 km or more, cross the area from northeast to southwest. Drainages in this region of Saskatchewan tend to be weakly developed and normally consist of small creeks which drain one lake into another. Vegetation here is diverse and consists of forests of Jack Pine and black spruce, with lichen, Canada blueberry, and lichen as the understory. Brunisolic soils dominate the well-drained slopes in the region, within Gleysols and Organics, and local Cryosols in small, poorly drained swales and flats (Acton et al. 1998). Habitat is available for many wildlife species including moose (*Alces alces*), woodland caribou (*Rangifer tarandus groenlandicus*), red fox (*Vulpes vulpes*), snowshoe hare (*Lepus americanus*), wolf (*Canis lupus*), black bear (*Ursus americanus*) lynx (*Felis lynx*), beaver (*Castor canadensis)*, upland birds, waterbirds and amphibians.

The Project area is within the area of the province claimed to be the traditional territory of the English River First Nation. In addition to this, residents of Ile a la Crosse and Pinehouse First Nation have also indicated verbally they have recent and historical traditional ties to the region hosting the proposed Project (Appendix D).

Within heritage sensitive portions of the Project area, the terrain primarily consists of Jack Pine forests over well drained, rolling to undulating uplands (Photo 1). Large escarpments were also noted throughout various parts of the Project area (Photo 2). There are several lakes and creeks in proximity to the Project area (Photo 3); however, only two of these are named. The largest water source in the Project area is Russel Lake, which is located south of the Project. The second largest water source is Kratchkowsky Lake, which parallels the southern and western extent of the Gryphon site (Photo 4).

Photo 1: View of upland adjacent to Phoenix 3 access road corridor, looking southwest.

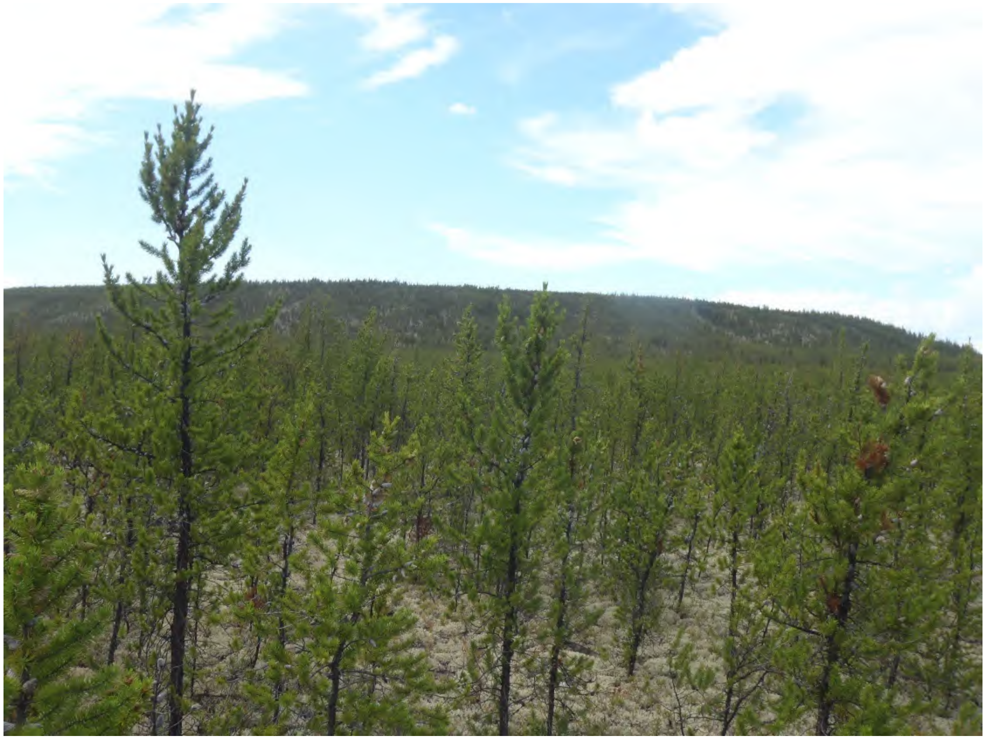


Photo 2: View of upland intersected by Phoenix 1 access road corridor, looking northwest.

Photo 3: View of lake located between Phoenix 1 and 3 access road corridor, looking northwest from Highway 914.

Photo 4: View of Kratchkowsky Lake in proposed Gryphon infrastructure heritage survey area, looking south.

3.0 PREVIOUS ARCHAEOLOGICAL RESEARCH

The database for previously recorded heritage resources was queried to determine if previously recorded heritage resources occur in areas within or adjacent to the immediate Project area. The results indicated that nine previously recorded heritage resources are located on the same 1:50,000 National Topographic System (NTS) Mapsheets (74H/11 and 74H/6) as the Project (Table 2). This includes artifact scatter sites (n=2), artifact find sites (n=5), one artifact/feature combination site, and one recurrent feature site. Three sites are of unknown cultural affiliation, five originate from the Precontact period, and at least one has been identified as originating from the Post-Contact period.

Table 2: Previously Recorded Heritage Resources on 1:50,000 NTS Mapsheet 74N/7

Site Type	Definition	No. of Sites
Artifact Find	Sites consisting of five or fewer artifacts.	2
Artifact Scatter	Sites consisting of six or more artifacts.	5
Artifact/Feature Combo	Sites consisting of a combination of features and artifacts.	1
Recurrent Feature	Sites consisting of two or more features of the same kind.	1
Total		**9**

Of the 9 heritage sites, only one (HjNh-1) is located within 5 km of the proposed Project area. This site consists of an artifact find site of unknown cultural affiliation which was identified during an HRIA survey conducted for the McArthur River access road construction project (Golder 1994).

A map illustrating the traditional territories of the English River First Nation was also reviewed as part of the overview (Appendix D). The map indicates that the Project is located within the estimated Caribou range and is also intersected by a winter trail. Accordingly, there is the potential to encounter remnants of activities associated to the traditional territories.

4.0 ARCHAEOLOGICAL FIELDWORK

4.1.1 Methods

The heritage baseline study targeted areas of the Project located within heritage sensitive areas. For the northern parklands and boreal forest of Saskatchewan, the Heritage Conservation Branch considers lands to be archaeologically sensitive if they are:

- within 500 m of a Site of Special Nature or other significant heritage resource;
- within 250 m of permanent watercourses and lakes greater than 1 km in length;
- along dry, upland margins of a major bog or fen greater than 1 km in size;
- within 50 m of historic trails;
- within 250 m of strandlines; and
- on prominent uplands, escarpments and hills/ridges within 500 m of a water source.

The objectives of the HRIA flow from the principles outlined in *The Heritage Property Act.* More specifically, studies were completed with the following objectives:

- identification of heritage sensitive areas within the project area;
- complete appropriate levels of inspection within the project area;
- identify and record heritage resources within heritage sensitive areas (if present); and
- recommend appropriate mitigation measures to deal with any recorded heritage resources in conflict.

To satisfy the regulatory requirements of the Heritage Conservation Branch, the HRIA was completed using a pedestrian reconnaissance and visual inspection program complemented with sub-surface testing. These field techniques, combined with the information collected from previous archaeological research were used in identifying any potential Precontact and historic-era heritage resources that may be present in the Project area. Pedestrian surface reconnaissance is the most common method used by archaeologists to identify archaeological sites (i.e., surface features) within a Project area (Ruppé 1966). Conversely, visual inspection of the ground is particularly effective in areas with good surface visibility, such as regions of limited soil development and sparse vegetation (Schiffer et al. 1978). Archaeological sites such as surficial artifact finds and scatters are commonly found through visual inspections. Shovel probes were excavated in judgementally selected areas to determine the presence (or absence) of subsurface cultural deposits. Not only are shovel probes commonly used by archaeologists to locate and identify subsurface cultural deposits, but they can also provide important information on the integrity, dimensions, and density of cultural materials found at archaeological sites (Krakker et al. 1983; Nance and Ball 1986; Kintigh 1988).

The pedestrian reconnaissance, visual inspection and subsurface testing program for the Project was carried out by the permit holder, an assistant and a member of the English River First Nation. Detailed field notes and digital photographs were taken to document the Project environment while hand-held Global Positioning System (GPS) units were used to document surveyed areas and relevant Project features. The Universal Transverse Mercator (UTM) location of each shovel probe was also recorded with the GPS units (Appendix B). All shovel probes measured approximately 40 centimetres (cm) by 40 cm. Excavated soils from these shovel probes were hand sorted with a trowel for cultural materials and wall profiles were examined for intact paleosol horizons beneath the sod level. Upon identification of a heritage resource, shovel tests (i.e., shovel probes in which the excavated matrix is screened through a quarter inch mesh) would be excavated at, and in areas adjacent to the heritage resource. Shovel tests measure approximately 50 cm by 50 cm and the wall profiles examined for intact paleosols. After recording the pertinent site information, digital photographs were taken and a site sketch was created. The results of the assessment are discussed below.

4.1.2 Fieldwork Results for Access Road Options

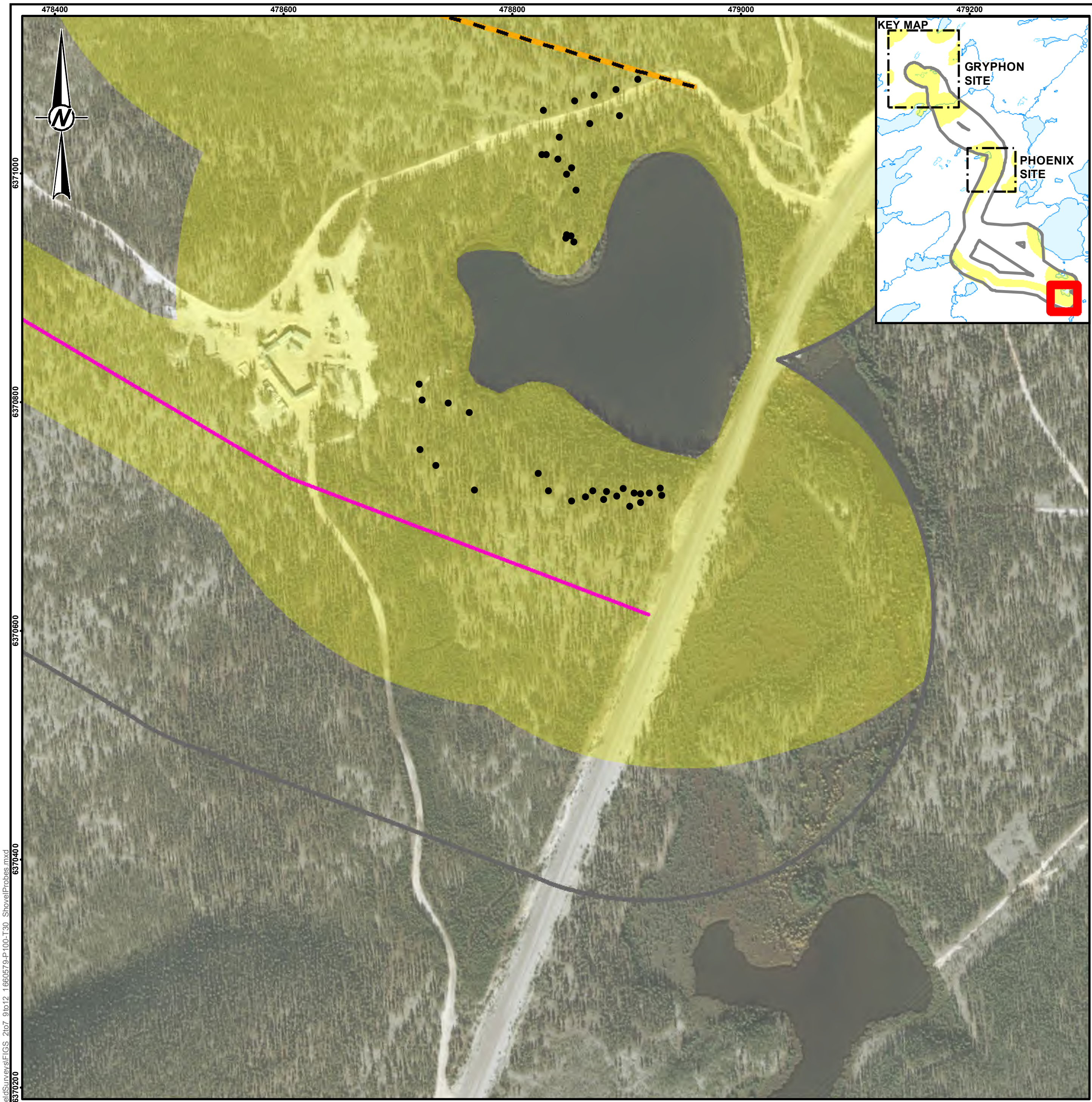
Only heritage sensitive portions of the five, 500 m wide access road options were assessed during the HRIA. Three of these (e.g., Phoenix 1, 2 and 3) will connect the Phoenix site to Highway 914 while the remaining two (e.g., Gryphon 1 and 2) will connect the Phoenix site to the Gryphon site. Using the criteria listed in Section 4.1.1, a combination of Geographic Information System (GIS) data, NTS mapsheets and aerial imagery reviews were used to identify potential heritage sensitive lands, while in-field inspections were used to confirm, or identify additional heritage sensitive locales.

The HRIA consisted of a pedestrian reconnaissance, visual inspection and subsurface testing programs of portions of the Project located in heritage sensitive areas (Figures 2, 3, 4, 5, 6 and 7). With the exception of an approximate 2,300 m stretch that extends through the Phoenix heritage survey area and an approximate 200 m stretch within the Gryphon heritage survey area, all road options have different trajectories and primarily traverse non-heritage sensitive boreal forests, with only isolated portions of the access roads located within heritage sensitive lands. In-field assessments confirmed the presence of numerous locales of surficial disturbances (i.e., access roads, clearings, gravel pits, terrace and sandy exposures) throughout various portions of the road options. This was particularly significant along the Phoenix 3 option, which overlapped an existing access road for most of its route and traverses an existing gravel pit (Photos 5 and 6). All exposures located within heritage sensitive portions of the road options were visually inspected for cultural materials that could pertain to partially intact sites (if present), while pedestrian reconnaissance was used in areas adjacent to these disturbances to identity any surficial features that may have been present (Photo 7). An old exploration camp comprised of several mobile office trailers was identified adjacent to the western extent of a small lake immediately north of the Phoenix 3 road option (Photo 8); however, this camp does not meet the criteria to be classified as an archaeological resource as pertains to a recent exploration event. Accordingly, there are no further concerns. No heritage resources were identified during the pedestrian reconnaissance and visual inspection programs of the access roads.

The excavation of shovel probes and tests were confined to elevated, well drained landforms with defined topographic edges, located within 250 m of waterbodies with shorelines greater than 1 km in length. There were some prominent landforms beyond the 250 mheritage screening criteria buffer; however, a brief inspection confirmed that these landforms were extensively sloped with poorly defined edges and limited soil deposition, confirming that it is unlikely for archaeological sites to be found in these areas. A total of 206 shovel probes and 5 shovel tests were judgementally excavated throughout heritage sensitive portions of the four road options. (Photos 9 and 10; Appendix B). This count includes shovel probes excavated within portions of the access roads that traverse through the Gryphon and Phoenix heritage study areas. Although there were some variations, the general stratigraphic profile can be summarized as follows:

- 0 to 3 cm organic duff;
- 3 to 25 cm grey sand; and
- 25 to 40 cm tan sand.

The shovel testing program resulted in the identification of one heritage resource (HiNi-6). This heritage resource will be discussed in the subsequent section of this HRIA report. No additional heritage resources were identified during the course of the assessment.



LEGEND

● SHOVEL PROBE

ACCESS ROAD OPTIONS

PHOENIX-1

PHOENIX-2

PHOENIX-3

ACCESS ROAD OPTION CORRIDOR BOUNDARY

ASSESSED AREA

PROPOSED INFRASTRUCTURE HERITAGE SURVEY AREA

0 100 200

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REFERENCE(S)

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CLIENT
DENISON MINES CORPORATION

PROJECT
WHEELER RIVER PROJECT HERITAGE BASELINE STUDY

TITLE
LOCATION OF BASELINE STUDY AND HERITAGE RESOURCES

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-11-15
DESIGNED	TH
PREPARED	SBM/LMS
REVIEWED	TH
APPROVED	BN

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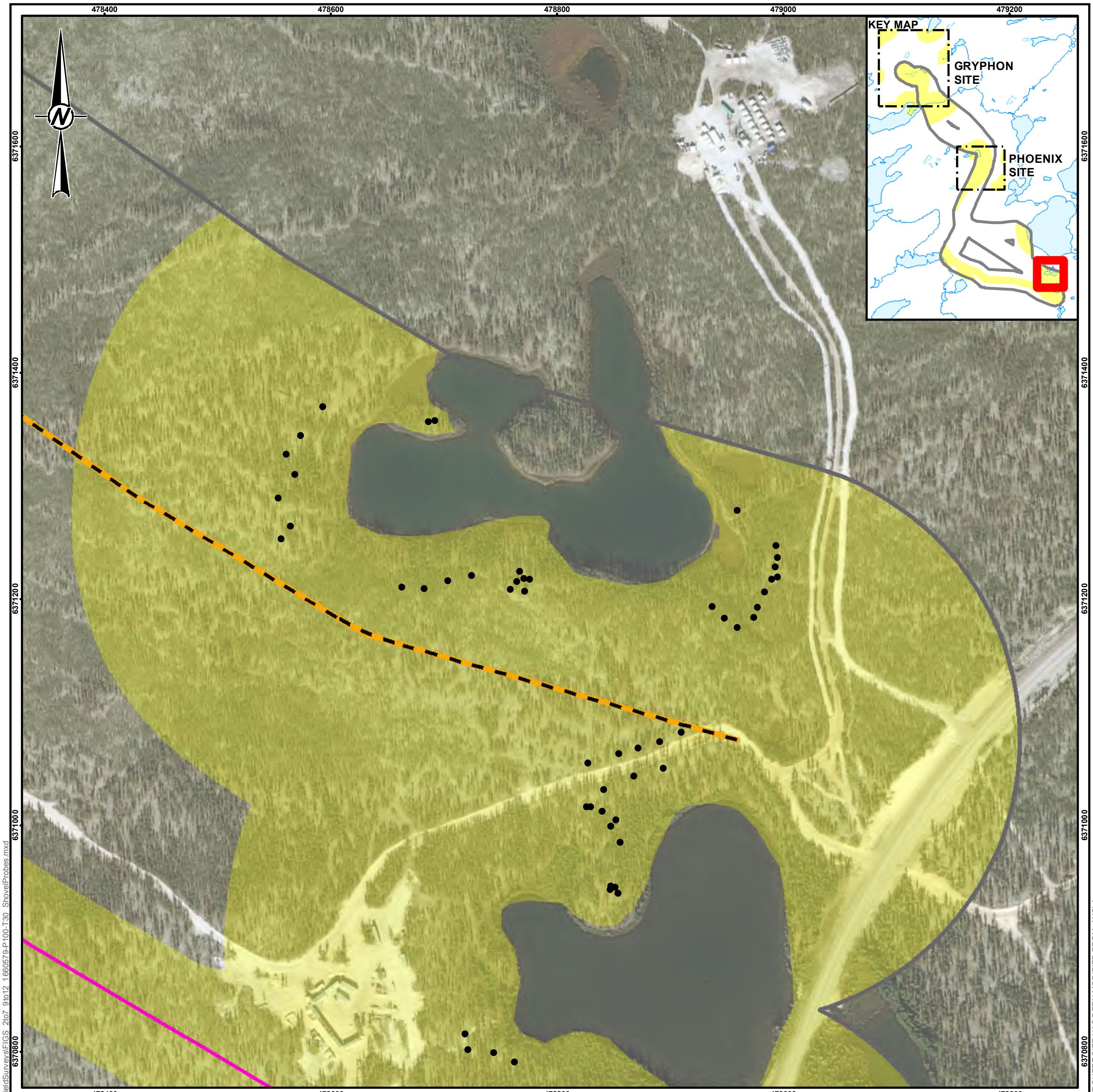

LEGEND

- ● SHOVEL PROBE

ACCESS ROAD OPTIONS

- PHOENIX-1
- PHOENIX-2
- PHOENIX-3
- ACCESS ROAD OPTION CORRIDOR BOUNDARY
- ASSESSED AREA
- PROPOSED INFRASTRUCTURE HERITAGE SURVEY AREA

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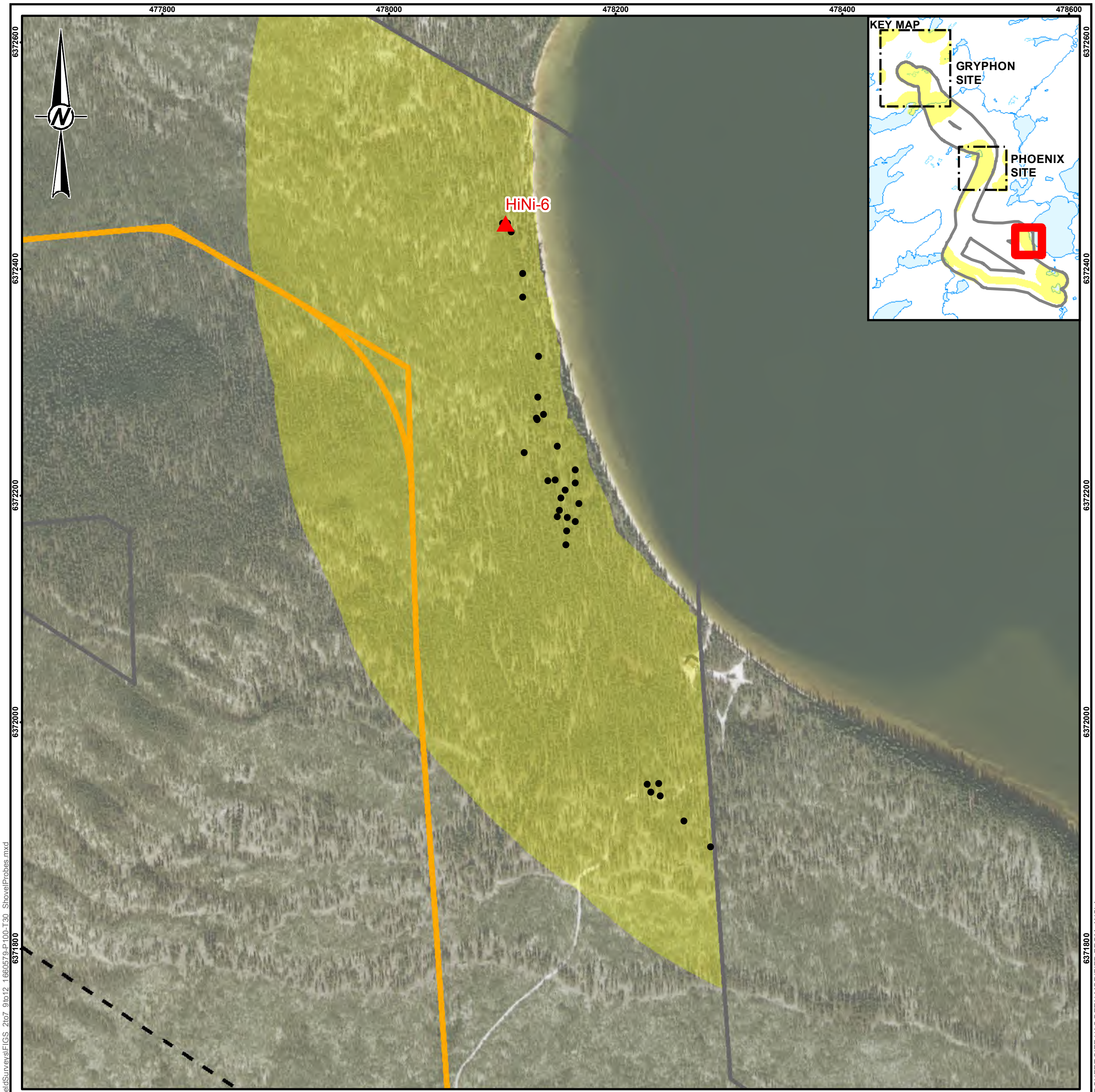

LEGEND

- NEW HERITAGE RESOURCE
- SHOVEL PROBE

ACCESS ROAD OPTIONS

- PHOENIX-1
- PHOENIX-2
- ACCESS ROAD OPTION CORRIDOR BOUNDARY
- ASSESSED AREA
- PROPOSED INFRASTRUCTURE HERITAGE SURVEY AREA

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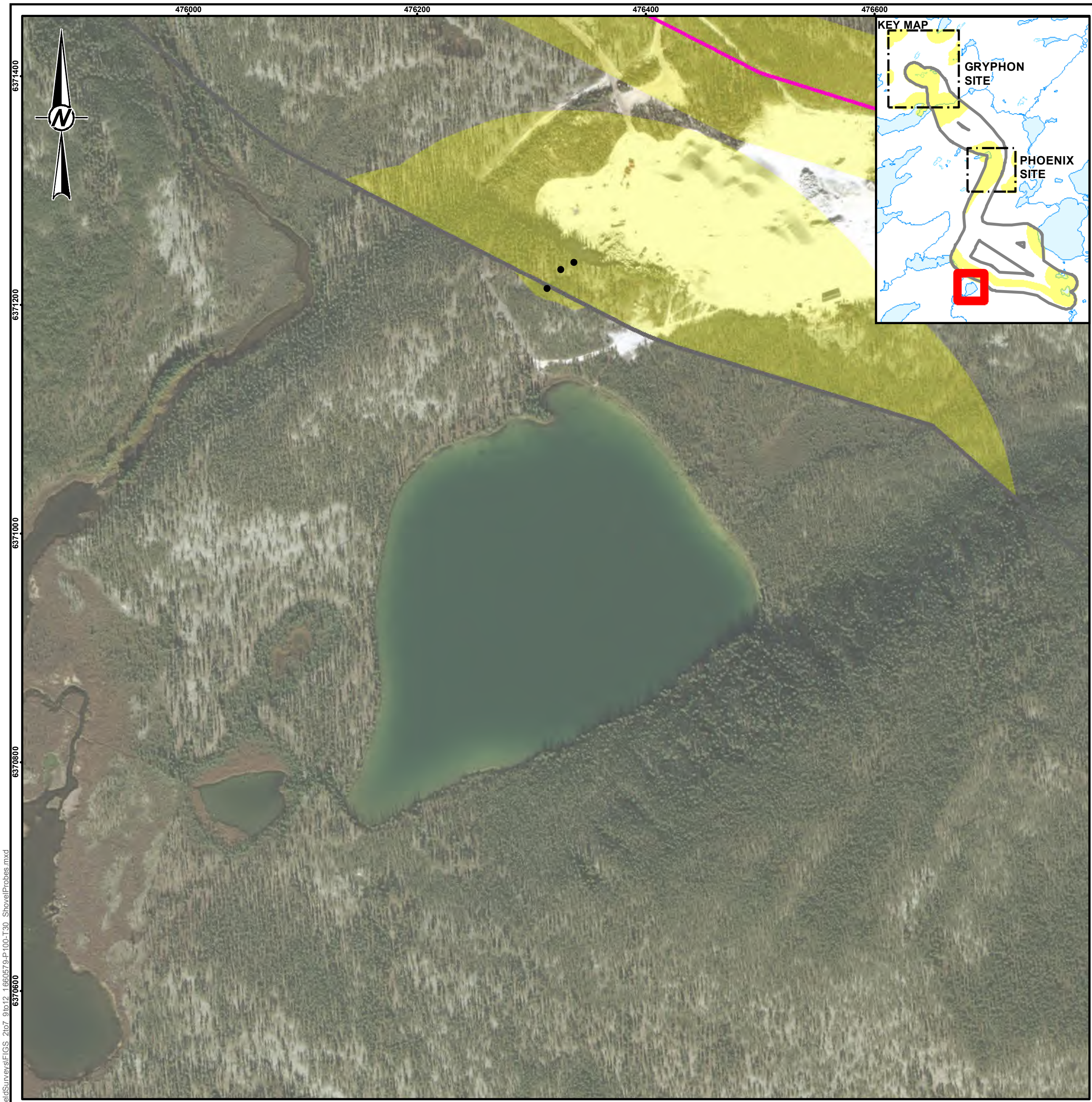

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- ● SHOVEL PROBE

ACCESS ROAD OPTIONS

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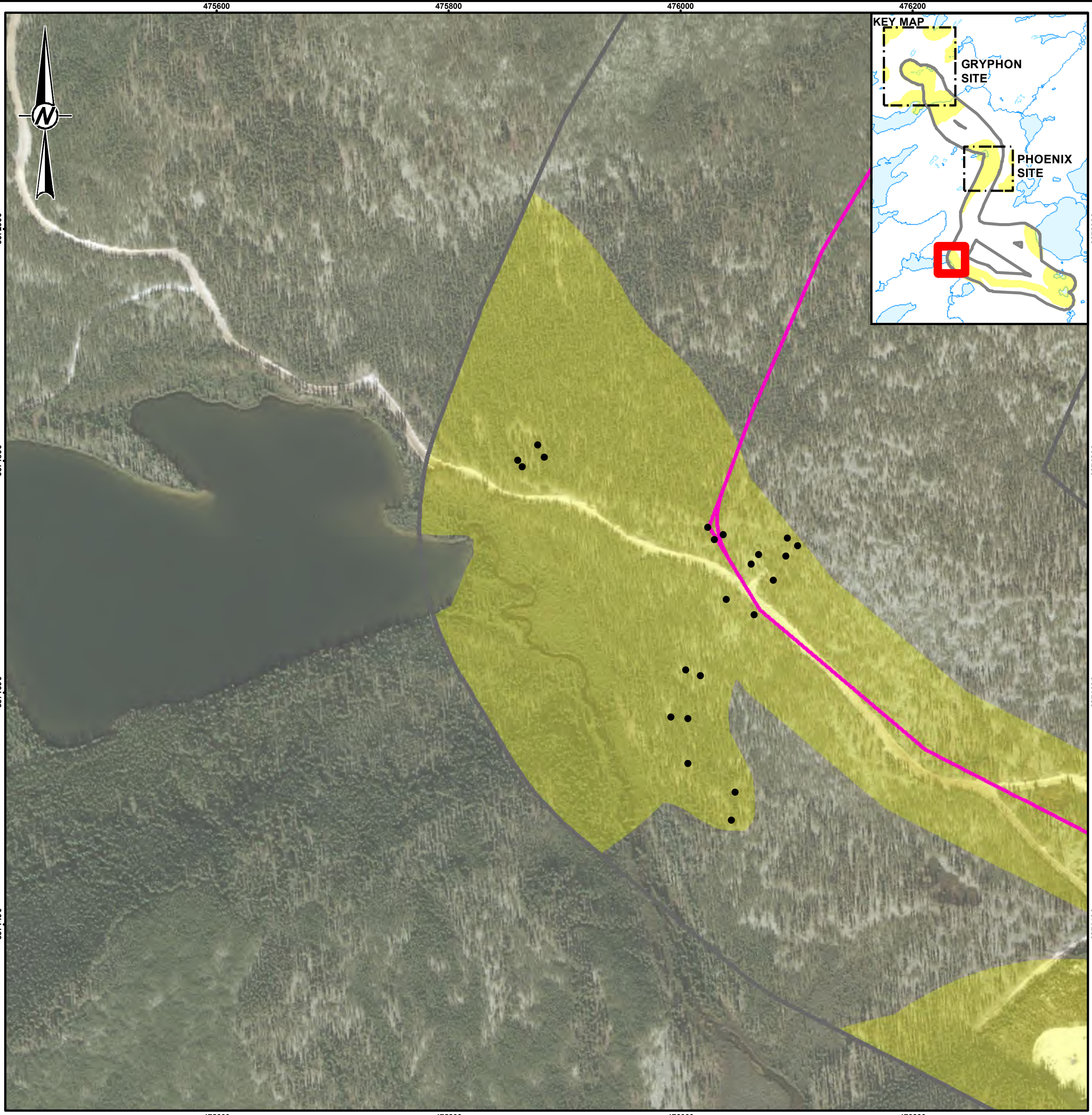

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CLIENT
DENISON MINES CORPORATION

PROJECT
WHEELER RIVER PROJECT HERITAGE BASELINE STUDY

TITLE
LOCATION OF BASELINE STUDY AND HERITAGE RESOURCES

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-11-15
DESIGNED	TH
PREPARED	SBM/LMS
REVIEWED	TH
APPROVED	BN

PROJECT NO.	PHASE	REV.	FIGURE
1660579	P100	1	6

PATH: G:\CLIENTS\DENISON MINES\Wheeler River\Figures\1660579_Heritage_Baseline\P100_Heritage\T30_FieldSurveys\FIGS_2to7_9to12_1660579-P100-T30_ShovelProbes.mxd

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25mm
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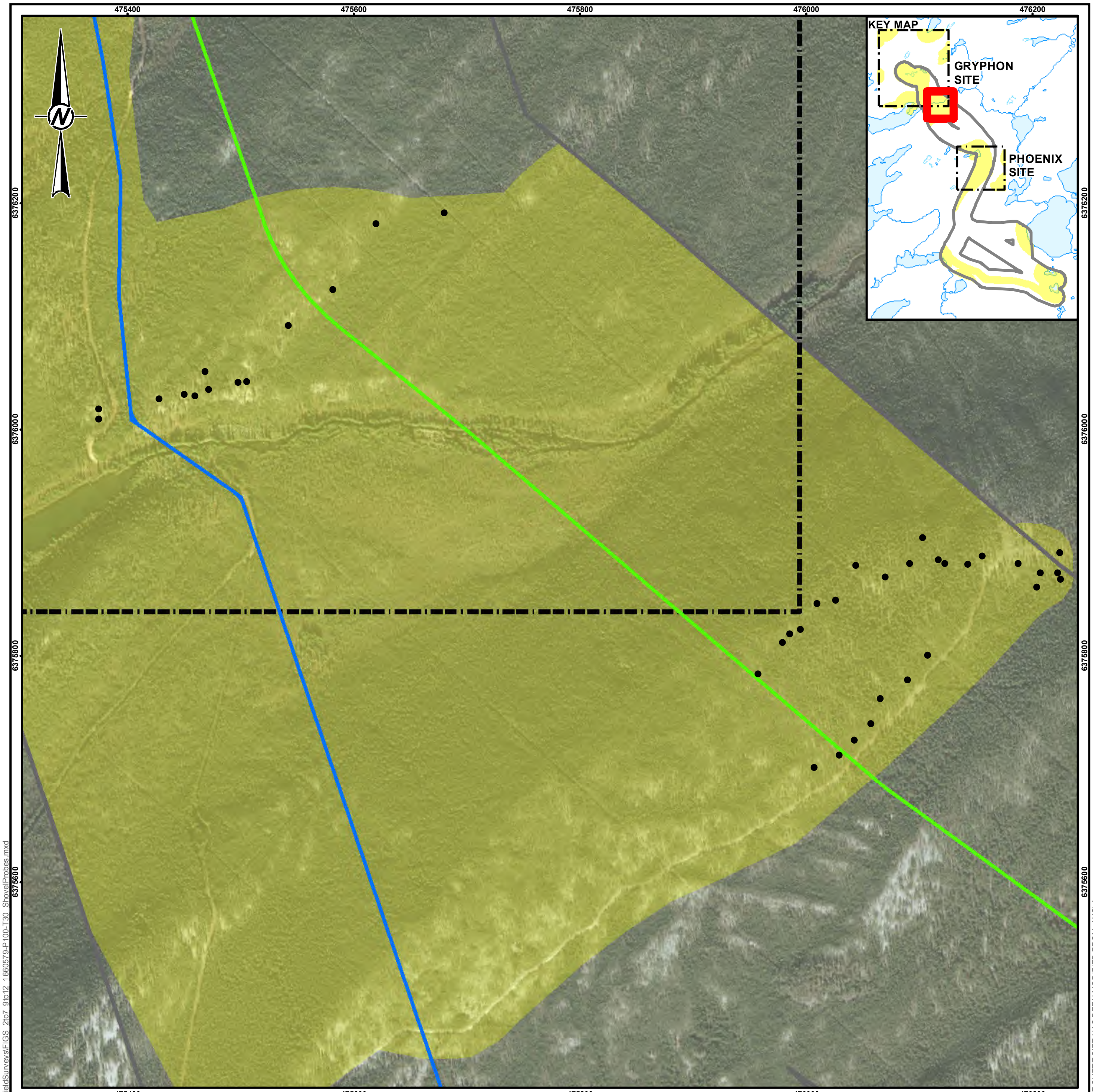

LEGEND

- SHOVEL PROBE

ACCESS ROAD OPTIONS

- GRYPHON-1
- GRYPHON-2
- ACCESS ROAD OPTION CORRIDOR BOUNDARY
- ASSESSED AREA
- PROPOSED INFRASTRUCTURE HERITAGE SURVEY AREA

0 100 200

1:5,000 METRES

REFERENCE(S)

1. INFRASTRUCTURE PROVIDED BY THE CLIENT AUGUST 25, 2016. FILE NAME: 1CD019-011-DENSION-WR-ROADALIGNMENT_20160825_EPK.DXF
2. HERITAGE RESOURCES OBTAINED FROM HERITAGE CONSERVATION BRANCH, MINISTRY OF PARKS, CULTURE AND SPORT, 2017.
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PROJECTION: UTM ZONE 13 DATUM: NAD 83

CLIENT

DENISON MINES CORPORATION

PROJECT

WHEELER RIVER PROJECT HERITAGE BASELINE STUDY

TITLE

LOCATION OF BASELINE STUDY AND HERITAGE RESOURCES

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-11-15
DESIGNED	TH
PREPARED	SBM/LMS
REVIEWED	TH
APPROVED	BN

PROJECT NO.	PHASE	REV.	FIGURE
1660579	P100	1	7

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IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A

25mm

Photo 5: View of existing road within Phoenix 1 access road option, looking northwest.

Photo 6: View of existing road within Phoenix 3 access road option, looking northwest.

Photo 7: View of existing gravel pit intersected by Phoenix 3 access road option, looking northeast.

Photo 8: View of abandoned exploration camp within Phoenix 3 access road option, looking southwest

Photo 9: Shovel testing in Phoenix 1 access road option, looking north.

Photo 10: Shovel testing in Phoenix 3 access road option, looking north.

4.1.2.1 HiNi-6

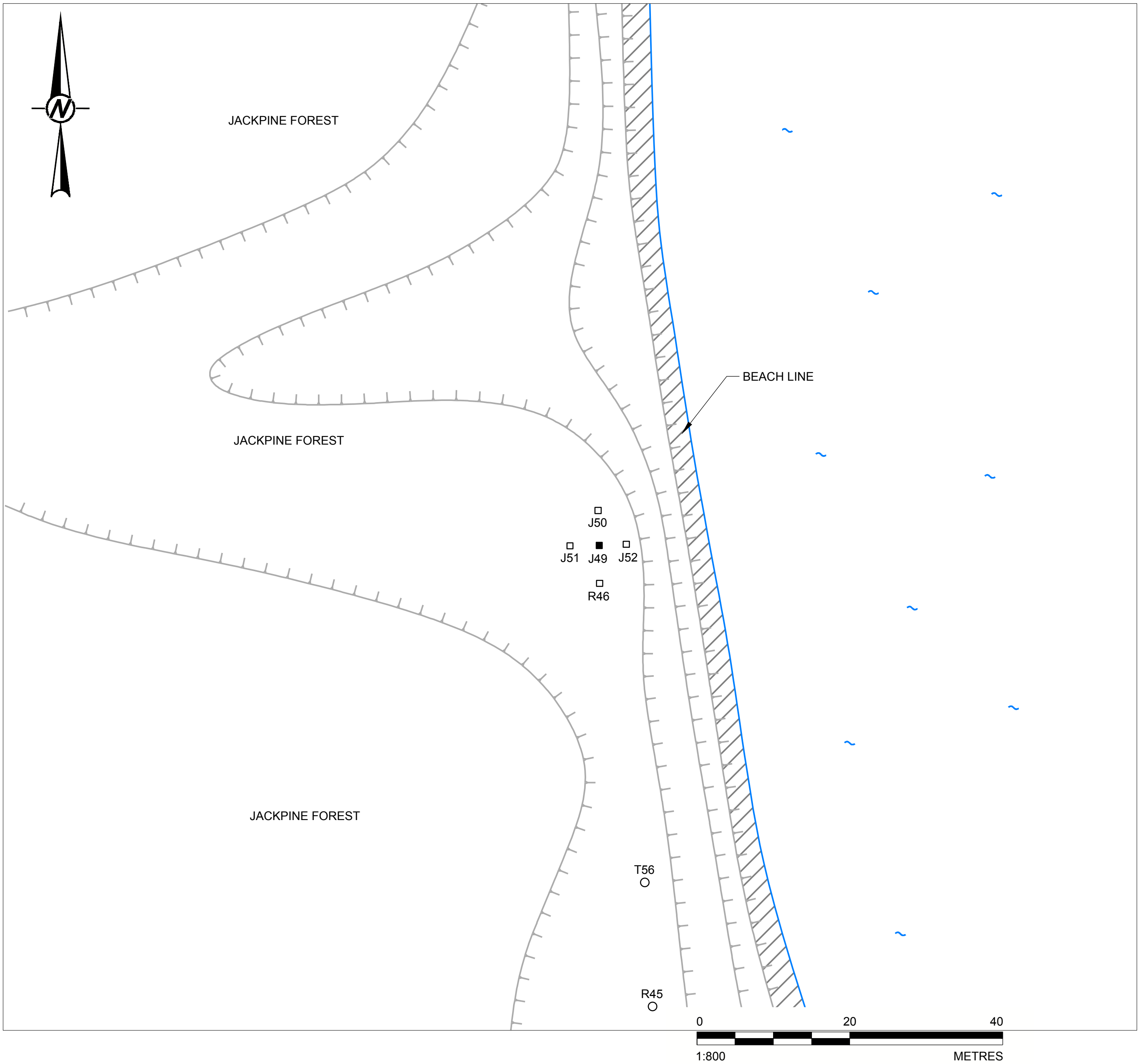
HiNi-6 is an Artifact Find site of an unknown Precontact cultural affiliation (Figure 8). The site is located on a terrace edge that overlooks a large lake to the east (Photo 11). The landform is flat, backed by undulating terrain to the west and bordered by a small drainage to the north. The eastern edge of the landform abruptly slopes down to a sandy beach that parallels the edge of the lake.

A large, grey quartzite secondary flake was identified in shovel probe J49 at approximately 15 cm depth below surface (Photo 12; Appendix C). It exhibits unifacial retouch along the left lateral edge (concave). Upon its discovery, the shovel probe was converted to a shovel test and four additional shovel tests were excavated in areas immediately adjacent to the positive test. Although there were some variations, the general stratigraphic profile can be summarized as follows:

- 0 to 3 cm organic duff;
- 3 to 15 cm grey sand; and
- 15 to 35 cm tan brown sand.

No additional cultural materials or features were identified during the shovel testing program at HiNi-6. The shovel testing program determined that the site has limited interpretive potential; as such, there are no further concerns attached to the site.

Photo 11: HiNi-6, arrow indicates location of positive shovel test J49, looking east.



LEGEND

- POSITIVE SHOVEL PROBE
- NEGATIVE SHOVEL PROBE
- POSITIVE SHOVEL TEST
- NEGATIVE SHOVEL TEST
- SLOPE
- WATERBODY

CLIENT
DENISON MINES CORPORATION

PROJECT
WHEELER RIVER PROJECT HERITAGE BASELINE STUDY

TITLE
SKETCH MAP OF HiNi-6

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-08-29
PREPARED	JMC
DESIGN	TH
REVIEW	TH
APPROVED	BN

PROJECT No.	PHASE	Rev.	FIGURE
1660579	P100	0	8

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IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A

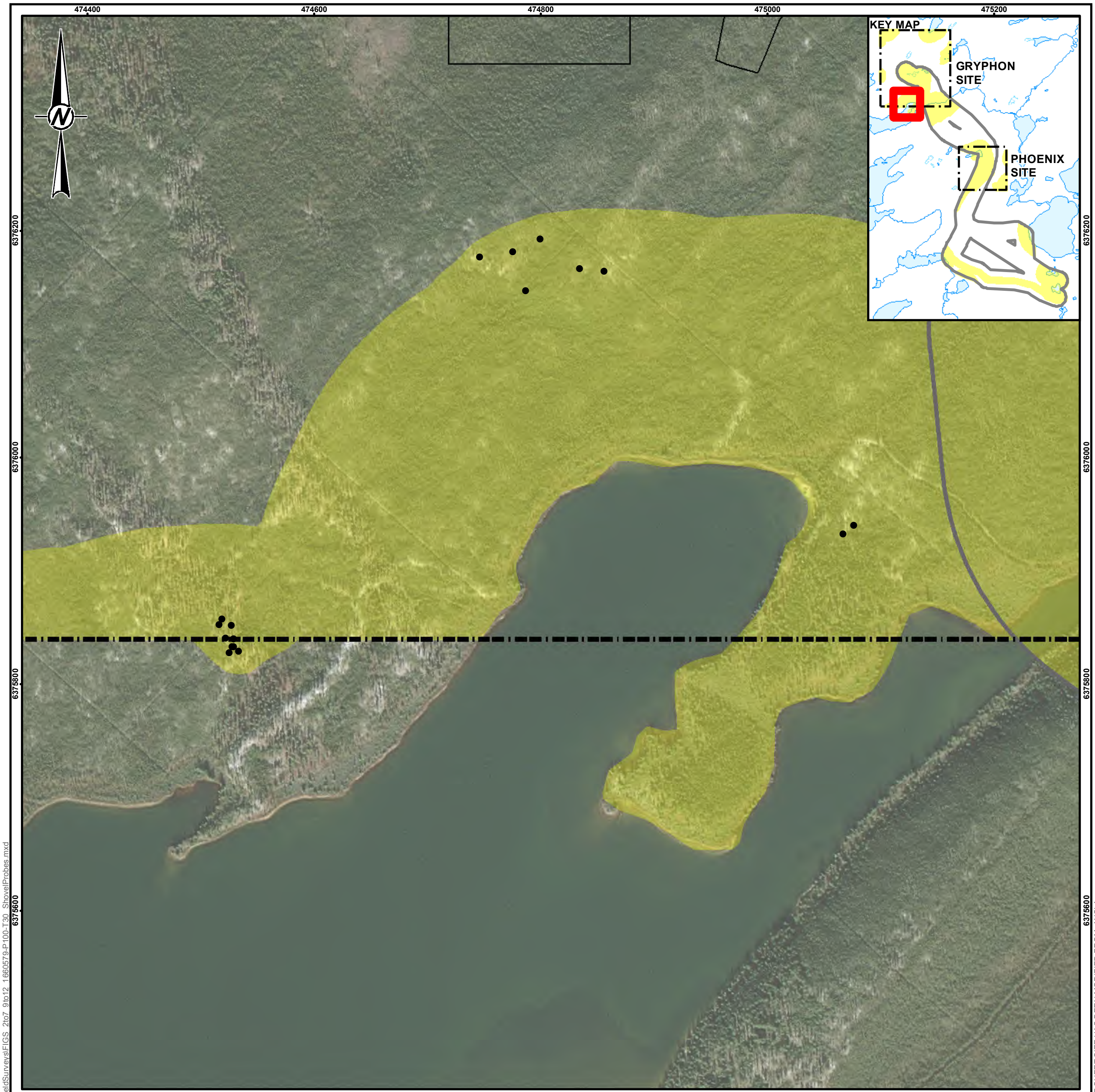
25 mm
0

Photo 12: HiNi-6, Retouched Flake.

4.1.3 Fieldwork Results for Gryphon Infrastructure Heritage Survey Area

The heritage survey area is an area of land surrounding the proposed infrastructure sites in which the HRIA will be contained in (Figure 1). Heritage sensitive areas assessed in the Gryphon heritage survey area were targeted through a combination of GIS, NTS maps and aerial imagery analysis, coupled with in-field inspections. Within the Gryphon heritage survey area, numerous access roads, trails and disturbed areas from previous and ongoing drilling activities were present. Many of these areas traversed prominent uplands within the proposed infrastructure locations (Photo 13), as well as paralleling the northern shoreline of Kratchkowsky Lake (Photo 14). Surficial exposures within these disturbed areas were excellent and were visually inspected for cultural materials and features while pedestrian reconnaissance was used in adjacent areas to identify any surficial heritage features that could have been present (e.g., historic cabins, etc.). No heritage resources were identified during the pedestrian reconnaissance and visual inspection programs.

In-field assessments determined that a majority of the prominent uplands within the Gryphon heritage survey area consists of extensively sloped, poorly defined bedrock outcrops with limited soil deposition. However, the assessment did identify several testable areas (e.g., defined terrace edges backed by level terrain with sufficient soil development). These areas were confined to terraces overlooking Kratchkowsky Lake at the southern extent of the heritage survey area, and adjacent to a small lake at the northeast extent of the heritage survey area (Figures 7, 9 and 10). A total of 43 shovel probes were judgementally excavated in the aforementioned areas (Photos 15 and 16; Appendix B). This count includes 13 shovel probes excavated within portions of the access road options that traverse through the Gryphon heritage survey area. Although there were some variations, the general stratigraphic profile can be summarized as follows:



LEGEND

- ● SHOVEL PROBE
- ACCESS ROAD OPTION CORRIDOR BOUNDARY
- ASSESSED AREA
- PROPOSED INFRASTRUCTURE
- PROPOSED INFRASTRUCTURE HERITAGE SURVEY AREA

0 100 200

1:5,000 METRES

REFERENCE(S)

1. INFRASTRUCTURE PROVIDED BY THE CLIENT AUGUST 25, 2016. FILE NAME: 1CD019-011-DENSION-WR-ROADALIGNMENT_20160825_EPK.DXF
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PROJECTION: UTM ZONE 13 DATUM: NAD 83

CLIENT
DENISON MINES CORPORATION

PROJECT
WHEELER RIVER PROJECT HERITAGE BASELINE STUDY

TITLE
LOCATION OF BASELINE STUDY AND HERITAGE RESOURCES

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-11-15
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PREPARED	SBM/LMS
REVIEWED	TH
APPROVED	BN

PROJECT NO.	PHASE	REV.	FIGURE
1660579	P100	1	9

PATH: G:\CLIENTS\DENISON MINES\Wheeler River\Figures\1660579_Heritage_Baseline\P100_Heritage\T30_FieldSurveys\FIGS_2to7_9to12_1660579-P100-T30_ShovelProbes.mxd

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A

25mm 0

Photo 13: View of drilling activities at Gryphon infrastructure site, looking north.

Photo 14: View of existing road adjacent to Kratchkowsky Lake, looking south.

Photo 15: Shovel testing on terrace edge adjacent to Kratchkowsky Lake, looking south.

Photo 16: Shovel testing adjacent to lake at northeast corner of Gryphon infrastructure heritage survey area, looking east.

- 0 to 3 cm organic duff;
- 3 to 13 cm grey sand; and
- 13 to 30 cm tan/orange sand.

No heritage resources were identified within the Gryphon heritage study area.

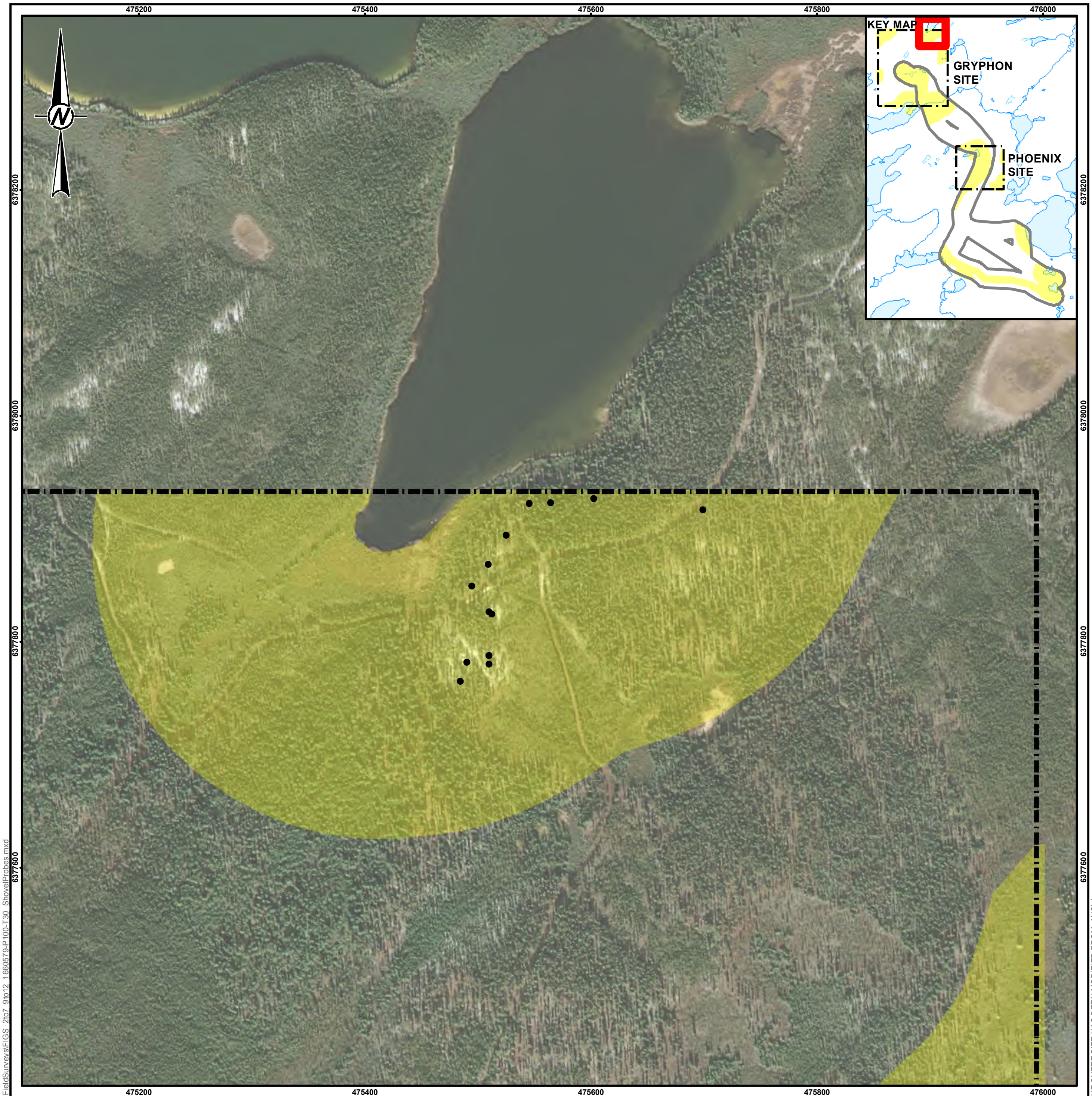
4.1.4 Fieldwork Results for Phoenix Infrastructure Heritage Survey Area

Similar to the Gryphon heritage study area, surficial disturbances resulting from various access roads, trails and clearings from drilling activities were present throughout the Phoenix heritage study area (Figures 11 and 12; Photos 17 and 18). Disturbances associated to drilling activities were located around the proposed infrastructure for the Phoenix site while the access roads and trails traversed various areas within the heritage study area (Photos 19 and 20). These areas were visually inspected for cultural materials and features while terrain immediately adjacent to these areas were inspected for any cultural features that may have been present (e.g., historic cabins, etc.). No heritage resources were identified.

Areas selected for subsurface testing within the Phoenix heritage study area were focused along the terrace edges of a lake located at the northwestern corner of the area (Photo 21), as well as a remnant terrace edge overlooking a large lake at the eastern extent of the area (Photo 22). In total, 63 shovel probes were judgementally excavated within the Phoenix heritage study area (Appendix B). This count includes 41 shovel probes excavated within portions of the access road options that traverse through the Phoenix heritage survey area. Although there were some variations, the general stratigraphic profile can be summarized as follows:

- 0 to 2 cm organic duff;
- 2 to 20 cm light grey sand; and
- 20 to 35 cm tan/orange sand.

No heritage resources were identified within the Phoenix heritage study area.



LEGEND

- SHOVEL PROBE
- ACCESS ROAD OPTION CORRIDOR BOUNDARY
- ASSESSED AREA
- PROPOSED INFRASTRUCTURE HERITAGE SURVEY AREA

0 100 200

1:5,000 METRES

REFERENCE(S)

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PROJECTION: UTM ZONE 13 DATUM: NAD 83

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CONSULTANT

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DESIGNED	TH
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REVIEWED	TH
APPROVED	BN

PROJECT NO.	PHASE	REV.	FIGURE
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IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A

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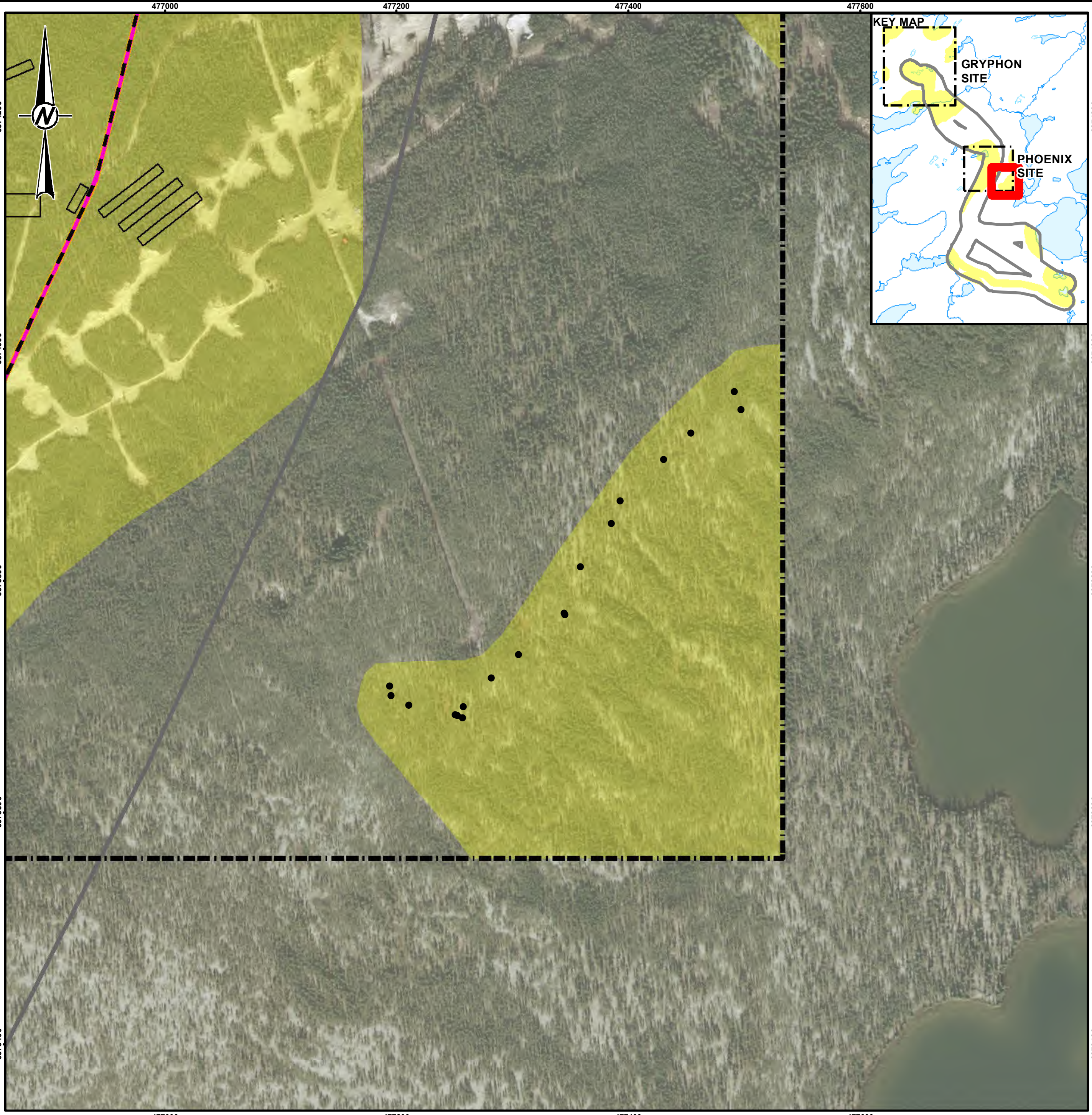

LEGEND

- SHOVEL PROBE

ACCESS ROAD OPTIONS

- PHOENIX-1
- PHOENIX-2
- PHOENIX-3
- ACCESS ROAD OPTION CORRIDOR BOUNDARY
- ASSESSED AREA
- PROPOSED INFRASTRUCTURE
- PROPOSED INFRASTRUCTURE HERITAGE SURVEY AREA

0 100 200

1:5,000 METRES

REFERENCE(S)

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PROJECTION: UTM ZONE 13 DATUM: NAD 83

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CONSULTANT
Golder Associates

YYYY-MM-DD	2017-11-15
DESIGNED	TH
PREPARED	SBM/LMS
REVIEWED	TH
APPROVED	BN

PROJECT NO.	PHASE	REV.	FIGURE
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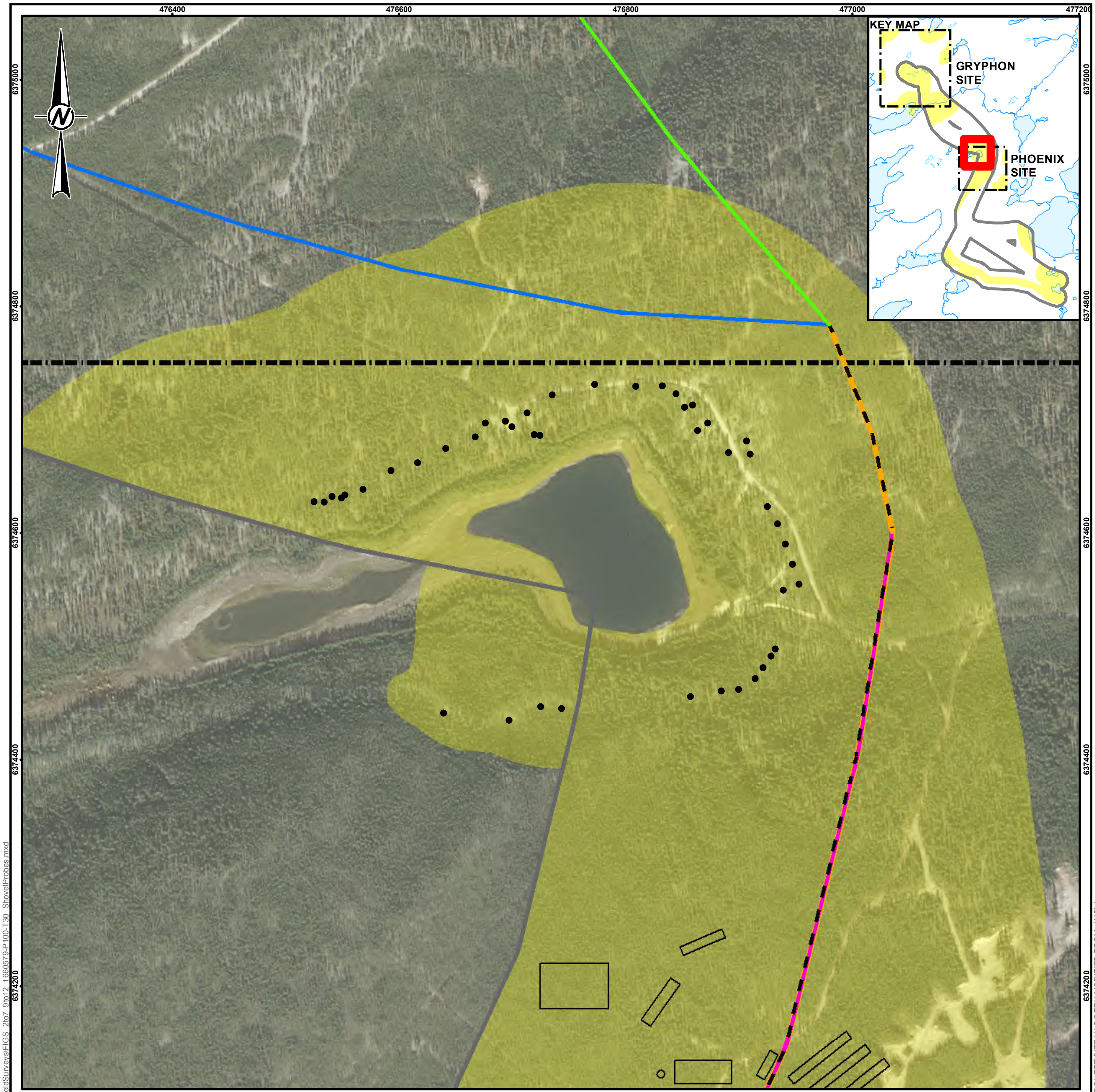

LEGEND

- SHOVEL PROBE

ACCESS ROAD OPTIONS

- PHOENIX-1
- PHOENIX-2
- PHOENIX-3
- GRYPHON-1
- GRYPHON-2
- ACCESS ROAD OPTION CORRIDOR BOUNDARY
- ASSESSED AREA
- PROPOSED INFRASTRUCTURE
- PROPOSED INFRASTRUCTURE HERITAGE SURVEY AREA

0 100 200

1:5,000 METRES

REFERENCE(S)

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APPROVED	BN

PROJECT NO.	PHASE	REV.	FIGURE
1660579	P100	1	12

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IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A

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Photo 17: View of Phoenix infrastructure site and drilling location, looking east.

Photo 18: Road paralleling terrace edge of lake in the Phoenix infrastructure heritage survey area and Phoenix 1, 2, 3 access road option, looking south

Photo 19: View of terraces along a lake in the Phoenix infrastructure heritage survey area, looking north.

Photo 20: View from southeast corner of Phoenix infrastructure heritage survey area, looking southeast.

Photo 21: View of terrace along a lake in the Phoenix infrastructure heritage survey area, looking north.

Photo 22: Shovel testing in the Phoenix infrastructure heritage survey area, looking east.

5.0 SUMMARY AND MANAGEMENT RECOMMENDATIONS

Golder conducted a heritage baseline study on behalf of Denison for the proposed Wheeler River Project in northern Saskatchewan. The study was completed using a pedestrian reconnaissance and visual inspection program, complimented by the excavation of 258 shovel probes and 5 shovel tests (Table 3). The assessment resulted in the identification of HiNi-6, an unknown Precontact Artifact Find that was identified on a terrace overlooking a large lake adjacent to the Phoenix 2 road option. The site was assessed and determined to have limited interpretive potential. No additional heritage concerns were identified during the course of the HRIA.

Table 3: Heritage Resource Impact Assessment Summary

Project Component	Option	Approximate Area Assessed (ha)	Documented Heritage Resources	Recommendations
Access Road	Phoenix 1	54	N/A	No Further Concerns
	Phoenix 2	66	HiNi-6	
	Phoenix 3	76	N/A	
	Gryphon 1	45	N/A	
	Gryphon 2	34	N/A	
Infrastructure	Phoenix Site	48	N/A	
	Gryphon Site	70	N/A	

ha = hectare; N/A = not applicable.

Based on the results of the HRIA, it is recommended that Denison be provided with regulatory approval per Section 63 of *The Heritage Property Act* for the project described. This Final Report fulfils the permitting requirements necessary for the completion of this HRIA.

Even the most thorough investigation may not identify all archaeological materials that may be present. Denison is advised that a Heritage Resource Management Plan be developed before construction commences. This plan should include a Chance Find Procedure, so that if unanticipated archaeological materials or features (including but not limited to, hearth features, lithic, ceramic and faunal artifacts, and human remains) are encountered as a result of construction activities, the materials or features can be suitably protected and preserved, while minimizing disruption to construction. The Heritage Conservation Branch and a qualified archaeologist will need to be contacted as soon as unanticipated archaeological materials or features are encountered.

6.0 CLOSURE

We trust the above meets your present requirements. If you have any questions or require additional details, please contact the undersigned.

GOLDER ASSOCIATES LTD.

Tam Huynh, M.A.
Archaeologist

Brad Novecosky, M.A.
Principal, Senior Archaeologist

TH/BN/crm/jlb

7.0 REFERENCES

Acton, D.F., G.A. Padbury, and C.T. Stushnoff

1998 *The Ecoregions of Saskatchewan*. Canadian Plains Research Centre, University of Regina.

Golder Associates Ltd (Golder).

1994 *McArthur River Access Road Heritage Resource Impact Assessment. Archaeological Investigation Permit No. 93-058.* Report on file with the Heritage Conservation Branch, Regina.

The Heritage Property Act

1979-80 SS cH-2.2 Available at: http://canlii.ca/t/52367. Accessed on: July 15, 2017.

Kintigh, K.W.

1988 The Effectiveness of Subsurface Testing: A Simulation Approach. *American Antiquity* 53:686-707.

Krakker, J.J., M.J. Shott, and P.D. Welch

1983 Design and Evaluation of Shovel-Test Sampling in Regional Archaeological Survey. *Journal of Field Archaeology* 10:469-480.

Nance, J.D. and B.F. Ball

1986 No Surprises? The Reliability and Validity of Test Pit Sampling. *American Antiquity* 51:457-483.

Ruppé, R.J.

1966 The Archaeological Survey: A Defense. *American Antiquity* 31:13-333.

Schiffer, M.B., A.P. Sullivan, and T.C. Klinger

1978 The Design of Archaeological Surveys. *World Archaeology* 10:1-28.

APPENDIX A

Glossary of Technical Terms

Archaeology	The study of past cultures through the scientific investigation of their material remains.
Artifact	Any object used or modified by people.
Artifact Find	A category for archaeological sites consisting of five or fewer artifacts.
Artifact Scatter	A category for archaeological sites consisting of more than five artifacts.
Artifact/Feature Combo	A category for archaeological sites consisting of a combination of both artifacts and features (e.g., stone circles and debitage).
B.P.	Before present. 1,000 B.P. = 1,000 years before 1950 A.D. or approximately 1,000 A.D.
Cairn	A mound of cobbles, often constructed on a hilltop usually functioning as a burial cover, cache cover, drive line, or landscape marker.
Ceramics	Clay artifacts, such as vessels, that have been intentionally fired.
Core	A stone from which flakes have been intentionally removed.
Debitage	Waste by-products from stone tool manufacture. This includes flakes and shatter.
Faunal Remains	Bones and other animal parts found in archaeological sites. If modified by human activities, they are considered artifacts (e.g., bone awl).
Feature	The remains of any non-portable human activity that can not be removed from a site without disturbing it (e.g., hearth or pit).
Fire Broken Rock	Rock which has been discoloured, cracked or otherwise altered by exposure to fire. This is frequently characteristic of prehistoric occupation sites and can be associated with hearth features.
Flake	A stone fragment intentionally detached from a source rock during tool manufacture. Three flake types are generally recognized: primary flakes represent early stages of reduction where the original cortex is present on the dorsal surface; secondary flakes represent later stages of reduction where no cortex is present; and tertiary flakes represent the final stages of reduction where small pressure flakes are removed to produce the cutting or scraping edge of a tool.
Hearth	A feature containing ash, charcoal, burned rock, or other evidence of fire created by people.
Heritage Resource	Any human or natural artifact or feature that is of interest for its architectural, historical, cultural, environmental, archaeological, palaeontological, aesthetic or scientific value.
Lithics	A general term used to refer to stone artifacts such as tools, cores or debitage.
Multiple Feature	A category for archaeological sites consisting of several features of different kinds (e.g., a cluster of stone circles and cairns).
Petroglyph	A rock art site formed by pecking a figure or symbol into a rock face.
Projectile Point	An inclusive term for a hafted arrow, spear or dart point.
Recurrent Feature	A category for archaeological sites consisting of several features of the same kind (e.g., a cluster of two or more stone circles).

Shatter	A stone fragment unintentionally detached from a core during stone tool manufacture. Shatter is often less well defined than the more purposefully removed flakes.
Shovel Probe	A 40 cm by 40 cm subsurface test where the excavated soils and sediments are hand trowelled for cultural materials.
Shovel Test	A 50 cm by 50 cm subsurface test where the excavated soils and sediments are passed through a 6 mm mesh screen.
Site	Any location with detectable evidence of past human activity.
Single Feature	A category for archaeological sites consisting of one feature, (e.g., a single stone circle).
Stone Circle	A Feature consisting of stone cobbles set out in a roughly circular outline. They are generally thought to have resulted from the use of stones to secure the edges of circular hide dwellings (tipis), although the stones may also have been used in constructing ceremonial structures.
Stratigraphy	The depositional layers within a site.

APPENDIX B

Shovel Probes and Tests

Location of Shovel Probes

Probe	Zone (NAD 83)	Easting	Northing	Cultural Materials	Palaeosols
J01	13V	476091	6371718	n/a	n/a
J02	13V	476093	6371734	n/a	n/a
J03	13V	476068	6371719	n/a	n/a
J04	13V	476037	6371737	n/a	n/a
J05	13V	475860	6371800	n/a	n/a
J06	13V	475877	6371814	n/a	n/a
J07	13V	476005	6371620	n/a	n/a
J08	13V	475992	6371579	n/a	n/a
J10	13V	476314	6371214	n/a	n/a
J11	13V	478910	6371082	n/a	n/a
J12	13V	478872	6371068	n/a	n/a
J13	13V	478855	6371063	n/a	n/a
J14	13V	478830	6371016	n/a	n/a
J15	13V	478848	6370999	n/a	n/a
J16	13V	478848	6370946	n/a	n/a
J17	13V	478854	6370940	n/a	n/a
J18	13V	478765	6371216	n/a	n/a
J19	13V	478759	6371208	n/a	n/a
J20	13V	478561	6371328	n/a	n/a
J20	13V	478663	6371211	n/a	n/a
J21	13V	478686	6371357	n/a	n/a
J22	13V	478720	6370758	n/a	n/a
J23	13V	478767	6370723	n/a	n/a
J24	13V	478852	6370714	n/a	n/a
J25	13V	478871	6370722	n/a	n/a
J26	13V	478892	6370718	n/a	n/a
J27	13V	478907	6370721	n/a	n/a
J28	13V	478931	6370719	n/a	n/a
J29	13V	477385	6373849	n/a	n/a
J29	13V	477195	6373701	n/a	n/a
J30	13V	477492	6373963	n/a	n/a
J31	13V	477393	6373869	n/a	n/a
J32	13V	477345	6373772	n/a	n/a
J33	13V	477257	6373682	n/a	n/a
J34	13V	476910	6374670	n/a	n/a
J35	13V	476907	6374681	n/a	n/a
J36	13V	476859	6374713	n/a	n/a
J37	13V	476852	6374711	n/a	n/a
J38	13V	476833	6374730	n/a	n/a
J39	13V	476809	6374730	n/a	n/a
J40	13V	476735	6374721	n/a	n/a

Location of Shovel Probes

Probe	Zone (NAD 83)	Easting	Northing	Cultural Materials	Palaeosols
J41	13V	476719	6374687	n/a	n/a
J42	13V	476725	6374686	n/a	n/a
J43	13V	476677	6374697	n/a	n/a
J44	13V	476668	6374685	n/a	n/a
J45	13V	476593	6374655	n/a	n/a
J47	13V	476925	6374623	n/a	n/a
J48	13V	476948	6374572	n/a	n/a
J53	13V	478131	6372267	n/a	n/a
J54	13V	478120	6372238	n/a	n/a
J55	13V	478156	6372205	n/a	n/a
J56	13V	478152	6372198	n/a	n/a
J57	13V	478158	6372181	n/a	n/a
J58	13V	478157	6372169	n/a	n/a
J59	13V	478156	6372157	n/a	n/a
J60	13V	478239	6371935	n/a	n/a
J61	13V	478238	6371946	n/a	n/a
J62	13V	476188	6375882	n/a	n/a
J63	13V	476204	6375861	n/a	n/a
J64	13V	476225	6375868	n/a	n/a
J65	13V	476108	6375801	n/a	n/a
J66	13V	476066	6375763	n/a	n/a
J67	13V	476058	6375741	n/a	n/a
J68	13V	476008	6375702	n/a	n/a
J69	13V	475067	6375932	n/a	n/a
J70	13V	474747	6376177	n/a	n/a
J71	13V	474800	6376193	n/a	n/a
J72	13V	474835	6376167	n/a	n/a
J73	13V	474525	6375828	n/a	n/a
J74	13V	474522	6375841	n/a	n/a
J75	13V	474516	6375853	n/a	n/a
J76	13V	475525	6377895	n/a	n/a
J77	13V	475510	6377827	n/a	n/a
J78	13V	475513	6377825	n/a	n/a
J79	13V	475510	6377781	n/a	n/a
J80	13V	475460	6376030	n/a	n/a
J81	13V	475469	6376052	n/a	n/a
J82	13V	475498	6376042	n/a	n/a
J83	13V	475582	6376124	n/a	n/a
J84	13V	478990	6371218	n/a	n/a
J85	13V	478984	6371206	n/a	n/a
J86	13V	478974	6371184	n/a	n/a

Location of Shovel Probes

Probe	Zone (NAD 83)	Easting	Northing	Cultural Materials	Palaeosols
J87	13V	478948	6371183	n/a	n/a
R01	13V	476101	6371727	n/a	n/a
R02	13V	476080	6371697	n/a	n/a
R03	13V	476061	6371711	n/a	n/a
R04	13V	476030	6371732	n/a	n/a
R05	13V	475883	6371803	n/a	n/a
R06	13V	476017	6371614	n/a	n/a
R07	13V	476007	6371578	n/a	n/a
R08	13V	476007	6371539	n/a	n/a
R09	13V	476326	6371231	n/a	n/a
R10	13V	478891	6371074	n/a	n/a
R11	13V	478828	6371055	n/a	n/a
R12	13V	478826	6371016	n/a	n/a
R13	13V	478856	6370985	n/a	n/a
R14	13V	478847	6370943	n/a	n/a
R15	13V	478852	6370945	n/a	n/a
R16	13V	478771	6371207	n/a	n/a
R17	13V	478776	6371217	n/a	n/a
R18	13V	478682	6371209	n/a	n/a
R19	13V	478692	6371358	n/a	n/a
R19	13V	478554	6371289	n/a	n/a
R20	13V	478734	6370745	n/a	n/a
R21	13V	478832	6370722	n/a	n/a
R22	13V	478882	6370721	n/a	n/a
R23	13V	478897	6370724	n/a	n/a
R24	13V	478920	6370720	n/a	n/a
R25	13V	478930	6370725	n/a	n/a
R27	13V	477194	6373709	n/a	n/a
R28	13V	477497	6373948	n/a	n/a
R30	13V	477345	6373771	n/a	n/a
R31	13V	477250	6373685	n/a	n/a
R32	13V	476891	6374671	n/a	n/a
R33	13V	476873	6374697	n/a	n/a
R34	13V	476863	6374691	n/a	n/a
R35	13V	476845	6374723	n/a	n/a
R36	13V	476773	6374731	n/a	n/a
R37	13V	476713	6374706	n/a	n/a
R38	13V	476700	6374694	n/a	n/a
R39	13V	476694	6374699	n/a	n/a
R40	13V	476617	6374662	n/a	n/a
R41	13V	476541	6374632	n/a	n/a

Location of Shovel Probes

Probe	Zone (NAD 83)	Easting	Northing	Cultural Materials	Palaeosols
R42	13V	476549	6374631	n/a	n/a
R43	13V	476934	6374608	n/a	n/a
R44	13V	476953	6374555	n/a	n/a
R45	13V	478119	6372375	n/a	n/a
R46	13V	478108	6372433	n/a	n/a
R46	13V	478131	6372287	n/a	n/a
R47	13V	478149	6372244	n/a	n/a
R48	13V	478140	6372213	n/a	n/a
R49	13V	478147	6372214	n/a	n/a
R50	13V	478151	6372187	n/a	n/a
R51	13V	478149	6372182	n/a	n/a
R52	13V	478231	6371938	n/a	n/a
R53	13V	478228	6371945	n/a	n/a
R54	13V	476208	6375874	n/a	n/a
R55	13V	476222	6375874	n/a	n/a
R56	13V	476225	6375892	n/a	n/a
R57	13V	476090	6375779	n/a	n/a
R58	13V	476043	6375726	n/a	n/a
R59	13V	476030	6375712	n/a	n/a
R60	13V	475076	6375940	n/a	n/a
R61	13V	474776	6376182	n/a	n/a
R62	13V	474856	6376164	n/a	n/a
R63	13V	474529	6375833	n/a	n/a
R64	13V	474529	6375840	n/a	n/a
R65	13V	474527	6375852	n/a	n/a
R66	13V	475509	6377868	n/a	n/a
R67	13V	475495	6377850	n/a	n/a
R68	13V	475510	6377788	n/a	n/a
R69	13V	475428	6376027	n/a	n/a
R70	13V	475506	6376043	n/a	n/a
R72	13V	475620	6376183	n/a	n/a
R73	13V	478995	6371219	n/a	n/a
R74	13V	478977	6371193	n/a	n/a
R75	13V	478959	6371175	n/a	n/a
R76	13V	478937	6371194	n/a	n/a
T01	13V	476064	6371667	n/a	n/a
T02	13V	476040	6371681	n/a	n/a
T03	13V	476024	6371743	n/a	n/a
T04	13V	475864	6371795	n/a	n/a
T05	13V	476047	6371515	n/a	n/a
T06	13V	476044	6371490	n/a	n/a

Location of Shovel Probes

Probe	Zone (NAD 83)	Easting	Northing	Cultural Materials	Palaeosols
T08	13V	476337	6371237	n/a	n/a
T09	13V	478894	6371051	n/a	n/a
T10	13V	478868	6371044	n/a	n/a
T11	13V	478841	6371032	n/a	n/a
T12	13V	478841	6371013	n/a	n/a
T13	13V	478853	6371005	n/a	n/a
T14	13V	478771	6371218	n/a	n/a
T15	13V	478767	6371224	n/a	n/a
T16	13V	478725	6371221	n/a	n/a
T17	13V	478703	6371216	n/a	n/a
T18	13V	478565	6371265	n/a	n/a
T19	13V	478557	6371253	n/a	n/a
T20	13V	478569	6371310	n/a	n/a
T21	13V	478574	6371344	n/a	n/a
T22	13V	478593	6371370	n/a	n/a
T23	13V	478722	6370802	n/a	n/a
T24	13V	478719	6370816	n/a	n/a
T25	13V	478744	6370799	n/a	n/a
T26	13V	478763	6370791	n/a	n/a
T27	13V	478823	6370737	n/a	n/a
T28	13V	478864	6370717	n/a	n/a
T29	13V	478880	6370715	n/a	n/a
T30	13V	478903	6370709	n/a	n/a
T31	13V	478913	6370712	n/a	n/a
T32	13V	478913	6370720	n/a	n/a
T33	13V	477211	6373693	n/a	n/a
T34	13V	477258	6373692	n/a	n/a
T35	13V	477454	6373928	n/a	n/a
T36	13V	477431	6373905	n/a	n/a
T37	13V	477359	6373812	n/a	n/a
T38	13V	477305	6373737	n/a	n/a
T39	13V	477282	6373716	n/a	n/a
T40	13V	477253	6373684	n/a	n/a
T41	13V	476640	6374441	n/a	n/a
T42	13V	476697	6374435	n/a	n/a
T43	13V	476725	6374446	n/a	n/a
T44	13V	476744	6374445	n/a	n/a
T45	13V	476857	6374456	n/a	n/a
T46	13V	476885	6374460	n/a	n/a
T47	13V	476900	6374462	n/a	n/a
T48	13V	476915	6374471	n/a	n/a

Location of Shovel Probes

Probe	Zone (NAD 83)	Easting	Northing	Cultural Materials	Palaeosols
T49	13V	476922	6374481	n/a	n/a
T50	13V	476929	6374491	n/a	n/a
T51	13V	476932	6374497	n/a	n/a
T52	13V	476642	6374674	n/a	n/a
T53	13V	476568	6374638	n/a	n/a
T54	13V	476525	6374628	n/a	n/a
T55	13V	476534	6374627	n/a	n/a
T56	13V	478118	6372396	n/a	n/a
T56	13V	476941	6374590	n/a	n/a
T57	13V	476939	6374550	n/a	n/a
T57	13V	478132	6372323	n/a	n/a
T58	13V	478130	6372269	n/a	n/a
T59	13V	478137	6372272	n/a	n/a
T60	13V	478164	6372223	n/a	n/a
T61	13V	478165	6372211	n/a	n/a
T62	13V	478168	6372193	n/a	n/a
T63	13V	478164	6372177	n/a	n/a
T64	13V	478284	6371890	n/a	n/a
T65	13V	478261	6371913	n/a	n/a
T66	13V	476156	6375889	n/a	n/a
T67	13V	476143	6375882	n/a	n/a
T68	13V	476123	6375882	n/a	n/a
T69	13V	476117	6375886	n/a	n/a
T70	13V	476103	6375905	n/a	n/a
T71	13V	476092	6375882	n/a	n/a
T72	13V	476070	6375870	n/a	n/a
T73	13V	476044	6375880	n/a	n/a
T74	13V	476026	6375850	n/a	n/a
T75	13V	476010	6375847	n/a	n/a
T76	13V	475995	6375824	n/a	n/a
T77	13V	475986	6375820	n/a	n/a
T78	13V	475979	6375812	n/a	n/a
T79	13V	475958	6375785	n/a	n/a
T80	13V	474787	6376147	n/a	n/a
T81	13V	474534	6375829	n/a	n/a
T82	13V	474528	6375833	n/a	n/a
T83	13V	474519	6375858	n/a	n/a
T84	13V	475545	6377923	n/a	n/a
T85	13V	475565	6377923	n/a	n/a
T86	13V	475602	6377927	n/a	n/a
T87	13V	475699	6377917	n/a	n/a

Location of Shovel Probes

Probe	Zone (NAD 83)	Easting	Northing	Cultural Materials	Palaeosols
T88	13V	475490	6377782	n/a	n/a
T89	13V	475485	6377765	n/a	n/a
T90	13V	475375	6376010	n/a	n/a
T91	13V	475375	6376018	n/a	n/a
T92	13V	475450	6376031	n/a	n/a
T93	13V	475472	6376036	n/a	n/a
T94	13V	475543	6376092	n/a	n/a
T95	13V	475680	6376192	n/a	n/a
T96	13V	478993	6371228	n/a	n/a
T97	13V	478995	6371237	n/a	n/a
T98	13V	478994	6371248	n/a	n/a
T99	13V	478959	6371278	n/a	n/a

NAD = North American Datum; n/a = not applicable.

Location of Shovel Tests

Probe	Zone (NAD 83)	Easting	Northing	Cultural Materials	Palaeosols
J46	13V	476552	6374634	n/a	n/a
J49	13V	478104	6372440	n/a	n/a
J50	13V	478104	6372442	n/a	n/a
J51	13V	478101	6372441	n/a	n/a
J52	13V	478105	6372440	n/a	n/a

NAD = North American Datum; n/a = not applicable.

APPENDIX C

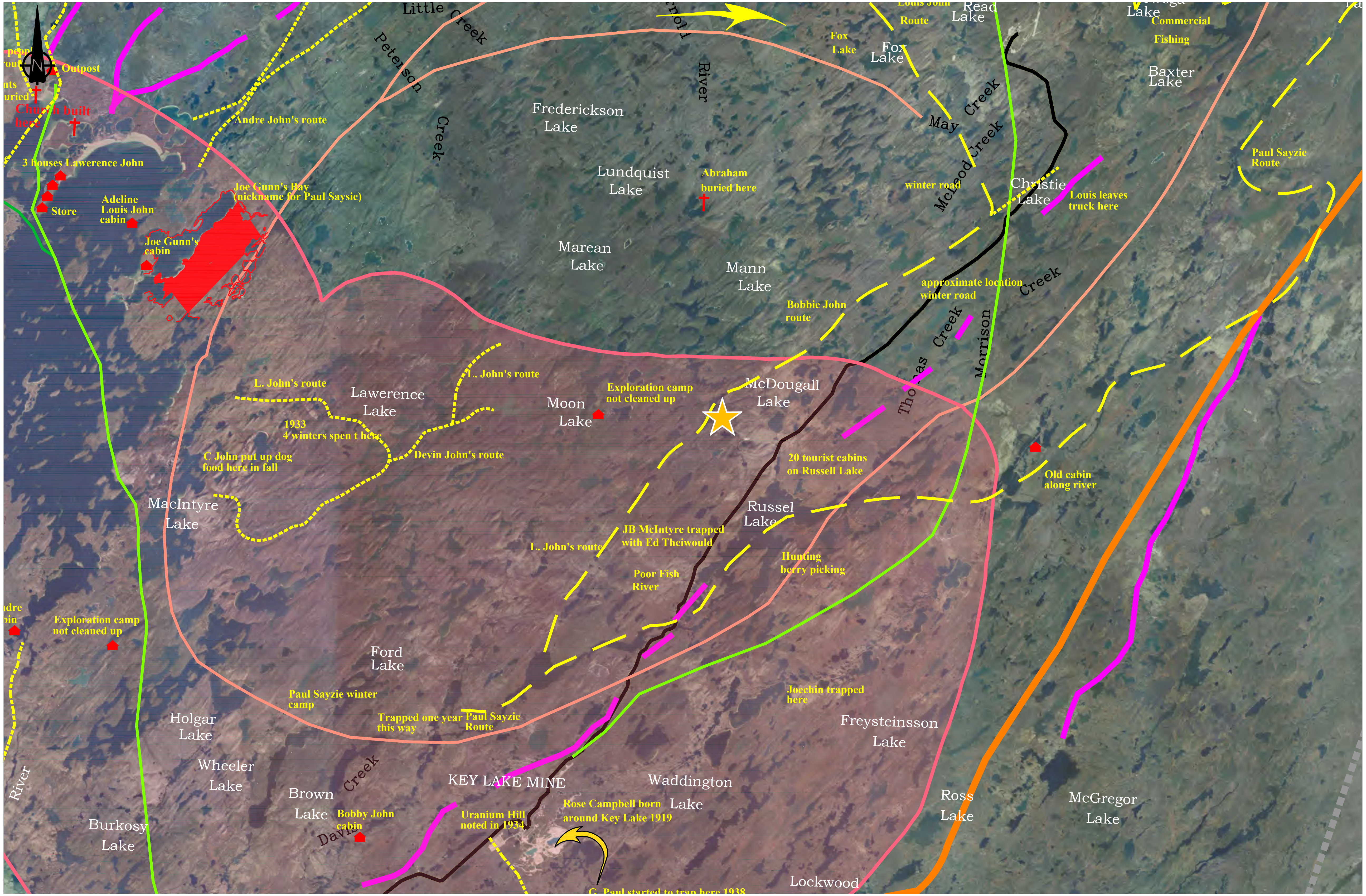
HiNi-6 Artifact Catalogue

Project No. 1660579
Permit No. 17-091
Borden No. HiNi-6

Catalogue #	Class	Description	Material	Notes	Freq.	Mass (g)	Length (mm)	Width (mm)	Thick. (mm)	Wpt	UTM Coordinates (NAD 83)
HiNi-6:1	Lithic	Retouched Flake	Quartzite	Left lateral edge unifacial retouch; 15 cm dbs	1	25.1	71.6	49.6	9.4	J49	13U 478104E 6372440N

APPENDIX D

Map Showing Traditional Territory of the English River First Nation



LEGEND

- Burial / Sacred
- Cabin
- Eskers
- Winter Trails
- Traditional Trails
- Provincial Highway
- ERFN Traditional Land Boundry
- Winter Road
- ERFN Boundry
- Reserve Land
- Estimated Caribou Range
- Wheeler River

srk consulting

Denison Mines

SUBSET OF ENGLISH RIVER FIRST NATION TRADITIONAL TERRITORIES DETAILED VIEW

WHEELER RIVER PROJECT

2017TT_EnglishRiver_March2_2017[1].dwg

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Golder Associates

Denison Mines

Wheeler River Project

Final Environmental Impact Statement

November 2024

Powering
PEOPLE, PARTNERSHIPS AND PASSION.

REPORT

Permit 19-065 Denison Mines Corporation Wheeler River Project

Heritage Resource Impact Assessment

Submitted to:

Pamela Bennett

Denison Mines Corporation
230 22nd St. East, Suite 200
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January 2020

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1 E-Copy - Golder Associates Ltd., Saskatoon, Saskatchewan

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EXECUTIVE SUMMARY

In 2017, a heritage baseline study was conducted under Archaeological Resource Investigation Permit 17-091 for Denison Mines Corporation's Wheeler River Project in northern Saskatchewan. In 2019, a refined Project footprint was submitted to the Heritage Conservation Branch (Ministry of Parks, Culture and Sport) for heritage screening which determined that there are new development areas located in heritage sensitive terrain that were not assessed during the 2017 heritage baseline study. As construction activities have the potential to impact archaeological sites, a Heritage Resource Impact Assessment was required for these new development areas.

The assessment was carried out between July 8 and 12, 2019, under Archaeological Resource Investigation Permit 19-065. Heritage sensitive portions of the Project were assessed using a combination of pedestrian reconnaissance and visual inspection field techniques, complimented by the judgemental excavation of 212 shovel probes and five shovel tests and resulted in the identification of one newly recorded archaeological site.

HjNi-1 is an Artifact Find site of an unknown Precontact cultural affiliation. The site is comprised of a secondary quartzitic sandstone flake that was recovered from the surface of an access road located near the confluence of a lake and creek at the northeast corner of the Phoenix buffer area. No additional archaeological materials were identified during further testing and inspections conducted within the immediate site area. As the site has limited interpretive potential, no further work is recommended for HjNi-1.

It is recommended that regulatory approval per Section 63 of *The Heritage Property Act* be granted for the Project to proceed as described. This Final Report fulfils the permitting requirements necessary for the completion of this Heritage Resource Impact Assessment.

Table of Contents

TABLES

FIGURES

PHOTO

APPENDICES

APPENDIX A
Glossary of Technical Terms

APPENDIX B
Location of Shovel Probes and Tests

APPENDIX C
Artifact Catalogue

APPENDIX D
English River First Nation Land Use Map

APPENDIX E
Pinehouse Kineepik Métis Local Land Use Map

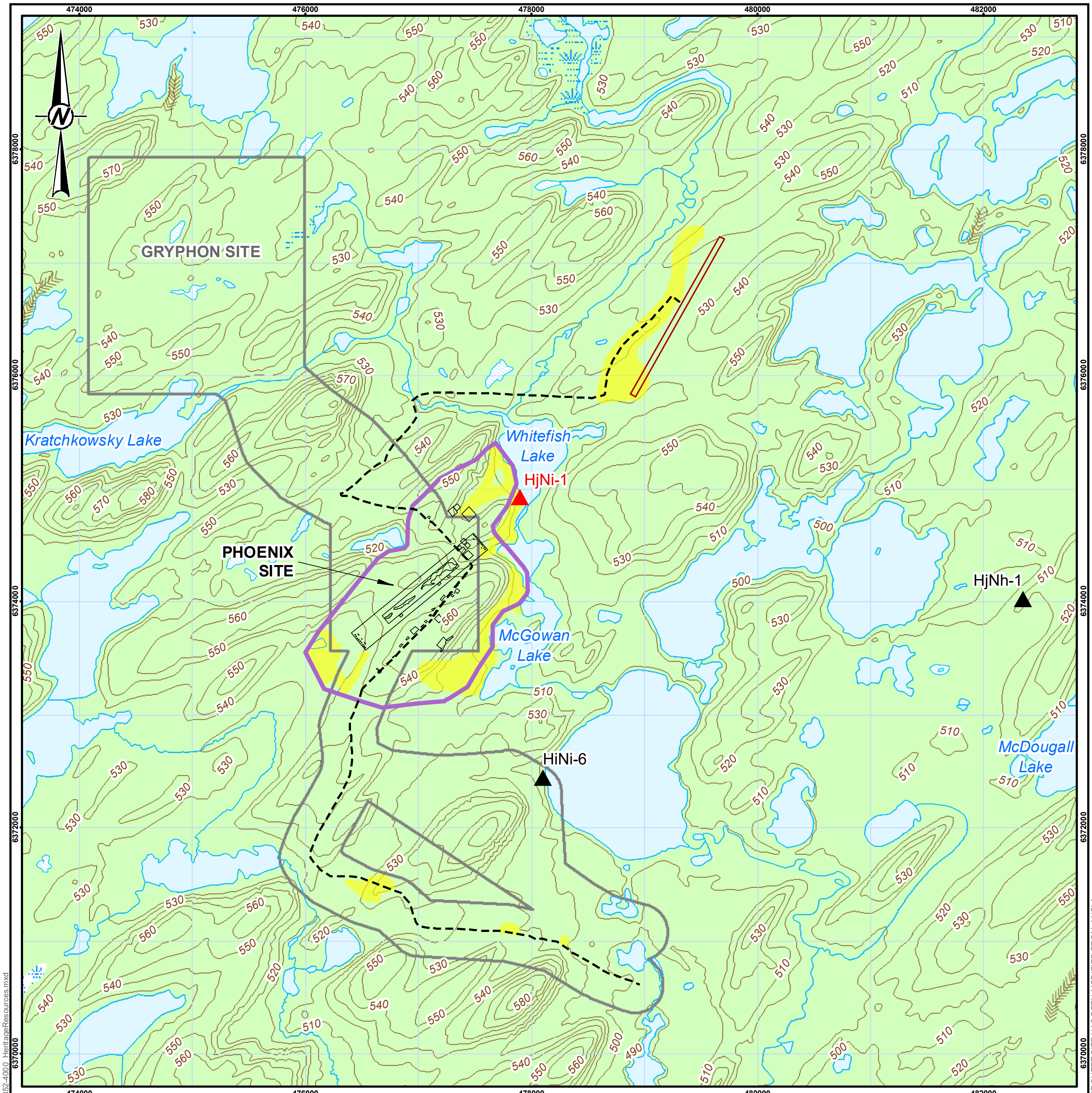
1.0 INTRODUCTION

Golder conducted a Heritage Resource Impact Assessment (HRIA) on behalf of Denison Mines Corporation (Denison) for their Wheeler River Project (the Project) in northern Saskatchewan. Located approximately 3 km northeast of Cameco Corporation's Key Lake Operations and 35 km southwest of Cameco's McArthur River Operation, the Project is situated along the eastern edge of the Athabasca Basin and is an advanced exploration stage uranium project.

In 2016, a preliminary Project footprint was submitted to the Heritage Conservation Branch (Ministry of Parks, Culture and Sport) for heritage screening and it was determined that portions of the proposed Project are in heritage sensitive terrain (i.e., hilly terrain and prominent uplands within 500 m of shorelines greater than 1 km in length). Accordingly, a baseline HRIA was conducted under Archaeological Resource Investigation Permit 17-091 for these Project components. HiNi-6, an Artifact Find site of an unknown Precontact cultural affiliation was identified during the assessment; however, the site has limited interpretive potential and no further work was recommended for HiNi-6. Given that no additional heritage concerns were identified during the HRIA, regulatory approval per Section 63 of *The Heritage Property Act* (1979-80) was recommended.

In 2019, Denison refined the Project footprint. The refined Project footprint consists of the addition of an airstrip, changes to the primary access road alignment, additional infrastructure at the Phoenix Site and a buffer zone around the Phoenix Site to accommodate design flexibility. Although much of the refined footprint overlaps the areas assessed during the 2017 HRIA, the remaining areas extend beyond the 2017 HRIA scope (Figure 1). The refined Project footprint was screened by the Heritage Conservation Branch for heritage sensitivities which determined that new Project components that were not assessed during the 2017 HRIA and located within 250 m of archaeologically sensitive terrain will require an HRIA (Heritage Conservation Branch File No. 19-993).

The HRIA was carried out on July 8 to 12, 2019, under Archaeological Resource Investigation Permit No. 19-065 issued to Tam Huynh (archaeologist, Golder Associates Ltd.) to identify, record and assess any heritage resources that may be impacted by the proposed project. This report contains the results of the HRIA. Section 2 will discuss the Project location while a summary of Denison's commitment to engagement as it relates to the objectives of this HRIA is contained in Section 3. Project specific details will be discussed in Section 4. Section 5 will provide an overview of previous archaeological research. The objectives and methods of this assessment will be contained in Section 6 while fieldwork results are in Section 7. A summary of the HRIA and associated recommendations is contained to Section 8. A glossary of technical terms is located in Appendix A. Shovel probe and test locations are included in Appendix B and an artifact catalogue is contained in Appendix C. Appendix D contains English River First Nation Land Use Maps while Pinehouse Kineepik Métis Local Land Use Maps are contained in Appendix E.



LEGEND

- ELEVATION CONTOUR (m)
- ESKER
- WATERCOURSE
- INTERMITTENT WATERBODY
- WATERBODY
- WETLAND
- WOODED AREA
- KNOWN HERITAGE RESOURCE
- NEW HERITAGE RESOURCE
- SITE ACCESS ROAD
- 2017 HRIA ASSESSMENT BOUNDARY
- ASSESSED AREA
- PHOENIX SITE BUFFER AREA
- PHOENIX SITE INFRASTRUCTURE
- PROPOSED AIRSTRIP

0 1,000 2,000

1:50,000 METRES

REFERENCE(S)

1. HERITAGE RESOURCES OBTAINED FROM HERITAGE CONSERVATION BRANCH, MINISTRY OF PARKS, CULTURE AND SPORT, 2019.
2. BASE DATA MAY BE OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED OR IHS MARKIT CANADA LIMITED.

PROJECTION: UTM ZONE 13 DATUM: NAD 83

CLIENT

DENISON MINES CORPORATION

PROJECT

WHEELER RIVER PROJECT
HERITAGE RESOURCE IMPACT ASSESSMENT

TITLE

LOCATION OF PROJECT AND HERITAGE RESOURCES

CONSULTANT

GOLDER

YYYY-MM-DD	2020-01-08
DESIGNED	TH
PREPARED	LMS
REVIEWED	TH
APPROVED	PY

PROJECT NO.	PHASE	REV.	FIGURE
19120852	4000	0	1

PATH: G:\ Clients\Denison\WheelerRiver\99_PROJECTS\19120852\4000\02_PRODUCTION\MXD\Fig1_19120852-4000_HeritageResources.mxd

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2.0 PROJECT LOCATION AND ENVIRONMENT

Terrain traversed by the Project footprint varies from jack pine forests over well drained, flat to undulating uplands to steeply sloped, exposed bedrock escarpments (Photos 1 and 2). Several access roads used for geotechnical/drilling studies were observed throughout the Project area, particularly within the Phoenix Site buffer area (Photo 3). The largest water sources within the immediate Project area are McGowan Lake and Whitefish Lake, which border the eastern extent of the Phoenix site buffer area (Photo 4).

The Project description provided above is typical of the Wheeler Upland Ecodistrict of the Athabasca Plain Ecoregion of Saskatchewan where the Project is located. This Ecodistrict represents a large area extending from Creek Lake to Hatchet and Wollaston Lakes and primarily consists of drumlinoid moraine landscapes covered in undulating glaciofluvial outwash deposits (Acton et al. 1998). Prominent eskers, some extending 100 km or more, cross the area from northeast to southwest. Drainages in this region of Saskatchewan tend to be weakly developed and normally consist of small creeks with drain from one lake into another. Vegetation here is diverse and consists of forests of jack pine and black spruce, with lichen and Canada blueberry. Brunisolic soils dominate the well-drained slopes in the region, within Gleysols and Organics, and local Cryosols in small, poorly drained swales and flats (Acton et al. 1998).

The Project area is within the area of the province that includes the traditional territory of the English River First Nation. In addition to this, residents of Ile a la Crosse and Pinehouse Kineepik Métis Local have also indicated that they have recent and historical traditional ties to the region hosting the proposed Project (Appendices D and E).

Photo 1: View of jack pine forest along access road alignment, looking southwest.

Photo 2: View of cutline towards large bedrock escarpment in the Phoenix site buffer area, looking northwest.

Photo 3: View of access roads in the Phoenix buffer area, looking southeast.

Photo 4: View of Whitefish Lake at the northeastern extent of the Phoenix buffer area, looking southeast.

3.0 ENGAGEMENT

Since 2016 Denison has been engaging with local Indigenous stakeholders throughout the Project development phases; thus, building positive relationships between all parties involved. This resulted in many socio-economic opportunities for Indigenous community members to be involved in the Project. In 2017, Joey George (English River First Nation) assisted Golder archaeologists in the 2017 baseline HRIA. When Golder returned to the area in 2019 for the current HRIA, they were joined by Patrick D'Jonaire (English River First Nation). Both individuals contributed to the successful completion of the HRIA's by assisting the archaeologists in the identification of heritage sensitive areas, as well as executing the field assessments.

Through Denison's commitment to Indigenous engagement in the context of this HRIA, careful consideration was given to the existing land use maps for both English River First Nation and Pinehouse Kineepik Metis Local (Appendices D and E). During the planning stages of the HRIA's, Golder reviewed the maps to a) better inform identification of areas that would be targeted for the HRIA's and, b) evaluate the potential for heritage resource sites to occur in traditional use locations identified on the maps. Although most of the activities depicted on the maps are centered around Cree Lake to the west and Pinehouse to the south, the review determined that wintering trails and traditional hunting locales do intersect the Project footprint. No burial or sacred sites were identified within the Project footprint.

4.0 PROJECT CONSTRUCION AND POTENTIAL IMPACTS

Full build construction methods will be required to develop and maintain the necessary infrastructure required for the Project. Heavy vehicular traffic can impact surface features. In boreal forest environments where soil development is limited, heritage resources typically occur at or near the ground surface and can be easily disturbed. Surface features such as cabins or hearths could be damaged or destroyed by clearing, heavy machinery traffic and equipment. Disturbance to subsoils and sediments through compression and removal could also negatively impact buried Precontact sites such as campsites, lithic reduction areas, or human burials. In buried sites such as these, context is important, and the value of the archaeological resource may be significantly reduced once it has been impacted. Impacts to heritage resources are permanent and irreversible.

5.0 PREVIOUS ARCHAEOLOGICAL RESEARCH

The database for previously recorded heritage resources maintained by the Heritage Conservation Branch was queried prior to initiation of the HRIA field study. The results of the database query indicated that there are 11 known heritage resource sites on National Topographic Map Sheets 74H/06 and 74H/11 (Table 1). Artifact Find sites (n=7) are the most common site type, followed by Artifact Scatter sites (n=2). Artifact/Feature Combination (n=1) and Recurrent Feature (n=1) sites have also been documented in the area.

Of the above mentioned sites, there are only two known sites within 5 km of the Project area: HiNi-6 and HjNh-1. HiNi-6 is an Artifact Find site of an unknown Precontact cultural affiliation that was identified during the baseline HRIA for this Project (Golder 2017). Located adjacent to the western terrace of a lake adjacent to the Phoenix 2 access road option, the site consists of a large, grey quartzite secondary flake that was identified in a shovel probe at approximately 15 cm depth below surface. No additional archaeological artifacts and/or features were identified during a thorough inspection of the sandy beach east of the site and additional testing within the site area. As the site has limited interpretive potential, no additional work was recommended for the site.

Table 1: Heritage Resource Site Types Recorded Within National Topographic Map Sheet 74H/06 and 74H/11

Site Type	Definition	No. of Sites
Artifact Find	Archaeological sites consisting of five or fewer artifacts. An artifact is any object used or modified by people (e.g., projectile point, pottery shards, lithic flakes).	7
Artifact Scatter	Archaeological sites consisting of six or more artifacts.	2
Recurrent Feature	Archaeological sites consisting of several features of the same kind.	1
Artifact/Feature Combination	Archaeological sites consisting of both artifacts and features.	1
	Total	**11**

No= number.

The second site, HjNh-1, is an Artifact Find site of an unknown Precontact cultural affiliation that was identified during an HRIA for the McArthur River access road (Golder 1994). Located approximately 800 m northwest of McDougall Lake, the site is comprised of a single sandstone secondary flake that was identified on a terrace overlooking an unnamed watercourse. No additional archaeological artifacts and/or features were identified at the site and no further work was recommended.

6.0 OBJECTIVES AND METHODS

The objectives of the HRIA flow from the principles outlined in *The Heritage Property Act.* More specifically, studies were completed with the following objectives:

- Complete appropriate levels of inspections in heritage sensitive areas.
- Document and assess heritage resources if encountered.
- Recommend appropriate mitigation measures to deal with any recorded heritage resources in potential conflict.

Using the criteria identified by the Heritage Conservation Branch (Heritage Conservation Branch File No. 19-993), a combination of Geographic Information System (GIS) data, NTS Map Sheet and aerial imagery reviews were used to identify the target areas for this HRIA. In-field inspections of these areas were then used to confirm whether further assessments were warranted. Once a heritage sensitive area was confirmed, surface survey and sub-surface testing methods were used to complete the objectives of the HRIA. Pedestrian reconnaissance and visual inspection were used to identify archaeological artifacts and features that may be visible on the ground surface and the effectiveness of these methodologies is dependent upon the landscape traversed by the project and the extent of disturbances caused by natural and/or human processes, if present. In areas with limited soil development and vegetation cover, visual inspection of the ground is effective in identifying cultural materials such as artifact finds, scatters, or partially buried features such as hearths. In areas of intact forest, archaeological features such as portage trails and historic structures such as cellar depressions, refuse pits, privy holes and unmarked burials can be encountered.

Subsurface testing was used to identify buried heritage resources that may be present within heritage sensitive areas. It can also be an effective tool to determine site boundaries if encountered. Shovel probes measuring approximately 40 cm by 40 cm were judgementally excavated in heritage sensitive areas where intact archaeological artifacts and features could be expected and their placement and spacing are dependent on the terrain being investigated. Excavated soils from these shovel probes were hand sorted with a trowel for cultural materials and their wall profiles were examined for intact paleosol horizons beneath the sod level. The location of each shovel probe was recorded with hand-held Global Positioning System (GPS) units and their locations are contained in Appendix B.

Heritage resource sites encountered during an HRIA are recorded and documented in accordance to provincial standards. Minimally, baseline attributes of the sites (e.g., find locations, shovel test/probe locations) are documented on a detailed topographic sketch map. Once a heritage resource is identified, shovel tests are excavated to determine site content and boundaries. These tests measure approximately 50 cm by 50 cm and the excavated soils are put through a 6 mm mesh screen to maximize artifact recovery, if present. Shovel test locations are also recorded with hand held GPS units and are contained in Appendix B.

The pedestrian reconnaissance, visual inspection and subsurface testing program for the current Project was carried out by two archaeologists and an assistant from English River First Nation. Detailed field notes and digital photographs were taken to document the Project environment while hand-held GPS units were used to document surveyed areas and relevant Project features. The results of the assessment are contained in the subsequent section of this HRIA report.

7.0 RESULTS

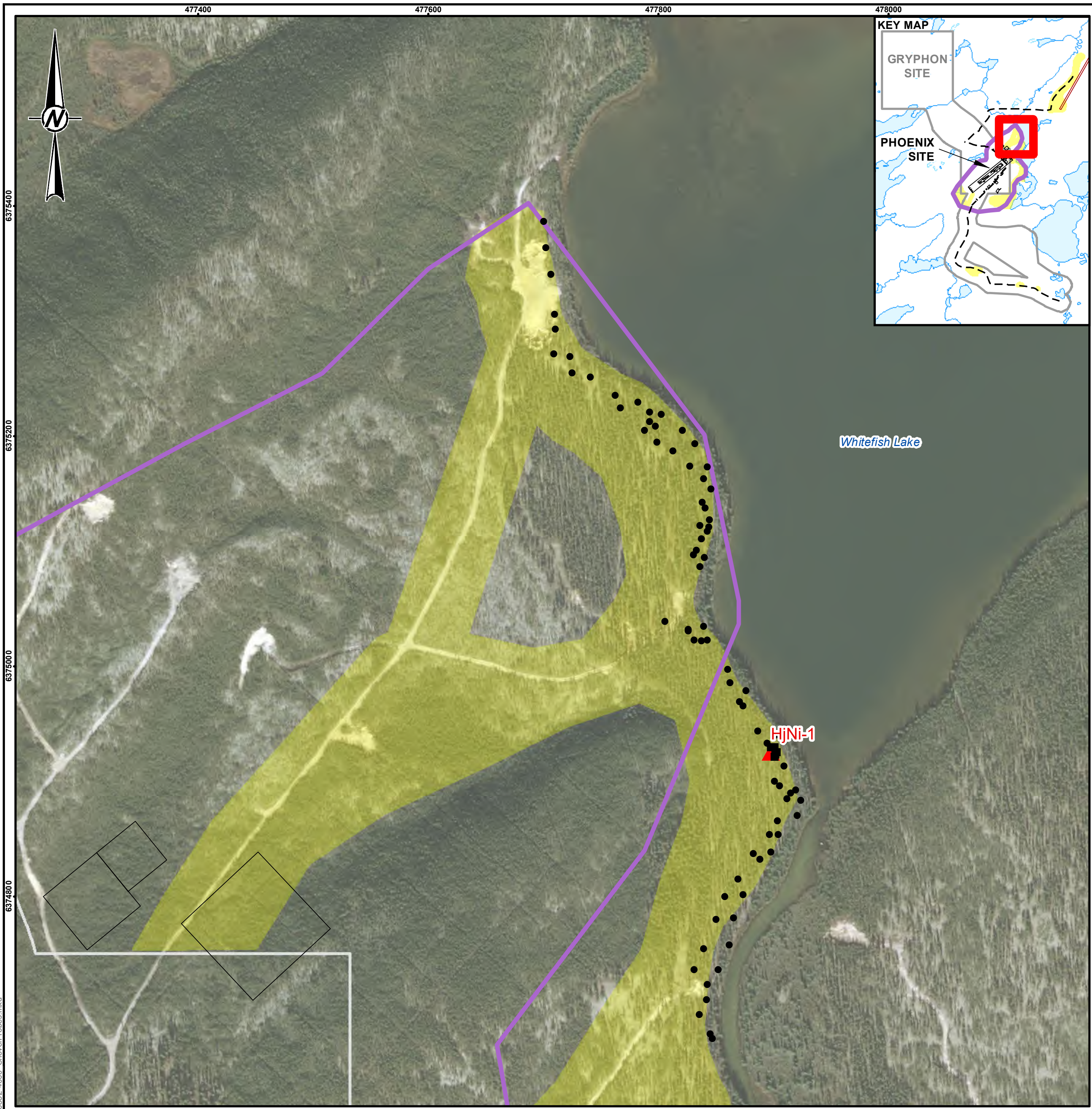
7.1 Fieldwork Results for the Phoenix Buffer Area

The Phoenix buffer area is comprised of an approximate 284 ha area that surrounds the Phoenix Infrastructure site for the Project. Although most of the area was assessed during Golder's 2017 HRIA, the northern, eastern and southwestern portions of the buffer area are outside of the 2017 assessed areas (Figures 2 to 5). As these areas are located within 250 m of significant water features and on terrain where archaeological sites have been identified elsewhere on similar terrain, they were the primary targets for the 2019 HRIA.

There are many access roads and disturbances throughout the Phoenix buffer area that were constructed and used for drilling purposes (Photos 3 and 4). All roads (including those located within the 2017 HRIA scope) were travelled during the 2019 HRIA to attain a better understanding of the Project area and to identify additional heritage sensitive areas. Exposures along roads outside of the 2017 HRIA scope were visually inspected for archaeological materials that could pertain to partially intact sites (if present). In addition to this, pedestrian reconnaissance was used in areas adjacent to disturbances to identify any surficial features that may be present (e.g., historic cabins, explorative camps). One newly recorded archaeological site was identified during these inspections: HjNi-1. This site will be discussed in detail in Section 6.4 of this HRIA report.

Subsurface tests were confined to well drained, elevated terrace edges immediately adjacent to permanent water sources. Along the eastern extent of the buffer area, this consisted of an approximate 822 m stretch of continuous terrace that overlooked a large lake and adjoining creek at the northeastern extent of the buffer area (Photos 6 to 9), and an approximate 944 m stretch terrace overlooking the southern portion of the large lake at the southeastern extent of the buffer area (Photos 10 to 14). Although portions of the terrace overlooking the creek are located just outside of the buffer area provided by Denison, Golder continued their assessment of this area as the confluence of the creek and lake was deemed to have high heritage potential.

At the southwestern extent of the buffer area, a terrace overlooking a small dried lake was encountered (Photos 15 and 16). Although this water feature is not considered to be significant, in-field assessment determined that the area high moderate to high heritage; therefore, was assessed for heritage resources.



LEGEND

- NEW HERITAGE RESOURCE
- SHOVEL PROBE
- SHOVEL TEST
- 2017 HRIA ASSESSMENT BOUNDARY
- ASSESSED AREA
- PHOENIX SITE BUFFER AREA
- PHOENIX SITE INFRASTRUCTURE

0 100 200

1:5,000 METRES

REFERENCE(S)

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CLIENT
DENISON MINES CORPORATION

PROJECT
WHEELER RIVER PROJECT
HERITAGE RESOURCE IMPACT ASSESSMENT

TITLE
LOCATION OF PROJECT, SHOVEL PROBES AND TESTS, AND HERITAGE RESOURCES

CONSULTANT

GOLDER

YYYY-MM-DD	2020-01-08
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PREPARED	LMS
REVIEWED	TH
APPROVED	PY

PROJECT NO.	PHASE	REV.	FIGURE
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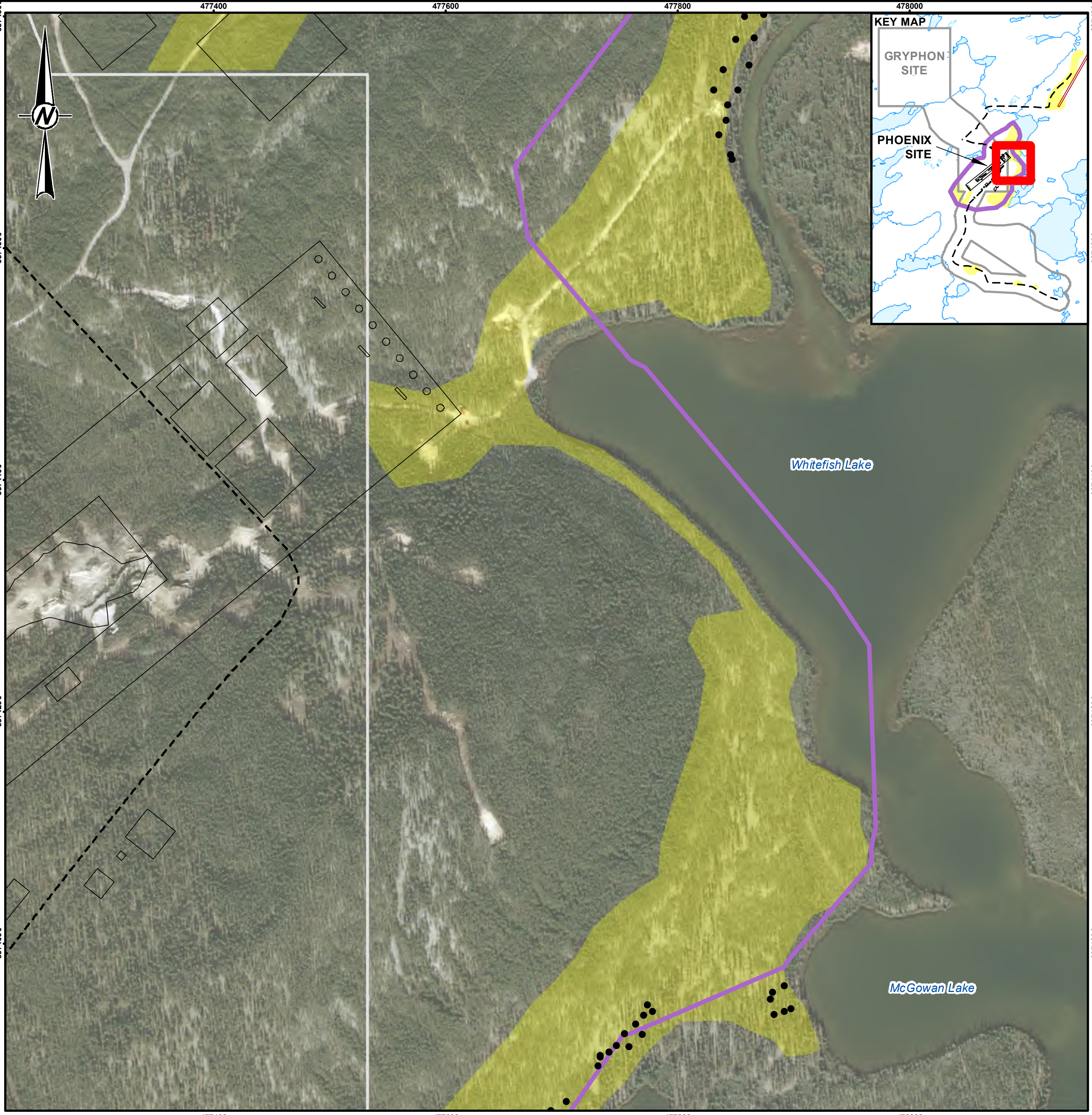

LEGEND

- SHOVEL PROBE
- SITE ACCESS ROAD
- 2017 HRIA ASSESSMENT BOUNDARY
- ASSESSED AREA
- PHOENIX SITE BUFFER AREA
- PHOENIX SITE INFRASTRUCTURE

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REFERENCE(S)

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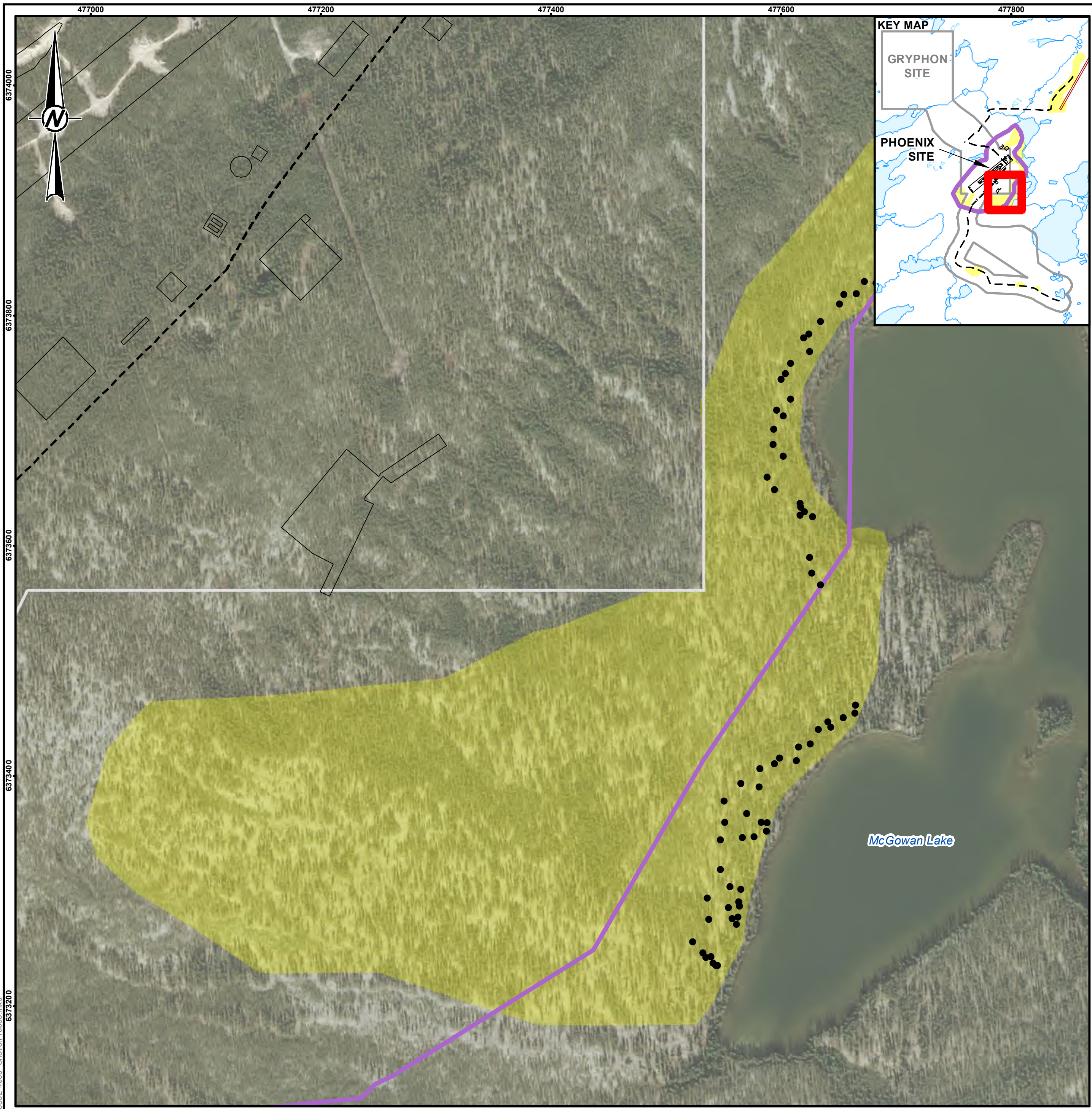

LEGEND

- ● SHOVEL PROBE
- SITE ACCESS ROAD
- 2017 HRIA ASSESSMENT BOUNDARY
- ASSESSED AREA
- PHOENIX SITE BUFFER AREA
- PHOENIX SITE INFRASTRUCTURE

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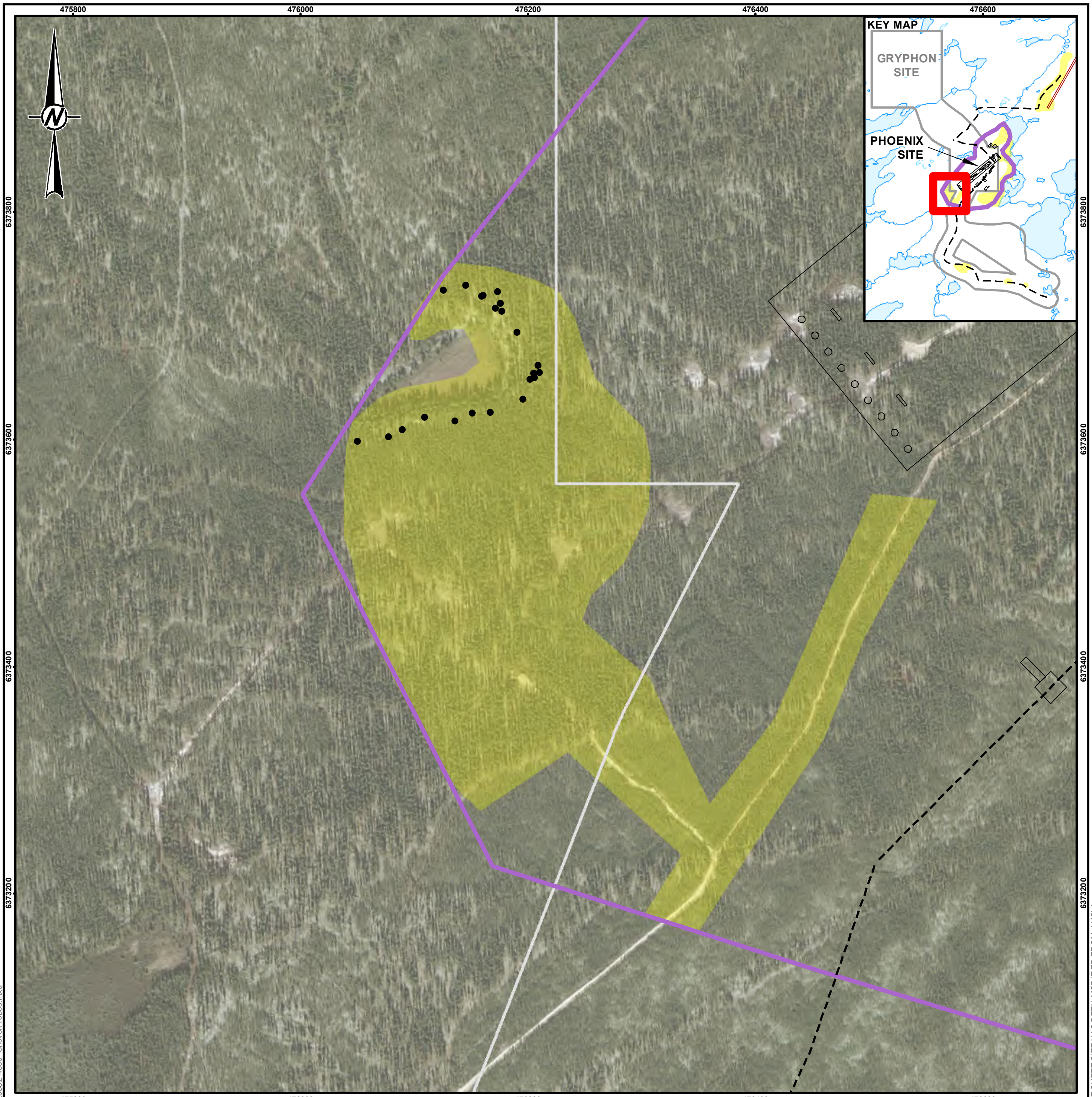

LEGEND

- ● SHOVEL PROBE
- - - SITE ACCESS ROAD
- 2017 HRIA ASSESSMENT BOUNDARY
- ASSESSED AREA
- PHOENIX SITE BUFFER AREA
- PHOENIX SITE INFRASTRUCTURE

0 100 200

1:5,000 METRES

REFERENCE(S)

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25mm

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Photo 5: Phoenix buffer area, surface inspection at the northern extent of the buffer area, looking east towards large lake.

Photo 6: Phoenix buffer area, testing along terrace overlooking Whitefish Lake, looking southeast

Photo 7: Phoenix buffer area, view of stream between Whitefish Lake, looking northeast

Photo 8: Phoenix buffer area, view of testing along the terrace adjacent to the stream in Photo 7, looking northwest

Photo 9: Phoenix buffer area, testing along terrace overlooking stream at the northeastern extent of the buffer area, looking southeast

Photo 10: Phoenix buffer area, surface inspection and testing at the eastern extent of the buffer area, looking west towards forest backing the terrace that overlooks a large lake.

Photo 11: Phoenix buffer area, testing along terrace overlooking McGowan Lake, looking southeast

Photo 12: Phoenix buffer area, testing along terrace overlooking McGowan Lake, looking northeast

Photo 13: Phoenix buffer area, testing along terrace overlooking McGowan Lake, looking southwest

Photo 14: Phoenix buffer area, testing along terrace overlooking McGowan Lake, looking northwest towards bedrock escarpment backing the terrace that overlooks a large lake.

Photo 15: Phoenix buffer area, testing along terrace overlooking lake at the southwestern extent of the buffer area, looking north

Photo 16: Phoenix buffer area, testing along terrace overlooking lake at the southwestern extent of the buffer area, looking southwest

A total of 179 shovel probes were excavated along terrace edges identified within (or in immediate proximity) to the Phoenix buffer area. Although there are some variations, the stratigraphic profile of the shovel probes excavated along the eastern extent of the buffer can be summarized as follows:

- 0 to 3 cm organic duff;
- 3 to 5 cm brown sand;
- 5 to 19 cm grey sand;
- 19 to 34 cm tan sand; and
- 34 to 50 cm grey sandy.

Conversely, the stratigraphic profile for the 22 shovel probes excavated at the small dried lake at the southwestern extent of the buffer area can be summarized as follows:

- 0 to 2 cm organic duff;
- 2 to 25 cm brown sand; and
- 25 to 40 cm grey/light brown sand.

All shovel probes were sterile for cultural materials and no paleosols were observed. No buried heritage resources were identified during the HRIA.

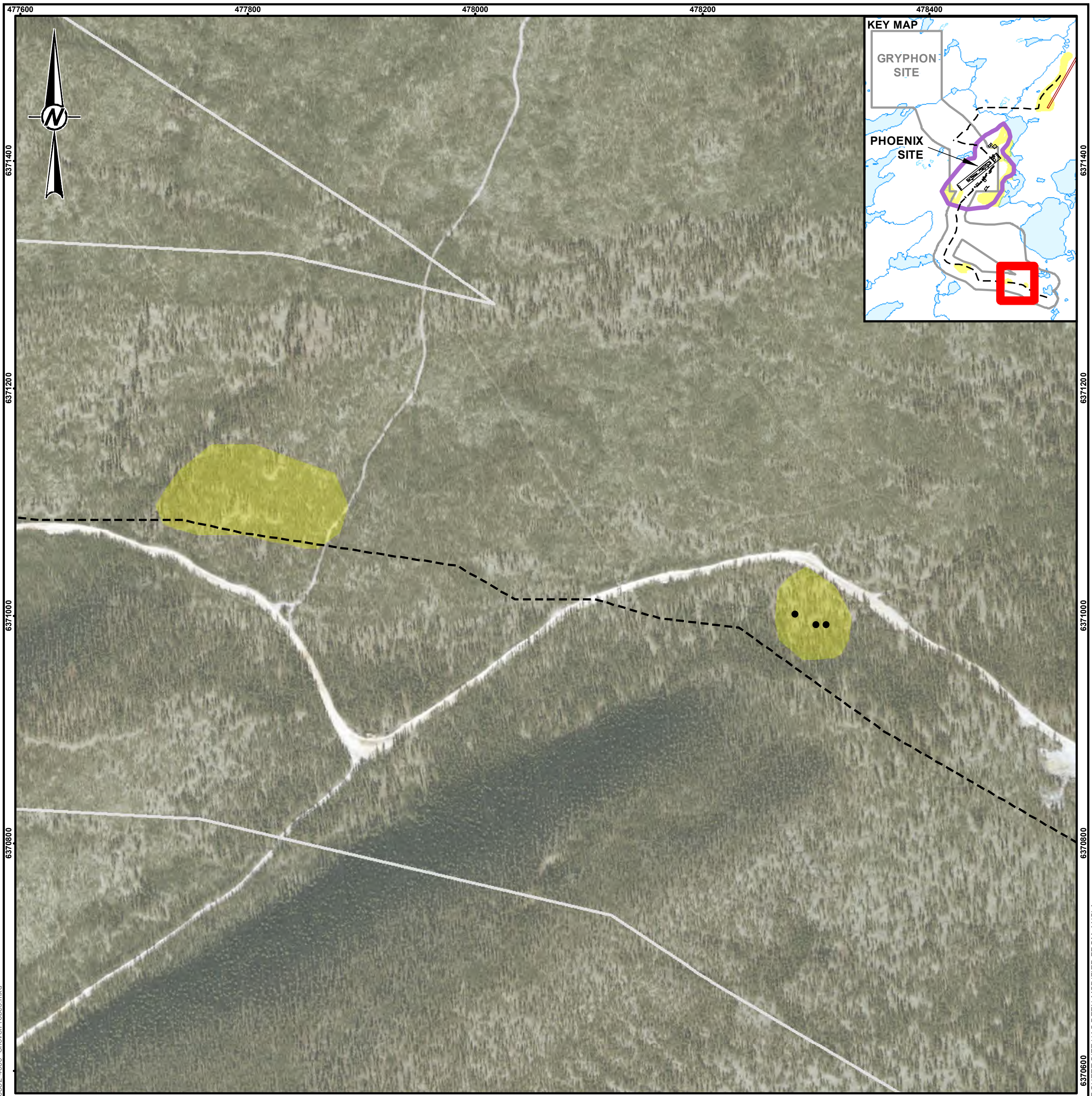
7.2 Fieldwork Results for the Adjusted Access Road Alignment

Although all portions of the adjusted access road alignment are contained within the 2017 HRIA scope, Golder conducted a visit to several areas along the adjusted alignment to evaluate their heritage sensitivity (Figures 6 and 7). These areas consisted of the tip of a large bedrock escarpment that overlooked a gravel pit to the south (Photo 17) and slightly elevated sandy knolls near low wet areas (Photo 18). Pedestrian surveys were conducted in these areas and disturbances from access roads were inspected for cultural materials. No heritage resources were identified.

A total of 11 shovel probes were excavated along the adjusted access road alignment to identify potential buried cultural components. The stratigraphic profile of these shovel probes can be summarized as follows:

- 0 to 1 cm organic duff;
- 1 to 3 cm brown sand;
- 3 to 12 cm grey sand; and
- 12 to 32 cm tan sand.

All shovel probes were sterile for cultural materials and no paleosols were observed. No buried heritage resources were identified during the assessment of the adjusted access road alignment.



LEGEND

- ● SHOVEL PROBE
- - - - SITE ACCESS ROAD
- 2017 HRIA ASSESSMENT BOUNDARY
- ASSESSED AREA

0 100 200
1:5,000 METRES

REFERENCE(S)
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CONSULTANT
GOLDER

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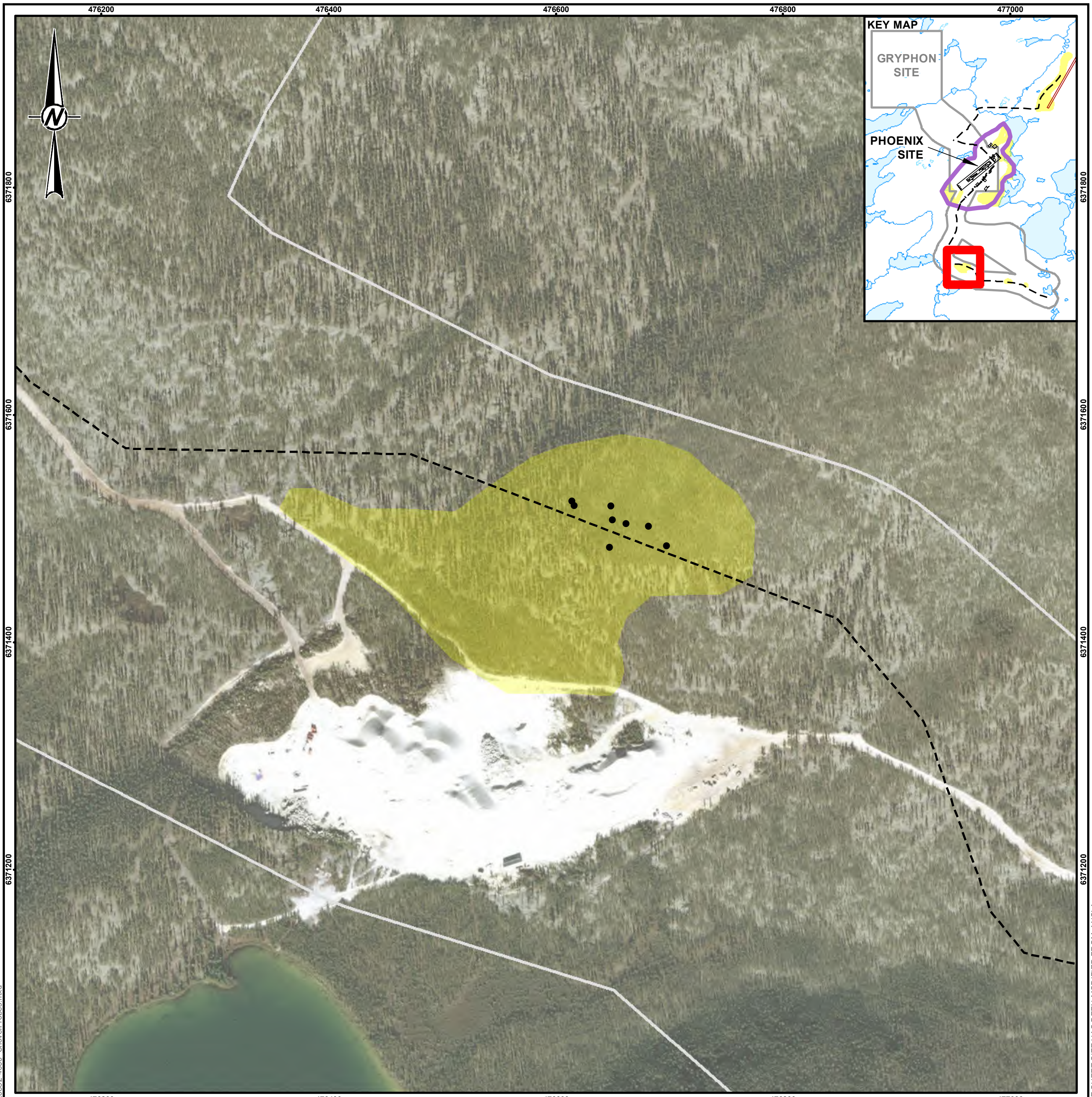

LEGEND

- ● SHOVEL PROBE
- - - SITE ACCESS ROAD
- 2017 HRIA ASSESSMENT BOUNDARY
- ASSESSED AREA

0 100 200

1:5,000 METRES

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Photo 17: Adjusted access road alignment, view of cutline on top of bedrock escarpment, looking southeast

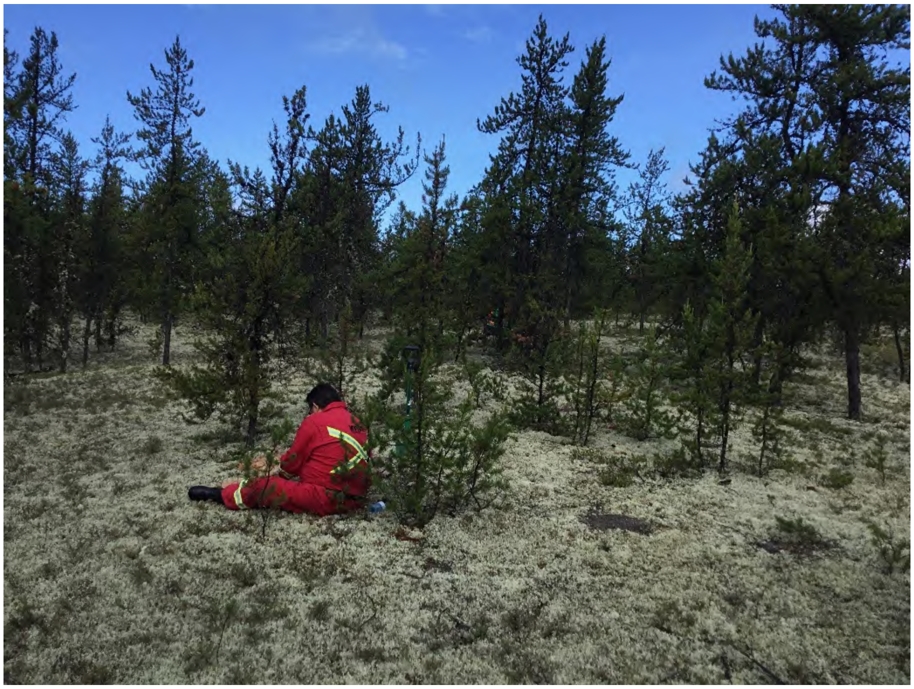


Photo 18: Adjusted access road alignment, testing at a slight rise on the alignment, looking northwest

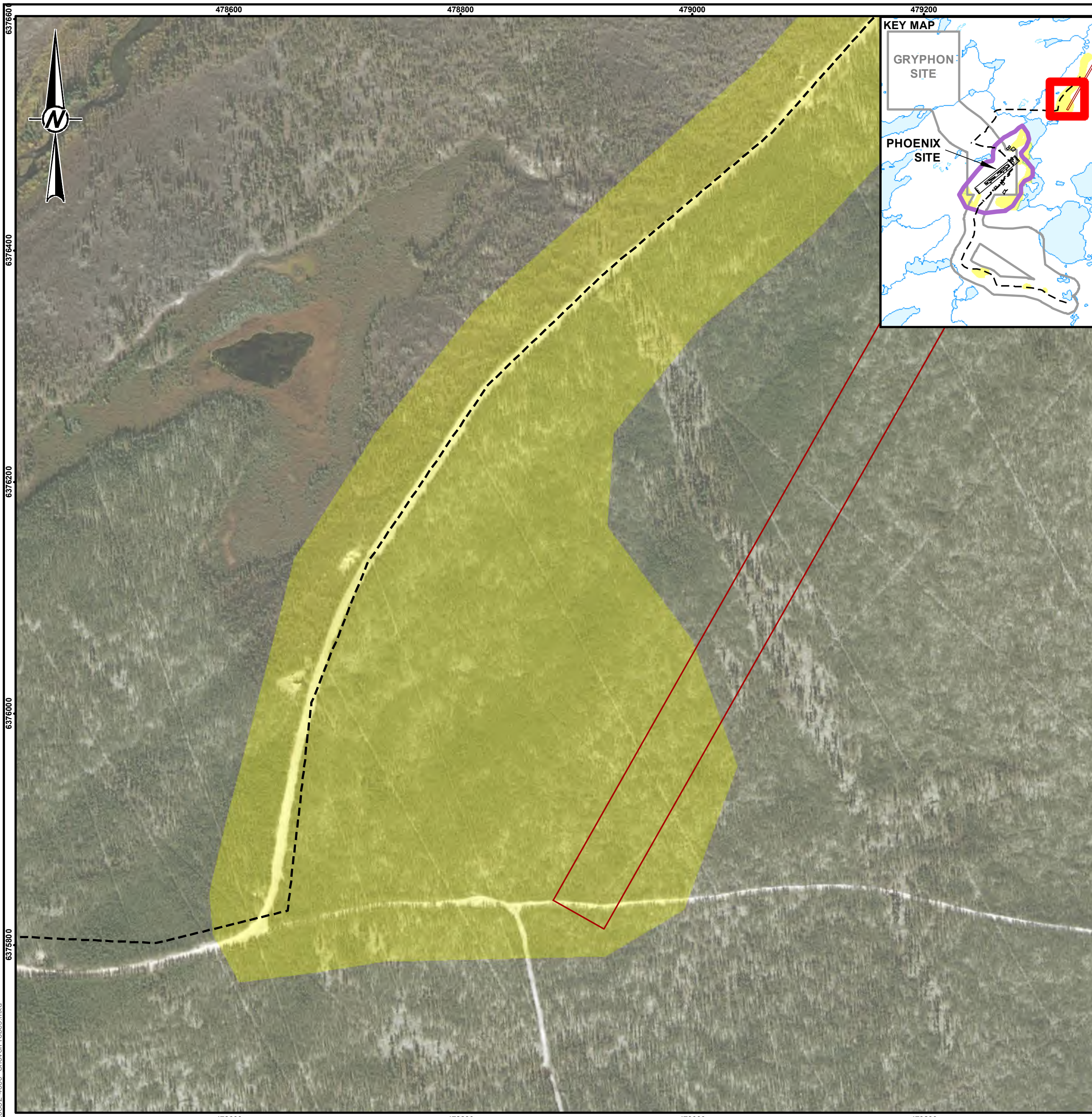
7.3 Fieldwork Results for the Airstrip

Measuring approximately 1,600 m long x 50 m wide, the proposed airstrip is on top of a landform located east of a creek that drains into the network of lakes bordering the eastern extent of the Phoenix buffer area (Figures 8 and 9). At its closest point, the airstrip is located approximately 375 m east of the creek; however, the average distance between the airstrip and creek is approximately 600 m.

Access to the airstrip is provided by an existing access road that parallels the western extent of the landform overlooking the creek valley and meanders along the upland in accordance to the slope break of the landform. At its closest point, the airstrip is approximately 111 m east of the access road; however, the average distance between the access road and airstrip is approximately 260 m (Photos 19 and 20).

In-field inspection determined that the location of the airstrip has low heritage potential as it is not on a significant landform and not within 250 m of a significant water source (Photos 19 to 23). However, the access road leading to the airstrip parallels the western extent of upland overlooking the creek valley and was deemed to have moderate to high potential. Accordingly, a surface inspection of disturbances along portions of the access road paralleling the proposed airstrip was conducted while areas immediately east of the access road were inspected to identify any surficial features that may be present (e.g., historic cabins, explorative camps). No heritage resources were identified.

Photo 19: Airstrip, access road adjacent to the western extent of the proposed airstrip, looking northeast



LEGEND

- SITE ACCESS ROAD
- ASSESSED AREA
- PROPOSED AIRSTRIP

0 100 200
1:5,000 METRES

REFERENCE(S)
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CONSULTANT
GOLDER

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DESIGNED	TH
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PROJECT NO.	PHASE	REV.	FIGURE
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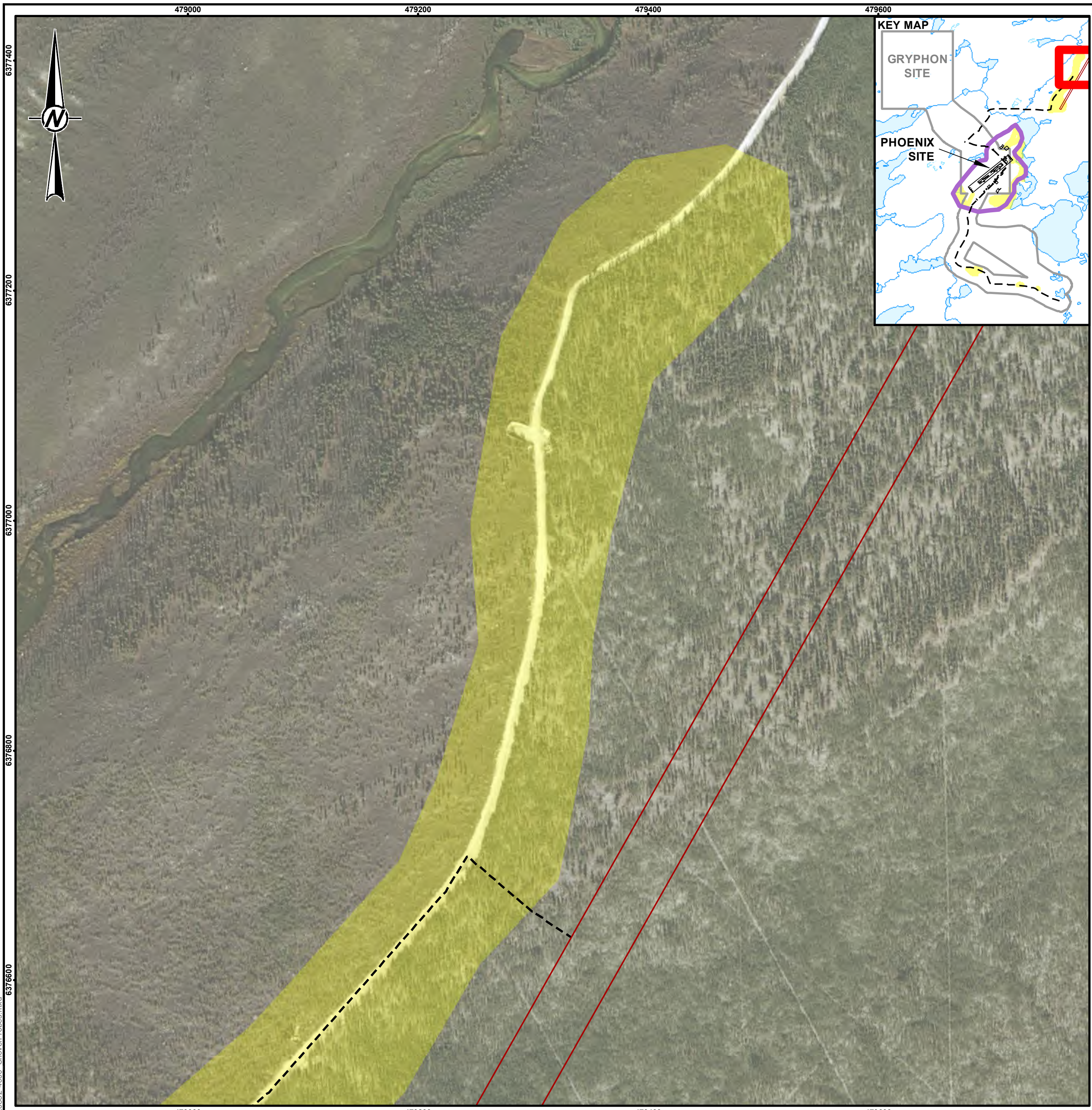

LEGEND

- SITE ACCESS ROAD
- ASSESSED AREA
- PROPOSED AIRSTRIP

0 100 200

1:5,000 METRES

REFERENCE(S)

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APPROVED	PY

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Photo 20: Airstrip, access road adjacent to the western extent of the proposed airstrip, looking west towards valley a creek that drains into the lakes near the Phoenix buffer area

Photo 21: Airstrip, view of cutline along proposed airstrip, looking southeast

Photo 22: Airstrip, view of general terrain at the proposed airstrip location from an elevated point on the west side of the access road, looking southeast.

Photo 23: Airstrip, view of terrain at the southern extent of the proposed airstrip location, looking northeast.

7.4 Newly Recorded Heritage Resource

7.4.1 HjNi-1

HjNi-1 is an Artifact Find site of an unknown Precontact cultural affiliation. The site is comprised of a secondary quartzitic sandstone flake that was recovered from the surface of an access road located near the confluence of a lake and creek at the northeast corner of the Phoenix buffer area (Photo 24; Figure 10). The immediate site location is characterized by flat, forested uplands that overlooks the above mentioned confluence to the north and is backed by a steeply sloped bedrock escarpment (Photos 25 and 26).

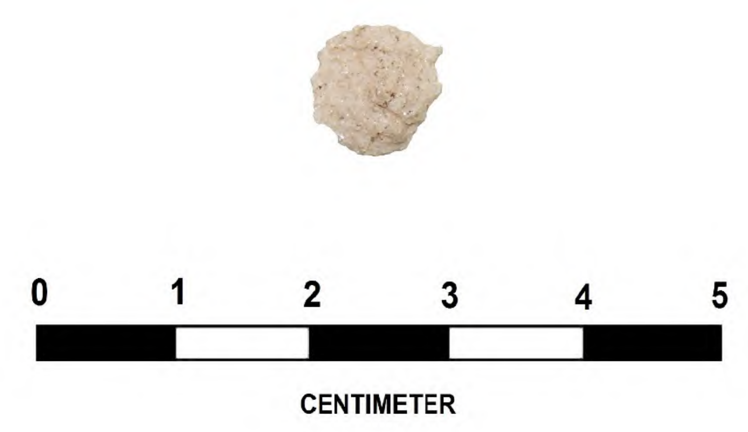
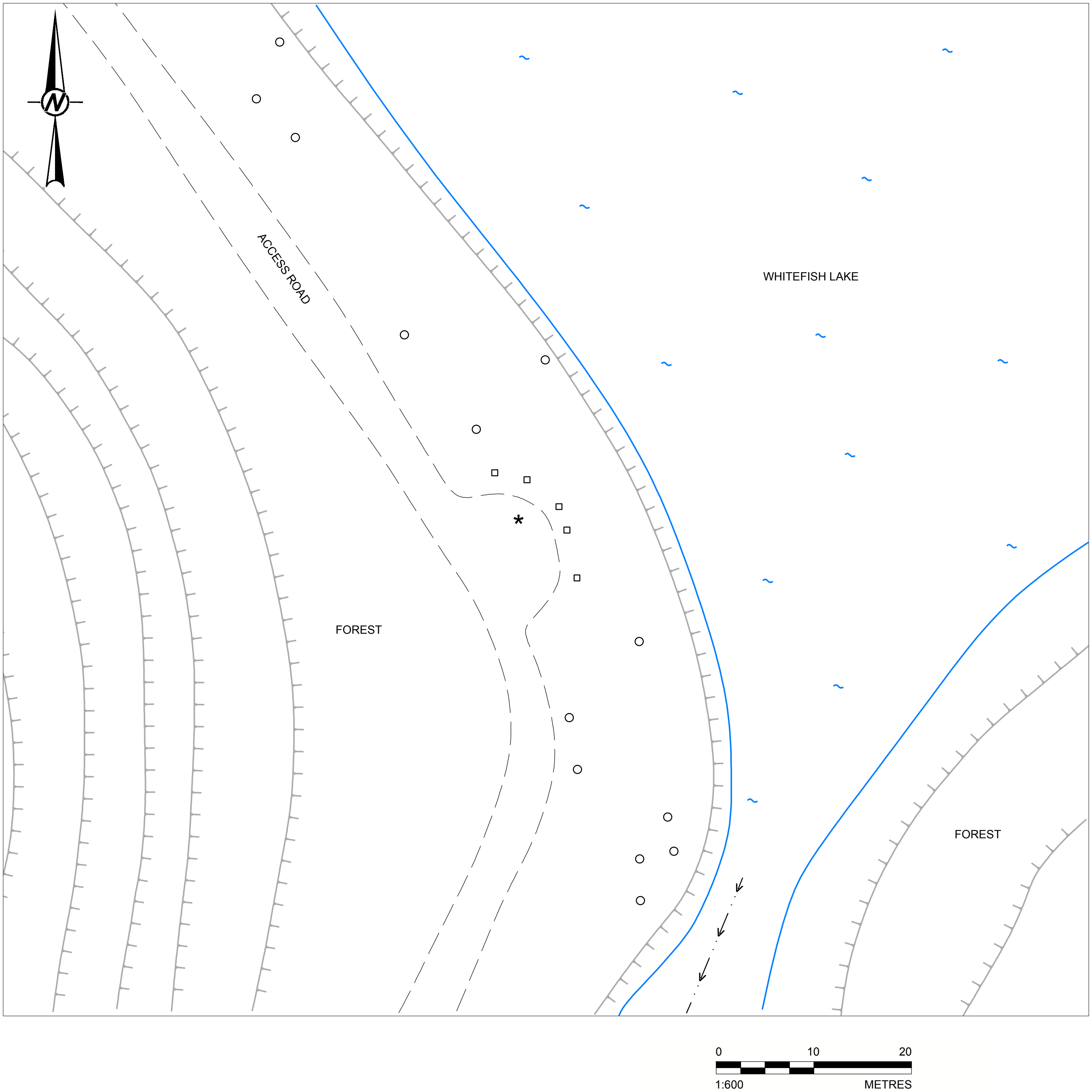


Photo 24: HjNi-1, view of dorsal surface of secondary flake

Five shovel tests were excavated along the boundaries of the disturbed area while exposures in the immediate area were visually inspected for additional cultural materials. The stratigraphic profile of the shovel tests can be summarized as follows:

- 0 to 2 cm organic duff;
- 2 to 4 cm brown sand;
- 4 to 17 cm brown/grey sand; and
- 17 to 32 cm tan sand.

All 5 shovel tests were sterile for cultural materials and paleosols. As the site has limited interpretive potential, no further work is recommended for HjNi-1.



LEGEND

- * ARTIFACT FIND
- ○ NEGATIVE SHOVEL PROBE
- □ NEGATIVE SHOVEL TEST
- SLOPE
- ACCESS ROAD
- WATERWAYS
- WATER BODY

CLIENT
DENISON MINES CORPORATION

PROJECT
WHEELER RIVER PROJECT
HERITAGE RESOURCE IMPACT ASSESSMENT

TITLE
SKETCH MAP OF HjNi-1

CONSULTANT

GOLDER

YYYY-MM-DD	2020-01-08
DESIGNED	JR
PREPARED	JMC
REVIEWED	TH
APPROVED	PY

PROJECT NO.	PHASE	REV.	FIGURE
19120852	4000	0	10

Photo 25: HjNi-1, shovel placed at find location, looking north towards Whitefish Lake.

Photo 26: HjNi-1, shovel placed at find location, looking east.

8.0 SUMMARY AND RECOMMENDATIONS

Golder conducted a HRIA on behalf of Denison for their Wheeler River Project in northern Saskatchewan. The HRIA stems from the results of a heritage baseline study for the Project conducted under Archaeological Resources Investigation Permit 17-091 and focused on heritage sensitive portions of a refined Project footprint located outside of the 2017 HRIA scope. The HRIA was completed using standard pedestrian reconnaissance and visual inspection field techniques, complimented by the excavation of 212 shovel probes and five shovel tests and resulted in the identification of HjNi-1, a Precontact Artifact Find site. The site is comprised of a secondary quartzitic sandstone flake that was recovered from the surface of an access road located near the confluence of a lake and creek at the northeast corner of the Phoenix buffer area. A thorough visual inspection of disturbances in the site area was conducted and five shovel tests were excavated in intact portions of forest immediately adjacent to the site; however, no additional archaeological materials or features were identified. As the site has limited interpretive potential, no further work is recommended for HjNi-1.

It is recommended that Denison be provided with regulatory approval per Section 63 of *The Heritage Property Act* for the proposed Project to proceed as described in this HRIA report. This Final Report fulfils the permitting requirements necessary for the completion of this HRIA.

Even the most thorough investigation may not identify all archaeological materials that may be present. Denison is advised that if unanticipated archaeological materials or features (including but not limited to, hearth features, lithic, ceramic and faunal artifacts, and human remains) are encountered as a result of construction or reclamation activities, all work in the immediate area should cease and the Heritage Conservation Branch and local authorities (if applicable) contacted.

Signature Page

Golder Associates Ltd.

Tam Huynh, M.A.
Archaeologist

Brad Novecosky, M.A.
Principal, Archaeologist

6.0 REFERENCES

Acton, D.F., G.A. Padbury, and C.T. Stushnoff

1998 *The Ecoregions of Saskatchewan*. Canadian Plains Research Centre, University of Regina.

Golder Associates Ltd. (Golder)

1994 *McArthur River Access Road Heritage Resource Impact Assessment*. Permit No. 93-053. Final Report on file with Heritage Conservation Branch, Regina.

2017 *Denison Mines Corporation Wheeler River Project Heritage Baseline Study*. Permit No. 17-091. Final Report on file with Heritage Conservation Branch, Regina.

The Heritage Property Act

1979-80 SS cH-2.2 Available at: http://canlii.ca/t/52367. Accessed on: October 13, 2019.

APPENDIX A

Glossary of Technical Terms

Archaeology	The study of past cultures through the scientific investigation of their material remains.
Artifact	Any object used or modified by people.
Artifact Find	A category for archaeological sites consisting of five or fewer artifacts.
Artifact Scatter	A category for archaeological sites consisting of more than five artifacts.
Artifact/Feature Combo	A category for archaeological sites consisting of a combination of both artifacts and features (e.g., stone circles and debitage).
B.P.	Before present. 1,000 B.P. = 1,000 years before 1950 A.D. or approximately 1,000 A.D.
Cairn	A mound of cobbles, often constructed on a hilltop usually functioning as a burial cover, cache cover, drive line, or landscape marker.
Ceramics	Clay artifacts, such as vessels, that have been intentionally fired.
Core	A stone from which flakes have been intentionally removed.
Debitage	Waste by-products from stone tool manufacture. This includes flakes and shatter.
Faunal Remains	Bones and other animal parts found in archaeological sites. If modified by human activities, they are considered artifacts (e.g., bone awl).
Feature	The remains of any non-portable human activity that can not be removed from a site without disturbing it (e.g., hearth or pit).
Fire Broken Rock	Rock which has been discoloured, cracked or otherwise altered by exposure to fire. This is frequently characteristic of prehistoric occupation sites and can be associated with hearth features.
Flake	A stone fragment intentionally detached from a source rock during tool manufacture. Three flake types are generally recognized: primary flakes represent early stages of reduction where the original cortex is present on the dorsal surface; secondary flakes represent later stages of reduction where no cortex is present; and tertiary flakes represent the final stages of reduction where small pressure flakes are removed to produce the cutting or scraping edge of a tool.
Hearth	A feature containing ash, charcoal, burned rock, or other evidence of fire created by people.
Heritage Resource	Any human or natural artifact or feature that is of interest for its architectural, historical, cultural, environmental, archaeological, palaeontological, aesthetic or scientific value.
Lithics	A general term used to refer to stone artifacts such as tools, cores or debitage.
Multiple Feature	A category for archaeological sites consisting of several features of different kinds (e.g., a cluster of stone circles and cairns).
Paleosol	A soil horizon that was buried by past geological processes and preserved as a dark organic layer in the archaeological record. Deeply buried archaeological sites are commonly found in association to a paleosol.
Petroglyph	A rock art site formed by pecking a figure or symbol into a rock face.
Projectile Point	An inclusive term for a hafted arrow, spear or dart point.
Recurrent Feature	A category for archaeological sites consisting of several features of the same kind (e.g., a cluster of two or more stone circles).

Shatter	A stone fragment unintentionally detached from a core during stone tool manufacture. Shatter is often less well defined than the more purposefully removed flakes.
Shovel Probe	A 40 cm by 40 cm subsurface test where the excavated soils and sediments are hand trowelled for cultural materials.
Shovel Test	A 50 cm by 50 cm subsurface test where the excavated soils and sediments are passed through a 6 mm mesh screen.
Site	Any location with detectable evidence of past human activity.
Single Feature	A category for archaeological sites consisting of one feature, (e.g., a single stone circle).
Stone Circle	A Feature consisting of stone cobbles set out in a roughly circular outline. They are generally thought to have resulted from the use of stones to secure the edges of circular hide dwellings (tipis), although the stones may also have been used in constructing ceremonial structures.
Stratigraphy	The depositional layers within a site.

APPENDIX B

Location of Shovel Probes and Tests

Location of Shovel Probes

Shovel Probe	Zone (NAD 83)	East	North	Cultural Materials	Palaeosols
T01	13V	478309	6370993	None	None
T02	13V	476698	6371485	None	None
T03	13V	476682	6371502	None	None
T04	13V	476662	6371504	None	None
T05	13V	476648	6371520	None	None
T06	13V	476206	6373654	None	None
T07	13V	476205	6373658	None	None
T08	13V	476202	6373653	None	None
T09	13V	476196	6373635	None	None
T10	13V	476209	6373665	None	None
T11	13V	476190	6373694	None	None
T12	13V	476126	6373731	None	None
T13	13V	476145	6373736	None	None
T14	13V	476160	6373727	None	None
T15	13V	477700	6375387	None	None
T16	13V	477702	6375364	None	None
T17	13V	477707	6375341	None	None
T18	13V	477710	6375306	None	None
T19	13V	477709	6375272	None	None
T20	13V	477725	6375255	None	None
T21	13V	477767	6375225	None	None
T22	13V	477793	6375213	None	None
T23	13V	477798	6375209	None	None
T24	13V	477788	6375205	None	None
T25	13V	477799	6375195	None	None
T26	13V	477813	6375187	None	None
T27	13V	477827	6375174	None	None
T28	13V	477839	6375143	None	None
T29	13V	477836	6375122	None	None
T30	13V	477838	6375111	None	None
T31	13V	477831	6375097	None	None
T32	13V	477833	6375101	None	None
T33	13V	477836	6375087	None	None
T34	13V	477831	6374736	None	None
T35	13V	477839	6374755	None	None
T36	13V	477850	6374781	None	None
T37	13V	477858	6374800	None	None
T38	13V	477869	6374816	None	None
T39	13V	477882	6374838	None	None
T40	13V	477897	6374854	None	None

Location of Shovel Probes

Shovel Probe	Zone (NAD 83)	East	North	Cultural Materials	Palaeosols
T41	13V	477904	6374866	None	None
T42	13V	477912	6374885	None	None
T43	13V	477906	6374896	None	None
T49	13V	477895	6374934	None	None
T50	13V	477887	6374944	None	None
T51	13V	477870	6374970	None	None
T52	13V	477863	6374986	None	None
T53	13V	477847	6374677	None	None
T54	13V	477617	6373626	None	None
T55	13V	477620	6373630	None	None
T56	13V	477594	6373649	None	None
T57	13V	477593	6373688	None	None
T58	13V	477594	6373702	None	None
T59	13V	477596	6373718	None	None
T60	13V	477600	6373745	None	None
T61	13V	477609	6373759	None	None
T62	13V	477620	6373781	None	None
T63	13V	477634	6373795	None	None
T64	13V	477654	6373818	None	None
T65	13V	477672	6373830	None	None
T66	13V	477689	6373836	None	None
T67	13V	477691	6373840	None	None
T68	13V	477697	6373839	None	None
T69	13V	477691	6373834	None	None
T70	13V	477705	6373840	None	None
T71	13V	477706	6373845	None	None
T71(b)	13V	477898	6373944	None	None
T72	13V	477892	6373942	None	None
T73	13V	477774	6373947	None	None
T74	13V	477764	6373931	None	None
T75	13V	477754	6373922	None	None
T76	13V	477733	6373903	None	None
T77	13V	477731	6373894	None	None
T78	13V	477625	6373590	None	None
T79	13V	477544	6373236	None	None
T80	13V	477541	6373237	None	None
T81	13V	477561	6373271	None	None
T82	13V	477562	6373277	None	None
T83	13V	477564	6373287	None	None
T84	13V	477588	6373359	None	None

Location of Shovel Probes

Shovel Probe	Zone (NAD 83)	East	North	Cultural Materials	Palaeosols
T85	13V	477588	6373352	None	None
T86	13V	477654	6373451	None	None
T87	13V	477641	6373447	None	None
T88	13V	477632	6373440	None	None
T89	13V	477615	6373425	None	None
T90	13V	477598	6373416	None	None
T91	13V	477582	6373406	None	None
T92	13V	477551	6373360	None	None
T93	13V	477547	6373345	None	None
T94	13V	477537	6373275	None	None
P01	13V	478300	6370993	None	None
PO2	13V	476614	6371524	None	None
PO3	13V	476647	6371483	None	None
PO4	13V	476050	6373599	None	None
PO5	13V	476110	6373619	None	None
PO6	13V	476151	6373623	None	None
PO7	13V	476210	6373659	None	None
PO8	13V	476160	6373726	None	None
PO9	13V	476174	6373730	None	None
PO10	13V	477843	6374724	None	None
PO11	13V	477862	6374758	None	None
PO12	13V	477889	6374833	None	None
PO13	13V	477905	6374854	None	None
PO14	13V	477915	6374890	None	None
PO15	13V	477901	6374900	None	None
PO16	13V	477909	6374914	None	None
PO17	13V	477874	6374966	None	None
PO18	13V	477860	6374998	None	None
PO19	13V	477826	6375033	None	None
PO20	13V	477826	6375031	None	None
PO21	13V	477806	6375040	None	None
PO22	13V	477845	6374680	None	None
PO23	13V	477617	6373637	None	None
PO24	13V	477602	6373678	None	None
PO24A	13V	477608	6373728	None	None
PO25	13V	477625	6373769	None	None
PO26	13V	477650	6373810	None	None
PO27	13V	477683	6373828	None	None
PO28	13V	477693	6373832	None	None
PO29	13V	477710	6373839	None	None

Location of Shovel Probes

Shovel Probe	Zone (NAD 83)	East	North	Cultural Materials	Palaeosols
PO30	13V	477713	6373851	None	None
PO31	13V	477880	6373952	None	None
PO32	13V	477883	6373939	None	None
PO33	13V	477779	6373941	None	None
PO34	13V	477733	6373902	None	None
PO35	13V	477741	6373906	None	None
PO35A	13V	477627	6373577	None	None
PO36	13V	477545	6373236	None	None
PO37	13V	477532	6373246	None	None
PO38	13V	477563	6373291	None	None
PO39	13V	477565	6373302	None	None
PO40	13V	477566	6373347	None	None
PO41	13V	477570	6373368	None	None
PO41A	13V	477643	6373442	None	None
PO42	13V	477626	6373428	None	None
PO43	13V	477594	6373411	None	None
PO44	13V	477551	6373378	None	None
PO45	13V	477536	6373294	None	None
MT1	13V	478282	6371002	None	None
MT2	13V	476617	6371520	None	None
MT3	13V	476650	6371508	None	None
MT4	13V	476077	6373602	None	None
MT5	13V	476090	6373609	None	None
MT6	13V	476136	6373616	None	None
MT7	13V	476167	6373624	None	None
MT8	13V	476177	6373713	None	None
MT9	13V	476171	6373715	None	None
MT10	13V	476176	6373720	None	None
MT11	13V	477711	6375293	None	None
MT12	13V	477724	6375269	None	None
MT13	13V	477741	6375251	None	None
MT14	13V	477763	6375236	None	None
MT15	13V	477782	6375230	None	None
MT16	13V	477793	6375221	None	None
MT17	13V	477803	6375219	None	None
MT18	13V	477821	6375205	None	None
MT19	13V	477832	6375194	None	None
MT20	13V	477843	6375173	None	None
MT21	13V	477840	6375163	None	None
MT22	13V	477846	6375155	None	None

Location of Shovel Probes

Shovel Probe	Zone (NAD 83)	East	North	Cultural Materials	Palaeosols
MT23	13V	477841	6375138	None	None
MT24	13V	477845	6375128	None	None
MT25	13V	477844	6375121	None	None
MT26	13V	477842	6375117	None	None
MT27	13V	477840	6375095	None	None
MT28	13V	477852	6374736	None	None
MT29	13V	477866	6374782	None	None
MT30	13V	477874	6374802	None	None
MT31	13V	477898	6374839	None	None
MT32	13V	477921	6374871	None	None
MT33	13V	477924	6374884	None	None
MT34	13V	477920	6374893	None	None
MT35	13V	477902	6374940	None	None
MT36	13V	477876	6374979	None	None
MT37	13V	477843	6375023	None	None
MT38	13V	477839	6375035	None	None
MT39	13V	477838	6375022	None	None
MT40	13V	477831	6375023	None	None
MT41	13V	477842	6374711	None	None
MT42	13V	477836	6374698	None	None
MT43	13V	477627	6373625	None	None
MT44	13V	477617	6373634	None	None
MT45	13V	477588	6373660	None	None
MT46	13V	477602	6373713	None	None
MT47	13V	477604	6373750	None	None
MT48	13V	477624	6373785	None	None
MT49	13V	477665	6373819	None	None
MT50	13V	477705	6373851	None	None
MT51	13V	477689	6373848	None	None
MT52	13V	477691	6373856	None	None
MT53	13V	477704	6373864	None	None
MT55	13V	477892	6373964	None	None
MT56	13V	477882	6373958	None	None
MT57	13V	477771	6373938	None	None
MT58	13V	477770	6373922	None	None
MT59	13V	477758	6373911	None	None
MT60	13V	477747	6373912	None	None
MT61	13V	477634	6373566	None	None
MT62	13V	477539	6373243	None	None
MT63	13V	477534	6373243	None	None

Location of Shovel Probes

Shovel Probe	Zone (NAD 83)	East	North	Cultural Materials	Palaeosols
MT64	13V	477557	6373276	None	None
MT65	13V	477554	6373286	None	None
MT66	13V	477555	6373304	None	None
MT67	13V	477576	6373347	None	None
MT68	13V	477583	6373360	None	None
MT69	13V	477664	6373454	None	None
MT70	13V	477665	6373462	None	None
MT71	13V	477613	6373414	None	None
MT72	13V	477581	6373391	None	None
MT73	13V	477565	6373394	None	None
MT74	13V	477547	6373318	None	None
MT75	13V	477523	6373256	None	None

Location of Shovel Tests

Shovel Probe	Zone (NAD 83)	East	North	Cultural Materials	Palaeosols
T44	13V	477902	6374924	None	None
T45	13V	477901	6374922	None	None
T46	13V	477903	6374926	None	None
T47	13V	477901	6374930	None	None
T48	13V	477898	6374930	None	None

APPENDIX C

Artifact Catalogue

Golder Project No.: 19120852
Project: Denison Wheeler River HRIA
Permit: 19-065
Researcher's Name: Tam Huynh
Site No. HjNi-1

Tag Button

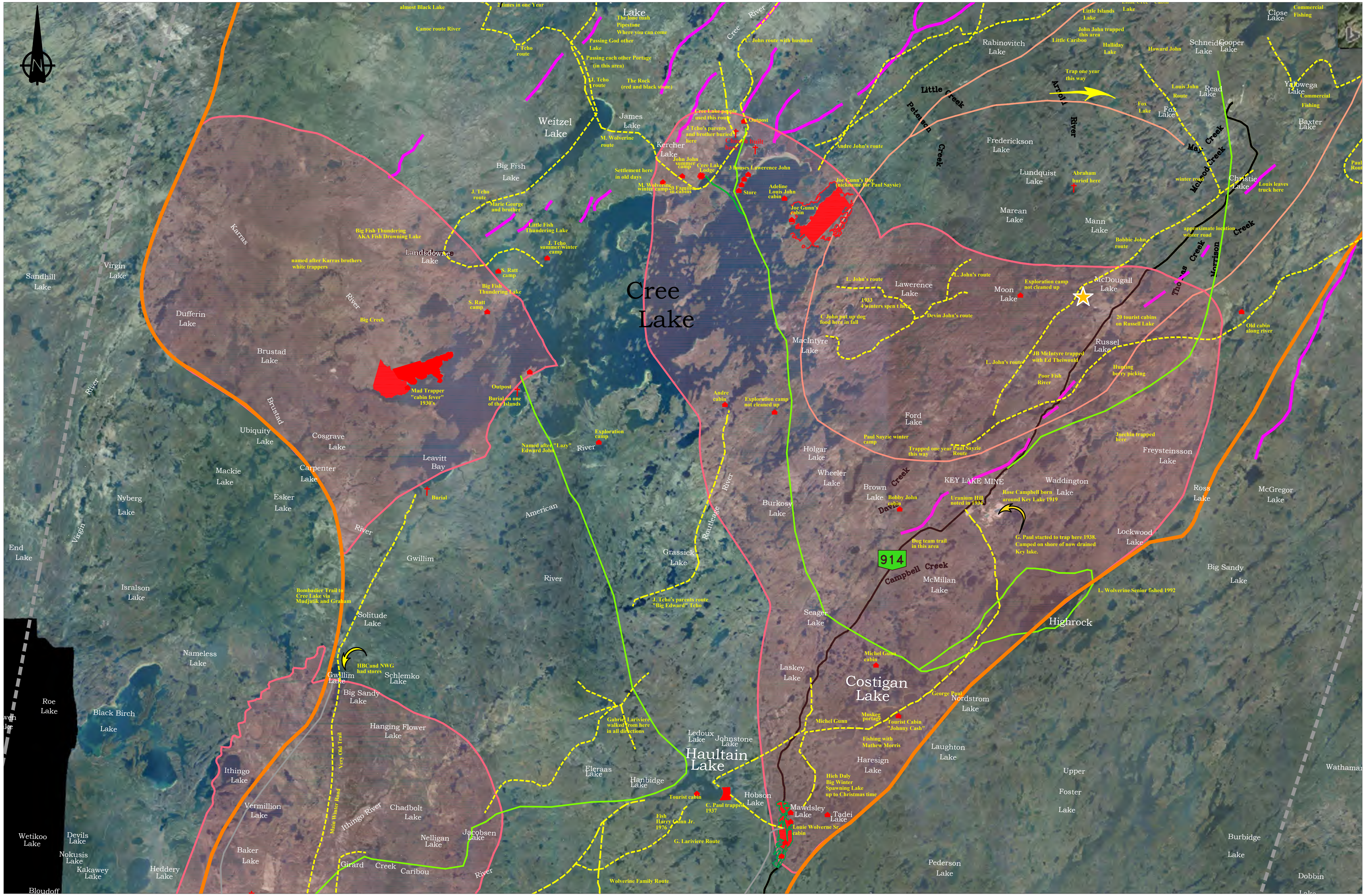
To create labels first select the rows containing the label information. Then click the button or use the keyboard shortcut ALT L.

To edit Catalogue Turn on "Developer" to access macro coding (File>Options>Customize Ribbon>check Developer; then click on Visual Basic on top left to view code)

Borden	Area	Unit/WPT	Quad	Level (cmbs)	Catalogue No.	Last Cat. #	Freq.	Size	Weight (g)	Artifact Class	Attribute 1 (e.g. lithic material type, vessel portion, animal species)	Attribute 2 (e.g. lithic material type, fcr modification, exterior finish, bone element,)	Attribute 3 (e.g. lithic colour, pottery paste type, bone side)	Attribute 4 (e.g. lithic artifact type, pottery temper, faunal age)	Attribute 5 (e.g. flake scars, bone element)	Attribute 6 (e.g. lithic modification, pottery decoration, bone modification)	Attribute 7 (flake termination)	Attribute 8 (lithic - portion present, faunal - portion present)	Notes (e.g. bone portion,)
HjNi-1	N/A	GAL1	N/A	surface	1 to 1	1	1	S2 (1 to 2 cm)	0.01	Lithic	Sandstone	Debitage	White	secondary	3-4 Scars		Hinge	Complete flk	small white sandstone flake

APPENDIX D

English River First Nation Land Use Map



LEGEND

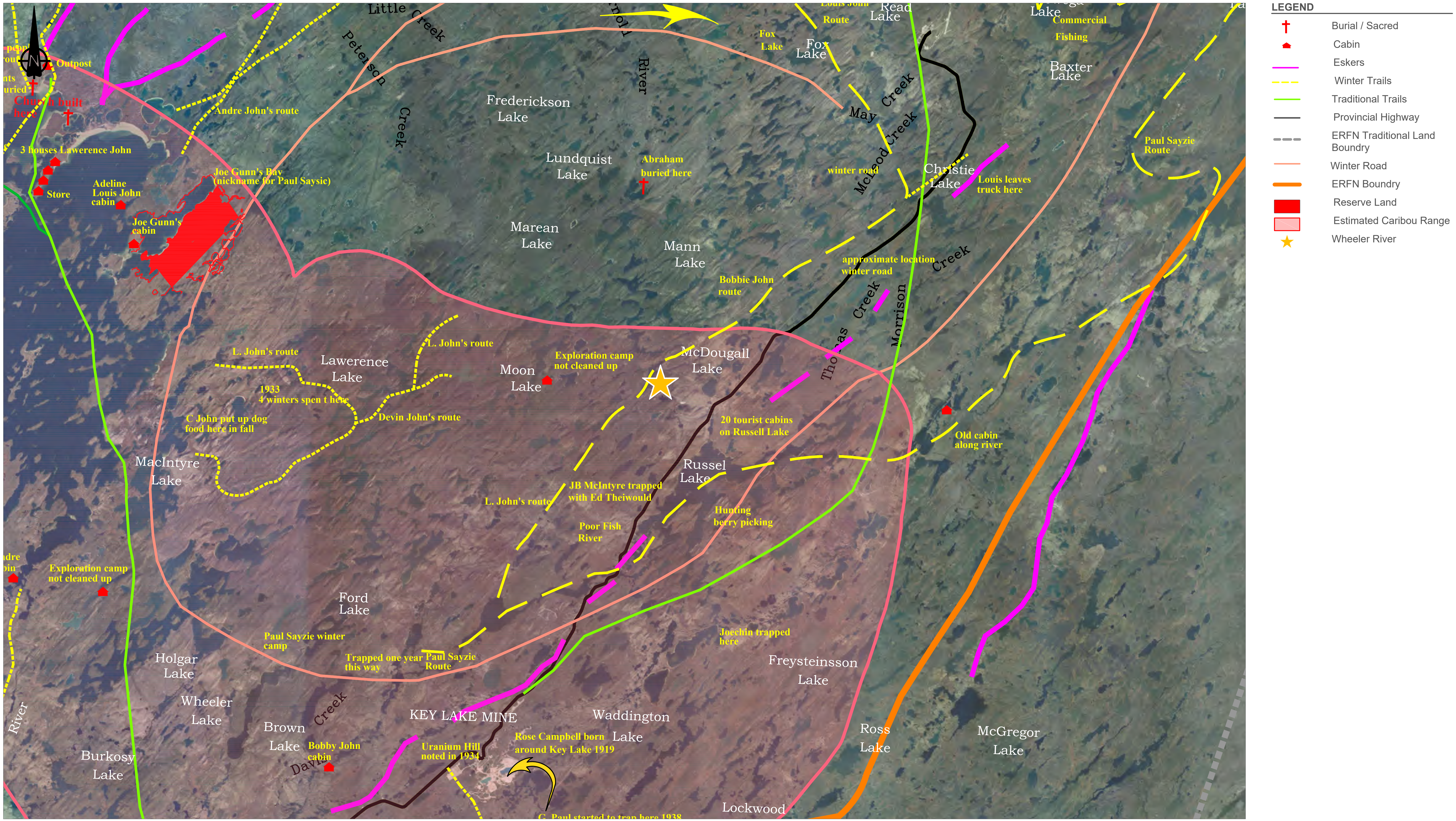
- Burial / Sacred
- Cabin
- Eskers
- Winter Trails
- Traditional Trails
- Provincial Highway
- ERFN Traditional Land Boundry
- Winter Road
- ERFN Boundry
- Reserve Land
- Estimated Caribou Range
- Wheeler River

srk consulting | Denison Mines | SUBSET OF ENGLISH RIVER FIRST NATION TRADITIONAL TERRITORIES

2017TT_EnglishRiver_March2_2017[1].dwg

WHEELER RIVER PROJECT

DATE: 03/10/17 | APPROVED: | FIGURE:



srk consulting

2017TT_EnglishRiver_March2_2017[1].dwg

Denison Mines

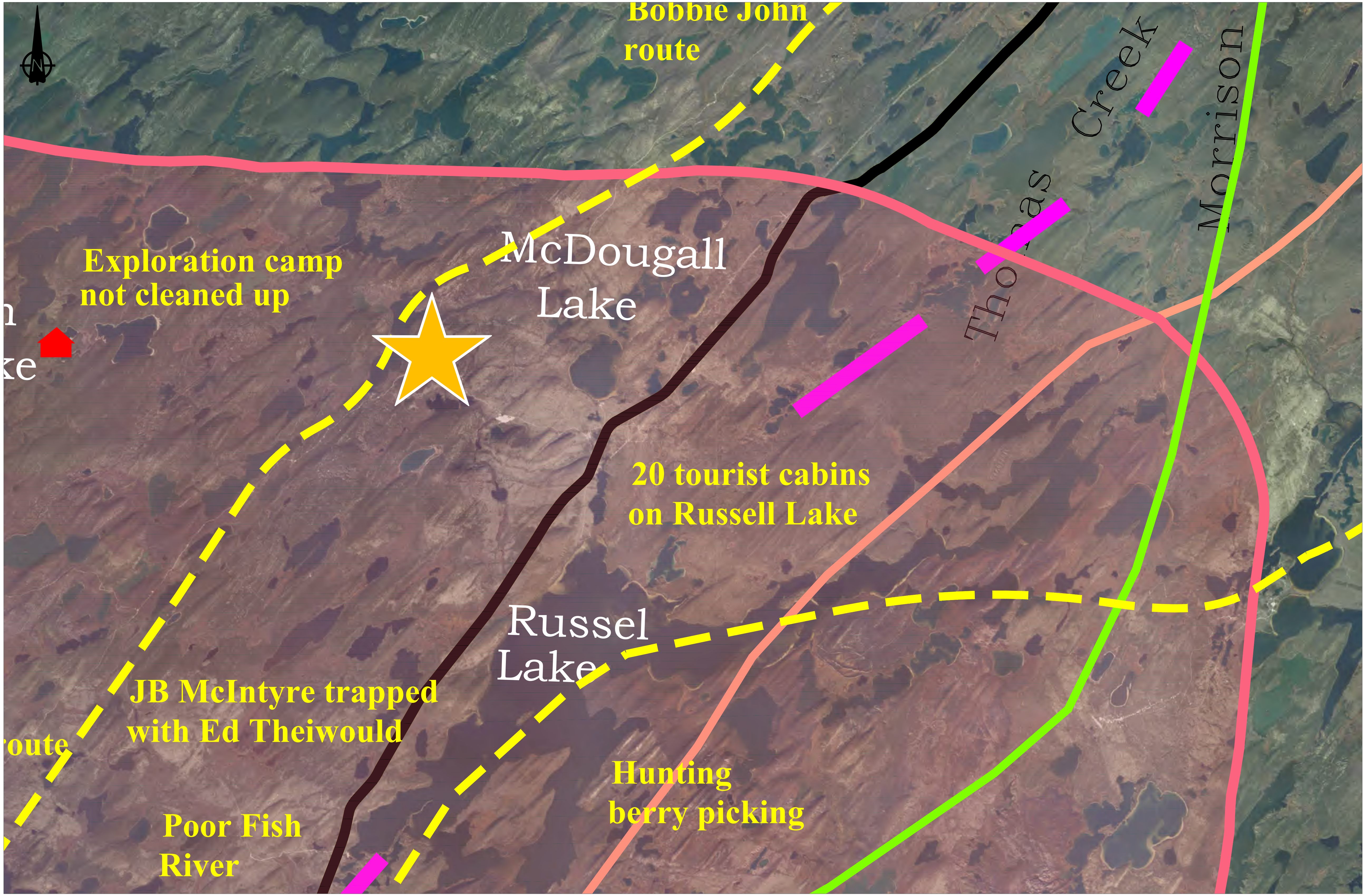
WHEELER RIVER PROJECT

SUBSET OF ENGLISH RIVER FIRST NATION TRADITIONAL TERRITORIES DETAILED VIEW

DATE: 03/10/17

APPROVED:

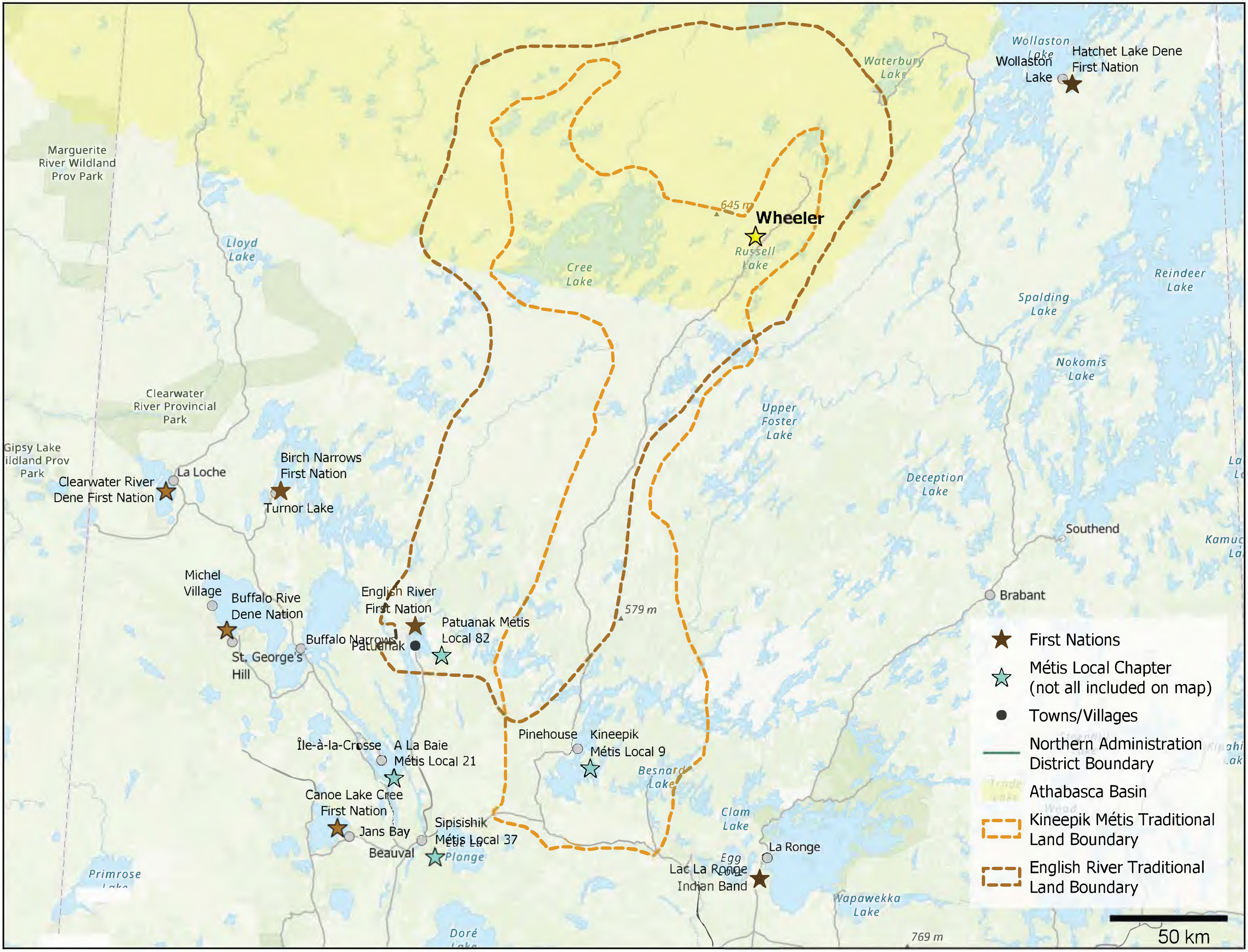
FIGURE:



LEGEND

- Cabin
- Eskers
- Winter Trails
- Traditional Trails
- Provincial Highway
- Winter Road
- Estimated Caribou Range
- Wheeler River

srk consulting	Denison Mines	SUBSET OF ENGLISH RIVER FIRST NATION TRADITIONAL TERRITORIES HIGHLY DETAILED VIEW
2017TT_EnglishRiver_March2_2017[1].dwg	WHEELER RIVER PROJECT	DATE: 03/10/17 · APPROVED: · FIGURE:

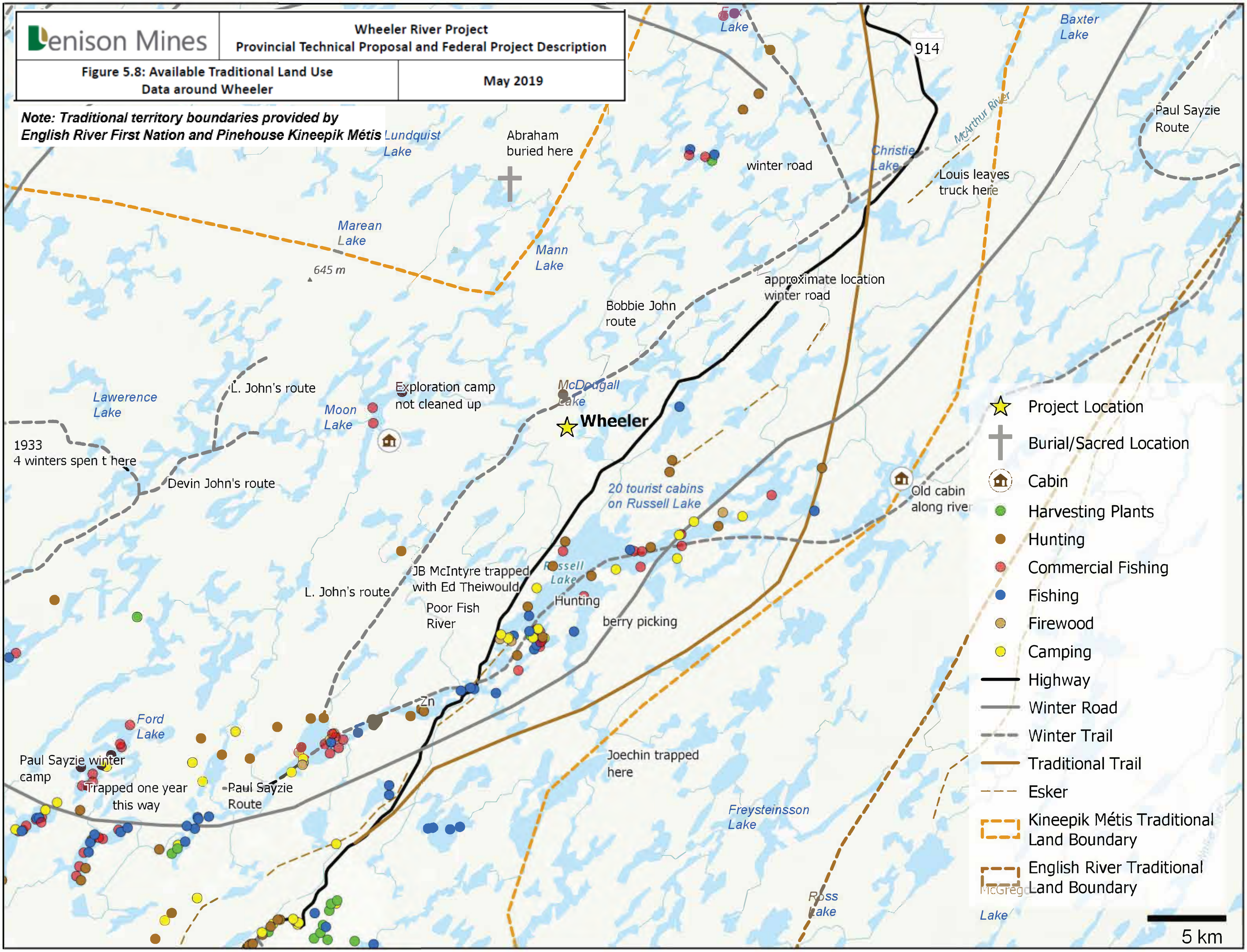


Wollaston Lake
Hatchet Lake Dene First Nation
Wollaston Lake
Waterbury Lake
Marguerite River Wildland Prov Park
645 m
Wheeler
Russell Lake
Cree Lake
Lloyd Lake
Reindeer Lake
Spalding Lake
Nokomis Lake
Upper Foster Lake
Clearwater River Provincial Park
Gipsy Lake Wildland Prov Park
La Loche
Clearwater River Dene First Nation
Birch Narrows First Nation
Turnor Lake
Deception Lake
Southend
Michel Village
Buffalo River Dene Nation
St. George's Hill
Buffalo Narrows
English River First Nation
Patuanak
Patuanak Metis Local 82
579 m
Brabant
Île-à-la-Crosse
A La Baie Métis Local 21
Pinehouse
Kineepik Métis Local 9
Besnard Lake
Canoe Lake Cree First Nation
Jans Bay
Beauval
Sipisishik Métis Local 37
Plonge
Clam Lake
La Ronge
Lac La Ronge Indian Band
Egg
Primrose Lake
Wapawekka Lake
Doré Lake
769 m
First Nations
Métis Local Chapter (not all included on map)
Towns/Villages
Northern Administration District Boundary
Athabasca Basin
Kineepik Métis Traditional Land Boundary
English River Traditional Land Boundary
50 km

Wheeler River Project
Provincial Technical Proposal and Federal Project Description

Figure 5.8: Available Traditional Land Use Data around Wheeler

May 2019



APPENDIX E

Pinehouse Kineepik Métis Local Land Use Map

Kineepik Metis Local

2011 & 2018 Use and Occupancy Map Survey
Map 1: Hodgepodge Map - All Categories

Fish Kill Sites
- lake trout
- grayling
- rod and reel
- different (fishing) gear
- domestic net
- commercial net

Bird Kill Sites
- ducks
- waterhen (coot)
- merganser
- geese
- loon
- swan
- sandhill crane
- ptarmigan
- grouse
- other bird
- (bird) eggs

Mammal Kill Sites
- moose
- caribou
- deer
- bear
- rabbit
- porcupine
- shot beaver
- shot muskrat
- other mammal

Furbearers and Trapping
- trapped muskrat
- trapped beaver
- trapping (all furbearers)
- trapping (all furbearers)

Vegetation Collection Sites
- medicine plant
- food plant
- berries
- specialty wood
- firewood
- construction wood
- moss
- earth material
- other plant
- medicine plant
- food plant
- berries
- firewood
- construction wood
- moss
- earth material
- other plant
- medicine plant
- berries
- specialty wood
- firewood
- construction wood
- moss
- other plant

Habitations and Fixed Cultural Sites
- birth site
- death site
- burial
- legend or spirit site
- sacred area
- gathering place
- settlement
- cabin, current, respondent stayed
- cabin, current, respondent never stayed
- cabin, abandoned, respondent stayed
- cabin, abandoned, respondent never stayed
- heritage cabin
- lean-to or under tarp
- shack-tent, current, respondent stayed
- shack-tent, current, respondent never stayed
- shack-tent, abandoned, respondent stayed
- shack-tent, abandoned, respondent never stayed
- tent (with stove)
- tent (without stove)
- under the stars
- other cultural
- other overnight
- birth site
- death site
- legend or spirit site
- gathering place
- settlement
- heritage cabin
- other cultural
- birth site
- legend or spirit site
- sacred area
- gathering place
- settlement
- heritage cabin
- other cultural

Base Map Features
- Highway Km markers
- 2018 study area limits
- 2011 study area limits
- Indian Reserve
- Parks

The Kineepik Métis Local located in the Northern Village of Pinehouse, Saskatchewan undertook the Kineepik Métis Local 2011 Use-and-Occupancy Map Survey and the Kineepik Métis Local 2018 Supplementary Use-and-Occupancy Map Survey to obtain a quality baseline inventory of harvesting and fixed cultural sites that living residents have used during their lifetimes. The 2018 survey mapped sites along the Key Lake Road corridor that extended north of the 2011 study area. A total of 139 Cree-speaking residents, the vast majority Métis, did individual map-biography interviews at which they were asked where they had engaged in each of 55 different land-use activities. There were 128 respondents in 2011 and 55 respondents in 2018, 44 of whom also participated in 2011. The 139 individuals mapped 36,525 features in 2011 and 2,045 features in 2018, for a combined total of 38,570 sites. With the exception of trapping, all the mapped animal features—including even the 'commercial net' sites—represent places where residents killed animals and took some home to feed their families. They are locations where people took country food for direct consumption. Other animal-procurement sites that support only the commercial, barter or peddling part of the local economy were not mapped.

The 38,570 sites are presented on one hodgepodge map (Map 1) to show the overall pattern of land use. The sites have also been consolidated as six summary maps (Maps 2-7) on which the information is grouped by theme: fish; birds; mammals; furbearers; vegetation; habitations and fixed cultural sites.

The information displayed does not depict all use and/or occupancy for either the respondents or other Pinehouse residents, and the 55 questionnaire categories are but a robust sample of the much larger number of possible land-based activities that could be mapped. The maps are the property of the Kineepik Métis Local and may not be viewed by unauthorized persons or duplicated or distributed without prior permission from the Local. Permission to use the maps does not diminish the user's obligation or duty to consult the Kineepik Métis Local and Northern Village of Pinehouse on any activity that impinges on residents' interests, rights or title.

The Kineepik Métis Local engaged Tobias and Associates to assist with the design and implementation of the survey, and GeoPraxis Inc. and PlanLab Ltd. to process the data and construct the thematic maps. The methodologies used to collect and process the data and present them on maps are described in detailed methodology reports.

Layouts completed in November, 2018
Basedata: NRCAN, CanVec 1:250,000
Projection: NAD 1983 CSRS UTM Zone 13N
Photos: Thanks to Henri Duperreault for the beautiful photos

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The Kineepik Métis Local

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1:355,000
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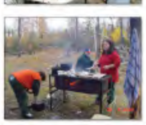


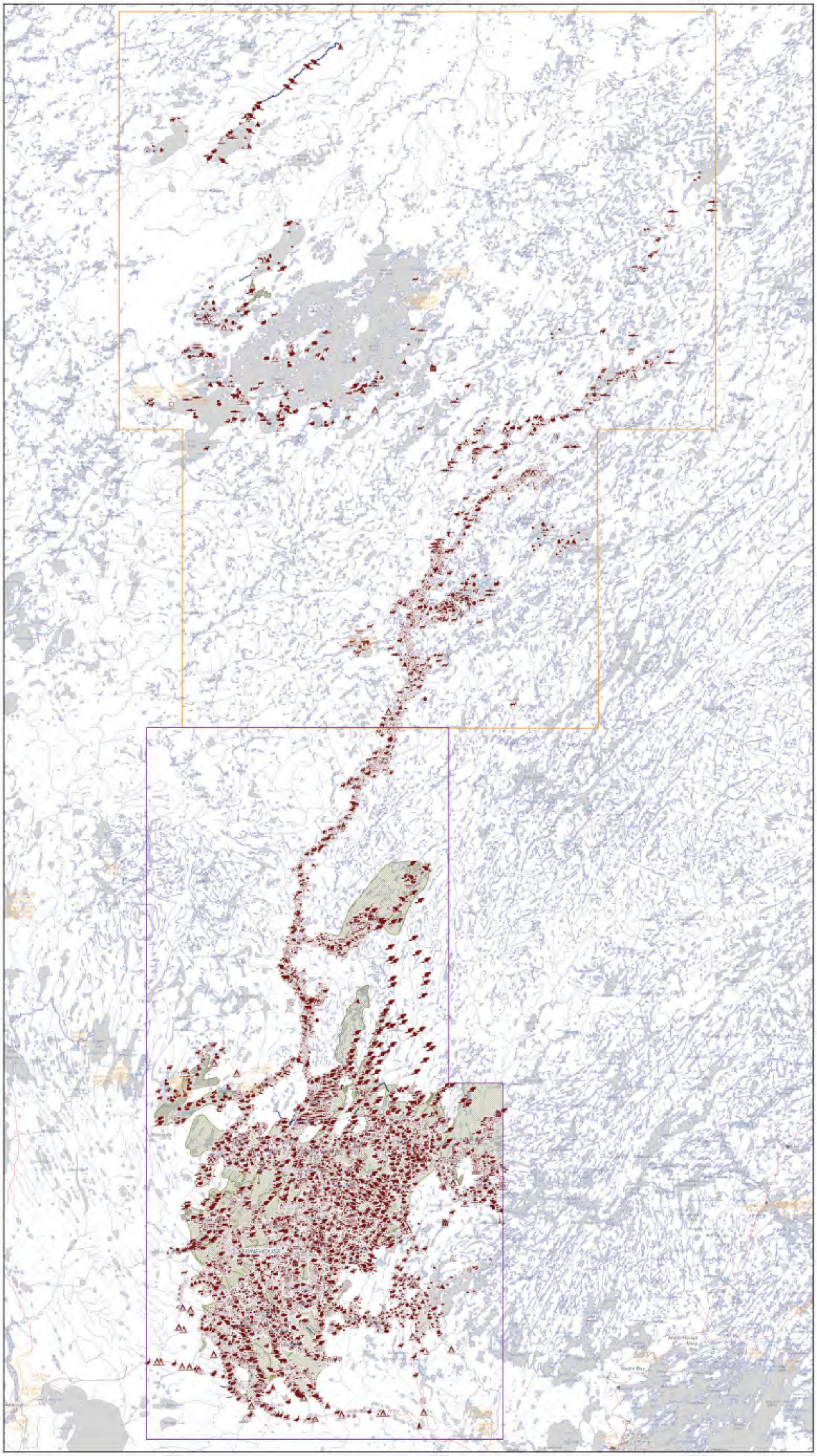

Kineepik Metis Local
2011 Use and Occupancy Map Survey
Map 1: Hodgepodge Map - All Categories















Fish
- lake trout
- commercial net
- domestic net
- rod and reel
- other fishing gear

Birds
- ducks
- merganser
- loon
- geese
- swan
- coot
- sandhill crane
- grouse
- ptarmigan
- other bird
- eggs

Mammals
- black bear
- moose
- white-tailed deer
- caribou
- shot beaver
- shot muskrat
- rabbit
- porcupine
- other mammal

Vegetation
- berries
- food plant
- medicine plant
- moss
- construction wood
- specialty wood
- firewood
- other plant or wood
- earth material
- berries
- food plant
- medicine plant
- moss
- construction wood
- firewood
- other plant or wood
- earth material
- berries
- medicine plant
- moss
- construction wood
- specialty wood
- firewood
- other plant or wood

Furbearers (Trapping)
- trapped beaver
- trapped muskrat
- all furbearers
- all furbearers

Habitations and Fixed Cultural Sites
- current cabin
- abandoned cabin
- heritage cabin
- current shack-tent
- abandoned shack-tent
- tent with stove
- tent without stove
- lean-to
- under the open sky
- other overnight structure
- old settlement
- gathering place
- birth site
- death site
- burial
- legend or spirit site
- sacred area
- other cultural site
- heritage cabin
- old settlement
- gathering place
- birth site
- death site
- legend or spirit site
- other cultural site
- heritage cabin
- old settlement
- gathering place
- birth site
- legend or spirit site
- sacred area
- other cultural site

Base Map Features
- Highway Km markers
- Study area limits
- Indian Reserve
- Parks

The Kineepik Métis Local located in the Northern Village of Pinehouse, Saskatchewan undertook the *Kineepik Métis Local 2011 Use-and-Occupancy Map Survey* to obtain a quality baseline inventory of harvesting and fixed cultural sites that living residents have used during their lifetimes. During February to April, 2011 a total of 122 Cree-speaking residents, the vast majority Métis, did individual map-biography interviews at which they were asked where they had engaged in each of 55 different land-use activities. They mapped 36,527 features. With the exception of trapping, all the mapped animal features—including even the 'commercial net' sites—represent places where residents killed animals and took some home to feed their families. They are locations where people took country food for direct consumption. Other animal-procurement sites that support only the commercial, barter or peddling part of the local economy were not mapped.

The 36,527 sites are presented on one hodgepodge map (Map 1) to show the overall pattern of land use. The sites have also been consolidated as six summary maps (Maps 2-7) on which the information is grouped by theme: fish; birds; mammals; furbearers; vegetation; habitations and fixed cultural sites.

The information displayed does not depict all use and/or occupancy for either the respondents or other Pinehouse residents, and the 55 questionnaire categories are but a robust sample of the much larger number of possible land-based activities that could be mapped. The maps are the property of the Kineepik Métis Local and may not be viewed by unauthorized persons or duplicated or distributed without prior permission from the Local. Permission to use the maps does not diminish the user's obligation or duty to consult the Kineepik Métis Local and Northern Village of Pinehouse on any activity that impinges on residents' interests, rights or title.

The Kineepik Métis Local engaged Tobias and Associates to assist with the design and implementation of the survey, and GeoPraxis Inc. and PlanLab Ltd. to process the data and construct the thematic maps. The methodologies used to collect and process the data and present them on maps will be described in methodology reports, to be drafted later in 2013.

Layouts completed in March, 2013.
Basedata: NRCAN, NTDB 1:250,000
Projection: NAD 1983 CSRS UTM Zone 13N
Photo Credit: Gratitude to Henri Duperreault for the beautiful photos

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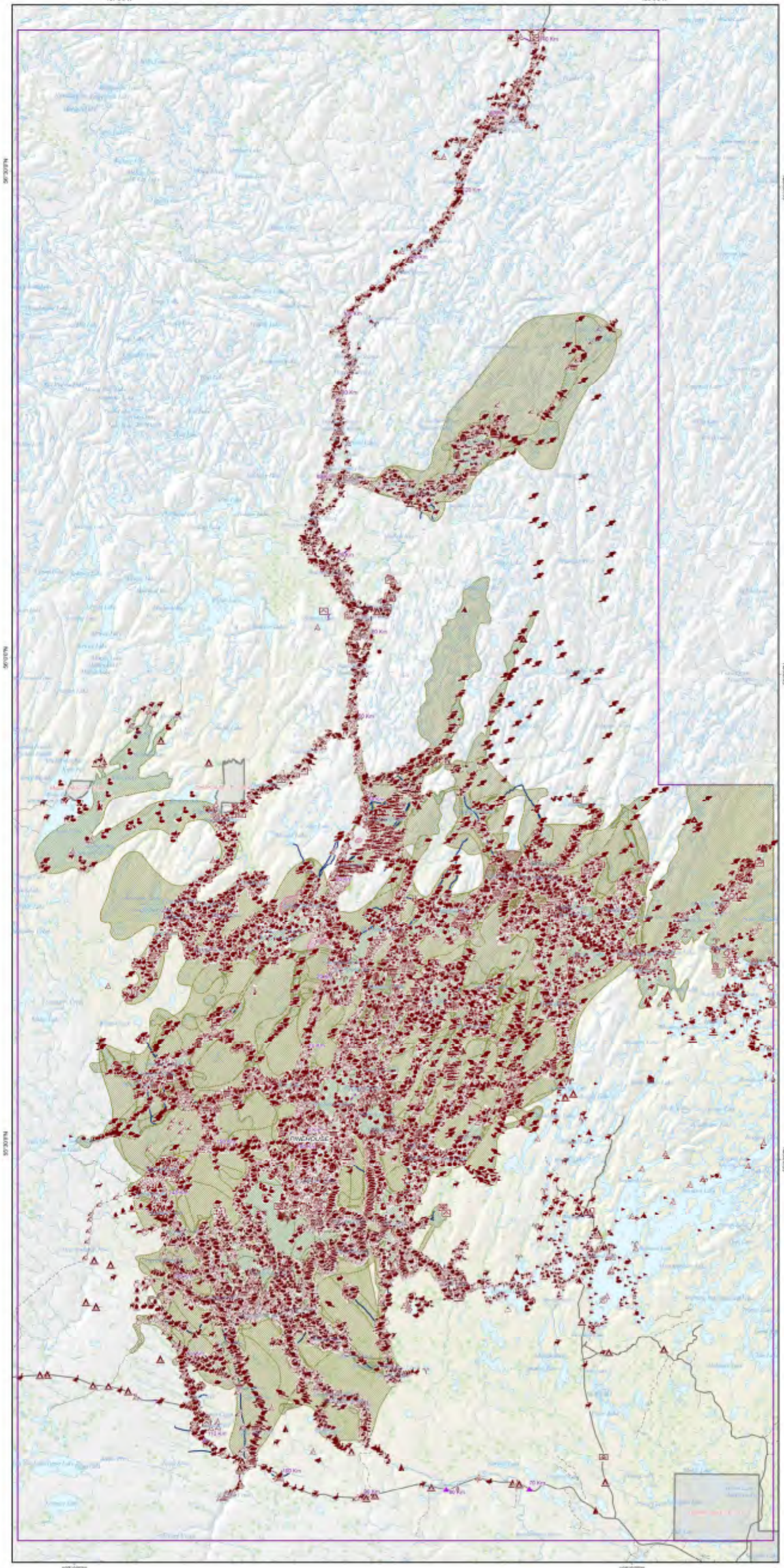
1:180,000

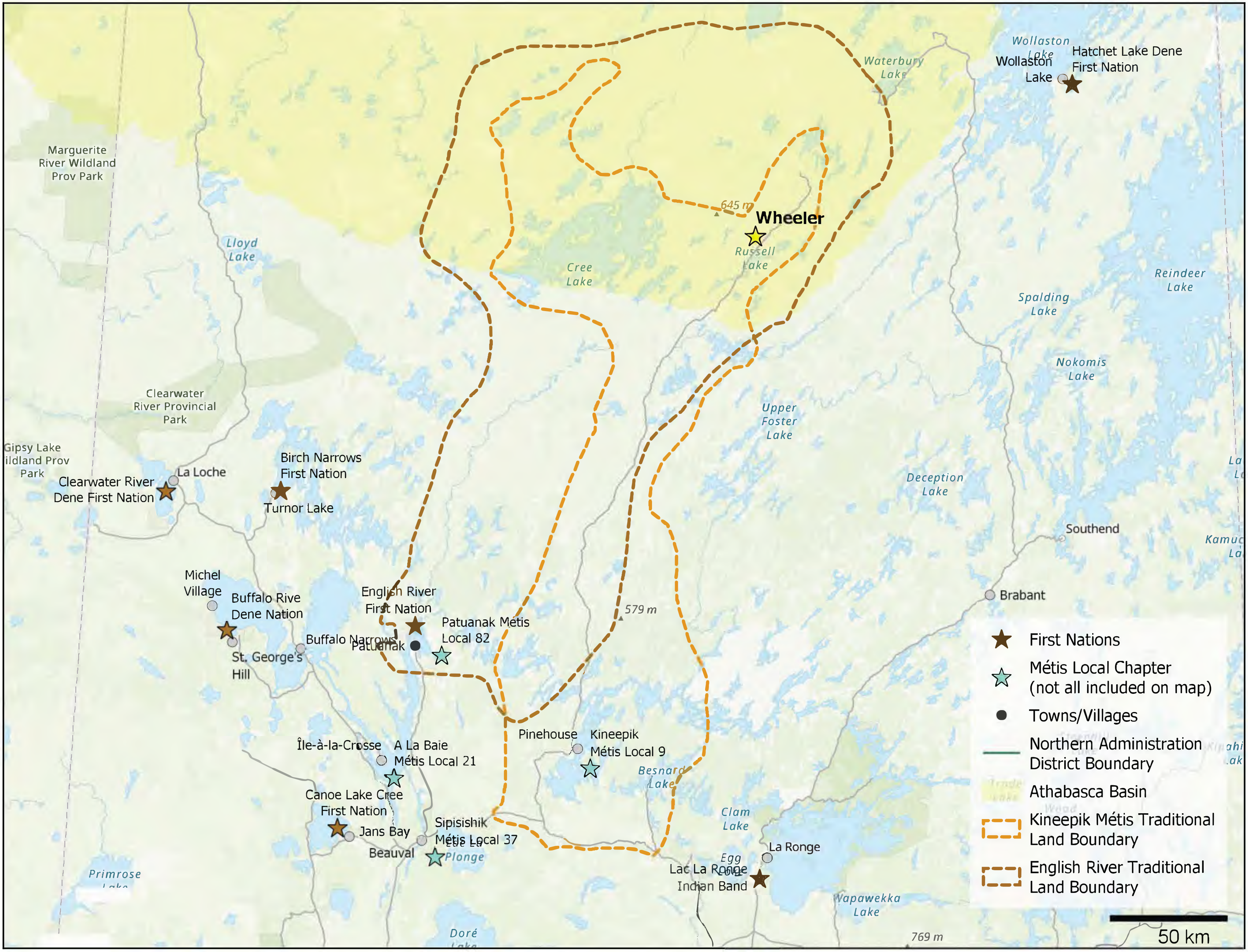
The Kineepik Métis Local

Tobias and Associates

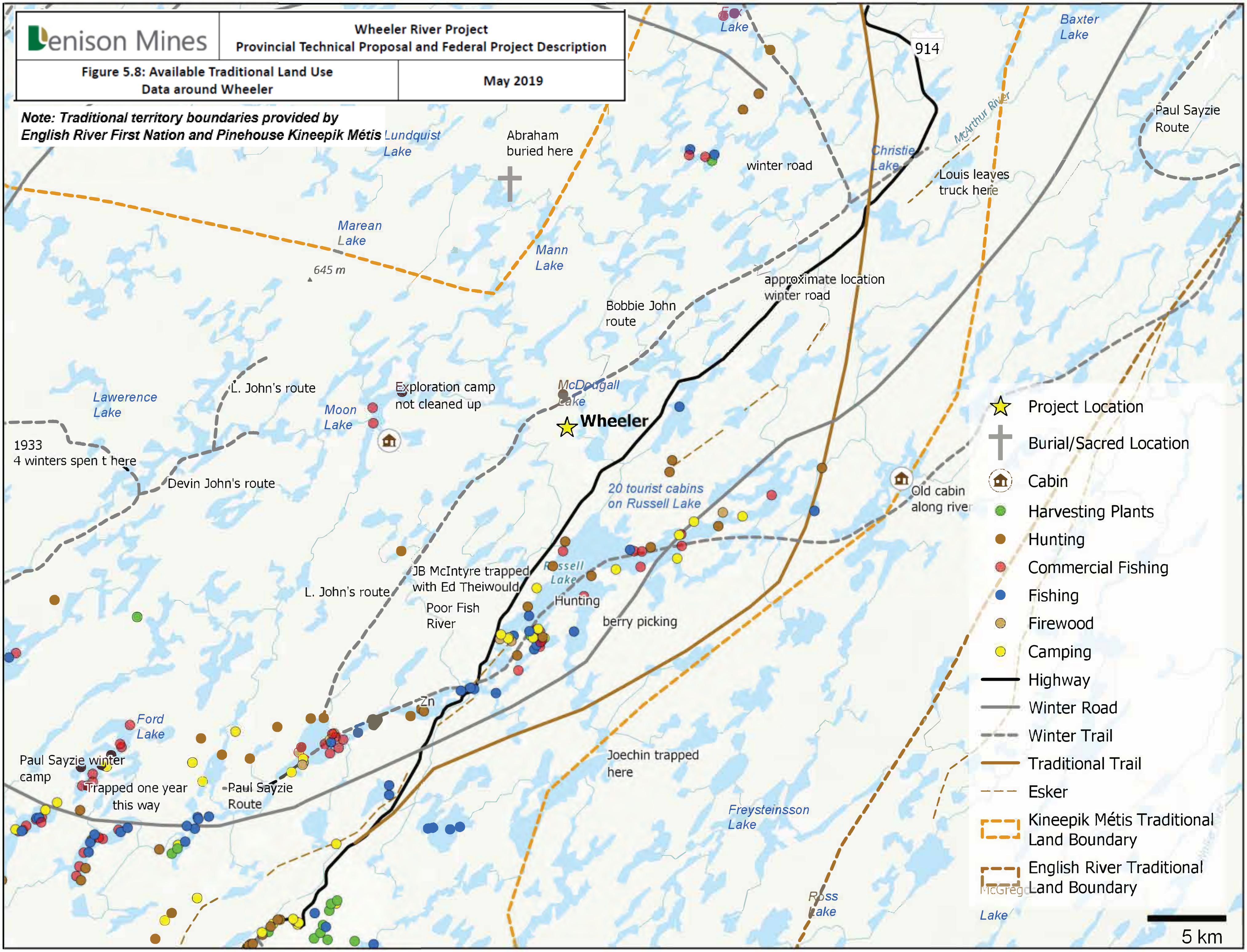
GeoPraxis Inc.

planlab





Wheeler
Russell Lake
Cree Lake
Wollaston Lake
Waterbury Lake
Hatchet Lake Dene First Nation
Marguerite River Wildland Prov Park
Lloyd Lake
Reindeer Lake
Spalding Lake
Nokomis Lake
Upper Foster Lake
Deception Lake
Clearwater River Provincial Park
Gipsy Lake Wildland Prov Park
La Loche
Clearwater River Dene First Nation
Birch Narrows First Nation
Turnor Lake
Southend
Brabant
Michel Village
Buffalo River Dene Nation
St. George's Hill
Buffalo Narrows
English River First Nation
Patuanak
Patuanak Metis Local 82
579 m
645 m
Île-à-la-Crosse
A La Baie Métis Local 21
Pinehouse
Kineepik Métis Local 9
Besnard Lake
Canoe Lake Cree First Nation
Jans Bay
Beauval
Sipisishik Métis Local 37
Lac La Plonge
Clam Lake
La Ronge
Egg Lake
Lac La Ronge Indian Band
Wapawekka Lake
Primrose Lake
Doré Lake
769 m
First Nations
Métis Local Chapter (not all included on map)
Towns/Villages
Northern Administration District Boundary
Athabasca Basin
Kineepik Métis Traditional Land Boundary
English River Traditional Land Boundary
50 km


Denison Mines
Wheeler River Project
Provincial Technical Proposal and Federal Project Description
Figure 5.8: Available Traditional Land Use Data around Wheeler
May 2019
Note: Traditional territory boundaries provided by English River First Nation and Pinehouse Kineepik Métis
Lundquist Lake
Abraham buried here
winter road
Christie Lake
McArthur River
Louis leaves truck here
Baxter Lake
Paul Sayzie Route
914
Marean Lake
Mann Lake
645 m
approximate location winter road
Bobbie John route
L. John's route
Lawerence Lake
Moon Lake
Exploration camp not cleaned up
McDougall Lake
Wheeler
1933 4 winters spen t here
Devin John's route
20 tourist cabins on Russell Lake
Old cabin along river
JB McIntyre trapped with Ed Theiwould
Russell Lake
L. John's route
Poor Fish River
Hunting
berry picking
Zn
Ford Lake
Paul Sayzie winter camp
Trapped one year this way
Paul Sayzie Route
Joechin trapped here
Freysteinsson Lake
Ross Lake
McGregor Lake
Project Location
Burial/Sacred Location
Cabin
Harvesting Plants
Hunting
Commercial Fishing
Fishing
Firewood
Camping
Highway
Winter Road
Winter Trail
Traditional Trail
Esker
Kineepik Métis Traditional Land Boundary
English River Traditional Land Boundary
5 km

golder.com

Denison Mines

Wheeler River Project

Final Environmental Impact Statement

November 2024

Powering PEOPLE, PARTNERSHIPS AND PASSION.

Section 12: Engagement Database Summary Table – Cultural Expression

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments (From Interested Party)	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
18-EN-ERFN-5.1	5	Workshop	2018-05-03	As part of the engagement program for the Wheeler River Project, Denison organized a workshop for English River First Nation at their Patuanak Reserve location for ERFN and Patuanak members to attend. The workshop aimed to gather community input in relation to road alignment options, treated effluent discharge locations, and mining methods. The meeting had been delayed many times, and was held in the Health Clinic because there was a regional power outage.	English River First Nation	I always come from the elders' perspective. Since 1906, the area where you're working has been Treaty 10 land. Those lands were the primary area of ERFN and contain burial sites and birth sites of ERFN members. The Dené name of the Wheeler River, Russell Lake and Cree Lake all come from the Denésuliné of English River. The elders have always expressed that it's a primary area of EFRN. One of our late elders was born north of there in 1922. Our traditional gathering place is there.	Denison considered this in section: Influence of Indigenous Knowledge, Local Knowledge, and Engagement on the Assessment And in section: Influence of Indigenous Knowledge, Local Knowledge, and Engagement on the Assessment, Other Sources of Information and Local Knowledge	The context in which this comment was used within the Quality of Life section of the EIS serves as a local perspective, documented as coming from a member of English River First Nation who attended a workshop in the year 2018.
18-EN-ERFN-5.3	5	Workshop	2018-05-03	Same as above	English River First Nation	For many years I've invited (the media) to come to our gathering on the Key Lake Road, to showcase and impress on the world that we're still using those areas. If you really want to work with us, you need to work with our council right from Day 1.	Denison considered this in section: Existing Environment, English River First Nation	The context in which this comment was used within the Quality of Life section of the EIS serves as a local perspective, documented as coming from a member of English River First Nation who attended a workshop in the year 2018. The record reference serves to highlight the existing environment in terms of ERFN land-based programming and supports.
21-EN-ERFNSUR-456.29	456	Survey	2021-04-09	As part of engagement activities for English River First Nation, Denison prepared and shared an online survey which included information about Denison, the Wheeler River Project, and posed validation questions about the Valued Components being assessed as part of the environmental assessment process. A total of 23 responses were received. The information related to the Valued Components was incorporated into the assessment.	English River First Nation	Denison Question: Why did you choose these valued components? Response: I chose those to emphasize how we value our ecosystem and to protect our traditional territory and please try to establish a resource management camp at KM 160 on Key Lake Road. To have young teenagers get to know about wildlife and names and characteristics of each wildlife, and forestry. To know all the names and traditional use of each trees and all the plants, fish species and aquatic. These are important for all young people to know. To get a hold of integrated resource management to assist with how they teach resource management	Denison considered this comment in section: Influence of Indigenous Knowledge, Local Knowledge, and Engagement on the Assessment.	The context in which this comment was used within the Quality of Life section of the EIS serves as a local perspective, documented as coming from a member of English River First Nation who completed a survey in the year 2021.

Section 12: Engagement Database Summary Table – Community Well-being

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments (From Interested Party)	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
16-EN-ERFN-100.17	100	Community Meeting	2016-07-27	Denison hosted a community meeting in Patuanak for English River First Nation members, the purpose of which was to provide an overview of the Wheeler River Project.	English River First Nation	Today because of climate change, things are starting to happen that normally didn't happen. Even the permafrost is now further down. In the Wheeler River area, where there's some permafrost, have your environment guys seen a change? Will there be a change? These are some of the questions that need to be answered in order to come out with a positive spin.	Denison considered this in section: Community Wellbeing, Existing Environment, Key Indicator: Community Cohesion And in section: Cumulative Effects, Climate Change Considerations	The context in which this comment was used within the Quality of Life section of the EIS serves as a local perspective, documented as coming from a member of English River First Nation who attended a community meeting in the year 2016. The record reference supports the current understanding of the existing environment and provides a local perspective with respect to climate change considerations. The Project is in a mapped area designated as Sporadic Discontinuous Permafrost. Large and/or expansive areas of continuous cryosolic soil and permafrost terrain do not occur within the RSA. For this reason, the potential effects are not expected to affect terrain stability within the Project Area within the life of the Project. Denison has completed an environment assessment to understand Project impacts on the environment. The assessment provides a description of the existing environment for valued components, including geological & groundwater, and terrestrial environments. Existing conditions are based on available information and are accompanied by supporting information that includes natural and human caused trends that are presently affecting baseline conditions. Denison determined that there will be no significant impacts as a result of Project activities.
18-EN-ERFN-5.35	5	Workshop	2018-05-03	As part of the engagement program for the Wheeler River Project, Denison organized a workshop for English River First Nation at their Patuanak Reserve location for ERFN and Patuanak members to attend. The workshop aimed to gather community input in relation to road alignment options, treated effluent discharge locations, and mining methods. The meeting had been delayed many times, and was held in the Health Clinic because there was a regional power outage.	English River First Nation	That would allow some natural filtration. We would have to see what the other members think of it. Because it's further away, there would be more filtration by the time it reached Russell Lake. What about spawning areas, caribou and moose calving areas? Caribou and moose eat low bush cranberries and lichen; lichen takes many years to grow and recover. There may be other things to consider, like medicinal areas - the elders will know.	Denison considered this in section: Community Wellbeing, Existing Environment, Key Indicator: Community Cohesion	The context in which this comment was used within the Quality of Life section of the EIS serves as a local perspective, documented as coming from a member of English River First Nation who attended a workshop in the year 2018. The record reference supports the current understanding of the existing environment.
18-EN-ERFN-5.58	5	Workshop	2018-05-03	Same as above	English River First Nation	We got $7.50 an hour plus $2/foot after 4,000 feet in 1979! If you're going to be a driller you have to put your social life aside until the job is done. 28 days is not long.	Denison considered this in section: Community Wellbeing, Existing Environment, Key Indicator: Community Cohesion	The context in which this comment was used within the Quality of Life section of the EIS serves as a local perspective, documented as coming from a member of English River First Nation who attended a workshop in the year 2018. The record reference supports the current understanding of the existing environment.
18-EN-ERFN-5.64	5	Workshop	2018-05-03	Same as above	English River First Nation	In the 1800s and early 1900s, our ancestors lived off those lands. They used the river	Denison considered this in section:	The context in which this comment was used within the Quality of Life section of the EIS serves as a local

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments (From Interested Party)	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
						systems - Mudjatik, Foster, Wheeler, Churchill. Ile a la Crosse, Beauval and Pinehouse have never known that area – north of the Churchill was always Denésuliné territory. That was respected. That showed in 1947 when the fur blocks were assigned by the province – N16 on the north side and N18 on the south – Costigan, Haultain River, Highrock, all those areas. This information was passed on to me from 1991 – 2000 from late elders who gathered and trapped in the area.	Community Wellbeing, Existing Environment, Key Indicator: Community Cohesion	perspective, documented as coming from a member of English River First Nation who attended a workshop in the year 2018. The record reference supports the current understanding of the existing environment.
18-EN-VB-4.39	4	Workshop	2018-01-18	As part of the engagement program for the Wheeler River Project, Denison organized a workshop in Beauval for community members to attend. The workshop gathered community input in relation to road alignment options, treated effluent discharge locations, and mining methods.	Village of Beauval	Our waterbodies up north change drastically; in the last two years we've even flooded over here, while a few years ago we were in drought mode.	Denison considered this in section: Community Wellbeing, Existing Environment, Key Indicator: Community Cohesion And in section: Cumulative Effects, Climate Change Considerations	The context in which this comment was used within the Quality of Life section of the EIS serves as a local perspective, documented as coming from a resident of Beauval, who attended a workshop in the year 2018. The record reference supports the current understanding of the existing environment, and provides a local perspective in terms of climate change considerations.
19-EN-PBN-135.5	135	Meeting	2019-02-01	Denison and Pinehouse leaders (Village, Kineepik Métis, and Pinehosue Business North) held a meeting, in which Denison provided an update on the Wheeler River Project, including the pending submission of the Project into the environmental assessment process.	Kineepik Métis Local #9, Village of Pinehouse Lake	Enquired into the different levels of education that would be required for the various permanent positions coming out of the project.	Denison considered this in section: Community Wellbeing, Existing Environment, Key Indicator: Income of Local Workers And in section: Community Wellbeing, Existing Environment, Key Indicator: Community Cohesion	The context in which this comment was used within the Quality of Life section of the EIS serves as a local perspective, documented as coming from Pinehouse/Kineepik Métis/Pinehouse Business North leadership, who attended a meeting in the year 2019. The record reference supports the current understanding of the existing environment.
21-EN-SUR-446.61	446	Survey	2021-02-16	As part of engagement activities for the municipalities of Beauval, Ile a la Crosse and Pinehouse Lake, Denison prepared and shared an online survey which included information about Denison, the Wheeler River Project, and posed validation questions about the Valued Components being assessed as part of the environmental assessment process. A total of 68 responses were received and 62 of the responses were considered complete, for a 91% completion rate. The information related to the Valued Components was incorporated into the assessment.	Unknown (Unknown)	Denison Question: Based on what you know so far about the Wheeler Project, what aspects of the project could benefit, or work well for your community? Response: Setting aside a legacy fund to benefit impacted communities now and into the future. Ensure employment is available to my community including a pick up point so that there is no undue hardship for workers.	Denison considered this in section: Influence of Indigenous Knowledge, Local Knowledge, and Engagement on the Assessment And in section: Existing Environment, Key Indicator: Community Cohesion	The context in which this comment was used within the Quality of Life section of the EIS serves as a local perspective, documented as coming from an individual who completed a survey that was available to residents from Beauval, Ile a la Crosse, and Pinehouse, in the year 2021. The record reference supports the current understanding of the existing environment.
21-EN-SUR-446.62	446	Survey	2021-02-16	Same as above	Unknown (Unknown)	Denison Question: Based on what you know so far about the Wheeler Project, what aspects of the project could benefit, or work well for your community?	Denison considered this in section: Influence of Indigenous Knowledge, Local Knowledge, and Engagement on the Assessment	The context in which this comment was used within the Quality of Life section of the EIS serves as a local perspective, documented as coming from an individual who completed a survey that was available to residents

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments (From Interested Party)	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
						Response: Developing an agreement to acknowledge the importance of positive relationships with indigenous communities - who are directly impacted - by mining industry. This has often overlooked by industry, and creates an oppositional relationship with communities. Please do not do this, like other companies have.	In section: Existing Environment, Key Indicator: Community Cohesion And in section: Cumulative Effects, Climate Change Considerations	from Beauval, Ile a la Crosse, and Pinehouse, in the year 2021. The record reference supports the current understanding of the existing environment, and provides a local perspective in terms of climate change considerations.
21-EN-SUR-446.78 and 21-EN-SUR-446.80	446	Survey	2021-02-16	Same as above	Unknown (Unknown)	Denison Question: Based on what you know so far about the Wheeler Project, what aspects of the project could be challenging or cause concern for your community? Response: The well being of people. Without adequate housing, there are many people that can not amount to their full potential if they can not even safely rest their head at night.	Denison considered this in section: Influence of Indigenous Knowledge, Local Knowledge, and Engagement on the Assessment In section: Existing Environment, Key Indicator: Income of Local Workers In section: Existing Environment, Key Indicator: Community Cohesion In section: Assessment of Project-Related Effects, Potential Project Related Effects, Potential Effect 1- Change in Population and Demographics And in section: Existing Environment, Key Indicator: Population and Demographics	The context in which this comment was used within the Quality of Life section of the EIS serves as a local perspective, documented as coming from an individual who completed a survey that was available to residents from Beauval, Ile a la Crosse, and Pinehouse, in the year 2021. The record reference supports the current understanding of the existing environment, and provides context in terms of change in population and demographics in relation to potential project related effects. Denison has completed an environment assessment to understand Project impacts on the environment. The assessment considers potential impacts to community well-being, of which key indicators include income of local workers and infrastructure & services. Denison has determined that there will be no significant adverse impacts as a result of Project activities. Project employment and business opportunities could result in additional income for individuals and households.
21-EN-SUR-446.79	446	Survey	2021-02-16	Same as above	Unknown (Unknown)	Denison Question: Based on what you know so far about the Wheeler Project, what aspects of the project could be challenging or cause concern for your community? Response: Direct benefits and positive impact to community. Environmental monitoring.	Denison considered this in section: Influence of Indigenous Knowledge, Local Knowledge, and Engagement on the Assessment	The context in which this comment was used within the Quality of Life section of the EIS serves as a local perspective, documented as coming from an individual who completed a survey that was available to residents from Beauval, Ile a la Crosse, and Pinehouse, in the year 2021. Denison, through a Human Resource Development Plan, will initially prioritize Indigenous and non-Indigenous communities in the LSA in terms of economic opportunities. Denison will negotiate with the Province of Saskatchewan to develop the Project's Surface Lease Agreement and the Human Resource Development Agreement, which will outline measures in relation to socio-economic parameters related to the Project, including in those relation to employment and training opportunities. The Environmental Management System provides processes, procedures, policies, assigned roles and responsibilities, and considers continual monitoring and improvement of organizational structures and practices. Details associated with the programs within the overall

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments (From Interested Party)	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
								umbrella of the environmental management system will be developed as the Project processes through licensing and permitting.
21-EN-SUR-446.81	446	Survey	2021-02-16	Same as above	Unknown (Unknown)	Denison Question: Based on what you know so far about the Wheeler Project, what aspects of the project could be challenging or cause concern for your community? Response: Dealing with opposing agencies/organizations/political parties. Jurisdictional challenges, MN-S/Métis Local/Municipal not being able to work in a healthy partnership for the benefit of all community members. Also, First Nations working with Métis communities needs to be encouraged/emphasized. Educate our elementary and High School students about uranium and the good that comes from this type of industry, in the north.	Denison considered this in section: Influence of Indigenous Knowledge, Local Knowledge, and Engagement on the Assessment In section: Existing Environment, Key Indicator: Income of Local Workers And in section: Existing Environment, Key Indicator: Community Cohesion	The context in which this comment was used within the Quality of Life section of the EIS serves as a local perspective, documented as coming from an individual who completed a survey that was available to residents from Beauval, Ile a la Crosse, and Pinehouse, in the year 2021. The record reference supports the current understanding of the existing environment in terms of income of local workers and community cohesion.
21-EN-SUR-446.82	446	Survey	2021-02-16	Same as above	Unknown (Unknown)	Denison Question: Based on what you know so far about the Wheeler Project, what aspects of the project could be challenging or cause concern for your community? Response: The depression that follows after the mines pack up and leave with the $$$	Denison considered this in section: Influence of Indigenous Knowledge, Local Knowledge, and Engagement on the Assessment In section: Existing Environment, Key Indicator: Population and Demographics In section: Existing Environment, Key Indicator: Income of Local Workers In section: Existing Environment, Key Indicator: Community Cohesion In section: Assessment of Project-Related Effects, Potential Project Related Effects, Potential Effect 1- Change in Population and Demographics And in section: Assessment of Project-Related Effects, Potential Project Related Effects, Potential Effect 2- Change in Income	The context in which this comment was used within the Quality of Life section of the EIS serves as a local perspective, documented as coming from an individual who completed a survey that was available to residents from Beauval, Ile a la Crosse, and Pinehouse, in the year 2021. The record reference supports the current understanding of the existing environment and provides context in terms of change in population and demographics, and change in income, in relation to potential project related effects. Denison, through a Human Resource Development Plan, will initially prioritize Indigenous and non-Indigenous communities in the LSA in terms of economic opportunities. Denison will negotiate with the Province of Saskatchewan to develop the Project's surface lease agreement and the Human Resource Development Agreement, which will outline measures in relation to socio-economic parameters related to the Project.
21-EN-SUR-446.83	446	Survey	2021-02-16	Same as above	Unknown (Unknown)	Denison Question: Based on what you know so far about the Wheeler Project, what aspects of the project could be challenging or cause concern for your community? Response: Lack of employment	Denison considered this in section: Influence of Indigenous Knowledge, Local Knowledge, and Engagement on the Assessment In section: Existing Environment, Key Indicator: Population and Demographics In section:	The context in which this comment was used within the Quality of Life section of the EIS serves as a local perspective, documented as coming from an individual who completed a survey that was available to residents from Beauval, Ile a la Crosse, and Pinehouse, in the year 2021. The record reference supports the current understanding of the existing environment, and provides context in terms of change in population and

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments (From Interested Party)	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
							Existing Environment, Key Indicator: Income of Local Workers In section: Existing Environment, Key Indicator: Community Cohesion In section: Assessment of Project-Related Effects, Potential Project Related Effects, Potential Effect 1- Change in Population and Demographics	demographics in relation to potential project related effects. Denison, through a Human Resource Development Plan, will initially prioritize Indigenous and non-Indigenous communities in the LSA in terms of economic opportunities. Denison will negotiate with the Province of Saskatchewan to develop the Project's surface lease agreement and the Human Resource Development Agreement, which will outline measures in relation to socio-economic parameters related to the Project.
21-EN-SUR-446.84	446	Survey	2021-02-16	Same as above	Unknown (Unknown)	Denison Question: Based on what you know so far about the Wheeler Project, what aspects of the project could be challenging or cause concern for your community? Response: When the mine eventually closes a lot of people are going to lose jobs	Denison considered this in section: Influence of Indigenous Knowledge, Local Knowledge, and Engagement on the Assessment In section: Existing Environment, Key Indicator: Population and Demographics In section: Existing Environment, Key Indicator: Income of Local Workers In section: Existing Environment, Key Indicator: Community Cohesion In section: Assessment of Project-Related Effects, Potential Project Related Effects, Potential Effect 1- Change in Population and Demographics And in section: Assessment of Project-Related Effects, Potential Project Related Effects, Potential Effect 2- Change in Income	The context in which this comment was used within the Quality of Life section of the EIS serves as a local perspective, documented as coming from an individual who completed a survey that was available to residents from Beauval, Ile a la Crosse, and Pinehouse, in the year 2021. The record reference supports the current understanding of the existing environment, and provides context in terms of change in population and demographics, and change in income, in relation to potential project related effects. Denison, through a Human Resource Development Plan, will initially prioritize Indigenous and non-Indigenous communities in the LSA in terms of economic opportunities. Denison will negotiate with the Province of Saskatchewan to develop the Project's surface lease agreement and the Human Resource Development Agreement, which will outline measures in relation to socio-economic parameters related to the Project.
21-EN-SUR-446.85	446	Survey	2021-02-16	Same as above	Unknown (Unknown)	Denison Question: Based on what you know so far about the Wheeler Project, what aspects of the project could be challenging or cause concern for your community? Response: The mental health of how the people will react when the land is being damaged.	Denison considered this in section: Influence of Indigenous Knowledge, Local Knowledge, and Engagement on the Assessment And in section Existing Environment, Key Indicator: Community Cohesion	The context in which this comment was used within the Quality of Life section of the EIS serves as a local perspective, documented as coming from an individual who completed a survey that was available to residents from Beauval, Ile a la Crosse, and Pinehouse, in the year 2021. The record reference supports the current understanding of the existing environment. Denison has completed an environment assessment to understand Project impacts on the environment. The assessment considers potential impacts to land and resource use, quality of life, and the terrestrial environment. Denison has determined that there will be no significant adverse impacts as a result of Project activities.
21-EN-SUR-446.89	446	Survey	2021-02-16	Same as above	Unknown (Unknown)	Denison Question: Based on what you know so far about the Wheeler Project, what	Denison considered this in section:	The context in which this comment was used within the Quality of Life section of the EIS serves as a local

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments (From Interested Party)	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
						aspects of the project could be challenging or cause concern for your community? Response: Water contamination.	Community Wellbeing, Existing Environment, Key Indicator: Community Cohesion	perspective, documented as coming from an individual who completed a survey that was available to residents from Beauval, Ile a la Crosse, and Pinehouse, in the year 2021. The record reference supports the current understanding of the existing environment. Denison has completed an environment assessment to understand Project impacts on the environment. The assessment considers potential impact to groundwater and lakes. Denison determined that there will be no significant impacts as a result of Project activities.
21-EN-ERFN-447.4	447	Virtual Meeting	2021-03-31	Denison hosted a virtual meeting for English River First Nation (Patuanak, La Plonge and Urban Members). Included in the discussion was an overview on the Valued Components for the Wheeler River Project, with a request to provide feedback to Denison via an online survey with specific questions pertaining to Valued Components.	English River First Nation	Will local companies (Tron, Des Nedhe) and local community members get priority for contracts/employment? Will there be opportunities for negotiations between ERFN and Denison so our community members don't lose out on opportunities?	Denison considered this in section: Community Wellbeing, Existing Environment, Key Indicator: Community Cohesion	The context in which this comment was used within the Quality of Life section of the EIS serves as a local perspective, documented as coming from a member of English River First Nation who attended a virtual meeting in the year 2021. The record reference supports the current understanding of the existing environment. Denison, through a Human Resource Development Plan, will initially prioritize Indigenous and non-Indigenous communities in the LSA in terms of economic opportunities. Denison will negotiate with the Province of Saskatchewan to develop the Project's surface lease agreement and the Human Resource Development Agreement, which will outline measures in relation to socio-economic parameters related to the Project.
21-EN-ERFN-447.12	447	Virtual Meeting	2021-03-31	Same as above	English River First Nation	Will locals get opportunities?	Denison considered this in section: Community Wellbeing, Existing Environment, Key Indicator: Community Cohesion	The context in which this comment was used within the Quality of Life section of the EIS serves as a local perspective, documented as coming from a member of English River First Nation who attended a virtual meeting in the year 2021. The record reference supports the current understanding of the existing environment. Denison, through a Human Resource Development Plan, will initially prioritize Indigenous and non-Indigenous communities, such as Pinehouse, in the LSA in terms of employment and training opportunities (anticipated to be in institutions in northern Saskatchewan) and will work with the leadership of these communities to assist in determining hiring and training practices during all phases of the Project, which could include such items as on-the-job training and career counselling to help with advancement from foundational positions, advance sharing of job qualification requirements, clearly identifying training requirements and working with various training institutions to make sure such appropriate training is available, and creation of scholarship and support programs. Denison will negotiate with the Province of Saskatchewan to develop the Project's SLA and the Human Resource Development Agreement, which

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments (From Interested Party)	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
								will outline measures in relation to socio-economic parameters related to the Project.
21-EN-ERFN-474.5	474	Meeting	2021-06-30	Denison, its third party consultants for socioeconomic and health and wellness assessment (Intergroup) and the English River First Nation Lands & Resources Officer and the third party consultant for English River First Nation held a meeting in which Denison provided an overview of the Wheeler River Project scope, and Intergroup provided an overview of the approach taken for the socioeconomic and wellness assessment for the Environmental Assessment.	English River First Nation	Can you integrate Indigenous land use into economic assessment? Find a value to put this into income? Fit within?	Denison considered this in section: Existing Environment, Key Indicator: Income of Local Workers	The context in which this comment was used within the Quality of Life section of the EIS serves as a local perspective, documented as coming from a member of English River First Nation/ERFN consultants who attended a meeting in the year 2021. The record reference supports the current understanding of the existing environment. The EIS considers the traditional economy as a key indicator as part of the economic valued component. The effect of Project-related activities on the traditional economy is measured as the change in the proportion of LSA residents participating in the traditional economy. See the Economics section of the EIS for more information.
22-EN-ERFN-618.20	618	Open House	2022-05-30	In collaboration with the Chief and Council of English River First Nation, Denison hosted an open house event at ERFN Patuanak Reserve, sharing information about the Wheeler River Project, the preliminary effects assessment of the Project, and proposed mitigation and monitoring. Denison advertised the event on the local radio, with posters around the community, on the local cable network, and through social media. Denison had a Dene translator available for attendees. Residents of the Hamlet of Patuanak were also advised about the open house and invited to attend. 31 attendees signed the sign in sheet. Information boards and area models were displayed, and staff Denison staff were available to answer questions. A survey was available for community members to complete, and remaining available online for 2 weeks following the open house.	English River First Nation	What is your plan for training and for young people? Are you going to hire people who don't have their Grade 12.	Denison considered this in section: Existing Environment, Key Indicator: Population and Demographics. And in section: Existing Environment, Key Indicator: Income of Local Workers.	The context in which this comment was used within the Quality of Life section of the EIS serves as a local perspective, documented as coming from a member of English River First Nation/ERFN consultants who attended an open house in the year 2022. The record reference supports the current understanding of the existing environment. Foundational positions (i.e., Entry Level) (82 jobs) require Grade 12 education and in-house training programs, although a combination of skills and experience may be considered. These positions would include process plant operators, site services, drillers, and catering/janitorial staff. Denison, through a Human Resource Development Plan, will initially prioritize Indigenous and non-Indigenous communities in the LSA in terms of economic opportunities. Denison will negotiate with the Province of Saskatchewan to develop the Project's surface lease agreement and the Human Resource Development Agreement, which will outline measures in relation to socio-economic parameters related to the Project.
22-EN-ERFN-621.10	621	Meeting	2022-05-30	Denison hosted a meeting with the Chief and Council of English River First Nation, hosted in ERFN Patuanak, to share information about the Wheeler River Project, preliminary effects assessment of the Project, and proposed mitigation and monitoring. A representative from the Canadian Nuclear Safety Commission and from the Province of Saskatchewan were also in attendance.	English River First Nation	Work co-ops for youth and students? Something to plan for.	Denison considered this in section: Existing Environment, Key Indicator: Income of Local Workers.	The context in which this comment was used within the Quality of Life section of the EIS serves as a local perspective, documented as coming from English River First Nation leadership, who attended a meeting in the year 2022. The record reference supports the current understanding of the existing environment. Denison, through a Human Resource Development Plan, will initially prioritize Indigenous and non-Indigenous communities in the LSA in terms of employment and training opportunities (anticipated to be in institutions in northern Saskatchewan) and will work with the leadership of these communities to assist in determining hiring and

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments (From Interested Party)	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
								training practices during all phases of the Project, which could include such items as on-the-job training and career counselling to help with advancement from foundational positions, advance sharing of job qualification requirements, clearly identifying training requirements and working with various training institutions to make sure such appropriate training is available, and creation of scholarship and support programs. Denison will negotiate with the Province of Saskatchewan to develop the Project's SLA and the Human Resource Development Agreement, which will outline measures in relation to socio-economic parameters related to the Project.
22-EN-ERFN-621.11	621	Meeting	2022-05-30	Same as above	English River First Nation	What are you doing for the community? Donations and housing?	Denison considered this in section: Influence of Indigenous Knowledge, Local Knowledge, and Engagement on the Assessment.	The context in which this comment was used within the Quality of Life section of the EIS serves as a local perspective, documented as coming from English River First Nation leadership, who attended a meeting in the year 2022.
22-EN-ERFN-621.13	621	Meeting	2022-05-30	Same as above	English River First Nation	We're passionate about the land, water and the medicines. (Sharing stories she's heard from Elder's.) "The government is going to give them approval. I just wish they'd treat the area like they would their own backyard"-"How much (space) are we going to have left. Sure its good money, but it comes at a sacrifice"	Denison considered this in section: Existing Environment, Key Indicator: Community Cohesion	The context in which this comment was used within the Quality of Life section of the EIS serves as a local perspective, documented as coming from English River First Nation leadership, who attended a meeting in the year 2022. The record reference supports the current understanding of the existing environment.
22-EN-SUR-652.68	652	Survey	2022-06-03	As part of engagement activities for English River First Nation, Beauval, and Pinehouse, Denison prepared and shared, both online and as a hardcopy during Spring Engagement meetings, a survey that asked a series of questions relating to the results of the environmental assessment. A total of 39 surveys were entirely or partially completed.	Unknown	Denison Question: Are there any topics that you would like to see including in monitoring plans? Response: Mental health; how are people feeling about this	Denison considered this in section: Existing Environment, Key Indicator: Income of Local Workers And in section: Existing Environment, Key Indicator: Community Cohesion	The context in which this comment was used within the Quality of Life section of the EIS serves as a local perspective, documented as coming from an individual who completed a survey that was available to residents of English River First Nation, Beauval, and Pinehouse, in the year 2022. The record reference supports the current understanding of the existing environment.
622.5	622	Meeting	2022-05-31	Denison hosted a meeting with the Mayor and Village Council of The Northern Village of Beauval, hosted at the Beauval Village Office, to share information about the Wheeler River Project, preliminary effects assessment of the Project, and proposed mitigation and monitoring.	Village of Beauval	How would workers get to site?	Denison considered this in section: Existing Environment, Key Indicator: Community Cohesion	The context in which this comment was used within the Quality of Life section of the EIS serves as a local perspective, documented as coming from Beauval leadership, who attended a meeting in the year 2022. The record reference supports the current understanding of the existing environment. The Project is proposed as a fly in-fly out operation.
620.9	620	Open House	2022-06-01	In collaboration with Kineepik Metis Local and the Village Council of Pinehouse Lake, Denison hosted an open house event at the Village of Pinehouse Lake, sharing	Kineepik Métis Local #9, Village of Pinehouse Lake	What kind of worker turn-around (shift) schedule are you thinking about? 1 and 1 is much better. I work 1 week on 1 week off with Cameco, then they changed to 2 weeks	Denison considered this in section: Existing Environment, Key Indicator: Community Cohesion	The context in which this comment was used within the Quality of Life section of the EIS serves as a local perspective, documented as coming from a resident of Pinehouse who attended an open house in the year 2022.

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments (From Interested Party)	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
				information about the Wheeler River Project, the preliminary effects assessment of the Project, and proposed mitigation and monitoring. Denison advertised the event on the local radio, with posters around the community, on the local cable network, and through social media. Denison had a Cree translator available for attendees. Information boards and area models were displayed, and staff Denison staff were available to answer questions. 52 attendees signed the sign in sheet. A survey was available for community members to complete, and remaining available online for 2 weeks following the open house.		on 2 weeks off. I had to quit because it was too difficult for the family.		The record reference supports the current understanding of the existing environment. The environmental assessment considered commuter rotation schedule of 2 weeks on/ 2 weeks off.

Section 12: Engagement Database Summary Table – Infrastructure and Services

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments (From Interested Party)	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
18-EN-ERFN-5.58	5	Workshop	2018-05-03	As part of the engagement program for the Wheeler River Project, Denison organized a workshop for ERFN at their Patuanak Reserve location for ERFN and Patuanak members to attend. The workshop aimed to gather community input in relation to road alignment options, treated effluent discharge locations, and mining methods. The meeting had been delayed many times, and was held in the Health Clinic because there was a regional power outage.	English River First Nation	We got $7.50 an hour plus $2/foot after 4,000 feet in 1979! If you're going to be a driller you have to put your social life aside until the job is done. 28 days is not long.	Denison considered this in section: Influence of Indigenous Knowledge, Local Knowledge, and Engagement on the Assessment.	The context in which this comment was used within the Quality of Life section of the EIS serves as a local perspective, documented as coming from a member of English River First Nation who attended a workshop in the year 2018.
20-LK-LEASESUR-267.104 20-LK-LEASESUR-267.105 20-LK-LEASESUR-267.106 20-LK-LODGESUR-267.107 20-LK-LEASESUR-267.108	267	Survey	2020-02-01	Denison sent all known local cabin and lodge leaseholders a survey in the mail to be completed regarding their interests in Wheeler River. Denison received 6 responses from the survey, which has informed it's understanding of leaseholder uses in the area and interests regarding elements to be assessed as part of the environmental assessment.	Leaseholder	Denison Question: What issues or concerns are of particular interest to you? What do you feel should be considered in the Project Environmental Impact Assessment? Response: Changes in traffic.	Denison considered this in section: Scope of Assessment, Valued Component Selection In section: Influence of Indigenous Knowledge, Local Knowledge, and Engagement on the Assessment And in section Assessment of Project-Related Effects, Potential Project-Related Effects, Potential Effect 1- Change in traffic	The context in which this comment was used within the Quality of Life section of the EIS serves as a local perspective, documented as coming from a leaseholder who completed a survey in the year 2020. The record reference provides context in terms of change in traffic in relation to potential project related effects. Denison has completed an environment assessment to understand Project impacts on the environment. The assessment considers changes in traffic volume. While it is expected that traffic north of the Key Lake gatehouse will increase by 23% during construction and 30% during operation, proven mitigation options are planned to reduce the risk of increased traffic. Denison has determined that there will be no significant impacts as a result of Project activities.
21-EN-SUR-446.77	446	Survey	2021-02-16	As part of engagement activities for the municipalities of Beauval, Ile a la Crosse and Pinehouse Lake, Denison prepared and shared an online survey which included information about Denison, the Wheeler River Project, and posed validation questions about the Valued Components being assessed as part of the environmental assessment process. A total of 68 responses were received and 62 of the responses were considered complete, for a 91% completion rate. The information related to the Valued Components was incorporated into the assessment and questions asked on the surveys was incorporated into the overall engagement database.	Unknown (Unknown)	Denison Question: Based on what you know so far about the Wheeler Project, what aspects of the project could be challenging or cause concern for your community? Response: Work Safety, community safety from through traffic (semi trucks etc.)	Denison considered this in section: Assessment of Project-Related Effects, Potential Project-Related Effects, Potential Effect 1- Change in traffic	The context in which this comment was used within the Quality of Life section of the EIS serves as a local perspective, documented as coming from an individual who completed a survey that was available to residents from Beauval, Ile a la Crosse, and Pinehouse, in the year 2021. The record reference provides context in terms of change in traffic in relation to potential project related effects. Denison has completed an environment assessment to understand Project impacts on the environment. The assessment considers changes in traffic volume. While it is expected that traffic north of the Key Lake gatehouse will increase by 23% during construction and 30% during operation, proven mitigation options are planned to reduce the risk of increased traffic. The environmental assessment additionally considers potential impacts to worker health. An Occupational Health and Safety Program will be designed to provide for the protection of workers in relation to Denison's activities. Denison has

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments (From Interested Party)	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
								determined that there will be no significant impacts as a result of Project activities.
21-EN-ERFN-473.6	473	Advisory Committee Meeting	2021-06-15	Denison and the Nuhtsiye-kwi Benéne Committee (Ancestral Lands Committee) of English River First Nation held a meeting. During the meeting topics discussed were: concluding discussions related to the geotechnical permit for the Wheeler River Project for 2021, site access considerations (related to ERFN usage of the Fox Lake road), a report on a subsidence assessment report undertaken by Denison and requested by ERFN, and an overview of a pilot project being undertaken by Denison related to reclamation of linear features in and around the Wheeler River Project area.	(Nuhtsiye-kwi Benéne Committee (Ancestral Lands Committee))	There hasn't been a problem with the access set-up with Cameco, so I don't anticipate one with this. I know a few areas where there is a good hunting and berry picking. I don't go through the gate, I go via the old Fox Lake road – you wouldn't even know I was around there. I don't think there will be a problem.	Denison considered this in section: Existing Environment, Description of Highway Infrastructure (Highway 914 and Highway 165)	The context in which this comment was used within the Quality of Life section of the EIS serves as a local perspective, documented as coming from a member of English River First Nation and participant in the Nuhtsiye-kwi Benéne Committee (Ancestral Lands Committee) who attended an advisory committee meeting in the year 2021. The record reference supports the current understanding of the existing environment.
21-EN-BLFN-570.5	570	Virtual Meeting	2021-09-29	As per the agreed-upon process set between Denison and the Ya'thi Néné Land and Resources Office regarding engagement activities for the Wheeler River Project, Denison hosted a virtual meeting for the leadership of the Athabasca Basin communities where the overall project, alternatives assessments undertaken over the years and Valued Components were discussed.	Black Lake First Nation	The Key Lake Mine gate access, I had to go through English River and the Saskatoon office to get to Russell Lake. I don't think it should be an issue for the people. Are you going to be using Key Lake Mine gate to access the mine site?	Denison considered this in section: Existing Environment, Description of Highway Infrastructure (Highway 914 and Highway 165)	The context in which this comment was used within the Quality of Life section of the EIS serves as a local perspective, documented as coming from Athabasca Basin leadership, represented by Ya'thi Néné Land and Resources Office, who attended a virtual meeting in the year 2021. The record reference supports the current understanding of the existing environment. Denison understands the importance of maintaining access to greatest degree possible for Indigenous people, while respecting the need for safety for all in the area. Access restrictions north of the Key Lake gate mean that use is restricted to lease holders (e.g., cabin owners) and select Indigenous communities. The Project does not propose any changes to the current access to Highway 914 north of Cameco's Key Lake Operation gate.
22-EN-VB-622.5	622	Meeting	2022-05-31	Denison hosted a meeting with the Mayor and Village Council of The Northern Village of Beauval, hosted at the Beauval Village Office, to share information about the Wheeler River Project, preliminary effects assessment of the Project, and proposed mitigation and monitoring.	Village of Beauval	How would workers get to site? Response from Denison: We've scoped an airstrip into the plan.	Denison considered this in section: Assessment of Project-Related Effects, Potential Project-Related Effects, Potential Effect 2 – Change in Community Infrastructure and Services	The context in which this comment was used within the Quality of Life section of the EIS serves as a local perspective, documented as coming from Beauval leadership, who attended a meeting in the year 2021. The record reference provides context in terms of change in community infrastructure in relation to potential project related effects. The Project is proposed as a fly in-fly out operation. An air strip and terminal are included as project components and were assessed as part of the environment assessment.

Denison Mines

Wheeler River Project

Final Environmental Impact Statement

November 2024

Powering PEOPLE, PARTNERSHIPS AND PASSION.

Appendix 12-B

Wheeler River Project

Community Profile
Beauval, Saskatchewan

InterGroup
CONSULTANTS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

The community profile for the Northern Village of Beauval (Beauval), Saskatchewan has been developed as an initial step towards characterizing the socio-economic baseline in relation to the Wheeler River Project.

This community profile includes the following sections:

- **Introduction**, including research approach;
- **Community Context**, including location, history, governance, population, and demographics;
- **Infrastructure and Services**, including community facilities and services, utilities and public services, and housing and accommodations; and
- **Economy**, including discussions on labour force, education and training, income, and the local economy.

1.1 APPROACH

Secondary data sources were used to characterize the existing socio-economic environment of Beauval, Saskatchewan. Sources used for data collection include existing literature and databases from public sources such as:

- Statistical data sources (e.g., Statistics Canada);
- Federal and provincial government reports and data; and
- Online sources (e.g., community web pages and profiles, available literature, business web pages, news articles and profiles).

1.1.1 Data Limitations

Data presented in the report have some limitations which include:

Statistics Canada Data Limitations. While Statistics Canada data can provide a preliminary understanding of a community, they should be interpreted with caution because of issues of comparability across years, confidentiality, and data quality. For the following community profile 2016 Statistics Canada data is relied upon; however, there are instances where comparisons with 2006 and 2011 data are made. It is noted that in 2011 there was a shift in how the census was administered, with a National Household Survey replacing the long-form census. One of the key differences was a shift from a mandatory to an optional response requirement for citizens.

Statistics Canada also suppresses data for confidentiality or data quality. Data suppression for confidentiality reasons is meant to prevent the disclosure of data that could be used to identify individuals. It is often used for income characteristics in geographic areas where the population or private households do not meet a certain threshold. Data suppression due to data quality is done for a variety of reasons, including incompletely enumerated reserve parcels or Indian settlements or a global non-response rate of higher than or equal to 50%.

Secondary Research: Research was limited to the review of existing literature and databases from a variety of secondary sources.

2.0 COMMUNITY CONTEXT

2.1 OVERVIEW

Beauval is located in northwestern Saskatchewan, just west of Lac la Plonge and is approximately 8 km northeast on Highway 165 from its junction with Highway 155 (Figure 1). Beauval is referred to as "beautiful valley" as the community is situated on hills that overlook the Beaver River Valley. The river and surrounding lakes in the region offer renowned pickerel fishing and are known to have large numbers of trout and northern pike. For this reason, commercial fishing is a main industry in the area, in addition to eco-tourism, and mining (Cameco n.d.a). Just over half (58.5%) of the population of Beauval self-identify as Métis, with the remainder identifying as First Nations (17.9%), non-Aboriginal (4.6%), and multiple Aboriginal ancestry (3.9%) (Statistics Canada 2016)[1]. Roughly three-quarters (76.6%) of the Beauval population reported English as their mother tongue, with the remaining quarter consisting of Aboriginal languages including Cree (Statistics Canada 2016).

2.2 HISTORY

The community of Beauval was established in the early twentieth century as a Roman Catholic mission and transportation hub. Originally located in Île-à-la-Crosse, the Beauval Indian Residential School (1860-1995) relocated to the community of Beauval in 1906. Four years later, a trading store opened catering to local trappers, later developing into an outpost (Cameco n.d.a). The trading post was situated near the Churchill River trade route for use by the Hudson's Bay Company, to this day people canoe this trade route for the scenery and historical significance (Village of Beauval n.d.). In 1969, the residential school was transferred to the Canadian Government's control. The Federal Government worked in partnership with a Board of Directors comprised of Meadow Lake District Indian Band Chiefs to run the school. In the mid-1970s the control of the residential school was transferred again from the Federal Government to a First Nations parent group. In 1979, the school land became part of English River First Nation's La Plonge Indian Reserve. Six years later in 1985 the Meadow Lake Tribal Council took control of the Beauval Indian Residential School and amalgamated it with both the La Plonge High School and

[1] Although there has been a shift to use of the term Indigenous as opposed to Aboriginal, when describing Statistics Canada data terminology has been used as consistent with Statistics Canada definitions. Statistics Canada defines Aboriginal identity persons who are First Nations (North American Indian), Métis or Inuk (Inuit) and/or those who are Registered or Treaty Indians (that is registered under the Indian Act of Canada) and/or those who have membership in a First Nation or Indian band. Aboriginal peoples of Canada are defined in the Constitution Act 1982 section 35 (2) as including the Indian Inuit and Métis peoples of Canada.

Beauval Student Residence. The newly amalgamed school was named the Beauval Indian Education Centre, which ran for ten years prior to being demolished by former students in 1995 (Niessen 2017).

Figure 1: Communities in the Vicinity of the Wheeler River Project

2.3 GOVERNANCE

Beauval is governed by a mayor, deputy mayor, and three councillors who follow a four-year election cycle (Government of Saskatchewan Municipal Directory System 2020, Government of Saskatchewan n.d.). The elected officials and their appointment date can be seen in Table 1 below.

Table 1: Elected Officials Beauval, Saskatchewan

Title	Name	Appointment Date
Mayor	Nick Daigneault	2020
Deputy Mayor	Dawn Ewart	2020
Councillor	James Dennet	2020
Councillor	Rosaire Alcrow	2020
Councillor	Mervin Morin	2020

Source: Government of Saskatchewan Municipal Directory System 2020, Government of Saskatchewan n.d.)

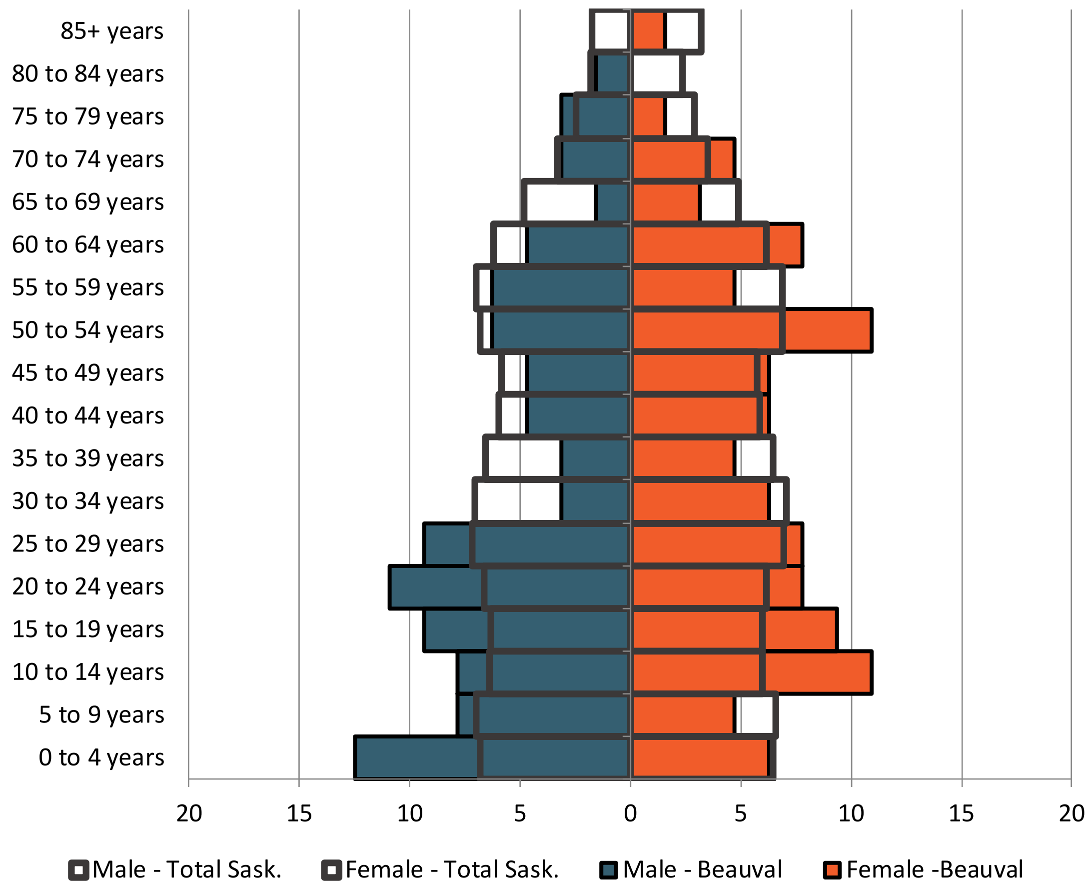
Beauval's Métis Local committee is part of the Métis Nation-Saskatchewan Northern Region III, which is one of twelve regions within Saskatchewan. Mervin Tex Bouvier is the regional director of the Northern Region III (Métis Nation-Saskatchewan n.d.). The Métis Local group works with Mayor and Council as well as other local groups to establish programs and events within the community (InterGroup Consultants Ltd., 2011).

2.4 BEAUVAL POPULATION

As of 2016, Statistics Canada reported that the population of Beauval was 640 which is a decrease in population from 756 residents in 2011 (Statistics Canada 2016; Statistics Canada 2011).

Figure 2 provides an illustration of the age and sex distribution for the population in 2016, compared to the age-sex structure for Saskatchewan as a whole. The population of Beauval tends to be younger in comparison to the province and the proportion of the Beauval population of working age and ages 65 and over is smaller than it is in Saskatchewan.

Figure 2: Age and Sex Distribution for Beauval and Saskatchewan (2016)



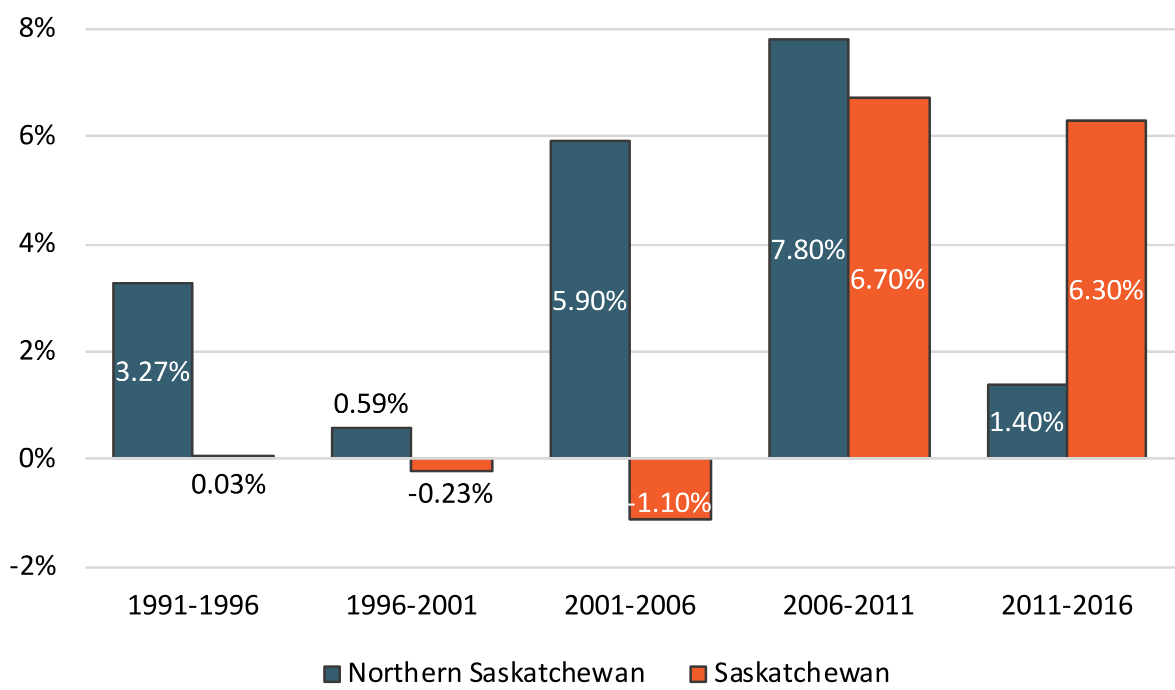
Source: Statistics Canada 2016.

Footnotes:
1. Population count does not include incompletely enumerated communities.

2.5 POPULATION GROWTH RATES OF NORTHERN SASKATCHEWAN AND SASKATCHEWAN

Figure 3 provides a comparison of population growth rates for northern Saskatchewan versus the province of Saskatchewan as a whole. Since 1991 northern Saskatchewan has experienced population growth on a constant basis, while the province of Saskatchewan experienced very little growth from 1991 to 1996, negative growth from 1996 to 2006 and only positive growth from 2006 to 2016.

Figure 3: Population Growth Rates Northern Saskatchewan and Saskatchewan



Source: Statistics Canada 1996, 2001, 2006, 2011, and 2016.

3.0 INFRASTRUCTURE AND SERVICES

This section describes the infrastructure and services available in Beauval. Topics include community facilities and services (including educational facilities, health facilities, social services, emergency services, recreational services, and transportation and access), utilities and public services, and housing and accommodations.

3.1 EDUCATIONAL FACILITIES

3.1.1 Childcare

Aboriginal HeadStart provides care for children aged three and four years of age, as well as provides support to parents (Village of Beauval n.d.). Childcare can also be accessed through the Beauval Childcare Centre Inc. located in the community (Yellowpages n.d.).

3.1.2 Primary and Secondary Education

Beauval has one school in the community, Valley View School, providing education for grades kindergarten to grade 12. The school has approximately 320 students and is equipped with computers and internet access for students. There are board-owned teacherages available for rent within the community of Beauval for teachers who work at Valley View School (Northern Lights School Division n.d.).

3.1.3 Post-secondary Education

There are several ways Beauval residents can access post-secondary education in northern Saskatchewan. The Gabriel Dumont Institute of Native Studies and Applied Research in Beauval provides Métis-specific education and employment in partnership with post-secondary institutions. The Institute offers education and career counselling to both adults with and without a high school diploma, as well as those looking for post-secondary education. Programs currently available to residents of Beauval include a month-long Heavy Equipment Operator course. (Gabriel Dumont Institute n.d.)

3.2 HEALTH FACILITIES AND SERVICES

Health services in Beauval can be accessed at the Beauval Health Centre run by Integrated Northern Health. The Health Centre is open Monday to Friday from 8am to 5pm, with a lunch time closure at noon. Services offered at the Beauval Health Centre include:

- Addiction services;
- Ambulance services;
- Dental Therapist;
- Diabetes education;
- Home care services;
- Mental health/Holistic health services (may include family support, suicide prevention, youth suicide services, addiction, National Native Alcohol and Drug Abuse Program (NNADAP) workers, mental health therapists);

- Nurse in Charge/Nurse Manager;
- Physician Services; and
- Public health (Immunization, public health services and programs, nutrition) (Saskatchewan Health Authority n.d.).

Integrated Northern Health is a partner of KidsFirst NORTH, a program offered in Beauval which helps parents gain important parenting skills and assists in supporting child development. Through the program families can access home visits as well as take part in community programming (Saskatchewan Health Authority, n.d.). The Growing Great Kids curriculum is the primary program which is delivered through home visits to off-reserve families who have enrolled during pregnancy or shortly after childbirth. The KidsFirst NORTH program includes:

- Screening and assessment;
- Prenatal case finding;
- Home visiting services;
- Mental health and addictions;
- Early learning; and
- Family support (KidsFirst NORTH n.d.).

3.3 SOCIAL SERVICES

The Health Centre provides social services to residents of Beauval including mental health and addiction services, and holistic health services (Saskatchewan Health Authority n.d.).

3.4 EMERGENCY SERVICES

Beauval has the following emergency services:

- **Fire services** are provided by a volunteer fire crew at a Fire Hall located within the community (FNMR - Northern Affairs Division 2012; Village of Beauval n.d.). A fire truck previously used at Cameco's Key Lake Mill was provided to the community after the truck was scheduled for replacement (Cameco n.d.b).
- **Policing services** are provided by the RCMP through a detachment in Beauval (FNMR – Northern Affairs Division 2012). In addition to regular policing services, this detachment provides:
    - Criminal records check;
    - Document verification;
    - Fingerprints;
    - General information;
    - Non-emergency complaints;
    - Report a crime; and
    - Vulnerable sector check (Royal Canadian Mounted Police 2015).

- **Ambulance services** are available within the community and provided by the Integrated Northern Health (Saskatchewan Health Authority n.d.).

3.5 RECREATION SERVICES

The community arena, Charles Gauthier Memorial Arena, provided recreational opportunities to Beauval residents before burning down in 2011 (CBC News 2011). The community presently has the Beauval Curling Rink, which has two curling rinks for residents to use. Other opportunities for recreation include:

- Ball diamonds;
- Running track;
- Gymnasium;
- Playgrounds;
- River Edge Park (camping, picnics);
- Trails (biking, skiing, and jogging); and
- Sports Ground (FNMR – Northern Affairs Division 2012).

3.6 TRANSPORTATION AND ACCESS

Highway 165 is maintained by Saskatchewan Highways and Infrastructure and is the only access road into the community of Beauval (Saskatchewan Ministry of Highways and Infrastructure n.d.). Internal roads within the community are either gravel or paved. The Beauval airport is located just southeast of the community. The airport has two narrow gravel runways with lighting at both ends which allow for access both during the day and evening (Nav Canada 2020).

3.7 UTILITIES AND PUBLIC SERVICES

The community has the following municipal services:

- Water treatment station and distribution; and
- Sewage collection.

Saskatchewan Telecommunications provides the community with telephone services, and electricity is supplied by Saskatchewan Power Corporation. High speed internet and cellular services are also available to residents.

3.8 HOUSING

Statistics Canada has several important indicators that help provide an understanding of the state of housing in communities. Taken together, the total number of homes and the total population in the communities on Census Day 2016 can provide a glimpse into the average number of residents living in each home.

Table 2 presents the housing characteristics for Beauval, northern Saskatchewan, and Saskatchewan according to the 2016 Census of Canada. In 2016, Beauval had 293 occupied private dwellings. Beauval had a higher number of average rooms per dwelling (6.5) in comparison to northern Saskatchewan (5.6), but less than Saskatchewan as a whole (6.7). The village had a lower average number of persons per household (3.1) than northern Saskatchewan (3.6), but higher than Saskatchewan as a whole (2.5). The percentage of households requiring major repairs in Beauval (8.53%) was nearly one third of the rate of northern Saskatchewan (30.73%) but similar to that of the province of Saskatchewan (8.67%).

Table 2: Housing Characteristics for Beauval, Northern Saskatchewan, and Saskatchewan (2016)

	Beauval[1]	Northern Saskatchewan[1,2]	Saskatchewan[1]
Total Number of Occupied Private Dwellings[3]	293	10,235	432,620
Average Number of Rooms per Dwelling	6.5	5.6	6.7
Average Number of Persons per Household	3.1	3.6	2.5
Households Requiring Major Repairs[4]	8.53%	30.73%	8.67%

Source: Statistics Canada 2016.

Footnotes:
1. Data has been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5, and in some cases 10. Columns may not add up due to rounding.
2. Northern Saskatchewan is defined as Census Division No.18.
3. 'Private dwelling' refers to a separate set of living quarters with a private entrance either from outside the building or from a common hall, lobby, vestibule, or stairway inside the building. The entrance to the dwelling must be one that can be used without passing through the living quarters of some other person or group of persons.
4. Major repairs include defective plumbing or electrical wiring, and structural repairs to walls, floors or ceilings.

4.0 ECONOMY

This section describes the economic environment for Beauval, as well as northern Saskatchewan and Saskatchewan for comparison. It presents labour force characteristics, education and training, income, employment, information on economic development, and local businesses.

4.1 LABOUR FORCE CHARACTERISTICS

The labour force includes persons over the age of fifteen years old during the period of the census who can contribute to the economy within a population. This statistic is usually described as a percentage and conveys the proportion of the population that the economy is dependent on.

Key indicators of labour force are:

- **Participation Rate:** the labour force participation rate reflects the number of people who are interested in participating in the workforce (population 15 years and over). This indicator is typically in conjunction with employment rates as it accounts for those people who may not be working (e.g., students, homemakers, institutionalized people).
- **Employment Rate:** reflects the proportion of the total population (aged 15 years and over) that was working Sunday, May 1 to Saturday, May 7, 2016.
- **Unemployment Rate:** accounts for the proportion of the total population (population in the labour force) that was not working Sunday, May 1 to Saturday, May 7, 2016.

4.1.1 Beauval Labour Force Characteristics

In 2016, Statistics Canada reported that 410 Beauval residents were eligible to participate in the labour force (i.e., individuals aged 15 years and over) of whom 210 were males and 195 were female (Table 3). The participation rate for residents was 57.3%, with a lower participation rate for female residents (56.4%) than male residents (61.9%). The overall participation rate for residents of Beauval was about 8.5% higher than the participation rates in northern Saskatchewan (48.8%) and 11% lower than the province of Saskatchewan (68.3%).

Approximately 45.1% of people ages 15 years and older living in Beauval were employed in 2016, compared to a lower employment rate in northern Saskatchewan (37.2%) and a higher employment rate in Saskatchewan (63.5%) as a whole. In 2016, Beauval residents had lower employment rates for female residents (43.6%) than male residents (50%). In comparison, the employment rates were similar for male (37.0%) and female (37.5%) residents of northern Saskatchewan. Saskatchewan had higher employment rates for males (67.5%) than females (59.5%).

The unemployment rate for Beauval in 2016 was 19.1%, which was lower than the unemployment rate in northern Saskatchewan (23.8%) and greater than the provincial average (7.1%). In 2016, male residents had a lower unemployment rate (19.2%) compared to female residents (22.7%). In contrast in northern Saskatchewan and Saskatchewan as a whole, male residents had a higher unemployment rate than female residents.

Table 3: Labour Force Characteristics for Beauval, Northern Saskatchewan, and Saskatchewan (2016)

	Beauval[1]			Northern Saskatchewan [1,2]			Saskatchewan[1]		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
Total Population 15 Years and Over by Labour Force Activity	410	210	195	25,295	12,610	12,685	857,295	424,260	433,035
In the Labour Force[3]	235	130	110	12,355	6,540	5,815	585,540	311,110	274,430
Employed[4]	185	105	85	9,420	4,660	4,755	544,095	286,330	257,760
Unemployed[5]	45	25	25	2,935	1,875	1,060	41,445	24,775	16,665
Not in the Labour Force[6]	175	85	90	12,940	6,070	6,870	271,760	113,155	158,605
Participation Rate[7]	57.3%	61.9%	56.4%	48.8%	51.9%	45.8%	68.3%	73.3%	63.4%
Employment Rate[8]	45.1%	50.0%	43.6%	37.2%	37.0%	37.5%	63.5%	67.5%	59.5%
Unemployment Rate[9]	19.1%	19.2%	22.7%	23.8%	28.7%	18.2%	7.1%	8.0%	6.1%

Source: Statistics Canada 2016.

Footnotes:

1. Data has been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5, and in some cases, 10. Columns may not add up due to rounding.
2. North Saskatchewan is defined as Census Division No.18.
3. "Labour Force" refers to persons who, during the week of Sunday, May 1 to Saturday, May 7, 2016, were either employed or unemployed and reported for populations aged 15 years and over in private households." (Source: 2016 Census Dictionary).

4. "Employed" refers to persons 15 years and over, excluding institutional residents who, during the week prior to Census Day: "(a) Did any work at all at a job or business, that is, paid work in the context of an employer-employee relationship, or self-employment. This also includes persons who did unpaid family work, which is defined as unpaid work contributing directly to the operation of a farm, business or professional practice owned and operated by a related member of the same household; or (b) Had a job but were not at work due to factors such as their own illness or disability, personal or family responsibilities, vacation or a labour dispute. This category excludes persons not at work because they were on layoff or between casual jobs, and those who did not then have a job (even if they had a job to start at a future date)." (Source: 2016 Census Dictionary).
5. "Unemployed" refers to persons who, during the week of Sunday May 1 to Saturday May 7 2016, were without paid work or without self-employment work and were available for work and either: a) had actively looked for paid work in the past four weeks; or b) were on temporary lay-off and expected to return to their job; or c) had definite arrangements to start a new job in four weeks or less." (Source: 2016 Census Dictionary).
6. "Not in the labour force" refers to persons who, during the week of Sunday May 1 to Saturday May 7, 2016, were neither employed nor unemployed. It includes students, homemakers, retired workers, seasonal workers in an 'off' season who were not looking for work, and persons who could not work because of a long-term illness or disability." (Source: 2016 Census Dictionary).
7. The "Participation Rate" refers to the number of people in the labour force in the week of Sunday May 1 to Saturday May 7, 2016, as a percentage of the population 15 years and over. (Source: 2016 Census Dictionary).
8. The "Employment Rate" refers to the number of people employed in the week of Sunday May 1 to Saturday May 7, 2016 as a percentage of the total population 15 years and over. (Source: 2016 Census Dictionary).
9. The "Unemployment Rate" refers to the number of people unemployed in the week of Sunday May 1 to Saturday May 7, 2016 expressed as a percentage of the population in the labour force. (Source: 2016 Census Dictionary).

4.2 EDUCATIONAL ATTAINMENT

This section describes rates of educational attainment for the community.

Table 4 provides the distribution of the highest level of education attained by Beauval residents compared to northern Saskatchewan and the province for 2016. Nearly one-third (29.3%) of the Beauval population 15 years and older had less than a high school certificate, which was lower than northern Saskatchewan (50.9%), but higher than the province as a whole (20.7%). The difference may partially reflect the younger demographics of the population in Beauval and northern Saskatchewan as compared to the province (Statistics Canada 2016). Male residents (32.6%) are more likely to have less than a high school certificate when compared to female residents (20.5%). This trend is similar to both northern Saskatchewan and Saskatchewan as a whole where male residents are more likely to not have the equivalent of a high school diploma.

Beauval had higher attainment rates for an apprenticeship, trades certificate or diploma (12.2%) than northern Saskatchewan (8.2%) and the province (10.4%). In Beauval, those who had completed this level of education saw males as the majority (18.6%) in comparison to females (5.1%).

Beauval residents had a higher completion rate for a post-secondary non-university certificate or degree (17.1%) than northern Saskatchewan (11.1%), and the same rate as Saskatchewan (17.1%). Beauval males (14%) had lower attainment rates than females (23.1%) for post-secondary non-university certificates or diplomas. This trend is seen across northern Saskatchewan and Saskatchewan. Statistics Canada tracks post-secondary certification or degree through:

- Apprenticeship or Trades Certificate or Diploma;
- Post-Secondary Non-University Certificate or Diploma;
- University Certificate or Diploma below the Bachelor’s Level; and
- University Degree.

Beauval residents had a higher completion rate for a university degree (11%) than northern Saskatchewan (7.4%), but lower than the province as a whole (18%). The trend throughout northern Saskatchewan and Saskatchewan is for more females to complete a university degree than males.

Table 4: Level of Educational Attainment for Beauval, Northern Saskatchewan, and Saskatchewan (2016)

	Beauval[1,2]			Northern Saskatchewan[1,2,3]			Saskatchewan[1,2]		
	Total	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**
Total Population 15 and Over by Highest Certificate, Diploma or Degree[4]	410	215	195	25,295	12,605	12,690	857,295	424,265	433,035
Less than High School Certificate	120 29.3%	70 32.6%	40 20.5%	12,865 50.9%	6,945 55.1%	5,920 46.7%	177,210 20.7%	96,680 22.8%	80,530 18.6%
High School Certificate or Equivalent[5]	115 28.0%	55 25.6%	60 30.8%	5,195 20.5%	2,250 17.9%	2,955 23.3%	261,210 30.5%	133,730 31.5%	127,480 29.4%
Apprenticeship or Trades Certificate or Diploma	50 12.2%	40 18.6%	10 5.1%	2,080 8.2%	1,495 11.9%	585 4.6%	89,440 10.4%	64,100 15.1%	25,340 5.9%
Post-Secondary Non-University Certificate or Diploma[6]	70 17.1%	30 14.0%	45 23.1%	2,810 11.1%	1,180 9.4%	1,630 12.8%	146,770 17.1%	51,240 12.1%	95,530 22.1%
University Certificate or Diploma Below the Bachelor's Level	0 0.0%	10 4.7%	10 5.1%	475 1.9%	110 0.9%	365 2.9%	28,195 3.3%	10,790 2.5%	17,405 4.0%
University Degree	45 11.0%	0 0.0%	40 20.5%	1,865 7.4%	630 5.0%	1,230 9.7%	154,480 18.0%	67,730 16.0%	86,745 20.0%

Source: Statistics Canada 2016.

Footnotes:
1. Statistics Canada data has been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5 and in some cases, 10. Columns may not add up due to rounding.

2. Educational attainment data for 2016 were derived from 30% data. However, on Indian reserves and in remote communities, Statistics Canada attempts to obtain data from 100% of the population.
3. Northern Saskatchewan is defined as Census Division No. 18.
4. "Highest certificate, diploma or degree" refers to the highest certificate, diploma or degree the individual has completed based primarily on time spent" in-class." For high school graduates, a university education is considered to be a higher level of education than a college diploma, while a college education is considered to be a higher level of education than a trade. Although some trades requirements may take as long or longer to complete than a given college or university program, the majority of time acquiring trade certification may be on-the-job, as opposed to being in a classroom.
5. "High school certificate or equivalent" includes persons who have graduated from a secondary school or equivalent. Excludes persons with a postsecondary certificate, diploma or degree.
6. "Postsecondary non-university certificate or diploma" includes non-degree-granting institutions such as community colleges, CEGEPs, private business colleges and technical institutes.

4.3 INCOME

Income determines the standard of living (e.g., quantity and quality of goods and services) available to individuals and households. Two indicators are provided in this section to better understand the incomes currently available for the residents for Beauval, northern Saskatchewan, and in Saskatchewan. Indicators provided by Statistics Canada include:

- Distribution of income by individuals and households; and
- Income sources, showing the distributions among employment, government payments and interest, and other investments for each community.

4.3.1 Income Levels

Table 5 presents the average personal employment income of the population aged 15 and older for Beauval, northern Saskatchewan, and Saskatchewan in 2015. Average personal income ($63,517) was higher than northern Saskatchewan ($57,985) and lower than the province of Saskatchewan ($64,855). In 2016, male residents in Beauval reporting income (n=210) earned on average $67,432, while females reporting income (n=230) earned on average $60,207. The gap between average income in Beauval was over $7,000 between females and males in 2016. This same trend is seen in northern Saskatchewan and Saskatchewan; however, Beauval had a smaller gap between male and female average salaries.

The Saskatchewan Low Income Tax Credit has a threshold of $32,643[2] (Government of Canada 2019). In 2015, 50% of the population of Beauval, 62% of individuals in northern Saskatchewan, and 40% of individuals in Saskatchewan had less than $30,000 in income. Female residents of Beauval (49%) were more likely to report less than $30,000 than males (47%), which is a trend that is also seen in northern Saskatchewan and Saskatchewan. In 2015, approximately 24% of Beauval residents, 14% of individuals in northern Saskatchewan, and 22% of individuals in Saskatchewan earned an income of $70,000 or greater.

[2] The Saskatchewan low-income tax credit is a tax-free amount paid to help Saskatchewan residents with low and modest incomes. For July 2018 and June 2019, the program provides a tax-free amount to individuals and families. The credit starts to be reduced when the adjusted family net income is more than $32,643.

Table 5: Distribution of Personal Income for Beauval, Northern Saskatchewan, and Saskatchewan (2015)

	Beauval[1,2,3]			Northern Saskatchewan[1,2,3,4]			Saskatchewan[1,2,3]		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
Average Employment Income for Full-Year Full-Time Workers	$63,517	$67,432	$60,207	$57,985	$64,790	$51,411	$64,855	$72,366	$54,808
Total Number of Private Households with Income	440	210	230	22695	11215	11485	822620	407715	415015
Under $10,000	80 18%	40 19%	40 17%	7080 31%	4025 36%	3055 27%	105780 13%	47325 12%	58455 14%
$10,000 to $19,999	75 17%	30 14%	40 17%	4305 19%	1750 16%	2550 22%	118380 14%	46195 11%	72180 17%
$20,000 to $29,999	65 15%	30 14%	35 15%	2830 12%	1145 10%	1690 15%	107890 13%	42345 10%	65545 16%
$30,000 to $39,999	45 10%	15 7%	30 13%	2120 9%	860 8%	1265 11%	95605 12%	41315 10%	54295 13%
$40,000 to $49,999	30 7%	10 5%	15 7%	1520 7%	645 6%	870 8%	89285 11%	42260 10%	47025 11%
$50,000 to $59,999	15 3%	10 5%	10 4%	1060 5%	485 4%	575 5%	70395 9%	36950 9%	33450 8%
$60,000 to $69,999	15 3%	5 2%	15 7%	790 3%	440 4%	355 3%	53855 7%	31055 8%	22795 5%
$70,000 to $79,999	25 6%	15 7%	10 4%	650 3%	345 3%	305 3%	41930 5%	25290 6%	16645 4%
$80,000 to $99,999	30 7%	10 5%	20 9%	1070 5%	590 5%	485 4%	60470 7%	36850 9%	23620 6%
$100,000 and over	50 11%	40 19%	15 7%	1270 6%	935 8%	335 3%	79030 10%	58125 14%	20905 5%

Source: Statistics Canada 2016.

Footnotes:

1. Data has been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5, and in some cases 10. Columns may not add up due to rounding.
2. Income variables do not account for inflation.
3. Personal income variables were derived from 20% sample data. However, on Indian Reserves and in remote communities, attempts are made to obtain data from 100% of the population.
4. Northern Saskatchewan is defined as Census Division No. 18.
5. Income refers to Total Income (i.e. personal income). Total income is the total money income received during the calendar year prior to the Census year. Sources of income are: wages and salaries, net farm income; net non-farm income from unincorporated business and/or professional practice; child benefits; Old Age Security pension and Guaranteed Income Supplement; benefits from Canada Pension Plan or Quebec Pension Plan; benefits from Employment Insurance; other income from government sources; dividends, interest on bonds, deposits and savings certificates and other investment income; retirement pensions, superannuation and annuities, including those from RRSPs and RRIFs; and other money income. Not included in all Census years as total income: income tax refunds, lump sum inheritance payments, gambling revenue, lump sum insurance policy settlements, capital gains or losses, receipts from the sale of property or belongings, loan repayments, property tax rebates or refunds of pension contributions.
6. The 2015 data sets group $80,000 to $99,999 as $80,000 to $89,999 and $90,000 to $99,999. These categories have been collapsed in the table.

Table 6 shows the distribution of household income for Beauval, northern Saskatchewan, and Saskatchewan for 2015. The average household income (2015) for Beauval residents $98,027, which is higher than northern Saskatchewan ($71,111) and Saskatchewan ($93,942) (Statistics Canada 2016). A lower proportion (18%) of households in Beauval had incomes of $30,000 or less than in northern Saskatchewan (29%), and a comparable rate to the province as a whole (17%). In 2015, approximately 54% of Beauval households, 28% of households in northern Saskatchewan, and 36% of households in Saskatchewan earned income in higher income brackets of $70,000 or greater.

Table 6: Distribution of Household Income for Beauval, Northern Saskatchewan, and Saskatchewan (2015)

	Beauval[1,2,3]	Northern Saskatchewan[1,2,3,4]	Saskatchewan[1,2,3]
Average Household Employment Income before Taxes in 2015 for Full-Year Full-Time Workers	$98,027	$71,111	$93,942
Total Number of Private Households with Income[5,6]	200	10,235	432,625
Under $5,000	0 0%	445 4%	6,930 2%
$5,000 to $9,999	0 0%	325 3%	4,575 1%
$10,000 to $14,999	10 5%	405 4%	7,675 2%
$15,000 to $19,999	10 5%	715 7%	18,025 4%
$20,000 to $29,999	15 8%	1,135 11%	33,720 8%
$30,000 to $39,999	25 13%	1,025 10%	35,110 8%
$40,000 to $49,999	10 5%	830 8%	33,870 8%
$50,000 to $59,999	5 3%	725 7%	31,595 7%
$60,000 to $69,999	20 10%	610 6%	29,700 7%
$70,000 to $79,999	5 3%	545 5%	27,605 6%
$80,000 to $89,999	5 3%	490 5%	25,810 6%
$90,000 to $99,999	15 8%	420 4%	23,280 5%
$100,000 to $124,999	20 10%	865 8%	48,375 11%
$125,000 to $149,999[7]	20 10%	605 6%	35,320 8%
$150,000 and over	40 20%	1,100 11%	71,035 16%

Source: Statistics Canada 2016.

Footnotes:
1. Data has been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5, and in some cases 10. Columns may not add up due to rounding.
2. Income variables do not account for inflation.

3. Household income variables were derived from 20% sample data. However, on Indian Reserves and in remote communities, attempts are made to obtain data from 100% of the population.
4. Northern Saskatchewan is defined as Census Division No. 18.
5. Income refers to Total Income (i.e. household income). Total income is the total money income received during the calendar year prior to the Census year. Sources of income are: wages and salaries, net farm income; net non-farm income from unincorporated business and/or professional practice; child benefits; Old Age Security pension and Guaranteed Income Supplement; benefits from Canada Pension Plan or Quebec Pension Plan; benefits from Employment Insurance; other income from government sources; dividends, interest on bonds, deposits and savings certificates and other investment income; retirement pensions, superannuation and annuities, including those from RRSPs and RRIFs; and other money income. Not included in all Census years as total income: income tax refunds, lump sum inheritance payments, gambling revenue, lump sum insurance policy settlements, capital gains or losses, receipts from the sale of property or belongings, loan repayments, property tax rebates or refunds of pension contributions.
6. Private household refers to a person or a group of persons (other than foreign residents) who occupy the same dwelling and do not have a usual place of residence elsewhere in Canada. It may consist of a family group (census family) with or without other persons, of two or more families sharing a dwelling, of a group of unrelated persons, or of one person living alone. Household members who are temporarily absent on Census Day (e.g., temporary residents elsewhere) are considered as part of their usual household. For census purposes, every person is a member of one and only one household. Unless otherwise specified, all data in household reports are for private households only.
7. Data sets grouped include: $20,000 to $29,999 as $20,000 to $24,999 and $25,000 to $29,999. These categories have been collapsed in the table; $30,000 to $39,999 as $30,000 to $34,999 and $35,000 to $39,999. These categories have been collapsed in the table; $40,000 to $49,999 as $40,000 to $44,999 and $45,000 to $49,999. These categories have been collapsed in the table; $150,000 and over as $150,000 to $199,999 and $200,000 and over. These categories have been collapsed in the table.

4.3.2 Beauval Sources of Income

Statistics Canada tracks three general categories or sources of income: employment and self-employment income, government payments, and interest and other investment income.

Table 7 illustrates that the percentage of income for the population of Beauval (80.7%) from employment income is higher than that of residents of northern Saskatchewan (72.0%) and Saskatchewan (73.2%). A higher percentage of males (85.2%) had employment income than females (75.4%), which reflected trends in northern Saskatchewan and Saskatchewan as a whole. The percentage of income from Government Transfer payments in Beauval (15.6%) was lower than northern Saskatchewan (21.8%), both were higher than that of the province as a whole (10.5%).

Table 7: Sources of Income for Beauval, Northern Saskatchewan, and Saskatchewan (2015)

	Beauval[1,2,3]			Northern Saskatchewan[1,2,3,4]			Saskatchewan[1,2,3]		
	Total	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**
Employment Income (%)[5]	80.7	85.2	75.4	72.0	78.8	64.2	73.2	76.8	68.0
Government Transfer Payments (%)[6]	15.6	10.3	21.7	21.8	14.4	30.0	10.5	7.2	15.2
Other (%)[7]	3.7	4.5	2.9	*6.2*	6.8	5.8	16.3	16.0	16.8

Source: Statistics Canada 2016.

Footnotes:
1. Sources of income variables for the Census were derived from 20% sample data. However, on Indian reserves and in remote communities, attempts are made to obtain data from 100% of the population.
2. Data has been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5, and in some cases 10. Columns may not add up due to rounding.
3. Sources of income of a population group or a geographic area, refers to the relative share of each income source or group of sources, expressed as a percentage of the aggregate total income of that group or area. Percentages may not add up to 100% due to rounding.
4. Northern Saskatchewan is defined as Census Division No. 18.
5. Employment Income include all income received as wages, salaries and commissions from paid employment and net self-employment income from farm or non-farm unincorporated business and/or professional practice during the reference period.
6. Government transfer include all cash benefits received from federal, provincial, territorial or municipal governments during the reference period. It includes (1) Old Age Security pension, Guaranteed Income Supplement, Allowance or Allowance for the Survivor; (2) Retirement, disability, and survivor benefits from Canada Pension Plan and Quebec Pension Plan; (3) benefits from Employment Insurance and Quebec parental insurance plan, (4) Child benefits from federal and provincial programs; (5) social assistance benefits; (6) workers' compensation benefits; (7) working income tax benefit; (8) goods and services tax credit and harmonized sales tax credit; and (9) other income from government sources. For the 2016 Census, the reference period is the calendar year 2015 for all income variables.

7. Other income sources include severance pay and retirement allowances, alimony, child support, periodic support from other persons not in the household, income from abroad (excluding interest and dividends), non-refundable scholarships, bursaries, fellowships and study grants, and artists' project grants. Other income was calculated as a total (100%) minus employment income (%) and government transfer payments (%).

4.4 LOCAL ECONOMY

This section describes employment by sector, economic development, and local business for Beauval, Saskatchewan.

4.4.1 Local Business

Table 8 displays the local businesses within Beauval which support the local economy.

Table 8: Local Businesses in Beauval

Business	Description
Amyott Inn	Inn
Amy's Bar and Motel	Bar and hotel
Angler's Trail Resort	Fishing camp outfitters, family recreation, beach, convenience store, restaurant and boat rental
Beauval Health Centre	Health services
Beauval Development Inc.	Municipal economic development
Beauval General Store	Travel Center, gas, restaurant, and general store
Beauval Marine and Small Engine Repair	Boats, snowmobile, and ATV repairs, mechanical services, shrink wrap boats, boat storage, Kimpex dealer, marine oil and parts available
Beauval Taxi	Taxi service
Blueberry Hills Natural Spring Water	Spring water bottling business
Butt and Top Construction	Forestry Construction, roads, housing, renovations, water and sewer logging, brush clearing
English River Travel Centre	Travel agent
GDI Training and Employment	Career counselling, education, training, student support and job placement
Keeley Lake Lodge 1989	Hunting Lodge
MDeez Confectionary and Gas Bar Ltd.	Confectionary, gas, and post office

Business	Description
Northern Enterprise Fund	Loans for northern businesses and projects
Northern Store	Grocery, general merchandise, and financial services
Pine Ridge Bible Camp	Seasonal religious service
Pineridge Ford	Car dealership
Polar Oils Ltd.	Bulk oil dealer
Primrose Lake Economic Development Corporation	Economic development assistance and business, loans, and scholarships
Sandy Beach Resort	Resort
SIIT Industrial Career Centre	Career services, technical training, job coaching, driver license training, career planning, academic upgrading, career counselling, safety training (CSTC), and apprenticeship indenturing
Sipisishk Communications Inc. (CIPI 96.5 FM)	Radio station

Source: Village of Beauval Saskatchewan n.d.

4.4.2 Beauval Employment by Sector

Table 9 outlines employment by sector Beauval compared to residents of northern Saskatchewan and Saskatchewan. The data indicates that the key sectors for employment are educational services (26%), mining, quarrying, and oil and gas extractions (13%), and retail trade (11%). For northern Saskatchewan, key sectors for employment are education (18%), health care and assistance (15%) and public administration (14%). For the province as a whole, health care and social assistance (13%); retail (11%); and agriculture, forestry, fishing, and hunting (9%) were the key sectors for employment.

Data indicates males and females within the village of Beauval are employed in different industries. Key industrial sectors for the employment of males include mining, quarrying, and oil and gas extractions (24%) and retail trade (16%). Key industrial sectors for employment for females include educational services (41%) and health care and social assistance (14%).

Table 9: Employment by Sector for Beauval, Northern Saskatchewan, and Saskatchewan (2016)

	Beauval[1]			Northern Saskatchewan[1,2]			Saskatchewan[1]		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
Total Labour Force population aged 15 years and over by industry[3]	235	125	110	12,355	6,540	5,815	585,540	311,110	274,430
Industry – not applicable[4]	20	-	20	1,565	910	660	10,225	5,205	5,020
All industry categories[5]	215	125	85	10,790	5,635	5,155	575310	305905	269410
Agriculture; forestry; fishing and hunting	15	15	0	240	220	20	51,255	36,820	14,440
Mining; quarrying; and oil and gas extraction	30	30	0	1,165	1,025	145	23,070	20,040	3,025
Utilities	0	0	0	95	80	15	5,395	3,780	1,610
Construction	0	0	0	800	735	70	49,310	43,460	5,850
Manufacturing	0	10	0	150	120	30	26,710	21,000	5,710
Wholesale Trade	0	0	10	105	70	35	20,480	15,325	5,155
Retail Trade	25	20	10	1,015	455	555	63,360	30,185	33,180
Transportation and Warehousing	15	10	0	445	325	120	24,755	19,385	5,370

	Beauval[1]			Northern Saskatchewan[1,2]			Saskatchewan[1]		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
Information and Cultural Industries	0	0	0	90	45	45	10,005	5,055	4,950
Finance and Insurance	0	0	0	95	20	75	20,155	6,495	13,655
Real Estate and Rental Leasing	0	0	0	90	65	25	7,650	4,425	3,220
Professional; Scientific and Technical Services	0	0	0	165	70	95	25,250	12,985	12,265
Management of Companies and Enterprises	0	0	0	10	10	0	1,340	680	660
Admin. and Support; Waste Mgmt and Remediation	10	10	0	310	165	145	16,395	9,660	6,735
Educational Services	60	15	45	1,895	530	1,365	45,360	13,670	31,690
Health Care and Social Assistance	20	0	15	1,660	290	1,370	72,625	11,285	61,335
Arts; Entertainment and Recreation	0	0	0	100	55	45	10,545	5,120	5,425
Accommodation and Food Services	10	10	0	585	270	310	37,785	14,295	23,490
Other Services (Except Public Administration)	0	10	0	250	135	115	25,680	12,590	13,090
Public Administration	20	15	10	1,520	955	570	38,180	19,640	18,535

Source: Statistics Canada 2016.

Footnotes:

1. Data has been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5, and in some cases 10. Columns may not add up due to rounding.
2. Northern Saskatchewan refers to Census Division No. 18.
3. Includes the experienced labour force which refers to persons aged 15 years and over who during the Census were employed and the unemployed who had last worked for pay or in self employment prior to the Census.
4. Includes unemployed persons aged 15 years and over who have never worked for pay or in self-employment or who had last worked prior to January 1, 2015.
5. Refers to the general nature of the business carried out in the establishment where the person worked. The data are produced according to the North American Industry Classification System (NAICS) 2012 with 25% sample data.

4.4.3 Beauval Economic Development

Beauval Development Inc. (BDI) seeks economic development opportunities for the community of Beauval. Beauval Development Inc supports both local development projects and provides support to local entrepreneurs. After their incorporation in 2014, their initial investment was an office rental space called Sister Simard Center. The same year, BDI purchased their first business, Blueberry Hills Water Bottling. Their newly acquired water bottling company became their first business operation (Beauval Development Inc. n.d.). The following year, BDI along with Primrose Lake Economic Development Corporation and the Clarence Campeau Development Foundation began work on a $2.3 million-dollar office and gymnasium complex. Established in 2016, the complex has several tenants including the Northern Village of Beauval Administration office, the Gabriel Dumont Institute, Saskatchewan Government Insurance, and BDI Kitchen and Catering (Beauval Development Inc. n.d.).

5.0 REFERENCES

Cameco. (n.d.a). Community Profiles – Beauval. https://www.cameconorth.com/community/community-profiles/beauval [Accessed April 9, 2021].

Cameco. (n.d.b). Key Lake Fire Truck Finds News Life in Beauval. https://www.cameconorth.com/community/stories/key-lake-fire-truck-finds-new-life-in-beauval [Accessed April 30, 2021].

Gabriel Dumont Institute of Native Studies and Applied Research (n.d.). Programs and courses. https://gdins.org/programs-and-courses/what-we-offer/ [Accessed April 7, 2021].

Government of Canada (2020). Child and family benefits, Province of Saskatchewan. https://www.canada.ca/en/revenue-agency/services/child-family-benefits/provincial-territorial-programs/province-saskatchewan.html [Accessed April 7, 2021].

Government of Saskatchewan (n.d.). Municipal Election Dates and Workshops. https://www.saskatchewan.ca/government/municipal-administration/elections/municipal-election-dates-and-workshops [Accessed May 21, 2021].

Government of Saskatchewan (2020). Municipal Directory System. http://www.mds.gov.sk.ca/apps/Pub/MDS/muniDetails.aspx?cat=5&mun=2603 [Accessed April 7, 2021].

KidsFirst NORTH (n.d.). Home. https://www.kidsfirstnorth.com/ [Accessed April 7, 2021].

Métis Nation-Saskatchewan (n.d.) Executive, Regional Directors & Ministers. https://metisnationsk.com/governance/#regions [Accessed April 7, 2021].

Nav Canada (2020). Canada Flight Supplement. https://www.navcanada.ca/en/ecfs_03_en.pdf [Accessed June 8, 2021].

Niessen, Shauna. 2017. Shattering the Silence: The Hidden History of Indian Residential Schools in Saskatchewan. https://www2.uregina.ca/education/saskindianresidentialschools/beauval-indian-residential-school/ [Accessed April 9, 2021].

Northern Business Directory (2021). https://www.northernbusinessdirectory.ca/reports/directory.pdf [Accessed April 7, 2021].

Northern Lights School Division No. 113 (n.d.). Beauval. https://www.nlsd113.ca/apps/pages/index.jsp?uREC_ID=1067796&type=d&pREC_ID=1358306 [Accessed April 7, 2021].

Northern Saskatchewan Health Services (n.d.). Beauval Health Centre. http://ehealth-north.sk.ca/facility.aspx?m=4&facility=248 [Accessed April 7, 2021].

Royal Canadian Mounted Police (2015). Beauval Detachment. https://www.rcmp-grc.gc.ca/detach/en/d/264 [Accessed April 30, 2021].

Saskatchewan Health Authority (n.d.-a). KidsFirst NORTH. http://www.mcrhealth.ca/programs_services/kids_first_north.html [Accessed April 7, 2021].

Yellow Pages (n.d.). Beauval Childcare Centre Inc. https://www.yellowpages.ca/bus/Saskatchewan/Beauval/Beauval-Childcare-Centre-Inc/100181632.html [Accessed June 4, 2021].

Statistics Canada. (2011). Census Profile, Beauval, Northern Village. Released November 29, 2017. https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/Page.cfm?Lang=E&Geo1=CSD&Code1=4718033&Geo2=PR&Code2=24&Data=Count&SearchText=La&SearchType=Begins&SearchPR=01&B1=All [Accessed March 3, 2020].

Statistics Canada. (2016). Census Profile, Beauval, Northern Village. Released November 29, 2017. https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/Page.cfm?Lang=E&Geo1=CSD&Code1=4718033&Geo2=PR&Code2=24&Data=Count&SearchText=La&SearchType=Begins&SearchPR=01&B1=All [Accessed April 7, 2021].

Statistics Canada. (2016). Division No. 18. Ottawa. Released November 29, 2017. https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/page.cfm?Lang=E&Geo1=CD&Code1=4718&Geo2=CSD&Code2=4718090&Data=Count&SearchText=Division%20No.%2018&SearchType=Begins&SearchPR=01&B1=All [Accessed April 7, 2021].

Village of Beauval. (n.d.). Visiting. http://www.villageofbeauval.ca/main.aspx?CategoryCode=47615773-CD0B-4668-8B13-398E20D842A1 [Accessed April 9, 2021].

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Wheeler River Project

Community Profile

English River First Nation and Patuanak

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

The community profile for English River First Nation (ERFN), Saskatchewan has been developed as an initial step towards characterizing the socio-economic baseline in relation to The Wheeler River Project. The community profile also includes details for the northern hamlet of Patuanak, which is closely tied to ERFN's main reserve Wapachewunak 192D.

This community profile includes the following sections:

- **Introductio**n, including research approach;
- **Community Overview**, including location, history, governance, population, and demographics;
- **Infrastructure and Services**, including community facilities and services, utilities and public services, and housing and accommodations; and
- **Economy**, including discussions on labour force, education and training, income, and the local economy.

1.1 APPROACH

Secondary data sources were used to characterize the existing socio-economic environment. Sources used for data collection include existing literature and databases from public sources such as:

- Statistical data sources (e.g., Statistics Canada);
- Federal and provincial government reports and data; and
- Online sources (e.g., community web pages and profiles, available literature, business web pages, news articles and profiles).

1.1.1 Data Limitations

Data presented in the report have some limitations which include:

Statistics Canada Data Limitations. While Statistics Canada data can provide a preliminary understanding of a community, they should be interpreted with caution because of issues of comparability across years, confidentiality, and data quality. For the following community profile 2016 Statistics Canada data is relied upon; however, there are instances where comparisons with 2006 and 2011 data are made. It is noted that in 2011 there was a shift in how the census was administered, with a National Household Survey replacing the long-form census. One of the key differences was a shift from a mandatory to an optional response requirement for citizens. Statistics Canada also suppresses data for confidentiality or data quality. Data suppression for confidentiality reasons is meant to prevent the disclosure of data that could be used to identify individuals. It is often used for income characteristics in geographic areas where the population or private households do not meet a certain threshold. Data suppression due to data quality is done for a variety of reasons, including incompletely enumerated reserve parcels or Indian settlements or a global non-response rate of higher than or equal to 50%.

Secondary Research: Research was limited to the review of existing literature and databases from a variety of secondary sources.

2.0 COMMUNITY CONTEXT

2.1 OVERVIEW

English River First Nation (ERFN) is located approximately 500 km north of Saskatoon in Treaty 10 territory as seen in Figure 1. The First Nation has 19 different reserve parcels, although only Wapachewunak 192D and La Plonge 192 are populated:

Resident population:

- Wapachewunak 192D – population: 565; and
- La Plonge 192 – population 148.

No resident population:

- Cree Lake 192G;
- Dipper Rapids 192C;
- Elak Dase 192A;
- English River 192H;
- English River First Nation Cable Bay Cree Lake I.R.;
- English River FN Barkwell Bay No. 192l;
- English River FN Beauval Forks No. 192O;
- English River FN Cable Bay Cree Lake No. 192M;
- English River FN Flatstone Lake No. 192L;
- English River FN Haultain Lake No. 192K;
- Grasswoods 192J;
- Ille a La Crosse 192E;
- Knee Lake 192B;
- Leaf Rapids 192P;
- Mawdsley Lake Reserve No. 192R;
- Primeau Lake 192F; and
- Slush Lake Reserve No. 192Q (Government of Canada 2019b).

English River First Nation’s main reserve parcel, Wapachewunak 192D (“Wapachewunak”), is adjacent to the northern hamlet of Patuanak (Figure 1) on the Churchill River and acts as the administrative centre of the First Nation (Meadow Lake Tribal Council, n.d.). Although separate administrative entities, the two communities are interconnected. Located half a kilometre down the road from each other, they share much of the same infrastructure and services, including a school, roads, an airport, a landfill, and medical facilities. The facilities and services that supply education, healthcare, policing, and recreation to the communities is governed by a board structure with one position open to a representative from the hamlet of Patuanak and the rest to representatives from ERFN. Family connections between the two communities are strong. Administrative differences between the communities are largely the result of jurisdiction. (Key Lake Extension Project 2011).

English River First Nation's La Plonge 192 ("La Plonge") reserve parcel near Beauval (Figure 1), Saskatchewan is also populated. For the purposes of this report, references to ERFN refer primarily to the on-reserve communities of Wapachewunak and La Plonge, the two locations with year-round residents. It should be noted that while the La Plonge reserve is home to permanent residents, the First Nation is administered from the reserve at Wapachewunak.

Statistics Canada enumerates Wapachewunak, La Plonge and Patuanak separately, and provides the basis for much of the information presented. Information on ERFN citizens residing off-reserve is not readily available from secondary sources. To the extent possible, these communities are described separately within this document, but the interconnectedness among the locations means certain topics (e.g., infrastructure and services) are described collectively.

2.2 HISTORY

English River First Nation is a community of Denesuline or Dene people (historically called Chipewyan), with a long history in northern Saskatchewan. Prior to the mid 1700s, the Dene were known to live off the caribou on the northern edge of the boreal forest and into the barren grounds. The abundance of caribou for food and skins were important factors in their survival (Smith, 1976). In Samuel Hearne's inland travels in 1769-1772, he noted that the Chipewyan required little in the way of trade goods, as the caribou provided almost all of their needs (Smith, 1981). The movement of the Dene into the boreal forest was encouraged by the Hudson Bay Company (HBC) to gain their active participation in the fur trade (Yerbury, 1976; Gillespie, 1976). To achieve this, the HBC actively recruited and trained people in the skills of trapping and skinning (Jarvenpa, 1980).

The move into the boreal forest was enabled by a peace agreement between the Cree and the Dene in the winter of 1715-1716 (Gillespie, 1976; Smith, 1976). A subsequent smallpox epidemic (1781) drastically reduced the Cree population in the boreal forest region of western Saskatchewan, followed by outbreaks of influenza that further reduced the population (Smith, 1976; Yerbury, 1976). As the Dene moved into the boreal forest in the areas around Cree Lake and south to Île-à-la-Crosse their reliance on caribou was decreased and the use of moose, other wildlife, and pemmican from the trading posts increased in their diet. The move into the boreal forest resulted in a loss of self-sufficiency based on caribou, and greater reliance on the trading posts (Yerbury 1976).

In the late 1800s, the Canadian government signed seven treaties with Indigenous communities across the prairies. In northern Saskatchewan, communities were motivated to sign treaty to maintain their traditional lifestyle, and to balance the influx of settlers into the area. The initial request of the present-day ERFN was ignored by the Canadian Government, as they did not see an economic benefit in signing a Treaty. However, in 1906 a Treaty was signed between three Bands (the English River [Dene], Clear Lake [Dene][1], and Canoe Lake [Cree]) and the Canadian Government forming Treaty 10. In exchange for over 200,000 square kilometres of land, the Dene and Cree people of the three communities were promised education, medicine, assistance caring for the elderly, annual payments, and a promise they would be able to maintain their traditional way of living.

As a result, Treaty Day was established as a time to celebrate in the community, with preparation starting the week prior to the event. A tent with tables were setup, and members of the community would line up to receive their payment. Everyone would sit together, talk and ask questions to their leaders, who at this time were the only authority within the community. The community came together to solve problems and having the leader as a single source of governance seemed to benefit the community greatly (Dodson et al. 2006).

The "promise not to interfere with their hunting, trapping, and fishing was the most important one made at the treaty negotiations. These activities have sustained (the community) since time immemorial and they knew that any limitations would endanger their well-being" (Dodson et al. 2006). Although the Government representatives ensured them they would not be prevented from hunting and fishing in their country, they did not explain that the government could place restrictions on these activities from time to time if deemed necessary. It was soon recognized that the Federal Government's motivation behind the treaty was to exploit the area, and new laws impeded the most important aspect of the treaty, maintaining a traditional way of life (Dodson et al. 2006).

In 1907, the Province of Saskatchewan which had jurisdiction over fur bearing and game animals, passed legislation that imposed hunting seasons and restrictions on certain species. "Over the next several decades, both the federal and provincial governments, citing conservation and economic necessities, introduced legislation that slowly eroded the hunting, fishing and trapping rights" (Dodson et al. 2006). Regulations on where First Nations were allowed to fish were passed in the 1920s and '30s in an effort to establish a commercial fishery. In 1930, the federal government passed the Natural Resources Transfer Act, which gave Saskatchewan control over its natural resources. The Northern Fur Conservation Block partitioned much of northern Saskatchewan into 89 Fur Conservations Areas in 1946 (Government of Saskatchewan 2012). English River First Nation continues to use Fur Block N-18 and N-16 as the heart of their traditional territory.

By the early 1940's many families relocated from settlement areas on Dipper Lake, Primeau Lake, Knee Lake, and Cree Lake to the settlement at Patuanak. Men continued to make trips for trapping and fishing, and would travel from their community in different seasons to deliver fur and food (Jarvenpa 1976). This pattern continued into the 1970's when Patuanak became a permanent settlement in the region. The attraction to housing, electricity, elementary school, stores, and other services provided incentive for people to relocate, although a small number of people continued to live in various smaller settlements (Jarvenpa 1977).

[1] The Clear Lake Band, then known as Peter Pond First Nation, split into Birch Narrows Dene Nation and Buffalo River Dene Nation in 1972.

Figure 1: Communities in the Vicinity of the Wheeler River Project

2.3 GOVERNANCE

2.3.1 English River First Nation

English River First Nation is governed by a Chief and six Councillors, who are supported by a Band Manager (Table 1). The appointment date for First Nations officials in English River First Nation was October 2019 with an expiry date of October 2023 (Indigenous and Northern Affairs Canada 2019). English River First Nation is a member of the Meadow Lake Tribal Council (MLTC).

Table 1: Chief and Council English River First Nation, Saskatchewan

Title	Name	Appointment Date
Chief	Jerry Bernard	October 27, 2019
Councillor	Irene Apesis	October 27, 2019
Councillor	Jenny Wolverine	October 27, 2019
Councillor	Katrina Eaglechild	October 27, 2019
Councillor	Megan Gar	October 27, 2019
Councillor	Randy McIntyre	October 27, 2019
Councillor	Sandra Wolverine	October 27, 2019
Band Manager	Morley Campbell	October 27, 2019

Source: Government of Canada 2019.

2.3.2 Patuanak

Patuanak is governed by a mayor and two aldermen (Table 2) who are elected on a four-year cycle. The northern hamlet is part of the Métis Northern Region III with Métis Local 82 located in Patuanak (Nuclear Waste Management Organization 2013).

Table 2: Elected Officials Patuanak, Saskatchewan

Title	Name	Appointment Date
Mayor	Maurice Hazel	2016
Alderman	Darcy Lariviere	2016
Alderman	Estelle Florence	2016

Source: Source: Government of Saskatchewan Municipal Directory System, 2018.

2.4 ENGLISH RIVER FIRST NATION POPULATION

As of 2016, Statistics Canada reported that the population on-reserve in Wapachewunak was 565 which is an increase in population from the 482 residents in 2011 (Statistics Canada 2016; Statistics Canada 2011). La Plonge saw an increase in population in 2016 as well with 148 residents, a 29% increase from the population size of 115 in 2011. This change should be interpreted with some caution as it may reflect a change from the National Household Survey to the long-form census (see Section 1.1.1).

Figure 2 provides an illustration of the age and sex distribution for the 2016 population in Wapachewunak and La Plonge, compared to the age and sex distribution for Saskatchewan as a whole. Wapachewunak and La Plonge have a larger proportion of residents under the age of 19, and smaller proportion of residents 55 years and older in comparison to the province of Saskatchewan. The population of Wapachewunak and La Plonge are younger than the province as a whole.

Figure 2: Age and Sex Distribution for English River On-Reserve in Wapachewunak and La Plonge compared to Saskatchewan (2016)

Source: Statistics Canada 2016.

Footnotes:
1. Population count does not include incompletely enumerated communities.

2.4.1 Registered Population of English River First Nation

English River First Nation citizens reside both on- and off-reserve (Table 3). As of February 2020, English River First Nation had a total registered population of 1,644 citizens, 803 males and 841 females (Indigenous and Northern Affairs Canada 2019). Of these, nearly half the population (783 citizens) live on-reserve. The remaining members (861), did not live on an English River First Nation reserve parcel (Wapachewunak and La Plonge), with 38 living on other First Nation reserves (17 males and 21 females) and 823 living off reserve (403 males and 420 females).

Table 3: Registered Population of English River First Nation (February 2020)

Residency	Total[1]	Male[1]	Female[1]
Registered On-Reserve	783 (48%)	383 (48%)	400 (48%)
Registered Off-Reserve[2]	861 (52%)	420 (52%)	441 (52%)
Total Registered Population	**1,644 (100%)**	**803 (100%)**	**841 (100%)**

Source: Indigenous and Northern Affairs Canada, 2019.

Footnotes:

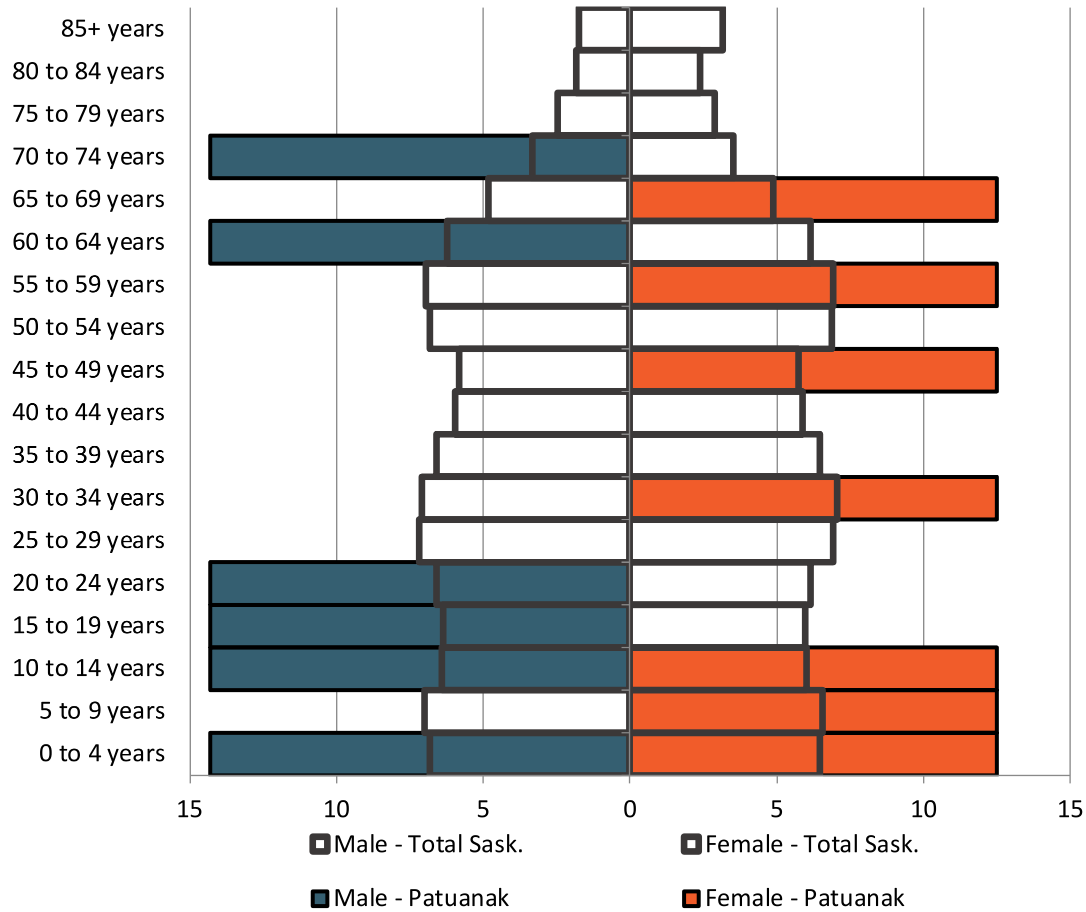
1. Percentages are based on Total Registered Population.
2. Registered Off-Reserve includes on other reserves, on own crown land, on other band crown land, on no band crown land, and off-reserve.

2.5 PATUANAK POPULATION

As of 2016, Statistics Canada reported that the population in Patuanak was 73, an increase in population from the 64 residents in 2011 (Statistics Canada 2016; Statistics Canada 2011).

Figure 3 provides an illustration of the age and sex distribution for the 2016 population in Patuanak, compared to the age and sex distribution for Saskatchewan as a whole.

Figure 3: Age and Sex Distribution for Patuanak compared to Saskatchewan (2016)



Source: Statistics Canada 2016.

Footnotes:

1. Data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5, and in some cases 10. Rows may not add up due to rounding.

Table 4 presents the Indigenous population of Patuanak, northern Saskatchewan, and Saskatchewan in 2016. Of the 75 individuals living in Patuanak in 2016, 65 self-identify as First Nations (87% of total population) and 10 self-identify as Métis (13% of total population) for a total of 75 individuals self-identifying as Indigenous (or 100% of the population) (Statistics Canada 2016). Patuanak had a higher proportion of its total population self-identify as Indigenous than both northern Saskatchewan and Saskatchewan. In Patuanak, a higher proportion of its total population self-identify as First Nations when compared to Métis, which is similar to northern Saskatchewan and Saskatchewan. There were no residents in Patuanak or northern Saskatchewan who self-identified as Inuk.

Table 4: Indigenous Population of Patuanak, Northern Saskatchewan, and Saskatchewan

	Population[1,2]			Indigenous Population[1,2,3,4]			First Nation[1,2,5]			Métis[1,2,6]		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Patuanak	75 (100%)	35 (47%)	40 (53%)	75 (100%)	25 (33%)	40 (53%)	65 (87%)	25 (33%)	40 (53%)	10 (13%)	0 (0%)	0 (0%)
Northern Saskatchewan[7]	37,065 (100%)	18,640 (50%)	18,425 (50%)	32,010 (86%)	15,945 (43%)	16,070 (43%)	25,575 (69%)	12,730 (34%)	12,845 (35%)	6,435 (17%)	3,215 (9%)	3,225 (9%)
Saskatchewan	1,098,350 (100%)	545,785 (50%)	552,565 (50%)	172,810 (16%)	83,745 (8%)	89,055 (8%)	114,570 (10%)	55,275 (5%)	59,290 (5%)	57,880 (5%)	28,325 (3%)	29,550 (3%)

Source: Statistics Canada 2016.

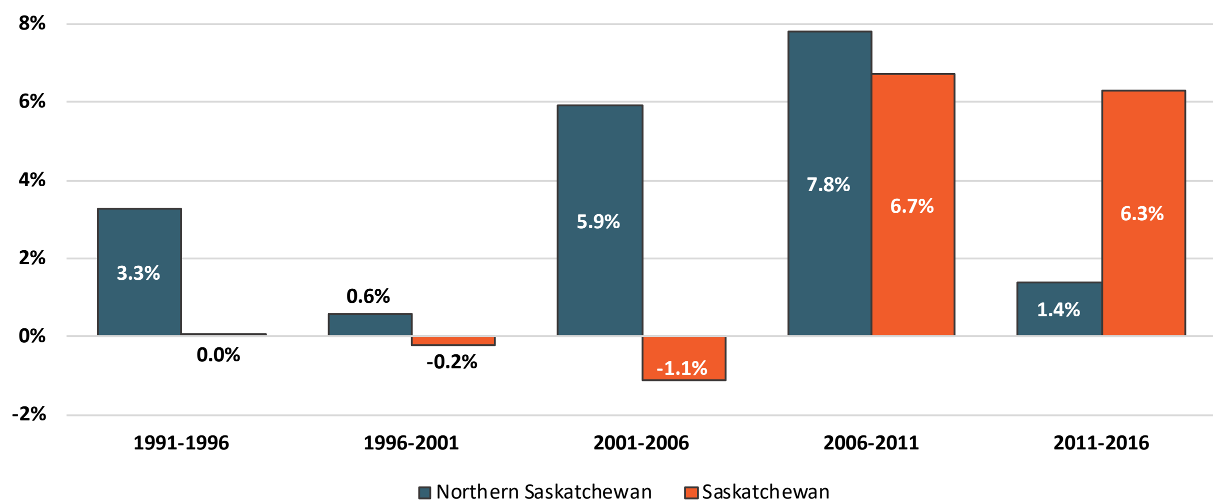
Footnotes:

1. Population count does not include incompletely enumerated communities.
2. Data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5, and in some cases 10. Rows may not add up due to rounding.
3. Total Aboriginal identity population is composed of those persons who reported identifying with at least one Aboriginal group, that is, First Nation (North American Indian), Métis or Inuit and/or those who reported being a Treaty Indian or a Registered Indian, as defined by the Indian Act of Canada and/or those who reported they were members of an Indian band or First Nation.
4. Percentage of Indigenous Population has been calculated based on Total Population.
5. Percentage of First Nation identity has been calculated based on Total Population.
6. Percentage of Métis identity has been calculated based on Total Population.
7. Northern Saskatchewan is defined as Census Division No. 18.

2.6 POPULATION GROWTH RATES OF NORTHERN SASKATCHEWAN AND SASKATCHEWAN

Figure 4 provides a comparison of population growth rates for northern Saskatchewan versus the province of Saskatchewan as a whole. Since 1991 northern Saskatchewan has experienced population growth on a constant basis, while the province of Saskatchewan experienced very little growth from 1991 to 1996, negative growth from 1996 to 2001 and 2001 to 2006, and only positive growth from 2006 to 2011 and 2011 to 2016.

Figure 4: Population Growth Rates Northern Saskatchewan and Saskatchewan



Source: Statistics Canada 1996, 2001, 2006, 2011, and 2016.

3.0 INFRASTRUCTURE AND SERVICES

This section describes the infrastructure and services available on-reserve in Wapachewunak and La Plonge, and in Patuanak. As Wapachewunak and Patuanak are closely interconnected and accessed by residents of both communities, they are discussed collectively. Topics include community facilities and services (including educational facilities, health facilities, social services, emergency services, recreational services, and transportation and access), utilities and public services, and housing and accommodations.

3.1 EDUCATIONAL FACILITIES

3.1.1 Elementary and High School

The St. Louis School located in Patuanak provides education to children from kindergarten to grade twelve. St. Louis School also offers Dene and has staff employed who provide literacy and math assistance, as well as special education for students (English River School n.d.). Classes at St. Louis School have Traditional Knowledge built into the curriculum in an effort to maintain traditional identity. The First Nation also runs Mission Hill Elementary School in La Plonge. Following graduation from Mission Hill, La Plonge students attend the Valleyview Highschool in Beauval (Nuclear Waste Management Organization 2013).

3.1.2 Post-secondary Education

In 2011 the University of Saskatchewan opened the Office of Aboriginal Initiatives in English River First Nation's Grasswood urban reserve south of Saskatoon. This centre gives a place for community members to access general information about the university, such as enrollment, potential employment and research opportunities (University of Saskatchewan n.d.).

There are several options for community members to access postsecondary education within the area. The University of Saskatchewan offers courses through Northlands College and there are campuses located in La Ronge, Creighton, Île-à-la-Crosse and Buffalo Narrows. Each of these campuses require a few hours at minimum to commute to and from the community, with Creighton being the farthest at roughly a seven hour drive one-way. As a result, students are required to relocate to attend classes at these campuses. Students have access to a variety of certification options such as University education, Technology and Trades diplomas and certificates, and Adult Basic Education (Northlands College n.d.).

First Nations students who meet eligibility criteria can receive financial assistance for post-secondary education through Indigenous Services Canada (ISC). To attain financial assistance for education students must be enrolled in a recognized educational institution and successfully complete courses towards their degree, diploma or certificate (Government of Canada 2020).

Through a Collaboration Agreement between Cameco Corporation, Orano and English River First Nation in 2012, a trust for post-secondary education has been assisting English River residents with post-secondary education funding. Through the trust, 58 students from English River First Nation received scholarships in 2018. The trust also aids with purchasing school supplies for children in elementary and high school, and funding sports and recreation programs (Joint Implementation Committee 2018).

3.2 HEALTH FACILITIES AND SERVICES

English River Health Services is located in Patuanak and is run by the Keewatin Yatthé Regional Health Authority. The health facility is open during the week from 8:30am-4:30pm with a one-hour lunch when they are closed. The health facility is staffed with a Registered Nurse and Registered Practical Nurse. A doctor visits the clinic on a monthly basis. Specialty health services including dental, psychological, and optical are among some of the specialties not offered on a regular basis in Patuanak (Northern Saskatchewan Health Services n.d.). Residents of La Plonge access health services through the health clinic located eight kilometres west in Beauval, also operated by the Keewatin Yatthé Regional Health Authority (Nuclear Waste Management Organization 2013).

The English River Health facility offers the following services to residents in the area including:

- Addiction Services;
- Community Health Developer/Rep;
- Dental Therapist;
- Dietician;
- Emergency Air Medevac;
- Home Care Services;
- Medical Transport Coordinator/Clerk;
- Mental Health/Holistic Health Services (Services may include family support, suicide prevention, youth suicide services, addictions, NNADAP workers, mental health therapists.);
- Primary Care Services (Nurse Practitioner, Physician Services, Maternal Child Health Worker); and
- TeleHealth Services (Northern Saskatchewan Health Services n.d.).

3.3 SOCIAL SERVICES

There are a few social services and organizations available to ERFN residents including:

- Interagency forum including health, social, education and other organizations;
- National Native Alcohol and Drug Abuse Program;
- Indian Child Family Services Program;
- Aboriginal Head Start Program;
- Women's Group;
- Community Youth Group;
- Fundraising Group; and
- Healing Group (Nuclear Waste Management Organization 2013).

In addition to social services, there are annual events held by the community to strengthen social connections. Every year English River First Nation holds a healing canoeing journey, with 2019 marking the tenth year of the event. The healing journey is to help people heal from grief and trauma, and also brings mental health awareness to the community. The tenth event in 2019 consisted of 50 elders and youth who paddled down Pine River and Beaver River (APTN News 2019).

For about 24 years, members of the community return to a traditional lifestyle for a week duration with the goal of strengthening families referred to as the Family Conference. Workshops are planned for all members of a family to participate in to bring strength and overcome historical and generational trauma. Some of the activities offered free of charge to all family members include massages, haircuts, foot care, and make-up and beauty services (APTN News 2019).

3.4 EMERGENCY SERVICES

3.4.1 English River has the following emergency services:

- **Fire services** are provided by fire suppression groups that work towards reducing fire risks in the area. There are basic fire halls located in Patuanak and in nearby Beauval (Nuclear Waste Management Organization 2013).
- **Policing services** are provided by the RCMP, which has a detachment office located in Beauval. Services provided by this detachment include criminal records check, document verification, fingerprinting, general information, nonemergency complaints, crime reporting, and vulnerable sector checks (RCMP 2015).
- **Ambulance services** are available in Patuanak and Beauval for La Plonge residents. The majority of emergency health services are accessed by medevac air transport to larger hospitals such as Île-à-la-Crosse, Prince Albert, Meadow Lake, or Saskatoon (Nuclear Waste Management Organization 2013).

3.5 RECREATION SERVICES

There are several recreational buildings in Patuanak for the community for use. The Ovide G. McIntyre Memorial Arena is operated by the First Nation and has four dressing rooms, broadcasting capability during games and a kitchen for preparing and selling food. Hockey games are held at the arena as well as travelling attractions that come through the community and on occasion, graduation ceremonies. The adult supervised Youth Centre in Patuanak has several forms of entertainment for youth including a television, stereo, foosball, pool tables, and games. The William Apesis Memorial Band Hall can be used for social gatherings such as weddings, receptions. town meetings. Musicians frequently use the Band Hall as there is a stage inside (Nuclear Waste Management Organization 2013).

There are recreational or protected areas near some of the reserve parcels in absence of provincial or national parks. These include Lac La Plonge, Little Amyot Lake Recreation Site, Migratory Bird Concentration Site, and Fort Black. There are three parks within Patuanak or in close proximity including the treaty grounds near the Band Office, the Lein Wolverine Park near the Band Hall and a community beach and picnic area just outside of Patuanak (Nuclear Waste Management Organization 2013).

3.6 TRANSPORTATION AND ACCESS

Highway 918 is maintained by Saskatchewan Highways and Infrastructure and is the only access road into Patuanak and Wapachewunak. Just over an hour south of Patuanak at the southern terminus of Highway 918 is La Plonge, which connected to Highway 165 at Beauval.

3.7 UTILITIES AND PUBLIC SERVICES

The following utilities and public services are available on-reserve and in the community of Patuanak:

- Water treatment station and distribution;
- Sewage collection and lagoon;
- Landfill;
- Cemetery;
- Telephone and internet provided by Saskatchewan Telecommunications; and
- Electricity provided by SaskPower (Nuclear Waste Management Organization, 2013).

Saskatchewan Telecommunications (SaskTel) provides telephone, internet, and tv services to both Patuanak and on-reserve in Wapachewunak. In 2019, Sasktel's new maxTV Stream was made available to 25 Northern and Indigenous communities in Saskatchewan including Patuanak and English River First Nation. The new service provides faster and a more reliable internet service (SaskTel 2019).

3.8 HOUSING

Statistics Canada has a number of important indicators that help provide an understanding of the state of housing in communities. Taken together, the total number of homes and the total population in the communities on Census Day 2016 can provide a glimpse into the average number of residents living in each home.

3.8.1 English River First Nation Housing

Table 5 presents the housing characteristics on-reserve for Wapachewunak and La Plonge compared to northern Saskatchewan and Saskatchewan. In 2016, on-reserve there were 184 occupied dwellings in Wapachewunak and 46 in La Plonge. Northern Saskatchewan had 10,235 and Saskatchewan as a whole had 432,620. On-reserve, Wapachewunak had the lowest number of average rooms per house (5.2), while La Plonge (6.1) was higher than northern Saskatchewan (5.6). The province as a whole (6.7) had the highest average rooms per house. The percentage of households requiring major repairs on-reserve in Wapachewunak (48.9%) and La Plonge (65.2%) were greater than northern Saskatchewan (30.7%) and the province as a whole (8.7%).

Table 5: Housing Characteristics On-Reserve for Wapachewunak and La Plonge compared to Northern Saskatchewan and Saskatchewan (2016)

	ERFN On-Reserve		Northern Saskatchewan[2]	Saskatchewan
	Wapachewunak[1]	La Plonge[1]		
Private Households Occupied by Residents	184	46	10,235	432,620
Average Number of Rooms per dwelling	5.2	6.1	5.6	6.7
Households Requiring Major Repairs[3]	90 (48.9%)	30 (65.2%)	3,145 (30.7%)	37,520 (8.7%)

Source: Statistics Canada 2016.

Footnotes:
1. Data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5, and in some cases 10. Columns may not add up due to rounding.
2. Northern Saskatchewan is defined as Census Division No.18.
3. Major repairs include dwellings needing major repairs such as dwellings with defective plumbing or electrical wiring, and dwellings needing structural repairs to walls, floors or ceilings.

3.8.2 Patuanak Housing

Table 6 presents the housing characteristics for Patuanak compared to northern Saskatchewan and Saskatchewan. There were 27 occupied private dwellings in Patuanuak. Patuanak (5.4) had the lowest average number of rooms per dwelling compared to northern Saskatchewan (6.0) and the province as a whole (6.7). Over a third of Patuanak homes (37%) required major repairs.

Table 6: Housing Characteristics in Patuanak compared to Northern Saskatchewan and Saskatchewan (2016)

	Patuanak[1]	Northern Saskatchewan[2]	Saskatchewan
Private Households Occupied by Residents	27	10,235	432,620
Average Number of Rooms per dwelling	5.4	6.0	6.7
Households Requiring Major Repairs[3]	10 (37%)	3,145 (30.7%)	37,520 (8,7%)

Source: Statistics Canada 2016.

Footnotes:
1. Data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5, and in some cases 10. Columns may not add up due to rounding.
2. Northern Saskatchewan is defined as Census Division No.18.
3. Major repairs include dwellings needing major repairs such as dwellings with defective plumbing or electrical wiring, and dwellings needing structural repairs to walls, floors or ceilings.

4.0 ECONOMY

This section describes the economic environment for English River First Nation both on and in Patuanak, as well as northern Saskatchewan and Saskatchewan for comparison. It presents labour force characteristics, education and training, income, employment, information on economic development, and local businesses.

4.1 LABOUR FORCE CHARACTERISTICS

The labour force includes persons over the age of fifteen years old during the period of the census who can contribute to the economy within a population. This statistic is usually described as a percentage and conveys the proportion of the population that the economy is dependent on.

Key indicators of labour force are:

- **Participation Rate:** the labour force participation rate reflects the number of people who are interested in participating in the workforce (population 15 years and over). This indicator is typically in conjunction with employment rates as it accounts for those people who may not be working (e.g., students, homemakers, institutionalized people), but are still active contributors in the economy.
- **Employment Rate:** reflects the proportion of the total population (aged 15 years and over) that was working Sunday May 1 to Saturday May 7, 2016.
- **Unemployment Rate:** accounts for the proportion of the total population (population in the labour force) that was not working Sunday May 1 to Saturday May 7, 2016.

4.1.1 English River Labour Force Characteristics

In 2016, Statistics Canada reported that on-reserve there were 430 residents in Wapachewunak and 110 in La Plonge eligible to participate in the labour force as seen in Table 7. This is compared to 25,295 residents eligible in northern Saskatchewan and 857,295 eligible in the province as a whole. The participation rate for on-reserve residents was 43.0% for Wapachewunak and 31.8% for La Plonge. In comparison, northern Saskatchewan (48.8%) and Saskatchewan (68.3%) both had higher participation rates than the three communities.

The employment rates in Wapachewunak (33.7%) and La Plonge (31.8%) were comparable in 2016. The employment rates of the three communities were comparable to that of northern Saskatchewan (37.2%), but the province of Saskatchewan (63.5%) had the highest employment rates in 2016. Unemployment rates for Wapachewunak (21.6%) in 2016 were comparable to northern Saskatchewan (23.8%), but greater than the province as a whole (7.1%).

Table 7: Labour Force Characteristics for English River First Nation On-Reserve in Wapachewunak and La Plonge compared to Northern Saskatchewan and Saskatchewan (2016)

	ERFN On-reserve						Northern Saskatchewan[2]			Saskatchewan		
	Wapachechewunak[1]			La Plonge[1]								
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Total Population 15 Years and Over by Labour Force Activity	430	205	215	110	50	55	25,295	12,610	12,685	857,295	424,260	433,035
In the Labour Force[3]	185	90	95	35	15	25	12,355	6,540	5,815	585,540	311,110	274,430
Employed[4]	145	65	85	35	15	20	9,420	4,660	4,755	544,095	286,330	257,760
Unemployed[5]	40	25	10	0	0	0	2,935	1,875	1,060	41,445	24,775	16,665
Not in the Labour Force[6]	240	115	120	70	35	35	12,940	6,070	6,870	271,760	113,155	158,605
Participation Rate[7]	43.0%	43.9%	44.2%	31.8%	30.0%	45.5%	48.8%	51.9%	45.8%	68.3%	73.3%	63.4%
Employment Rate[8]	33.7%	31.7%	39.5%	31.8%	30.0%	36.4%	37.2%	37.0%	37.5%	63.5%	67.5%	59.5%
Unemployment Rate[9]	21.6%	27.8%	10.5%	0.0%	0.0%	0.0%	23.8%	28.7%	18.2%	7.1%	8.0%	6.1%

Source: Statistics Canada 2016.

Footnotes:
1. Data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5, and in some cases, 10. Columns may not add up due to rounding.
2. North Saskatchewan is defined as Census Division No.18.
3. “Labour Force” refers to persons who, during the week of Sunday, May 1 to Saturday, May 7, 2016, were either employed or unemployed and reported for populations aged 15 years and over in private households.” (Statistics Canada 2019).

4. "Employed" refers to persons 15 years and over, excluding institutional residents who, during the week prior to Census Day: "(a) Did any work at all at a job or business, that is, paid work in the context of an employer-employee relationship, or self-employment. This also includes persons who did unpaid family work, which is defined as unpaid work contributing directly to the operation of a farm, business or professional practice owned and operated by a related member of the same household; or (b) Had a job but were not at work due to factors such as their own illness or disability, personal or family responsibilities, vacation or a labour dispute. This category excludes persons not at work because they were on layoff or between casual jobs, and those who did not then have a job (even if they had a job to start at a future date)." (Statistics Canada 2019).
5. "Unemployed" refers to persons who, during the week of Sunday May 1 to Saturday May 7 2016, were without paid work or without self-employment work and were available for work and either: a) had actively looked for paid work in the past four weeks; or b) were on temporary lay-off and expected to return to their job; or c) had definite arrangements to start a new job in four weeks or less." (Statistics Canada 2019).
6. "Not in the labour force" refers to persons who, during the week of Sunday May 1 to Saturday May 7 2016, were neither employed nor unemployed. It includes students, homemakers, retired workers, seasonal workers in an 'off' season who were not looking for work, and persons who could not work because of a long-term illness or disability." (Statistics Canada 2019).
7. The "Participation Rate" refers to the number of people in the labour force in the week of Sunday May 1 to Saturday May 7 2016, as a percentage of the population 15 years and over. (Statistics Canada 2019).
8. The "Employment Rate" refers to the number of people employed in the week of Sunday May 1 to Saturday May 7 2016 as a percentage of the total population 15 years and over. (Statistics Canada 2019).
9. The "Unemployment Rate" refers to the number of people unemployed in the week of Sunday May 1 to Saturday May 7 2016 expressed as a percentage of the population in the labour force. (Statistics Canada 2019).

4.1.2 Patuanak Labour Force Characteristics

In 2016, Statistics Canada reported that there were 55 Patuanak residents eligible to participate in the labour force (i.e., individuals aged 15 years and over) as seen in Table 8. This is compared to 25,295 residents were eligible in northern Saskatchewan and 857,295 were eligible in the province as a whole. The participation rate for Patuanak residents was 36.4% compared to northern Saskatchewan (48.8%) and Saskatchewan (68.3%), which both had higher participation rates. The employment rate in Patuanak (36.4%) was comparable to northern Saskatchewan (37.2%), both of which were less than the province as a whole (63.5%). Unemployment rates for Patuanak (50.0%) were greater than both northern Saskatchewan (23.8%) and the province as a whole (7.1%).

Table 8: Labour Force Characteristics for English River First Nation in Patuanak compared to Northern Saskatchewan and Saskatchewan (2016)

	Patuanak[1]			Northern Saskatchewan[2]			Saskatchewan		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
Total Population 15 Years and Over by Labour Force Activity	55	25	30	25,295	12,610	12,685	857,295	424,260	433,035
In the Labour Force[3]	20	10	10	12,355	6,540	5,815	585,540	311,110	274,430
Employed[4]	20	10	0	9,420	4,660	4,755	544,095	286,330	257,760
Unemployed[5]	10	0	0	2,935	1,875	1,060	41,445	24,775	16,665
Not in the Labour Force[6]	30	15	15	12,940	6,070	6,870	271,760	113,155	158,605
Participation Rate[7]	36.4%	40.0%	33.3%	48.8%	51.9%	45.8%	68.3%	73.3%	63.4%
Employment Rate[8]	36.4%	40.0%	0.0%	37.2%	37.0%	37.5%	63.5%	67.5%	59.5%
Unemployment Rate[9]	50.0%	0.0%	0.0%	23.8%	28.7%	18.2%	7.1%	8.0%	6.1%

Source: Statistics Canada 2016.

Footnotes:
1. Data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5, and in some cases, 10. Columns may not add up due to rounding.
2. North Saskatchewan is defined as Census Division No.18.
3. "Labour Force" refers to persons who, during the week of Sunday, May 1 to Saturday, May 7, 2016, were either employed or unemployed and reported for populations aged 15 years and over in private households." (Source: 2016 Census Dictionary).

4. "Employed" refers to persons 15 years and over, excluding institutional residents who, during the week prior to Census Day: "(a) Did any work at all at a job or business, that is, paid work in the context of an employer-employee relationship, or self-employment. This also includes persons who did unpaid family work, which is defined as unpaid work contributing directly to the operation of a farm, business or professional practice owned and operated by a related member of the same household; or (b) Had a job but were not at work due to factors such as their own illness or disability, personal or family responsibilities, vacation or a labour dispute. This category excludes persons not at work because they were on layoff or between casual jobs, and those who did not then have a job (even if they had a job to start at a future date)." (Source: 2016 Census Dictionary).
5. "Unemployed" refers to persons who, during the week of Sunday May 1 to Saturday May 7 2016, were without paid work or without self-employment work and were available for work and either: a) had actively looked for paid work in the past four weeks; or b) were on temporary lay-off and expected to return to their job; or c) had definite arrangements to start a new job in four weeks or less." (Source: 2016 Census Dictionary).
6. "Not in the labour force" refers to persons who, during the week of Sunday May 1 to Saturday May 7, 2016, were neither employed nor unemployed. It includes students, homemakers, retired workers, seasonal workers in an 'off' season who were not looking for work, and persons who could not work because of a long-term illness or disability." (Source: 2016 Census Dictionary).
7. The "Participation Rate" refers to the number of people in the labour force in the week of Sunday May 1 to Saturday May 7, 2016, as a percentage of the population 15 years and over. (Source: 2016 Census Dictionary).
8. The "Employment Rate" refers to the number of people employed in the week of Sunday May 1 to Saturday May 7, 2016 as a percentage of the total population 15 years and over. (Source: 2016 Census Dictionary).
9. The "Unemployment Rate" refers to the number of people unemployed in the week of Sunday May 1 to Saturday May 7, 2016 expressed as a percentage of the population in the labour force. (Source: 2016 Census Dictionary).

4.2 EDUCATIONAL ATTAINMENT

This section describes rates of educational attainment for ERFN members living in Wapachewunak and La Plonge and residents of Patuanak.

4.2.1 English River First Nation Educational Attainment

Table 9 provides the distribution of the highest level of education attained by on-reserve English River First Nation residents in Wapachewunak and La Plonge compared to northern Saskatchewan and the province for 2016. Residents on-reserve in Wapachewunak (45.9%) and in La Plonge (38.1%) had comparable rates for having obtained less than a high school certificate. The rates seen in on-reserve in English River First Nation are less than northern Saskatchewan (50.9%), but higher than the province as a whole (20.7%). Male residents are more likely to have less than a high school certificate on-reserve in Wapachewunak (52.4%) and La Plonge (50.0%) compared to female residents on-reserve in Wapachewunak (40.9%) and La Plonge (36.4%). This trend is similar to both northern Saskatchewan and Saskatchewan as a whole where male residents are more likely to not have the equivalent of a high school diploma.

Statistics Canada tracks post-secondary certification or degree through:

- Apprenticeship or Trades Certificate or Diploma;
- Post-Secondary Non-University Certificate or Diploma;
- University Certificate or Diploma Below the Bachelor's Level; and
- University Degree.

Residents on-reserve in Wapachewunak (9.4%) had comparable attainment rates for an apprenticeship, trades certificate or diploma as northern Saskatchewan (8.2%) and Saskatchewan (10.4%). Residents on-reserve in La Plonge (23.8%) had higher attainment rates than both northern Saskatchewan (8.2%) and the province as a whole (10.4%).

On-reserve in Wapachewunak (8.2%) and La Plonge (9.5%) residents had the lowest attainment rates for a post-secondary non-university certificate or diploma compared to northern Saskatchewan (11.1%) and the province as a whole (17.1%). On-reserve males had lower attainment rates than females for post-secondary non-university certificates or diplomas. This trend is seen across northern Saskatchewan and Saskatchewan.

Table 9: Level of Educational Attainment for English River First Nation On-Reserve in Wapachewunak and La Plonge compared to Northern Saskatchewan and Saskatchewan (2016)

	ERFN On-reserve						Northern Saskatchewan[2,3]			Saskatchewan[2]		
	Wapachewunak[1,2]			La Plonge[1,2]								
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Total Population 15 and Over by Highest Certificate, Diploma or Degree[4]	425	210	220	105	50	55	25,295	12,605	12,690	857,295	424,265	433,035
Less than High School Certificate	195 45.9%	110 52.4%	90 40.9%	40 38.1%	25 50.0%	20 36.4%	12,865 50.9%	6,945 55.1%	5,920 46.7%	177,210 20.7%	96,680 22.8%	80,530 18.6%
High School Certificate or Equivalent[5]	125 29.4%	60 28.6%	70 31.8%	20 19.0%	10 20.0%	10 18.2%	5,195 20.5%	2,250 17.9%	2,955 23.3%	261,210 30.5%	133,730 31.5%	127,480 29.4%
Apprenticeship or Trades Certificate or Diploma	40 9.4%	25 11.9%	15 6.8%	25 23.8%	15 30.0%	0 0.0%	2,080 8.2%	1,495 11.9%	585 4.6%	89,440 10.4%	64,100 15.1%	25,340 5.9%
Post-Secondary Non-University Certificate or Diploma[6]	35 8.2%	15 7.1%	15 6.8%	10 9.5%	10 20.0%	10 18.2%	2,810 11.1%	1,180 9.4%	1,630 12.8%	146,770 17.1%	51,240 12.1%	95,530 22.1%
University Certificate or Diploma Below the Bachelor's Level	10 2.4%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	475 1.9%	110 0.9%	365 2.9%	28,195 3.3%	10,790 2.5%	17,405 4.0%
University Degree	25	0	20	10	0	0	1,865	630	1,230	154,480	67,730	86,745

	ERFN On-reserve						Northern Saskatchewan[2,3]			Saskatchewan[2]		
	Wapachewunak[1,2]			La Plonge[1,2]								
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
	5.9%	0.0%	9.1%	9.5%	0.0%	0.0%	7.4%	5.0%	9.7%	18.0%	16.0%	20.0%

Source: Statistics Canada 2016.

Footnotes:
1. Statistics Canada data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5 and in some cases, 10. Columns may not add up due to rounding.
2. Educational attainment data for 2016 were derived from 30% data. However, on Indian reserves and in remote communities, Statistics Canada attempts to obtain data from 100% of the population.
3. Northern Saskatchewan is defined as Census Division No. 18.
4. "Highest certificate, diploma or degree" refers to the highest certificate, diploma or degree the individual has completed based primarily on time spent" in-class." For high school graduates, a university education is considered to be a higher level of education than a college diploma, while a college education is considered to be a higher level of education than a trade. Although some trades requirements may take as long or longer to complete than a given college or university program, the majority of time acquiring trade certification may on-the-job, as opposed to being in a classroom.
5. "High school certificate or equivalent" includes persons who have graduated from a secondary school or equivalent. Excludes persons with a postsecondary certificate, diploma or degree.
6. "Postsecondary non-university certificate or diploma" includes non-degree-granting institutions such as community colleges, CEGEPs, private business colleges and technical institutes.

4.2.2 Patuanak Educational Attainment

Table 10 provides the distribution of the highest level of education attained by residents in Patuanak compared to northern Saskatchewan and the province for 2016. Residents in Patuanak 15 years and older (45.5%) having obtained less than a high school certificate are less than northern Saskatchewan (50.9%), but higher than the province as a whole (20.7%). Male residents are more likely to have less than a high school certificate in Patuanak (60.0%), compared to female residents (40.0%). This trend is similar to both northern Saskatchewan and Saskatchewan where male residents are more likely to not have the equivalent of a high school diploma. Patuanak residents (18.2%) had higher attainment rates for an apprenticeship, trades certificate or diploma than northern Saskatchewan (8.2%) and the province as a whole (10.4%). Residents in Patuanak (18.2%) saw the highest number of residents attaining post-secondary non-university certificate or diploma compared to northern Saskatchewan (11.1%) and the province as a whole (17.1%). Males had lower attainment rates than females for post-secondary non-university certificates or diplomas.

Table 10: Level of Educational Attainment for English River First Nation in Patuanak compared to Northern Saskatchewan and Saskatchewan (2016)

	Patuanak[1,2]			Northern Saskatchewan[2,3]			Saskatchewan[2]		
	Total	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**
Total Population 15 and Over by Highest Certificate, Diploma or Degree[4]	55	25	25	25,295	12,605	12,690	857,295	424,265	433,035
Less than High School Certificate	25 45.5%	15 60.0%	10 40.0%	12,865 50.9%	6,945 55.1%	5,920 46.7%	177,210 20.7%	96,680 22.8%	80,530 18.6%
High School Certificate or Equivalent[5]	10 18.2%	10 40.0%	10 40.0%	5,195 20.5%	2,250 17.9%	2,955 23.3%	261,210 30.5%	133,730 31.5%	127,480 29.4%
Apprenticeship or Trades Certificate or Diploma	10 18.2%	10 40.0%	0 0.0%	2,080 8.2%	1,495 11.9%	585 4.6%	89,440 10.4%	64,100 15.1%	25,340 5.9%
Post-Secondary Non-University Certificate or Diploma[6]	10 18.2%	0 0.0%	10 40.0%	2,810 11.1%	1,180 9.4%	1,630 12.8%	146,770 17.1%	51,240 12.1%	95,530 22.1%
University Certificate or Diploma Below the Bachelor's Level	0 0.0%	0 0.0%	0 0.0%	475 1.9%	110 0.9%	365 2.9%	28,195 3.3%	10,790 2.5%	17,405 4.0%
University Degree	0 0.0%	0 0.0%	0 0.0%	1,865 7.4%	630 5.0%	1,230 9.7%	154,480 18.0%	67,730 16.0%	86,745 20.0%

Source: Statistics Canada 2016.

Footnotes:

1. Statistics Canada data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5 and in some cases, 10. Columns may not add up due to rounding.
2. Educational attainment data for 2016 were derived from 30% data. However, on Indian reserves and in remote communities, Statistics Canada attempts to obtain data from 100% of the population.
3. Northern Saskatchewan is defined as Census Division No. 18.
4. "Highest certificate, diploma or degree" refers to the highest certificate, diploma or degree the individual has completed based primarily on time spent" in-class." For high school graduates, a university education is considered to be a higher level of education than a college diploma, while a college education is considered to be a higher level of education than a trade. Although some trades requirements may take as long or longer to

complete than a given college or university program, the majority of time acquiring trade certification may on-the-job, as opposed to being in a classroom.

5. "High school certificate or equivalent" includes persons who have graduated from a secondary school or equivalent. Excludes persons with a postsecondary certificate, diploma or degree.
6. "Postsecondary non-university certificate or diploma" includes non-degree-granting institutions such as community colleges, CEGEPs, private business colleges and technical institutes.

4.3 INCOME

Income determines the standard of living (e.g., quantity and quality of goods and services) available to individuals and households. Two indicators are provided in this section to better understand the incomes currently available for the residents for Wapachewunak, La Plonge, Patuanak, northern Saskatchewan, and Saskatchewan. Indicators provided by Statistics Canada include:

- Distribution of income by individuals and households; and
- Income sources, showing the distributions among employment, government payments and interest, and other investments for each community.

Data on personal income for on-reserve residents in La Plonge, and in Patuanak are not available for confidentiality reasons.

4.3.1 English River First Nation Personal and Household Income

Table 11 presents the average personal employment income of the population aged 15 and older for on-reserve in Wapachewunak, northern Saskatchewan, and Saskatchewan in 2015. For confidentiality reasons due to a small population size personal employment income is not available for La Plonge. Personal income on-reserve in Wapachewunak ($45,343) was lower than northern Saskatchewan ($57,985) and the province of Saskatchewan ($64,855). In 2016 male residents of Wapachewunak reporting income earned on average $57,811, while females reporting income earned on average $37,239, a gap of over $20,000. This same trend is seen in northern Saskatchewan and Saskatchewan, however Wapachewunak had the largest gap between male and female average salaries.

The Saskatchewan Low Income Tax Credit has a threshold of $32,643[2] (Government of Canada 2018). In 2015, 62.4% of the population of Wapachewunak, 62.6% of individuals in northern Saskatchewan, and 40.4% of individuals in Saskatchewan had less than $30,000 in income. Female residents of Wapachewunak (62.7%) were more likely to report less than $30,000 than males (59.5%), a trend which is seen in northern Saskatchewan and Saskatchewan. In 2015, approximately 10.6% of Wapachewunak residents, 13.2% of individuals in northern Saskatchewan, and 22.1% of individuals in Saskatchewan earned income in higher income brackets of $70,000 or greater.

[2] The Saskatchewan low-income tax credit is a tax-free amount paid to help Saskatchewan residents with low and modest incomes. For July 2018 and June 2019, the program provides a tax-free amount to individuals and families. The credit starts to be reduced when the adjusted family net income is more than $32,643.

Table 11: Distribution of Personal Income for English River First Nation On-Reserve in Wapachewunak compared to Northern Saskatchewan and Saskatchewan (2015)

	ERFN On-reserve Wapachewunak[1,2,3]			Northern Saskatchewan[2,4]			Saskatchewan[2]		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
Average Employment Income for Full-Year Full-Time Workers[5]	$45,343	$57,811	$37,239	$57,985	$64,790	$51,411	$64,855	$72,366	$54,808
Total Number of Private Households with Income[5]	425	210	215	22,695	11,215	11,485	822,620	407,715	415,015
Under $10,000	105 25%	60 29%	45 21%	7,080 31%	4,025 36%	3,055 27%	105,780 13%	47,325 12%	58,455 14%
$10,000 to $19,999	100 24%	40 19%	60 28%	4,305 19%	1,750 16%	2,550 22%	118,380 14%	46,195 11%	72,180 17%
$20,000 to $29,999	60 14%	25 12%	30 14%	2,830 12%	1,145 10%	1,690 15%	107,890 13%	42,345 10%	65,545 16%
$30,000 to $39,999	40 9%	15 7%	25 12%	2,120 9%	860 8%	1,265 11%	95,605 12%	41,315 10%	54,295 13%
$40,000 to $49,999	15 4%	0 0%	10 5%	1,520 7%	645 6%	870 8%	89,285 11%	42,260 10%	47,025 11%
$50,000 to $59,999	20 5%	10 5%	5 2%	1,060 5%	485 4%	575 5%	70,395 9%	36,950 9%	33,450 8%
$60,000 to $69,999	10 2%	5 2%	5 2%	790 3%	440 4%	355 3%	53,855 7%	31,055 8%	22,795 5%
$70,000 to $79,999	15 4%	5 2%	10 5%	650 3%	345 3%	305 3%	41,930 5%	25,290 6%	16,645 4%
$80,000 to $99,999[6]	5 1%	0 0%	10 5%	1070 5%	590 5%	485 4%	60,470 7%	36,850 9%	23,620 6%

	ERFN On-reserve Wapachewunak[1,2,3]			Northern Saskatchewan[2,4]			Saskatchewan[2]		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
$100,000 and over	25 6%	20 10%	5 2%	1270 6%	935 8%	335 3%	79,030 10%	58,125 14%	20,905 5%

Source: Statistics Canada 2016.

Footnotes:
1. Data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5, and in some cases 10. Columns may not add up due to rounding.
2. Income variables do not account for inflation.
3. Personal income variables were derived from 20% sample data. However, on Indian Reserves and in remote communities, attempts are made to obtain data from 100% of the population.
4. Northern Saskatchewan is defined as Census Division No. 18.
5. Income refers to Total Income (i.e. personal income). Total income is the total money income received during the calendar year prior to the Census year. Sources of income are: wages and salaries, net farm income; net non-farm income from unincorporated business and/or professional practice; child benefits; Old Age Security pension and Guaranteed Income Supplement; benefits from Canada Pension Plan or Quebec Pension Plan; benefits from Employment Insurance; other income from government sources; dividends, interest on bonds, deposits and savings certificates and other investment income; retirement pensions, superannuation and annuities, including those from RRSPs and RRIFs; and other money income. Not included in all Census years as total income: income tax refunds, lump sum inheritance payments, gambling revenue, lump sum insurance policy settlements, capital gains or losses, receipts from the sale of property or belongings, loan repayments, property tax rebates or refunds of pension contributions.
6. The 2015 data sets group $80,000 to $99,999 as $80,000 to $89,999 and $90,000 to $99,999. These categories have been collapsed in the table.

Table 12 shows the distribution of household income for Wapachewunak, northern Saskatchewan and Saskatchewan for 2015. The average household income (2015) for Wapachewunak residents ($60,621), was lower than northern Saskatchewan ($71,111) and the province of Saskatchewan ($93,942) (Statistics Canada 2016). A higher proportion (32.4%) of Wapachewunak households had incomes of $30,000 or less than in northern Saskatchewan (22.6%) and Saskatchewan (12.2%). In 2015, approximately 32.4% of Wapachewunak households, 39.3% of households in northern Saskatchewan, and 53.5% of households in Saskatchewan earned income in higher income brackets of $70,000 or greater.

Table 12: Distribution of Household Income for English River First Nation On-Reserve in Wapachewunak compared to Northern Saskatchewan and Saskatchewan (2015)

	ERFN On-reserve	Northern Saskatchewan[2,4,5]	Saskatchewan[2,5]
	Wapachewunak[1,2,5]		
Average Household Employment Income before Taxes in 2015 for Full-Year Full-Time Workers[3]	$60,621	$71,111	$93,942
Total Number of Private Households with Income[6]	185	10,235	432,625
Under $5,000	5 3%	445 4%	6,930 2%
$5,000 to $9,999	5 3%	325 3%	4,575 1%
$10,000 to $19,999	25 14%	405 4%	7,675 2%
$20,000 to $29,999[7]	25 14%	1,135 11%	33,720 8%
$30,000 to $39,999	15 8%	1,025 10%	35,110 8%
$40,000 to $49,999	15 8%	830 8%	33,870 8%
$50,000 to $59,999	25 14%	725 7%	31,595 7%
$60,000 to $69,999	10 5%	610 6%	29,700 7%
$70,000 to $79,999	15 8%	545 5%	27,605 6%
$80,000 to $89,999	10 5%	490 5%	25,810 6%

	ERFN On-reserve	Northern Saskatchewan[2,4,5]	Saskatchewan[2,5]
	Wapachewunak[1,2,5]		
$90,000 to $99,999	5 3%	420 4%	23,280 5%
$100,000 to $124,999	10 5%	865 8%	48,375 11%
$125,000 to $149,999	5 3%	605 6%	35,320 8%
$150,000 and over	15 8%	1,100 11%	71,035 16%

Source: Statistics Canada 2016.

Footnotes:
1. Data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5, and in some cases 10. Columns may not add up due to rounding.
2. Income variables do not account for inflation.
3. Household income variables were derived from 20% sample data. However, on Indian Reserves and in remote communities, attempts are made to obtain data from 100% of the population.
4. Northern Saskatchewan is defined as Census Division No. 18.
5. Income refers to Total Income (i.e. household income). Total income is the total money income received during the calendar year prior to the Census year. Sources of income are: wages and salaries, net farm income; net non-farm income from unincorporated business and/or professional practice; child benefits; Old Age Security pension and Guaranteed Income Supplement; benefits from Canada Pension Plan or Quebec Pension Plan; benefits from Employment Insurance; other income from government sources; dividends, interest on bonds, deposits and savings certificates and other investment income; retirement pensions, superannuation and annuities, including those from RRSPs and RRIFs; and other money income. Not included in all Census years as total income: income tax refunds, lump sum inheritance payments, gambling revenue, lump sum insurance policy settlements, capital gains or losses, receipts from the sale of property or belongings, loan repayments, property tax rebates or refunds of pension contributions.
6. Private household refers to a person or a group of persons (other than foreign residents) who occupy the same dwelling and do not have a usual place of residence elsewhere in Canada. It may consist of a family group (census family) with or without other persons, of two or more families sharing a dwelling, of a group of unrelated persons, or of one person living alone. Household members who are temporarily absent on Census Day (e.g., temporary residents elsewhere) are considered as part of their usual household. For census purposes, every person is a member of one and only one household. Unless otherwise specified, all data in household reports are for private households only.
7. Data sets grouped include: $20,000 to $29,999 as $20,000 to $24,999 and $25,000 to $29,999. These categories have been collapsed in the table; $30,000 to $39,999 as $30,000 to $34,999 and $35,000 to $39,999. These categories have been collapsed in the table; $40,000 to $49,999 as $40,000 to $44,999 and $45,000 to $49,999. These categories have been collapsed in the table; $150,000 and over as $150,000 to $199,999 and $200,000 and over. These categories have been collapsed in the table.

4.3.2 English River First Nation Sources of Income

Statistics Canada tracks three general categories or sources of income: employment and self-employment income, government payments, and interest and other investment income.

Table 13 illustrates that the percentage of income for the population of Wapachewunak (72.6%) from employment income is comparable to that of residents of northern Saskatchewan (72.0%) and Saskatchewan (73.2%). A higher percentage of males (79.6%) had employment income than females (64.9%), which reflected trends in northern Saskatchewan and Saskatchewan as a whole. The percentage of income from Government Transfer payments in Wapachewunak (25.1%) was higher than northern Saskatchewan (21.8%), both which were approximately twice that of the province as a whole (10.5%).

Table 13: Sources of Income for English River First Nation On-Reserve in Wapachewunak compared to Northern Saskatchewan and Saskatchewan (2015)

	ERFN On-reserve Wapachewunak[1,2,3]			Northern Saskatchewan[4]			Saskatchewan		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
Employment Income (%)[5]	72.6%	79.6%	64.9%	72.0%	78.8%	64.2%	73.2%	76.8%	68.0%
Government Transfer Payments (%)[6]	25.1%	18.8%	32.7%	21.8%	14.4%	30%	10.5%	7.2%	15.2%
Other (%)[7]	2.3%	1.6%	2.4%	6.2%	6.8%	5.8%	16.3%	16%	16.8%

Source: Statistics Canada 2016.

Footnotes:

1. Sources of income variables for the Census were derived from 20% sample data. However, on Indian reserves and in remote communities, attempts are made to obtain data from 100% of the population.
2. Data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5, and in some cases 10. Columns may not add up due to rounding.
3. Sources of income of a population group or a geographic area, refers to the relative share of each income source or group of sources, expressed as a percentage of the aggregate total income of that group or area. Percentages may not add up to 100% due to rounding.
4. Northern Saskatchewan is defined as Census Division No. 18.
5. Employment Income include all income received as wages, salaries and commissions from paid employment and net self-employment income from farm or non-farm unincorporated business and/or professional practice during the reference period.
6. Government transfer include all cash benefits received from federal, provincial, territorial or municipal governments during the reference period. It includes (1) Old Age Security pension, Guaranteed Income Supplement, Allowance or Allowance for the Survivor; (2) Retirement, disability, and survivor benefits from Canada Pension Plan and Quebec Pension Plan; (3) benefits from Employment Insurance and Quebec parental insurance plan, (4) Child benefits from federal and provincial programs; (5) social assistance benefits; (6) workers' compensation benefits; (7) working income tax benefit; (8) goods and services tax credit and harmonized sales tax credit; and (9) other income from government sources. For the 2016 Census, the reference period is the calendar year 2015 for all income variables.
7. Other income sources include severance pay and retirement allowances, alimony, child support, periodic support from other persons not in the household, income from abroad (excluding interest and dividends), non-refundable scholarships, bursaries, fellowships and study grants, and artists' project grants. Other income was calculated as a total (100%) minus employment income (%) and government transfer payments (%).

4.4 LOCAL ECONOMY

This section describes employment by sector, economic development, and local business for English River First Nation Saskatchewan.

4.4.1 Local Business

Table 14 displays the local businesses within English River which support the local economy.

Table 14: Local Businesses in English River First Nation

Business	Description
AllTron Electric	Joint venture with Alliance Energy Ltd.
Beauval Gas and Grocery	Grocery store, restaurant, gas station and convenience store
Canadian Shield Insurance Services Ltd.	Insurance services
Cameco Northern Affairs Office (Patuanak)	Cameco local office
Des Nedge Development Inc./Tron Power	Construction and mining services
English River First Nation (Patuanak)	First Nations public services and administration
English River Fish Plant (Patuanak)	Fish packing and wholesale distribution
English River Gas Bar (Patuanak)	Gas, convenience store and ATM
English River Recreation and Area (Patuanak)	Arena and youth recreation
Golden Wally Outfitters	Outfitting business
Grasswood Business Centre/English River Travel Centre	Business and Travel Centre
J & Son’s Taxi	Taxi service
JV Driver	Construction and engineering services
Mawdsley Lake Fishing Lodge	Fishing lodge
March Consulting and Engineering	Potash industry
Michelle’s Hair Design	Hair salon

Business	Description
MineTec Sales	Electrical Panel sales
Mudjatik Enterprises	Mudjatik Thyssen Mining Joint Venture and Construction
Mudjatik River Outfitters	Outfitting business
Northern Store	Store
Patuanak Communication Society	Communication station, FM radio, local radio, broadcasting, tv scroll, bingo
Patuanak Taxi	Taxi service

Source: Northern Saskatchewan Business Directory 2020, Nuclear Waste Management Organization 2013.

4.4.2 English River First Nation Employment by Sector

Table 15 outlines employment by sector in on-reserve in English River First Nation compared to residents of northern Saskatchewan and Saskatchewan. The data indicates that the key sectors for employment on-reserve in Wapachewunak are public administration (18.9%), educational services (16.2%) and mining, quarrying, and oil and gas extraction (13.5%). Key sectors for employment on-reserve in La Plonge are agriculture, forestry, fishing and hunting (25.0%) and retail trade (25.0%). For northern Saskatchewan, key sectors for employment are education (15.3%), health care and assistance (13.4%) and public administration (12.3%). For the province as a whole, health care and social assistance (12.4%); retail (10.8%); and agriculture, forestry, fishing, and hunting (8.8%) were the key sectors for employment.

Data indicates that males and females on-reserve in Wapachewunak and La Plonge are employed in different industries. Key sectors for employment of males in Wapachewunak include mining, quarrying, and oil and gas extraction (22.2%), and public administration (22.2%). For females, key sectors for employment are educational services (31.6%), health care and social assistance (15.8%) and public administration (15.8%).

Table 15: Employment by Sector for English River First Nation On-Reserve in Wapachewunuak and La Plonge compared to Northern Saskatchewan and Saskatchewan (2016)

	ERFN On-reserve						Northern Saskatchewan[2]			Saskatchewan		
	Wapachewunak[1]			La Plonge[1]								
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Total Labour Force population aged 15 years and over by industry[3,4]	185	90	95	40	15	20	12,355	6,540	5,815	585,540	311,110	274,430
Industry – not applicable	15	10	10	10	0	0	1,565	910	660	10,225	5,205	5,020
All industry categories	170	80	90	35	15	20	10,790	5,635	5,155	575,310	305,905	269,410
Agriculture; forestry; fishing and hunting	0	0	0	10	0	0	240	220	20	51,255	36,820	14,440
Mining; quarrying; and oil and gas extraction	25	20	10	0	0	0	1,165	1,025	145	23,070	20,040	3,025
Utilities	0	0	0	0	0	0	95	80	15	5,395	3,780	1,610
Construction	15	15	0	0	0	0	800	735	70	49,310	43,460	5,850
Manufacturing	0	0	0	0	0	0	150	120	30	26,710	21,000	5,710
Wholesale Trade	0	0	0	0	0	0	105	70	35	20,480	15,325	5,155
Retail Trade	20	10	10	10	10	10	1,015	455	555	63,360	30,185	33,180

	ERFN On-reserve						Northern Saskatchewan[2]			Saskatchewan		
	Wapachewunak[1]			La Plonge[1]								
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Transportation and Warehousing	0	10	0	0	0	10	445	325	120	24,755	19,385	5,370
Information and Cultural Industries	0	0	0	0	0	0	90	45	45	10,005	5,055	4,950
Finance and Insurance	0	0	0	0	0	0	95	20	75	20,155	6,495	13,655
Real Estate and Rental Leasing	0	0	0	0	0	0	90	65	25	7,650	4,425	3,220
Professional; Scientific and Technical Services	0	0	0	0	0	0	165	70	95	25,250	12,985	12,265
Management of Companies and Enterprises	0	0	0	0	0	0	10	10	0	1,340	680	660
Admin. and Support; Waste Mgmt and Remediation	0	10	10	0	0	0	310	165	145	16,395	9,660	6,735
Educational Services	30	0	30	0	0	0	1,895	530	1,365	45,360	13,670	31,690
Health Care and Social Assistance	15	0	15	0	0	10	1,660	290	1,370	72,625	11,285	61,335
Arts; Entertainment and Recreation	0	0	0	0	0	0	100	55	45	10,545	5,120	5,425

	ERFN On-reserve						Northern Saskatchewan[2]			Saskatchewan		
	Wapachewunak[1]			La Plonge[1]								
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Accommodation and Food Services	10	10	0	0	0	0	585	270	310	37,785	14,295	23,490
Other Services (Except Public Administration)	0	0	0	0	0	0	250	135	115	25,680	12,590	13,090
Public Administration	35	20	15	0	0	0	1,520	955	570	38,180	19,640	18,535

Source: Statistics Canada 2016.

Footnotes:
1. Data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5, and in some cases 10. Columns may not add up due to rounding.
2. Northern Saskatchewan refers to Census Division No. 18.
3. Includes the experienced labour force which refers to persons aged 15 years and over who during the Census were employed and the unemployed who had last worked for pay or in self employment prior to the Census.
4. Includes unemployed persons aged 15 years and over who have never worked for pay or in self-employment or who had last worked prior to January 1, 2015.
5. Refers to the general nature of the business carried out in the establishment where the person worked. The data are produced according to the North American Industry Classification System (NAICS) 2012 with 25% sample data.

Historically it has been common for Wapachewunak to have higher unemployment rates than La Plonge. A possible explanation for this could be that the location of La Plonge is less remote, resulting in easier access to employment opportunities, as well the population size is much smaller than Wapachewunak (Nuclear Waste Management Organization 2013). There are a number of community and privately owned businesses which provide employment to residents on-reserve and in Patuanak as seen in Table 14. There are local grocery, gas and convenience stores such as Beauval Gas and Grocery which employs 35 people mainly ERFN members.

Owned and operated by English River First Nation, Tron is one of their major employers providing employment for tradespeople and office staff. As the First Nation cannot supply enough skilled employees the company requires, Tron hires people in the surrounding area as well. To assist with employee participation rates from both the First Nation and northern Saskatchewan, Tron provides orientation and training programs which has been successful in increasing participation rates. Tron and their associated companies earn $70 million in profits annually (Nuclear Waste Management Organization 2013).

Those employed at the various uranium operations (Key Lake Mill, Rabbit Lake Mine, Cigar Lake Mine, and MacArthur River Mine) in the region participate in a fly-in/-out commuter rotation system, requiring them to be away from the community. ERFN is the only First Nation in Canada where members flying to work off-reserve are tax exempt (Nuclear Waste Management Organization 2013). South of Saskatoon is English River First Nation's Grasswood reserve which has a business centre, business complex and travel complex which generates revenues for the First Nation (Nuclear Waste Management Organization 2013).

Through the Collaboration Agreement with Cameco and Orano, funds assisted with upgrading the community fish plant, allowing fishermen to process their catch. This reduces the costs to transport fish to a processing facility therefore reducing costs and providing an option for fishermen to sell locally (Joint Implementation Committee 2018).

4.4.3 Patuanak Employment by Sector

Table 16 outlines employment by sector in Patuanak compared to residents of northern Saskatchewan and Saskatchewan. Key sectors for employment in Patuanak are utilities, retail trade, educational services, and health care, and social assistance. Data indicates that males and females are employed in different industries. Key sector of males in Patuanak include public administration whereas educational services are a key sector for females.

Table 16: Employment by Sector for English River First Nation in Patuanak compared to Northern Saskatchewan and Saskatchewan (2016)

	Patuanak[1]			Northern Saskatchewan[2]			Saskatchewan		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
Total Labour Force population aged 15 years and over by industry[3,4]	20	10	10	12,355	6,540	5,815	585,540	311,110	274,430
Industry – not applicable	0	0	0	1,565	910	660	10,225	5,205	5,020
All industry categories	25	15	10	10,790	5,635	5,155	575,310	305,905	269,410
Agriculture; forestry; fishing and hunting	0	0	0	240	220	20	51,255	36,820	14,440
Mining; quarrying; and oil and gas extraction	0	0	0	1,165	1,025	145	23,070	20,040	3,025
Utilities	10	0	0	95	80	15	5,395	3,780	1,610
Construction	0	0	0	800	735	70	49,310	43,460	5,850
Manufacturing	0	0	0	150	120	30	26,710	21,000	5,710
Wholesale Trade	0	0	0	105	70	35	20,480	15,325	5,155

	Patuanak[1]			Northern Saskatchewan[2]			Saskatchewan		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
Retail Trade	10	0	0	1,015	455	555	63,360	30,185	33,180
Transportation and Warehousing	0	0	0	445	325	120	24,755	19,385	5,370
Information and Cultural Industries	0	0	0	90	45	45	10,005	5,055	4,950
Finance and Insurance	0	0	0	95	20	75	20,155	6,495	13,655
Real Estate and Rental Leasing	0	0	0	90	65	25	7,650	4,425	3,220
Professional; Scientific and Technical Services	0	0	0	165	70	95	25,250	12,985	12,265
Management of Companies and Enterprises	0	0	0	10	10	0	1,340	680	660
Admin. and Support; Waste Mgmt and Remediation	0	0	0	310	165	145	16,395	9,660	6,735
Educational Services	0	0	10	1,895	530	1,365	45,360	13,670	31,690

	Patuanak[1]			Northern Saskatchewan[2]			Saskatchewan		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
Health Care and Social Assistance	10	0	0	1,660	290	1,370	72,625	11,285	61,335
Arts; Entertainment and Recreation	0	0	0	100	55	45	10,545	5,120	5,425
Accommodation and Food Services	0	0	0	585	270	310	37,785	14,295	23,490
Other Services (Except Public Administration)	0	0	0	250	135	115	25,680	12,590	13,090
Public Administration	0	10	0	1,520	955	570	38,180	19,640	18,535

Source: Statistics Canada 2016.

Footnotes:
1. Data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5, and in some cases 10. Columns may not add up due to rounding.
2. Northern Saskatchewan refers to Census Division No. 18.
3. Includes the experienced labour force which refers to persons aged 15 years and over who during the Census were employed and the unemployed who had last worked for pay or in self employment prior to the Census.
4. Includes unemployed persons aged 15 years and over who have never worked for pay or in self-employment or who had last worked prior to January 1, 2015.
5. Refers to the general nature of the business carried out in the establishment where the person worked. The data are produced according to the North American Industry Classification System (NAICS) 2012 with 25% sample data.

4.4.4 English River First Nation Economic Development

Des Nedhe Development LP was established by English River First Nation in 1991 to create sustainable employment and business opportunities for English River members. Since its inception, Des Nedhe Development has invested in established companies that are leaders in Saskatchewan's mining and construction industry and expanded its portfolio into the areas of retail and real estate development and management. (Des Nedhe Development n.d.).

Among the businesses and partnership managed either solely or as joint ventures by Des Nedhe Development are:

- Tron Construction and Mining;
- Mudjatik Thyseen Mining Ltd. Partnership;
- Retail Division; and
- Renewable Energy Partnership with Peter Ballantyne Cree Nation.

Tron Construction and Mining: Tron is an industrial contactor specializing in mechanical, piping, electrical, instrumentation and structural steel (Office of the Treaty Commissioner n.d.). Tron has been a namesake in the Saskatchewan mining industry for more than 25 years and employs a highly skilled workforce (Des Nedhe n.d.). Tron provides various construction and mining related services which include:

- Civil, which includes clearing and grubbing, earthwork, foundations, retaining walls, and utilities;
- Infrastructure, which includes process and loading facilities construction, structures and ancillary buildings, pond, tank and reservoir construction, tailings, dams, dikes, spillway, and batch plant construction;
- Mechanical, which includes mechanical maintenance and construction, piping, pumping and mine dewatering systems, and water diversion and distribution;
- Services, which includes water and septic hauling, site services, and batch plant operation; and
- Electrical, which includes electrical maintenance and construction, and crushing and conveying systems (Des Nedhe n.d.).

Mudjatik Thyseen Mining Ltd. Partnership: Des Nedhe along with Thyssen Mining and other First Nations, Métis and northern Saskatchewan municipalities entered into a joint mining venture for Cameco called Mudjatik Thyssen Mining (MTM) Ltd. Partnership (Joint Implementation Committee 2018).

Retail Division: An important part of Des Nedhe's business is their retail division which includes the Grasswood Gas Bar and Convenience Store; Grasswood Vehicle Wash; Patuanak Gas Bar and Convenience Store; and Beauval General Store, Gas Bar and Restaurant (Des Nedhe Development n.d.).

Renewable Energy Partnership with Peter Ballantyne Cree Nation: Des Nedhe is also involved with renewable energy as their partnership with Peter Ballantyne Cree Nation has bid on projects for SaskPower including solar panel installation for residential buildings.

A portion of the Des Nehde’s profits goes towards investments to acquire new assets including:

- Athabasca Catering, which is the main supplier of food services for mining operations in northern Saskatchewan;
- Northern Resource Trucking provides transportation of commodities within and to the north;
- Creative Fire is a communications firm based in Saskatoon; and
- JNE Welding supplies steel fabrication to mining, construction, petrochemical and power-generation sectors across North America (Des Nedhe Development n.d.).

5.0 REFERENCES

APTN National News (2019). English River residents spend a week on the land to heal, strengthen families. https://aptnnews.ca/2019/08/21/english-river-residents-spend-a-week-on-the-land-to-heal-strengthen-families/ [Accessed February 6, 2020].

APTN National News (2019). English River youth, elders paddle on healing journey. https://aptnnews.ca/2019/08/17/english-river-youth-elders-paddle-on-healing-journey/ [Accessed February 6, 2020].

Des Nedhe Development (n.d.). https://desnedhe.com/ [Accessed March 6, 2020].

English River School (n.d.). St. Louis School English River First Nation. http://www.englishriverschool.ca/index.php [Accessed February 6, 2020].

First Nations University of Canada (n.d). http://fnuniv.ca/ [Accessed February 25, 2020].

First Nations Land Management Resource Centre (n.d.). English River. https://labrc.com/first-nation/english-river/ [Accessed February 6, 2020].

Gillespie B.C. (1976) Changes in Territory and Technology of the Chipewyan. Arctic Anthropology. Volume 13, Number 1, 1976, pp.6-11. University of Wisconsin Press. Available at http://www.jstor.org/stable/40315884 [Accessed July 23, 2010].

Global News (2013). Cameco, Areva, sign deal with Saskatchewan First Nation for uranium mine. https://globalnews.ca/news/602421/cameco-areva-sign-deal-with-saskatchewan-first-nation-for-uranium-mine/ [Accessed February 6, 2020].

Government of Canada (2013). English River First Nation – Connectivity Profile. https://www.aadnc-aandc.gc.ca/eng/1357840942234/1360166101399 [Accessed February 6, 2020].

Government of Canada (2019a). Governance English River First Nation. https://fnp-ppn.aadnc-aandc.gc.ca/fnp/Main/Search/FNGovernance.aspx?BAND_NUMBER=400&lang=eng [Accessed February 12, 2020].

Government of Canada (2019b). Reserves/Settlements/Villages. https://fnp-ppn.aadnc-aandc.gc.ca/fnp/Main/Search/FNReserves.aspx?BAND_NUMBER=400&lang=eng [Accessed March 3, 2020].

Government of Canada (2020). Post-Secondary Student Support Program. https://www.sac-isc.gc.ca/eng/1100100033682/1531933580211 [Accessed March 3, 2020].

Government of Saskatchewan (2012). Saskatchewan Fur Program. http://www.environment.gov.sk.ca/Default.aspx?DN=15f85859-9ba5-40a5-b448-244f4cfd7998 [Accessed March 4, 2020].

Government of Saskatchewan (2018). Northern Hamlet of Patuanak. http://www.mds.gov.sk.ca/apps/Pub/MDS/muniDetails.aspx?cat=5&mun=2617 [Accessed February 6, 2020].

Jarvenpa, R. (1976). Spatial and Ecological Factors in the Annual Economic Cycle of the English River Band of Chipewyan. Arctic Anthropology, Vol.13, No.1 (1976), pp. 43-69 Published by: University of Wisconsin Press.

Jarvenpa, R. (1977). Subarctic Indian Trappers and Band Society: The Economics of Male Mobility. Human Ecology. Volume 5, Number 3, 1977, pp. 223-259. Plenum Publishing Corporation, New York.

Jarvenpa, R. (1980). The trappers of Patuanak: toward a spatial ecology of modem hunters. Ottawa: National Museum of Man, Mercury Series. Canadian Ethnology Services Paper No. 67, Ottawa.

Joint Implementation Committee (2018). Collaboration Agreement. http://s3-us-west-2.amazonaws.com/assets-us-west-2/annual/ERFN_2018_CA_Report.pdf [Accessed February 25, 2020].

Meadow Lake Tribal Council (n.d.). English River First Nation. https://www.mltc.net/nations/erfn/ [Accessed February 6, 2020].

Northern Business Directory (2013). English River First Nation (ERFN) – Northern Hamlet of Patuanak.https://www.northernbusinessdirectory.ca/busdir/images/PDF/Community%20Profiles/Boreal%20West/EnglishRiver-Patuanak-Updated2013.pdf [Accessed February 6, 2020].

Northern Business Directory (2020). https://www.northernbusinessdirectory.ca/reports/directory.pdf [Accessed February 6, 2020].

Northern Saskatchewan Health Services (n.d.). English River Health Services. http://www.ehealth-north.sk.ca/facility.aspx?m=4&facility=99 [Accessed February 6, 2020].

Nuclear Waste Management Organization (2013). Draft Community Profile English River First Nation, Saskatchewan. https://www.nwmo.ca/~/media/Site/Files/PDFs/2015/11/04/17/37/2309_apm-rep-06144-0047-erfn_community_profile_-_draft_.ashx?la=en [Accessed February 6, 2020].

Office of the Treaty Commissioner (n.d.). Des Nedhe Development. http://www.otc.ca/reconciliations/details/des_nedhe_development.html [Accessed February 6, 2020].

Peter Dodson et. al (2006). In Their Own Land: Treaty Ten and the Canoe Lake, Clear Lake, and English River Bands. http://www.otc.ca/public/uploads/resource_photo/In_Their_Own_Land1.pdf [Accessed March 2, 2020].

Royal Canadian Mounted Police (2015). Beauval detachment Saskatchewan. http://www.rcmp-grc.gc.ca/detach/en/d/264#Beauval [Accessed February 6, 2020].

SaskTel (2019). SaskTel brings the next generation of TV and entertainment to Northern and Indigenous communities with launch of maxTV Stream. https://www.sasktel.com/about-us/news/2019/sasktel-brings-next-gen-tv-entertainment-to-northen-communities [Accessed February 6, 2020].

Smith, J. (1976). Local Band Organization of the Caribou Eater Chipewyan. Arctic Anthropology, 13(1), 12-24. Retrieved March 5, 2020, from www.jstor.org/stable/40315885

Smith, J. G. E. (1981). Chipewyan. As found in Handbook of North American Indians. William C. Sturtevant (ed.). Volume 6: Subarctic. June Helm (Ed.). Smithsonian Institution, Washington.

Statistics Canada (2019). Dictionary. https://www12.statcan.gc.ca/census-recensement/2016/ref/dict/az1-eng.cfm [Accessed March 6, 2020].

University of Saskatchewan (n.d.). Off-campus and Online. https://admissions.usask.ca/programs/off-campus.php#Youroptions [Accessed February 6, 2020].

Yerbury, J.C. (1976) The Post-Contact Chipewyan: Trade Rivalries and Changing Territorial Boundaries. Ethnohistroy. Volume 23, Number 3, Summer 1976, pp.237-263. Duke University Press. Available at http://www.jstor.org/stable/481254 [Accessed July 23, 2010].

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Wheeler River Project

Community Profile
Pinehouse, Saskatchewan

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

The community profile for Pinehouse, Saskatchewan (sometimes referred to as Pinehouse Lake) has been developed as an initial step towards characterizing the socio-economic baseline in relation to The Wheeler River Project.

This community profile includes the following sections:

- **Introduction**, including research approach;
- **Community Context,** including location, population, and demographics;
- **Infrastructure and Services**, including community facilities and services, utilities and public services, and housing and accommodations; and
- **Economy**, including discussions on labour force, education and training, income, and the local economy.

1.1 APPROACH

Secondary data sources were used to characterize the existing socio-economic environment of Pinehouse, Saskatchewan. Sources used for data collection include existing literature and databases from public sources such as:

- Statistical data sources (e.g., Statistics Canada);
- Federal and provincial government reports and data; and
- Online sources (e.g., community web pages and profiles, available literature, business web pages, news articles and profiles).

1.1.1 Data Limitations

Data presented in the report have some limitations which include:

Statistics Canada Data Limitations. While Statistics Canada data can provide a preliminary understanding of a community, they should be interpreted with caution because of issues of comparability across years, confidentiality, and data quality. For the following community profile 2016 Statistics Canada data is relied upon; however, there are instances where comparisons with 2006 and 2011 data are made. It is noted that in 2011 there was a shift in how the census was administered, with a National Household Survey replacing the long-form census. One of the key differences was a shift from a mandatory to an optional response requirement for citizens. Statistics Canada also suppresses data for confidentiality or data quality. Data suppression for confidentiality reasons is meant to prevent the disclosure of data that could be used to identify individuals. It is often used for income characteristics in geographic areas where the population or private households do not meet a certain threshold. Data suppression due to data quality is done for a variety of reasons, including incompletely enumerated reserve parcels or Indian settlements or a global non-response rate of higher than or equal to 50%.

Secondary Research: Research was limited to the review of existing literature and databases from a variety of secondary sources.

2.0 COMMUNITY CONTEXT

2.1 OVERVIEW

Pinehouse is a village located in north-western Saskatchewan bordering Pinehouse Lake and is approximately 34 km north on highway 914 from its junction with highway 165. The original settlement was used by the Hudson Bay Company (HBC) in the early 1900s (McNab 1992). When used by the Hudson Bay Company, it was referred to as Souris River and was located approximately 15 km north of where it is currently. Roughly two-thirds of the population of Pinehouse identify as Métis, with the remainder identifying as First Nations and non-Aboriginal (Statistics Canada 2016)[1]. The mother tongue of the Pinehouse population is almost equal parts English and Cree (Statistics Canada 2016).

2.2 HISTORY

The Métis-Cree of Pinehouse are not descended from the Métis of the Red River Settlement area but are of a northern Métis ancestry (McNab 1992). The Métis in this area of Saskatchewan are predominately the product of French-Canadian voyageurs and Scottish or English traders. Historically, the Métis formed a transitional group between the Europeans of the fur trade and Indians in the area, performing the function of cultural brokers. Jarvenpa and Brumbach (1985) describe how the Métis became a working class who occupied a niche in the fur trade. Ethnographic research suggests that the Métis-Cree people of Pinehouse established themselves in the Pinehouse area in the early twentieth century. The original post was located at the north end of Pinehouse Lake (historically, it was called Snake Lake or kinêpiko-sâkahikam in Cree) near the Hudson Bay Company post at the Souris River. The settlement was also used by the Dene, many of whom departed when a smallpox epidemic killed a large percentage of the people in the area in 1901/1902 (McNab 1992, Tobias and Kay 1994). A group of Cree and Métis-Cree moved into the area from Île-à-la-Crosse and the La Ronge areas. In 1944, the Catholic church established St. Dominic’s Church in the present-day location of Pinehouse. This, combined with a school built several years later, drew the Métis Cree people from the north end of the lake and other areas to the community, beginning a shift to a more sedentary lifestyle (McNab, 1992).

In 1978, the first all-weather road was completely to Pinehouse and on to the Key Lake Uranium Operation. With the road, the community had its first link to the south, which altered where people went for resource use in the region and provided access to areas that were previously only accessible by foot, waterways, and dog teams. “The increased access to other communities

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[1] Although there has been a shift to use of the term Indigenous as opposed to Aboriginal, when describing Statistics Canada data terminology has been used as consistent with Statistics Canada definitions. Statistics Canada defines Aboriginal identity persons who are First Nations (North American Indian), Métis or Inuk (Inuit) and/or those who are Registered or Treaty Indians (that is registered under the Indian Act of Canada) and/or those who have membership in a First Nation or Indian band. Aboriginal peoples of Canada are defined in the Constitution Act 1982 section 35 (2) as including the Indian Inuit and Métis peoples of Canada.

brought with it social issues for Pinehouse residents, including drug and alcohol abuse" and represented a low point in the community's history (NWMO 2013).

The area supports rich diversity in a habitat important for the fish and animals that the community relied upon. The lake in particular provided whitefish, sucker, pickerel, and pike harvest for commercial and domestic purposes (Tobias and Kay 1993). Traditional activities, such as hunting, trapping, and fishing remain vital practices in the community. Tobias (as quoted in Nuclear Waste Management Organization, 2013) notes that the health of the traditional-food economy is absolutely vital to the well-being of Pinehouse residents. Pinehouse residents have a strong reliance on their traditional informal economy or 'income-in-kind' of hunting, trapping, and fishing. These activities (including the collection of medicinal plants/herbs, berries, and wild rice) have long been a part of the Pinehouse community as a means of providing sustenance and earning an income. Practice of these traditional and/or 'income-in-kind' activities are still prevalent today as a vital part of the Pinehouse economy and survival of its residents (Nuclear Waste Management Organization, 2013).

Pinehouse openly acknowledges the low points of the 1970s and is proud of the success they have achieved in rebuilding the community (Nuclear Waste Management Organization, 2013). Pinehouse has seen social benefits of supporting the use of the Cree language within the community. The use of Indigenous language at home is higher in Pinehouse in comparison to many communities in northern Saskatchewan and in the province as a whole. Along with the use of their traditional language, retaining their culture is of significant importance to the community. Maintaining their traditional culture is achieved by holding cultural activities that residents are encouraged to partake in, protecting areas of cultural importance and promoting cultural knowledge in their community (Nuclear Waste Management Organization, 2013).

Figure 1: Communities in the Vicinity of the Wheeler River Project

2.3 GOVERNANCE

Pinehouse is governed by a mayor and four alderman, who follow a three-year election cycle and meet every second and fourth Wednesday of the month (Government of Saskatchewan Municipal Directory System 2018). The elected officials and their appointment date can be seen in Table 1 below.

Table 1: Elected Officials Pinehouse, Saskatchewan

Title	Name	Appointment Date
Mayor	Mike Natomagan	September 21, 2016
Alderman	Leona Laviviere	September 21, 2016
Alderman	Conrad Misponas	September 21, 2016
Alderman	Betty Ann Durocher	September 21, 2016
Alderman	Vince Natomagan	September 21, 2016

Source: Government of Saskatchewan Municipal Directory System, 2018.

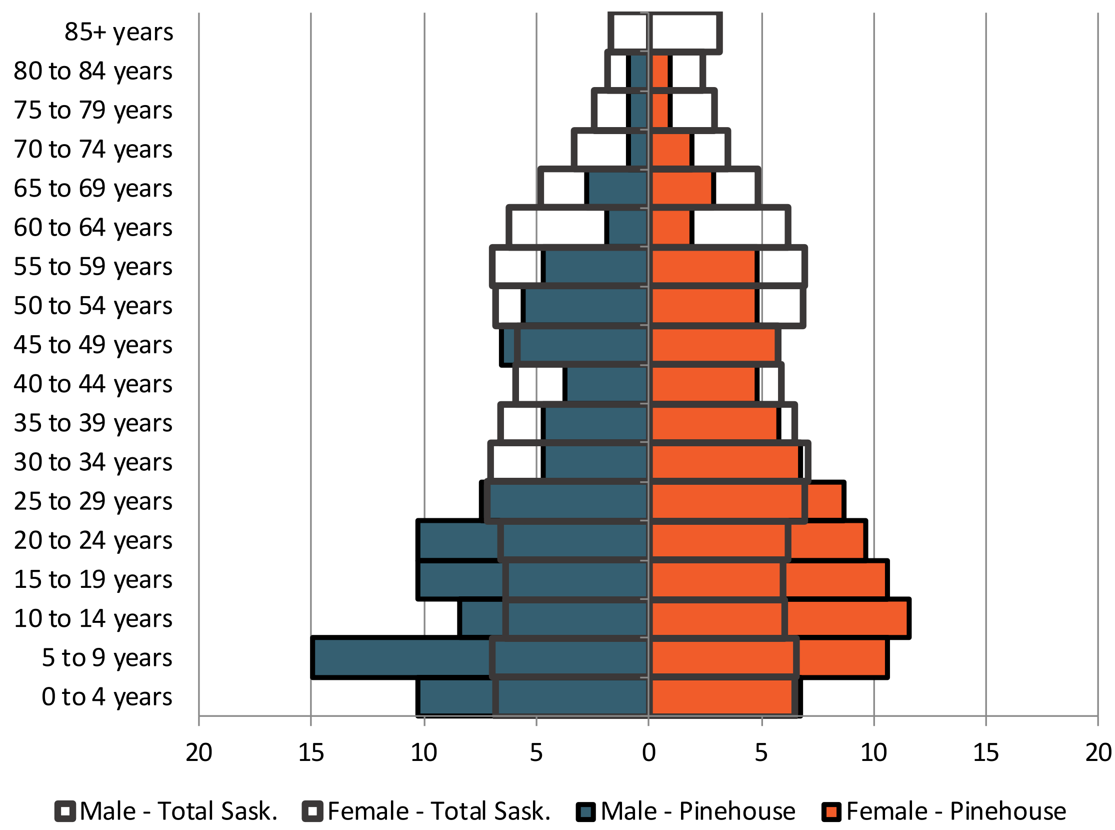
Kineepik Métis Local Inc. is the Métis Local committee for Pinehouse which consists of a board of nine local residents of Métis descent and two community Elders. Kineepik Métis Local meet on a monthly basis and is part of the Métis Nation-Saskatchewan Northern Region III, which is one of twelve regions within Saskatchewan. Mervin Tex Bouvier is the regional director of the Northern Region III (Métis Nation n.d.). The Métis Local group works with Mayor and Council as well as other local groups to establish programs and events within the community (InterGroup Consultants Ltd., 2011).

2.4 PINEHOUSE POPULATION

As of 2016, Statistics Canada reported that the population of Pinehouse was 1,052 which is an increase in population from 978 residents in 2011 (Statistics Canada 2016; Statistics Canada 2011).

Figure 2 provides an illustration of the age and sex distribution for the population in 2016, compared to the age-sex structure for Saskatchewan as a whole. The population of Pinehouse tends to be younger in comparison to the province and the proportion of the Pinehouse population of working age and ages 65 and over is smaller than it is in Saskatchewan.

Figure 2: Age and Sex Distribution for Pinehouse and Saskatchewan (2016)



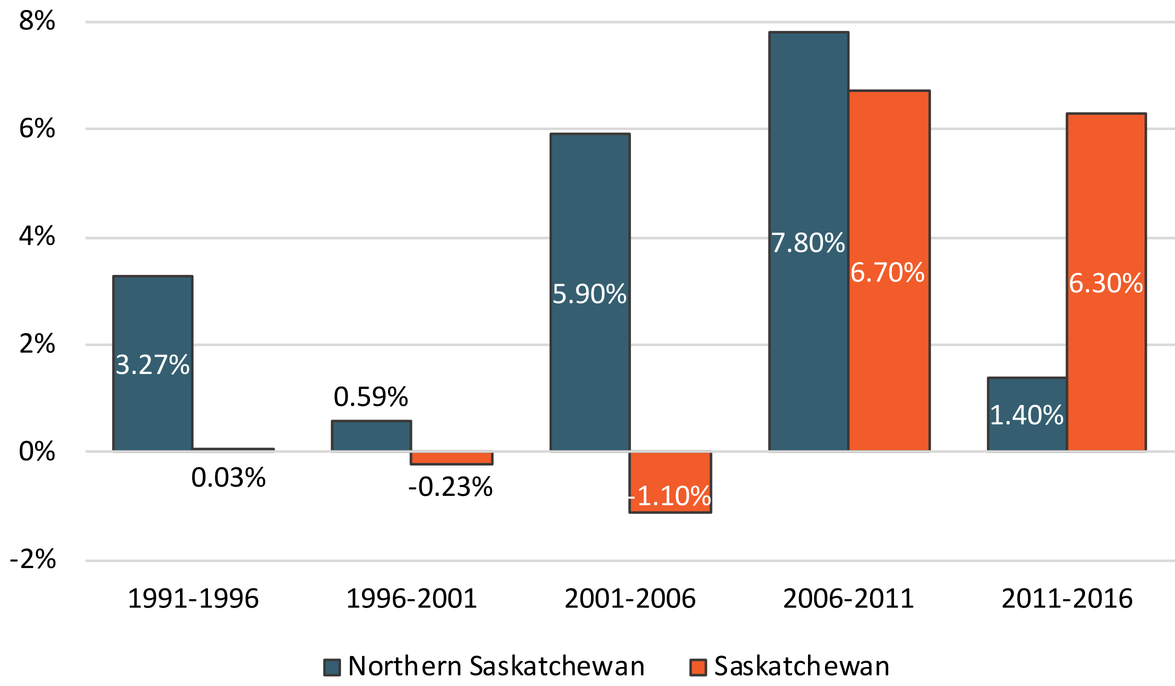
Source: Statistics Canada 2016.

Footnotes:
1. Population count does not include incompletely enumerated communities.

2.5 POPULATION GROWTH RATES OF NORTHERN SASKATCHEWAN AND SASKATCHEWAN

Figure 3 provides a comparison of population growth rates for northern Saskatchewan versus the province of Saskatchewan as a whole. Since 1991 northern Saskatchewan has experienced population growth on a constant basis, while the province of Saskatchewan experienced very little growth from 1991 to 1996, negative growth from 1996 to 2006 and only positive growth from 2006 to 2016.

Figure 3: Population Growth Rates Northern Saskatchewan and Saskatchewan



Source: Statistics Canada 1996, 2001, 2006, 2011, and 2016.

3.0 INFRASTRUCTURE AND SERVICES

This section describes the infrastructure and services available in Pinehouse. Topics include community facilities and services (including educational facilities, health facilities, social services, emergency services, recreational services, and transportation and access), utilities and public services, and housing and accommodations.

3.1 EDUCATIONAL FACILITIES

3.1.1 Childcare

Pinehouse offers childcare and nursery services for children through several daycare programs, some of which are funded by the Northern Lights School division (NLSD). There are three childcare providers in the community, each offering care for different age ranges. The Magloire Teen Infant Day Care provides daycare for children between six weeks to three years of age, Magloire Kiddie Care provides care for children aged 18 months to kindergarten and the Awasis Centre provides programs for preschool children. Families looking for in-home assistance with childcare can also access services provided by Kids First North Program (Northern Saskatchewan Business Directory 2019).

3.1.2 Primary and Secondary Education

The Minahik Waskahigan Elementary School and Minahik Waskahigan High School are located in separate buildings beside each other. They are both a part of the Northern Lights School Division.

There are roughly 200 students that attend the Minahik High School which aims to provide a well-rounded education to its students. The high school provides education to grades seven to twelve and the students have access to a gymnasium, science lab, home economics classroom, library, art room and computer lab (Northern Lights School Division No. 113 n.d.). There are also a variety of athletic programs offered to high school students such as football, volleyball, basketball, soccer and badminton. The school offers several extracurricular activities such as drama club, the Gender and Sexuality Alliance, Yearbook, Grad club and the Science Fair. The staff at the high school includes ten high school teachers and six educational assistants. The schools offer accommodations for teachers employed at the schools. There are also resources for numeracy/literacy, social work, career transitions, student support and an Elder on staff (Minahik Waskahigan High School n.d.).

3.1.3 Post-secondary Education

There are several ways Pinehouse residents can access post-secondary education in Northern Saskatchewan. Northlands College provides post-secondary education to communities in Northern Saskatchewan and has campuses located in La Ronge, Buffalo Narrows and Creighton. Residents from Pinehouse attend these campuses as they are the closest post-secondary schools to the community. Students have access to a variety of certification options such as university education, Technology and Trades diplomas and certificates, and Adult Basic Education (Northlands College n.d.-a). Their 2017-2018 Annual Report stated that their newly added Nursing Degree program through Saskatchewan Polytechnic in La Ronge had 15 graduates from northern Saskatchewan communities including Pinehouse (Northlands College Annual Report 2017-2018).

The University of Regina offers three stand-alone programs to northern communities in Saskatchewan including a Liberal Arts Certificate program in Pinehouse (Regina Leader-Post 2019).

The University also has an extensive list of courses spanning different disciplines offered online providing flexible learning opportunities (University of Regina n.d.).

The Gabriel Dumont Institute of Native Studies and Applied Research provides education and employment in partnership with post-secondary institutions for the Métis people. The Institute offers education and career counselling to both adults with and without a high school diploma, as well as those looking for post-secondary education. Following the Collaboration Agreement between Pinehouse, Cameco Corporation and Orano Canada Inc. (formerly AREVA Resources Inc.) signed in 2012, an apprenticeship program for Carpenters, Heavy Duty Mechanics, Industrial Mechanics and Welders was created through a partnership between the Institute and Pinehouse (Gabriel Dumont Institute of Native Studies and Applied Research, 2019). The Institute has also offered a Security Officer and Business Certificate programs within the community recently (Gabriel Dumont Institute of Native Studies and Applied Research, 2018a, 2018b).

Through the Collaboration Agreement the community received $30,000 for school programming, and other contributions to education/training by:

- Identifying training requirements for the community;
- Fill internships and student positions with community members;
- Work with educational institutions to organize career fairs;
- Provide pre-employment training programs;
- Identify candidates within the community for training programs;
- Provide unpaid work placements for residents enrolled in mining training programs; and
- Work with the community to provide scholarship programs to build skillsets (Northern Village of Pinehouse, Kineepik Metis Local Inc., Cameco Corporation and Areva Resources, 2012).

3.2 HEALTH FACILITIES AND SERVICES

Health facilities in Pinehouse can be accessed at the Health Centre run by the Mamawetan Churchill River Regional Health Authority. The Health Centre is open during the week for eight hours a day, Monday to Friday but offers a call-in service to a nurse outside of regular business hours for emergencies. Services provided include primary care, public health, mental health, health education, telehealth services, and home care services (Saskatchewan Health Authority n.d.-b). Pinehouse residents have access to pharmaceuticals from a local pharmacy in the community (Nuclear Waste Management Organization, 2013).

Specialists come to the community monthly and will hold day-long clinics for local health needs such as diabetes care, foot care, eye care, and physiotherapy services. Furthermore, services not available within the community can be arranged with the Health Centre for residents that must travel for health services, such as adult dental care as only children can access dental care within the community at the dental clinic in Minahik Elementary School. While non-urgent health care can be accessed within Pinehouse; minor emergency, urgent care services, and access to specialized equipment require residents to travel to neighbouring communities such as Meadow Lake, Prince Albert, La Ronge, or Saskatoon (InterGroup Consultants Ltd., 2011).

The Mamaweten Churchill River Health Region is a partner of KidsFirst NORTH, a program offered in Pinehouse which helps parents gain important parenting skills and assists in supporting child development. Through the program families can access home visits as well as take part in community programming (Saskatchewan Health Authority, n.d.-a). The Growing Great Kids curriculum is the primary program which is delivered through home visits to off-reserve families who have enrolled during pregnancy or shortly after childbirth. The KidsFirst NORTH program includes:

- Screening and assessment;
- Prenatal case finding;
- Home visiting services;
- Mental health and addictions;
- Early learning; and
- Family support (KidsFirst NORTH n.d.).

3.3 SOCIAL SERVICES

The Health Centre also provides social services to residents of Pinehouse, and together the Mamawetan Churchill River Regional Health Authority and Minahik Waskahigan School provide social workers to the community (Minahik Waskahigan n.d.). Other services offered through the Health Centre include addiction services and holistic health services (Saskatchewan Health Authority n.d.-b).

When road access to the community with the construction of Highway 918 occurred in the 1970s, Pinehouse saw new opportunities for economic development and connectivity to surrounding communities. The new connectivity to other communities resulted in an increased access to drugs and alcohol which led to abuse within the community. Through the Reclaiming Our Community initiative, Pinehouse has overcome these social challenges through recreation, education, awareness and traditional teachings. To ensure its effectiveness several interagency partnerships promote and support the initiative (Nuclear Waste Management Organization, 2013). There are other social services offered within the community including elders that can provide family assistance, youth intervention meetings, and cultural camps offered through Minahik Waskahigan School.

Through a Collaboration Agreement with Cameco and Orano several social initiatives were able to receive funding such as their Annual Elders Gathering, scholarships, recreation and housing (Cameco n.d.).

3.4 EMERGENCY SERVICES

Pinehouse has the following emergency services:

- **Fire services** are provided by a volunteer fire crew (Northern village of Pinehouse n.d.).
- **Policing services** are provided by the RCMP, which has an office across from the Town Office. The Pinehouse Police Management Board acts as a liaison between the RCMP and Pinehouse residents and is made up of volunteers that assist with coordinating the concerns of the community and the RCMP (InterGroup Consultants Ltd., 2011).

The community does not have an ambulance service, the nearest being in Beauval, Saskatchewan. With emergency hospital services located in La Ronge, Prince Albert, Meadow Lake, and Saskatoon, residents requiring emergency health care are medevaced by air to one of these locations (Nuclear Waste Management Organization, 2013).

3.5 RECREATION SERVICES

There are several recreational facilities such as an arena, community recreation hall and outdoor green space within the Pinehouse community (Nuclear Waste Management Organization, 2013). There is a local committee that runs recreational programs and organizes a variety of sports teams including baseball, volleyball, hockey and others. Shortly after the Collaboration Agreement between Pjnehouse, Kineepik Métis Local Inc., Cameco Corporation and Areva Resources Inc (now Orano) was signed, $1.3 million was invested into the community arena for an artificial ice plant (Global News 2014).

In September 2019, a group of high school students formed The Pinehouse Youth Panel which is supervised by a Restorative Program Co-ordinator. The Youth Panel uses a community building for their programs including a youth drop-in and information nights, grief and loss support, sharing circles, boys' and girls' clubs and a homework club. They also run the canteen in the Pinehouse Lake arena as a source of revenue. The Panel has plans to access provincial and federal funding in the future by becoming incorporated (larongeNOW 2019).

The community holds an annual Elders Gathering held in Pinehouse. The Gathering provides an opportunity for people of all ages to learn about their culture and the Elders. Food, music, dance and art are all part of the annual event. Opportunities to learn how to cook, prepare fish, woodcarving and how to make boats and paddles were some of the activities held this year (CBC News, 2019a).

There are community and family camps on lakes and rivers surrounding Pinehouse that residents like to use. North of the community on Key Lake Road there are camp sites available for use as well as the Gordon Lake Recreation Site (Nuclear Waste Management Organization, 2013).

3.6 TRANSPORTATION AND ACCESS

Highway 914 is maintained by Saskatchewan Highways and Infrastructure and is the only access road into the community of Pinehouse. Internal roads within the community are gravel and are maintained by the community.

3.7 UTILITIES AND PUBLIC SERVICES

The community has the following municipal services:

- Water treatment station and distribution;
- Sewage collection;
- Landfill; and
- Cemetery.

Saskatchewan Telecommunications provides the community with telephone services, and electricity is supplied by Saskatchewan Power Corporation. High speed internet and cellular services are also available to residents. Pinehouse receives its fuel from Federated Cooperatives located in Prince Albert who make bi-monthly deliveries to the community (Nuclear Waste Management Organization 2013).

Pinehouse Lake provides potable water to the community via a treatment plant and reservoir system on the north side of the community. There are two reservoirs which can hold 250,000 and 70,000 gallons of water. The treatment plant was constructed 50 years ago and has had renovations and upgrades to it since then. (InterGroup Consultants Ltd., 2011).

3.8 HOUSING

Statistics Canada has several important indicators that help provide an understanding of the state of housing in communities. Taken together, the total number of homes and the total population in the communities on Census Day 2016 can provide a glimpse into the average number of residents living in each home.

Table 2 presents the housing characteristics: Pinehouse, northern Saskatchewan, and Saskatchewan according to the 2016 Census of Canada. In 2016, Pinehouse had 265 occupied private dwellings. Pinehouse had comparable number of average rooms per house (5.4) in comparison to Northern Saskatchewan (5.6), but less than the province of Saskatchewan (6.7). The village also had a higher average number of persons per household (4.0) than Northern Saskatchewan (3.6) and Saskatchewan as a whole (2.5). The percentage of households requiring major repairs in Pinehouse was nearly half (16.9%) of the rate of northern Saskatchewan (30.73%) but almost double that of the province of Saskatchewan (8.67%).

Table 2: Housing Characteristics for Pinehouse, Northern Saskatchewan, and Saskatchewan (2016)

	Pinehouse[1]	**Northern Saskatchewan[1,2]**	**Saskatchewan[1]**
Total Number of Occupied Private Dwellings[3]	265	10,235	432,620
Average Number of Rooms per Dwelling	5.4	5.6	6.7
Average Number of Persons per Household	4.0	3.6	2.5
Households Requiring Major Repairs[4]	16.98%	30.73%	8.67%

Source: Statistics Canada 2016.

Footnotes:

1. Data has been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5, and in some cases 10. Columns may not add up due to rounding.
2. Northern Saskatchewan is defined as Census Division No.18.
3. "Total number of occupied private dwellings" is 100% data.
4. Major repairs include defective plumbing or electrical wiring, and structural repairs to walls, floors or ceilings.

4.0 ECONOMY

This section describes the economic environment for Pinehouse, as well as Northern Saskatchewan and Saskatchewan for comparison. It presents labour force characteristics, education and training, income, employment, information on economic development, and local businesses.

4.1 LABOUR FORCE CHARACTERISTICS

The labour force includes persons over the age of fifteen years old during the period of the census who can contribute to the economy within a population. This statistic is usually described as a percentage and conveys the proportion of the population that the economy is dependent on.

Key indicators of labour force are:

- **Participation Rate:** the labour force participation rate reflects the number of people who are interested in participating in the workforce (population 15 years and over). This indicator is typically in conjunction with employment rates as it accounts for those people who may not be working (e.g., students, homemakers, institutionalized people) but are still active contributors in the economy.
- **Employment Rate:** reflects the proportion of the total population (aged 15 years and over) that was working Sunday May 1 to Saturday May 7, 2016.
- **Unemployment Rate:** accounts for the proportion of the total population (population in the labour force) that was not working Sunday May 1 to Saturday May 7, 2016.

4.1.1 Pinehouse Labour Force Characteristics

In 2016, Statistics Canada reported that 715 Pinehouse residents were eligible to participate in the labour force (i.e., individuals aged 15 years and over) of whom 355 were men and 360 were women (Table 3). The participation rate for residents was 55.9%, with a lower participation rate for female residents (51.4%) than male residents (60.6%). The overall participation rate for residents of Pinehouse was about 7.1% higher than the participation rates in northern Saskatchewan (48.8%) and 12.4% lower than the province of Saskatchewan (68.3%).

Approximately 42.6% of people ages 15 years and older living in Pinehouse were employed in 2016, compared to a similar employment rate in northern Saskatchewan (37.2%) and a lesser employment rate in Saskatchewan (63.4%) as a whole. Pinehouse residents had similar employment rates for female residents (40%) and male residents (45%), which is higher than the employment rates for male (36.9%) and female (37.4%) residents of northern Saskatchewan. Saskatchewan had higher employment rates for males (67.5%) than females (59.5%).

The unemployment rate for Pinehouse in 2016 was 22.5%, which was similar in northern Saskatchewan (23.8%) and greater than the provincial average (7.1%). In 2016, male residents had a higher unemployment rate (25.6%) compared to female residents (21.6%). In northern Saskatchewan and in Saskatchewan as a whole, male residents also had a higher unemployment rate than female residents.

Table 3: Labour Force Characteristics for Pinehouse, Northern Saskatchewan, and Saskatchewan (2016)

	Pinehouse[1]			Northern Saskatchewan[1,2]			Saskatchewan[1]		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
Total Population 15 Years and Over by Labour Force Activity	715	355	360	25,295	12,610	12,685	857,295	424,260	433,035
In the Labour Force[3]	400	215	185	12,355	6,540	5,815	585,540	311,110	274,430
Employed[4]	305	160	145	9,420	4,660	4,755	544,095	286,330	257,760
Unemployed[5]	90	55	40	2,935	1,875	1,060	41,445	24,775	16,665
Not in the Labour Force[6]	315	140	180	12,940	6,070	6,870	271,760	113,155	158,605
Participation Rate[7]	55.9%	60.6%	51.4%	48.8%	51.9%	45.8%	68.3%	73.3%	63.4%
Employment Rate[8]	42.7%	45.1%	40.3%	37.2%	37.0%	37.5%	63.5%	67.5%	59.5%
Unemployment Rate[9]	22.5%	25.6%	21.6%	23.8%	28.7%	18.2%	7.1%	8.0%	6.1%

Source: Statistics Canada 2016.

Footnotes:
1. Data has been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5, and in some cases, 10. Columns may not add up due to rounding.
2. North Saskatchewan is defined as Census Division No.18.
3. "Labour Force" refers to persons who, during the week of Sunday, May 1 to Saturday, May 7, 2016, were either employed or unemployed and reported for populations aged 15 years and over in private households." (Source: 2016 Census Dictionary).

4. "Employed" refers to persons 15 years and over, excluding institutional residents who, during the week prior to Census Day: "(a) Did any work at all at a job or business, that is, paid work in the context of an employer-employee relationship, or self-employment. This also includes persons who did unpaid family work, which is defined as unpaid work contributing directly to the operation of a farm, business or professional practice owned and operated by a related member of the same household; or (b) Had a job but were not at work due to factors such as their own illness or disability, personal or family responsibilities, vacation or a labour dispute. This category excludes persons not at work because they were on layoff or between casual jobs, and those who did not then have a job (even if they had a job to start at a future date)." (Source: 2016 Census Dictionary).
5. "Unemployed" refers to persons who, during the week of Sunday May 1 to Saturday May 7 2016, were without paid work or without self-employment work and were available for work and either: a) had actively looked for paid work in the past four weeks; or b) were on temporary lay-off and expected to return to their job; or c) had definite arrangements to start a new job in four weeks or less." (Source: 2016 Census Dictionary).
6. "Not in the labour force" refers to persons who, during the week of Sunday May 1 to Saturday May 7 2016, were neither employed nor unemployed. It includes students, homemakers, retired workers, seasonal workers in an 'off' season who were not looking for work, and persons who could not work because of a long-term illness or disability." (Source: 2016 Census Dictionary).
7. The "Participation Rate" refers to the number of people in the labour force in the week of Sunday May 1 to Saturday May 7 2016, as a percentage of the population 15 years and over. (Source: 2016 Census Dictionary).
8. The "Employment Rate" refers to the number of people employed in the week of Sunday May 1 to Saturday May 7 2016 as a percentage of the total population 15 years and over. (Source: 2016 Census Dictionary).
9. The "Unemployment Rate" refers to the number of people unemployed in the week of Sunday May 1 to Saturday May 7 2016 expressed as a percentage of the population in the labour force. (Source: 2016 Census Dictionary).

4.2 EDUCATIONAL ATTAINMENT

This section describes rates of educational attainment for the community.

Table 4 provides the distribution of the highest level of education attained by Pinehouse residents compared to northern Saskatchewan and the province for 2016. Just over half (51.7%) of the Pinehouse population 15 years and older had less than a high school certificate, which was higher than northern Saskatchewan (50.9%) and the province as a whole (20.7%). The difference may partially reflect the younger demographics of the population in Pinehouse and northern Saskatchewan as compared to the province (Statistics Canada 2016). Male residents (56.3%) are more likely to have less than a high school certificate when compared to female residents (45.8%). This trend is similar to both northern Saskatchewan and Saskatchewan as a whole where male residents are more likely to not have the equivalent of a high school diploma.

Pinehouse residents had a comparable completion rate for a post-secondary certificate or degree (11.2%) as northern Saskatchewan (11.1%) but less than that of Saskatchewan (17.1%). Statistics Canada tracks post-secondary certification or degree through:

- Apprenticeship or Trades Certificate or Diploma;
- Post-Secondary Non-University Certificate or Diploma;
- University Certificate or Diploma below the Bachelor’s Level; and
- University Degree.

Pinehouse had lower attainment rates for an apprenticeship, trades certificate or diploma (7.7%) than northern Saskatchewan (8.2%) and the province (10.4%). In Pinehouse, those who had completed this level of education saw males as the majority (11.3%) in comparison to females (2.8%).

Pinehouse had higher attainment rates for a post-secondary non-university certificate or diploma (11.2% of population aged 15 years and older) when compared to northern Saskatchewan (11.1%), however Saskatchewan as a whole (17.1%) had higher completion rates for post-secondary non-university certificate or diploma. Pinehouse males (5.6%) had lower attainment rates than females (16.7%) for post-secondary non-university certificates or diplomas. This trend is seen across northern Saskatchewan and Saskatchewan.

Pinehouse had similar attainment rates for a university degree (7.0%) as northern Saskatchewan (7.4%), but the province of Saskatchewan (18%) had higher university degree attainment rates than both Pinehouse and northern Saskatchewan. The trend throughout Pinehouse, northern Saskatchewan, and Saskatchewan is for more females to complete a university degree than males.

Table 4: Level of Educational Attainment for Pinehouse, Northern Saskatchewan, and Saskatchewan (2016)

	Pinehouse[1,2]			Northern Saskatchewan[1,2,3]			Saskatchewan[1,2]		
	Total	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**
Total Population 15 and Over by Highest Certificate, Diploma or Degree[4]	715	355	360	25,295	12,605	12,690	857,295	424,265	433,035
Less than High School Certificate	370 51.7%	200 56.3%	165 45.8%	12,865 50.9%	6,945 55.1%	5,920 46.7%	177,210 20.7%	96,680 22.8%	80,530 18.6%
High School Certificate or Equivalent[5]	190 26.6%	80 22.5%	110 30.6%	5,195 20.5%	2,250 17.9%	2,955 23.3%	261,210 30.5%	133,730 31.5%	127,480 29.4%
Apprenticeship or Trades Certificate or Diploma	55 7.7%	40 11.3%	10 2.8%	2,080 8.2%	1,495 11.9%	585 4.6%	89,440 10.4%	64,100 15.1%	25,340 5.9%
Post-Secondary Non-University Certificate or Diploma[6]	80 11.2%	20 5.6%	60 16.7%	2,810 11.1%	1,180 9.4%	1,630 12.8%	146,770 17.1%	51,240 12.1%	95,530 22.1%
University Certificate or Diploma Below the Bachelor's Level	0 0.0%	0 0.0%	10 2.8%	475 1.9%	110 0.9%	365 2.9%	28,195 3.3%	10,790 2.5%	17,405 4.0%
University Degree	50 7.0%	20 5.6%	30 8.3%	1,865 7.4%	630 5.0%	1,230 9.7%	154,480 18.0%	67,730 16.0%	86,745 20.0%

Source: Statistics Canada 2016.

Footnotes:
1. Statistics Canada data has been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5 and in some cases, 10. Columns may not add up due to rounding.

2. Educational attainment data for 2016 were derived from 30% data. However, on Indian reserves and in remote communities, Statistics Canada attempts to obtain data from 100% of the population.
3. Northern Saskatchewan is defined as Census Division No. 18.
4. "Highest certificate, diploma or degree" refers to the highest certificate, diploma or degree the individual has completed based primarily on time spent" in-class." For high school graduates, a university education is considered to be a higher level of education than a college diploma, while a college education is considered to be a higher level of education than a trade. Although some trades requirements may take as long or longer to complete than a given college or university program, the majority of time acquiring trade certification may be on-the-job, as opposed to being in a classroom.
5. "High school certificate or equivalent" includes persons who have graduated from a secondary school or equivalent. Excludes persons with a postsecondary certificate, diploma or degree.
6. "Postsecondary non-university certificate or diploma" includes non-degree-granting institutions such as community colleges, CEGEPs, private business colleges and technical institutes.

4.3 INCOME

Income determines the standard of living (e.g., quantity and quality of goods and services) available to individuals and households. Two indicators are provided in this section to better understand the incomes currently available for the residents for Pinehouse, northern Saskatchewan, and in Saskatchewan. Indicators provided by Statistics Canada include:

- Distribution of income by individuals and households; and
- Income sources, showing the distributions among employment, government payments and interest, and other investments for each community.

4.3.1 Personal and Household Income

Table 5 presents the average personal employment income of the population aged 15 and older for Pinehouse, northern Saskatchewan, and Saskatchewan in 2015. Average personal income ($60,824) was higher than northern Saskatchewan ($57,985) and lower than the province of Saskatchewan ($64,855). In 2016, Male residents in Pinehouse reporting income (n=310) earned on average $70,648, while females reporting income (n=310) earned on average $49,423. The gap between average income in Pinehouse was over $21,000 between females and males in 2016. This same trend is seen in northern Saskatchewan and Saskatchewan, however Pinehouse had the largest gap between male and female average salaries.

The Saskatchewan Low Income Tax Credit has a threshold of $32,643[2] (Government of Canada 2019). In 2015, 58% of the population of Pinehouse, 62% of individuals in northern Saskatchewan, and 40% of individuals in Saskatchewan had less than $30,000 in income. Female residents of Pinehouse (16%) were more likely to report less than $30,000 than males (11%), which is a trend that is also seen in northern Saskatchewan and Saskatchewan. In 2015, approximately 16% of Pinehouse residents, 14% of individuals in northern Saskatchewan, and 22% of individuals in Saskatchewan earned an income of $70,000 or greater.

[2] The Saskatchewan low-income tax credit is a tax-free amount paid to help Saskatchewan residents with low and modest incomes. For July 2018 and June 2019, the program provides a tax-free amount to individuals and families. The credit starts to be reduced when the adjusted family net income is more than $32,643.

Table 5: Distribution of Personal Income for Pinehouse, Northern Saskatchewan, and Saskatchewan (2015)

	Pinehouse[1,2,3]			Northern Saskatchewan[1,2,3,4]			Saskatchewan[1,2,3]		
	Total	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**
Average Employment Income for Full-Year Full-Time Workers	$60,824	$70,648	$49,423	$57,985	$64,790	$51,411	$64,855	$72,366	$54,808
Total After-tax income groups in 2015 for population aged 15 years and over in private households[5]	625	310	310	22695	11215	11485	822620	407715	415015
Under $10,000	135 22%	75 24%	60 19%	7080 31%	4025 36%	3055 27%	105780 13%	47325 12%	58455 14%
$10,000 to $19,999	135 22%	55 18%	80 26%	4305 19%	1750 16%	2550 22%	118380 14%	46195 11%	72180 17%
$20,000 to $29,999	85 14%	35 11%	50 16%	2830 12%	1145 10%	1690 15%	107890 13%	42345 10%	65545 16%
$30,000 to $39,999	55 9%	25 8%	30 10%	2120 9%	860 8%	1265 11%	95605 12%	41315 10%	54295 13%
$40,000 to $49,999	50 8%	20 6%	30 10%	1520 7%	645 6%	870 8%	89285 11%	42260 10%	47025 11%
$50,000 to $59,999	30	15	20	1060	485	575	70395	36950	33450

	Pinehouse[1,2,3]			Northern Saskatchewan[1,2,3,4]			Saskatchewan[1,2,3]		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
	5%	5%	6%	5%	4%	5%	9%	9%	8%
$60,000 to $69,999	30	20	10	790	440	355	53855	31055	22795
	5%	6%	3%	3%	4%	3%	7%	8%	5%
$70,000 to $79,999	20	10	10	650	345	305	41930	25290	16645
	3%	3%	3%	3%	3%	3%	5%	6%	4%
$80,000 to $99,999[6]	40	20	15	1070	590	485	60470	36850	23620
	6%	6%	5%	5%	5%	4%	7%	9%	6%
$100,000 and over	45	40	5	1270	935	335	79030	58125	20905
	7%	13%	2%	6%	8%	3%	10%	14%	5%

Source: Statistics Canada 2016.

Footnotes:
1. Data has been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5, and in some cases 10. Columns may not add up due to rounding.
2. Income variables do not account for inflation.
3. Personal income variables were derived from 20% sample data. However, on Indian Reserves and in remote communities, attempts are made to obtain data from 100% of the population.
4. Northern Saskatchewan is defined as Census Division No. 18.
5. Income refers to Total Income (i.e. personal income). Total income is the total money income received during the calendar year prior to the Census year. Sources of income are: wages and salaries, net farm income; net non-farm income from unincorporated business and/or professional practice; child benefits; Old Age Security pension and Guaranteed Income Supplement; benefits from Canada Pension Plan or Quebec Pension Plan; benefits from Employment Insurance; other income from government sources; dividends, interest on bonds, deposits and savings certificates and other investment income; retirement pensions, superannuation and annuities, including those from RRSPs and RRIFs; and other money income. Not included in all Census years as total income: income tax refunds, lump sum inheritance payments, gambling revenue, lump sum insurance policy settlements, capital gains or losses, receipts from the sale of property or belongings, loan repayments, property tax rebates or refunds of pension contributions.
6. The 2015 data sets group $80,000 to $99,999 as $80,000 to $89,999 and $90,000 to $99,999. These categories have been collapsed in the table.

Table 6 shows the distribution of household income for Pinehouse, northern Saskatchewan and Saskatchewan for 2015. The average household income (2015) for Pinehouse residents $88,965, which is higher than northern Saskatchewan ($71,111) and lower than Saskatchewan ($93,942) (Statistics Canada 2016). A lower proportion (20%) of households had incomes of $30,000 or less than in northern Saskatchewan (29%) and Saskatchewan (17%). In 2015, approximately 35% of Pinehouse households, 28% of households in northern Saskatchewan, and 36% of households in Saskatchewan earned income in higher income brackets of $70,000 or greater.

Table 6: Distribution of Household Income for Pinehouse, Northern Saskatchewan, and Saskatchewan (2015)

	Pinehouse[1,2,3]	**Northern Saskatchewan[1,2,3,4]**	**Saskatchewan[1,2,3]**
Average Household Employment Income before Taxes in 2015 for Full-Year Full-Time Workers	88,965	71,111	93,942
Total Number of Private Households with Income[5,6]	270	10,235	432,625
Under $5,000	0 0%	445 4%	6,930 2%
$5,000 to $9,999	0 0%	325 3%	4,575 1%
$10,000 to $14,999	10 4%	405 4%	7,675 2%
$15,000 to $19,999	20 7%	715 7%	18,025 4%
$20,000 to $29,999	25 9%	1,135 11%	33,720 8%
$30,000 to $39,999	25 9%	1,025 10%	35,110 8%
$40,000 to $49,999	20 7%	830 8%	33,870 8%
$50,000 to $59,999	15 6%	725 7%	31,595 7%
$60,000 to $69,999	30 11%	610 6%	29,700 7%
$70,000 to $79,999	20 7%	545 5%	27,605 6%
$80,000 to $89,999	15 6%	490 5%	25,810 6%

	Pinehouse[1,2,3]	Northern Saskatchewan[1,2,3,4]	Saskatchewan[1,2,3]
$90,000 to $99,999	15 6%	420 4%	23,280 5%
$100,000 to $124,999	25 9%	865 8%	48,375 11%
$125,000 to $149,999[7]	20 7%	605 6%	35,320 8%
$150,000 and over	40 15%	1,100 11%	71,035 16%

Source: Statistics Canada 2016.

Footnotes:
1. Data has been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5, and in some cases 10. Columns may not add up due to rounding.
2. Income variables do not account for inflation.
3. Household income variables were derived from 20% sample data. However, on Indian Reserves and in remote communities, attempts are made to obtain data from 100% of the population.
4. Northern Saskatchewan is defined as Census Division No. 18.
5. Income refers to Total Income (i.e. household income). Total income is the total money income received during the calendar year prior to the Census year. Sources of income are: wages and salaries, net farm income; net non-farm income from unincorporated business and/or professional practice; child benefits; Old Age Security pension and Guaranteed Income Supplement; benefits from Canada Pension Plan or Quebec Pension Plan; benefits from Employment Insurance; other income from government sources; dividends, interest on bonds, deposits and savings certificates and other investment income; retirement pensions, superannuation and annuities, including those from RRSPs and RRIFs; and other money income. Not included in all Census years as total income: income tax refunds, lump sum inheritance payments, gambling revenue, lump sum insurance policy settlements, capital gains or losses, receipts from the sale of property or belongings, loan repayments, property tax rebates or refunds of pension contributions.
6. Private household refers to a person or a group of persons (other than foreign residents) who occupy the same dwelling and do not have a usual place of residence elsewhere in Canada. It may consist of a family group (census family) with or without other persons, of two or more families sharing a dwelling, of a group of unrelated persons, or of one person living alone. Household members who are temporarily absent on Census Day (e.g., temporary residents elsewhere) are considered as part of their usual household. For census purposes, every person is a member of one and only one household. Unless otherwise specified, all data in household reports are for private households only.
7. Data sets grouped include: $20,000 to $29,999 as $20,000 to $24,999 and $25,000 to $29,999. These categories have been collapsed in the table; $30,000 to $39,999 as $30,000 to $34,999 and $35,000 to $39,999. These categories have been collapsed in the table; $40,000 to $49,999 as $40,000 to $44,999 and $45,000 to $49,999. These categories have been collapsed in the table; $150,000 and over as $150,000 to $199,999 and $200,000 and over. These categories have been collapsed in the table.

4.3.2 Sources of Income

Statistics Canada tracks three general categories or sources, of income: employment and self-employment income, government payments, and interest and other investment income.

Table 7 illustrates that the percentage of income for the population of Pinehouse (75.8%) from employment income is comparable to that of residents of northern Saskatchewan (72.0%) and Saskatchewan (73.2%). A higher percentage of males had employment income than females, which reflected trends in northern Saskatchewan and Saskatchewan as a whole. The percentage of income from Government Transfer payments in Pinehouse (19.5%) was comparable to northern Saskatchewan (21.8%), both were roughly double that of the province as a whole (10.5%).

Table 7: Sources of Income for Pinehouse, Northern Saskatchewan, and Saskatchewan (2015)

	Pinehouse[1,2,3]			Northern Saskatchewan[1,2,3,4]			Saskatchewan[1,2,3]		
	Total	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**
Employment Income (%)[5]	75.8%	85.8%	64.4%	72.0%	78.8%	64.2%	73.2%	76.8%	68.0%
Government Transfer Payments (%)[6]	19.5%	12.2%	29.8%	21.8%	14.4%	30.0%	10.5%	7.2%	15.2%
Other (%)[7]	4.7%	2.0%	5.8%	6.2%	6.8%	5.8%	16.3%	16.0%	16.8%

Source: Statistics Canada 2016.

Footnotes:
1. Sources of income variables for the Census were derived from 20% sample data. However, on Indian reserves and in remote communities, attempts are made to obtain data from 100% of the population.
2. Data has been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5, and in some cases 10. Columns may not add up due to rounding.
3. Sources of income of a population group or a geographic area, refers to the relative share of each income source or group of sources, expressed as a percentage of the aggregate total income of that group or area. Percentages may not add up to 100% due to rounding.
4. Northern Saskatchewan is defined as Census Division No. 18.
5. Employment Income include all income received as wages, salaries and commissions from paid employment and net self-employment income from farm or non-farm unincorporated business and/or professional practice during the reference period.
6. Government transfer include all cash benefits received from federal, provincial, territorial or municipal governments during the reference period. It includes (1) Old Age Security pension, Guaranteed Income Supplement, Allowance or Allowance for the Survivor; (2) Retirement, disability, and survivor benefits from Canada Pension Plan and Quebec Pension Plan; (3) benefits from Employment Insurance and Quebec parental insurance plan, (4) Child benefits from federal and provincial programs; (5) social assistance benefits; (6) workers' compensation benefits; (7) working income tax benefit; (8) goods and services tax credit and harmonized sales tax credit; and (9) other income from government sources. For the 2016 Census, the reference period is the calendar year 2015 for all income variables.
7. Other income sources include severance pay and retirement allowances, alimony, child support, periodic support from other persons not in the household, income from abroad (excluding interest and dividends), non-refundable scholarships, bursaries, fellowships and study grants, and artists' project grants. Other income was calculated as a total (100%) minus employment income (%) and government transfer payments (%).

4.4 LOCAL ECONOMY

This section describes employment by sector, economic development, and local business for Pinehouse, Saskatchewan.

4.4.1 Local Business

Table 8 displays the local businesses within Pinehouse which support the local economy.

Table 8: Local Businesses in Pinehouse

Business	Description:
Cameco Northern Affairs Office – Pinehouse IR	Uranium company
Jonlaw Development Corporation	Accommodations
Kamkota Lodge	Hunting and fishing seasonal camp, accommodations, boat and motor rental and guiding.
Medi-Cross Pharmasave	Pharmacy
Minahik Cafe & Gas Bar	Gas station and restaurant
Pinehouse Business North Development Corporation	Heavy equipment, construction and other industrial services
Pinehouse Lake Co-Operative Limited	Grocery, hardware, clothing, general merchandise and post office
Pinehouse Local Fishermans Co-op	Commercial fishing and wholesale
Snake Lake Construction Ltd	Construction services

Source: Northern Saskatchewan Business Directory 2016, Nuclear Waste Management Organization 2013.

4.4.2 Employment by Sector

Table 9 outlines employment by sector Pinehouse compared to residents of northern Saskatchewan and Saskatchewan. The data indicates that the key sectors for employment are mining, quarrying, and oil and gas extractions (32%), educational services (17%), and health care and social assistance (13%). For Northern Saskatchewan, key sectors for employment are education (18%), health care and assistance (15%) and public administration (14%). For the province as a whole, health care and social assistance (13%); retail (11%); and agriculture, forestry, fishing, and hunting (9%) were the key sectors for employment.

Data indicates males and females within the village of Pinehouse are employed in different industries. Key industrial sectors for the employment of males include mining, quarrying, and oil and gas extractions (28%) and construction (7%). Key industrial sectors for employment for females include educational services (13%) and health care and social assistance (12%).

Employment opportunities within the community are limited, especially for residents without a high school education or higher. Due to this fact, most residents are employed in seasonal work such as: commercial fishing, trapping, guiding/outfitting, firefighting and mining, or unpaid work. The surrounding area provides some employment opportunities such as tourism, forestry and mining, though these positions can require skilled labour (Nuclear Waste Management Organization, 2013).

Table 9: Employment by Sector for Pinehouse, Northern Saskatchewan, and Saskatchewan (2016)

	Pinehouse[1]			Northern Saskatchewan[1,2]			Saskatchewan[1]		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
Total Labour Force population aged 15 years and over by industry[3]	400	215	185	12,355	6,540	5,815	585,540	311,110	274,430
Industry – not applicable[4]	55	35	25	1,565	910	660	10,225	5,205	5,020
All industry categories[5]	345	180	160	10,790	5,635	5,155	575,310	305,905	269,410
Agriculture; forestry; fishing and hunting	0	10	0	240	220	20	51,255	36,820	14,440
Mining; quarrying; and oil and gas extraction	110	95	15	1,165	1,025	145	23,070	20,040	3,025
Utilities	10	0	0	95	80	15	5,395	3,780	1,610
Construction	25	25	0	800	735	70	49,310	43,460	5,850
Manufacturing	0	0	0	150	120	30	26,710	21,000	5,710
Wholesale Trade	0	0	0	105	70	35	20,480	15,325	5,155
Retail Trade	25	10	20	1,015	455	555	63,360	30,185	33,180
Transportation and Warehousing	0	0	0	445	325	120	24,755	19,385	5,370
Information and Cultural Industries	0	10	0	90	45	45	10,005	5,055	4,950

	Pinehouse[1]			Northern Saskatchewan[1,2]			Saskatchewan[1]		
	Total	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**
Finance and Insurance	0	0	0	95	20	75	20,155	6,495	13,655
Real Estate and Rental Leasing	10	0	0	90	65	25	7,650	4,425	3,220
Professional; Scientific and Technical Services	0	0	0	165	70	95	25,250	12,985	12,265
Management of Companies and Enterprises	0	0	0	10	10	0	1,340	680	660
Admin. and Support; Waste Mgmt and Remediation	0	0	0	310	165	145	16,395	9,660	6,735
Educational Services	60	15	45	1,895	530	1,365	45,360	13,670	31,690
Health Care and Social Assistance	45	0	40	1,660	290	1,370	72,625	11,285	61,335
Arts; Entertainment and Recreation	0	0	0	100	55	45	10,545	5,120	5,425
Accommodation and Food Services	20	10	15	585	270	310	37,785	14,295	23,490
Other Services (Except Public Administration)	0	0	0	250	135	115	25,680	12,590	13,090
Public Administration	30	20	10	1,520	955	570	38,180	19,640	18,535

Source: Statistics Canada 2016.

Footnotes:
1. Data has been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5, and in some cases 10. Columns may not add up due to rounding.
2. Northern Saskatchewan refers to Census Division No. 18.
3. Includes the experienced labour force which refers to persons aged 15 years and over who during the Census were employed and the unemployed who had last worked for pay or in self employment prior to the Census.

4. Includes unemployed persons aged 15 years and over who have never worked for pay or in self-employment or who had last worked prior to January 1, 2015.
5. Refers to the general nature of the business carried out in the establishment where the person worked. The data are produced according to the North American Industry Classification System (NAICS) 2012 with 25% sample data.

Due to limited employment opportunities and training programs within near proximity to the community, Pinehouse has experienced high rates of unemployment. The mining industry, specifically uranium, provides employment opportunities to both Pinehouse and other communities in the area. Those employed at the various uranium operations in the region participate in a fly-in/out commuter rotation system, requiring them to be away from the community. Seasonal employment including fishing, trapping, guiding/outfitting and firefighting can provide a source of income for residents (Nuclear Waste Management Organization, 2013).

The Collaboration Agreement includes a Workforce Development Pillar which assists residents in obtaining employment with Cameco, Areva or the operations contractors. Tools to assist residents with employment include a skills database managed by Cameco which identifies available skills within the community and available training programs to facilitate the employment of Pinehouse residents with the mining operation. Pinehouse residents receive preferential status for employment opportunities (Collaboration Agreement 2012).

4.4.3 Economic Development

Pinehouse Business North (PBN) is an Indigenous owned and operated construction and mining services contracting company in Pinehouse. Started in 2007 to create employment and infrastructure within the community, PBN has grossed revenues over $12 million and employs over eighty locals within the area (Pinehouse Business North n.d.). Construction of a new 12-unit affordable housing complex in Pinehouse for senior citizens is set to be completed by the summer of 2018. Both the Federal and Provincial governments, the village of Pinehouse and PBN will be funding this venture. Community benefits of this project will include affordable housing to the elderly as well as employment and opportunities to train apprentices during the construction (Government of Saskatchewan 2016).

In 2012, Pinehouse entered into a $200 million Collaboration Agreement with Cameco and Orano which aimed to strengthen development and provide funding in Pinehouse while maintaining local culture and Indigenous roots within the community (Global News 2014). As part of the Collaboration Agreement, Cameco and Orano are to provide opportunities for capacity building in eligible Pinehouse businesses in regard to new contract work opportunities when they arise. This includes regular meetings between the industry and eligible businesses to discuss business performance so moving forward they are in a favourable position for continuing business, advice when requested from the community and feedback on unsuccessful bids. When contracting opportunities arise Cameco and Orano will use their best efforts to utilize one of the community businesses for the work. To assist with this effort, Pinehouse businesses are to be given a reasonable time consideration to bid on the contract and clear communication between Cameco and eligible businesses on any changes in the Northern Preferred Supplier Program which PBN is listed under (Northern Village of Pinehouse, Kineepik Metis Local Inc., Cameco Corporation and Areva Resources, 2012).

5.0 REFERENCES

Cameco Corporation (n.d.). Partnering for Prosperity with Pinehouse. https://www.cameconorth.com/community/stories/partnering-for-prosperity-with-pinehouse [Accessed December 11, 2019].

CBC News (2019a). Music, art, dance, food and humour a learning experience at Elders Gathering in northern Sask. https://www.cbc.ca/news/canada/saskatchewan/music-art-dance-food-humour-at-elders-gathering-1.5181214 [Accessed December 18, 2019].

CBC News (2019b). The Pressing need to learn from Indigenous elders. https://www.cbc.ca/news/canada/saskatchewan/walking-with-elders-1.5349553 [Accessed December 18, 2019].

Gabriel Dumont Institute of Native Studies and Applied Research (2019). GDI – Pinehouse Partnershup in Apprenticeship Programming. https://gdins.org/gdi-pinehouse-partnership-in-apprenticeship-programming/ [Accessed February 19, 2020].

Gabriel Dumont Institute of Native Studies and Applied Research (2018a). Security Officer Program a Resounding Success. https://gdins.org/security-officer-program-a-resounding-success/ [Accessed February 19, 2020].

Gabriel Dumont Institute of Native Studies and Applied Research (2018b). Pinehouse Business Program a Success. https://gdins.org/pinehouse-business-program-a-success/ [Accessed February 19, 2020].

Global News (2014). Saskatchewan village benefiting from deal with uranium companies. https://globalnews.ca/news/1222547/saskatchewan-village-benefiting-from-deal-with-uranium-companies/ [Accessed December 11, 2019].

Government of Canada (2019). Child and family benefits, Province of Saskatchewan. https://www.canada.ca/en/revenue-agency/services/child-family-benefits/provincial-territorial-programs/province-saskatchewan.html [Accessed November 25, 2019].

Government of Saskatchewan (2016). New Senior Housing Breaks Ground in Pinehouse. https://www.saskatchewan.ca/government/news-and-media/2016/june/16/housing-in-pinehouse [Accessed December 12, 2019].

Government of Saskatchewan (2018) Municipal Directory System. http://www.mds.gov.sk.ca/apps/Pub/MDS/muniDetails.aspx?cat=6&mun=2619 [Accessed November 25, 2019].

InterGroup Consultants Ltd. (2011). Socio-economic Baseline Annex for the Key Lake Extension Project. Winnipeg, Manitoba: Intergroup Consultants Ltd.

Jarvenpa, R., and Brumbach, H.J. (1985). Occupational status, ethnicity, and ecology: Metis Cree adaptations in a Canadian trading frontier. Human Ecology 13(3): 309-329.

KidsFirst NORTH (n.d.). Home. https://www.kidsfirstnorth.com/ [Accessed February 20, 2020].

LaRongeNOW (2019). Pinehouse Youth Panel making positive changes in northern community. https://larongenow.com/2019/11/26/pinehouse-youth-panel-making-positive-changes-in-northern-community/ [Accessed March 3, 2020].

McNab, M. (1992). Persistence and change in a northern Saskatchewan trapping community. (Unpublished MA thesis). University of Saskatchewan, Saskatoon, SK.

Métis Nation-Saskatchewan (n.d.) Executive, Regional Directors & Ministors. [https://metisnationsk.com/governance/#regions] Accessed December 17, 2019.

Minahik Waskahigan High School (n.d.). Minahik Waskahigan High School. http://www.mwhighschool.ca/ [Accessed December 12, 2019].

Northern Business Directory (2016). https://www.northernbusinessdirectory.ca/reports/directory.pdf [Accessed December 12, 2019].

Northern Lights School Division No. 113 (n.d.). Pinehouse. https://www.nlsd113.ca/apps/pages/index.jsp?uREC_ID=1067796&type=d&pREC_ID=1358303 [Accessed December 12, 2019].

Northlands College (n.d.-a). Our Campuses. https://trainnorth.ca/Saskatchewan%20College/Our%20Campuses [Accessed December 12, 2019].

Northlands College (n.d.-b). Northlands College Annual Report 2017-2018. https://trainnorth.ca/ckfinder/userfiles/files/2017-18%20Northlands%20College%20Annual%20Report.pdf [Accessed December 11, 2019].

Nuclear Waste Management Organization (2013). Draft Community Profile Northern Village of Pinehouse, Saskatchewan. https://www.nwmo.ca/~/media/Site/Files/PDFs/2015/11/04/17/37/2249_2013-11-14_cwba_pinehouse_community_profile_draft_.ashx?la=en [Accessed December 12, 2019].

Pinehouse Business North. (n.d.). http://pinehousebusinessnorth.ca/ [Accessed November 25, 2019].

Regina Leader-Post (2019). U of R exploring new programs in northern Sask. after community tour. https://leaderpost.com/news/local-news/u-of-r-exploring-new-programs-in-northern-sask-after-community-tour [Accessed December 12, 2019].

Saskatchewan Health Authority (n.d.-a). KidsFirst NORTH. http://www.mcrhealth.ca/programs_services/kids_first_north.html [Accessed February 20, 2020].

Saskatchewan Health Authority (n.d.-b). Mamawetan Churchill River Health Region. http://www.mcrhealth.ca/facilities.html [Accessed December 12, 2019].

Statistics Canada. (2011). Census Profile, Pinehouse, Northern Village. Released November 29, 2017. https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/page.cfm?Lang=E&Geo1=CSD&Code1=4718065&Geo2=PR&Code2=47&Searc

hText=PInehouse+Lake&SearchType=Begins&SearchPR=01&B1=All&TABID=1&type=0 [Accessed March 3, 2020].

Statistics Canada. (2016). Census Profile, Pinehouse, Northern Village. Released November 29, 2017. https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/page.cfm?Lang=E&Geo1=CSD&Code1=4718065&Geo2=PR&Code2=47&SearchText=PInehouse+Lake&SearchType=Begins&SearchPR=01&B1=All&TABID=1&type=0 [Accessed November 24, 2019].

Statistics Canada. (2016). Division No. 18. Ottawa. Released November 29, 2017. https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/page.cfm?Lang=E&Geo1=CD&Code1=4718&Geo2=CSD&Code2=4718090&Data=Count&SearchText=Division%20No.%2018&SearchType=Begins&SearchPR=01&B1=All [Accessed November 24, 2019].

The Northern Village of Pinehouse, Kineepik Metis Local Inc., Cameco Corporation and Areva Resources Inc. (2012). Collaboration Agreement. http://pinehouse.info/wp-content/uploads/2016/06/Collaboration-Agreement-final.pdf [Accessed February 25, 2020].

The Northern Village of Pinehouse (n.d.). Official Community Plan. https://www.planningforgrowthnorthsk.com/uploads/7/9/7/4/7974185/pinehouse_official_community_plan_draft_watermark.pdf [Accessed December 19, 2019].

Tobias, T., and Kay, J.J. (1994). The bush harvest in Pinehouse, Saskatchewan, Canada. Arctic 47(3): 201-221.

University of Regina (n.d.). Online Courses. https://www.uregina.ca/cce/flexible-learning/online/index.html [Accessed December 19, 2019].

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Appendix 12-C1: Population of the Local Study Area Communities, Northern Saskatchewan, and Saskatchewan from 1981 to 2021

	Population [1,2]							
	1981	1986	1991	1996	2001	2006	2011	2016
ERFN	356	478	525	556	557	665	597	713
La Plonge 192	0	124	104	120	123	139	115	148
Wapachewunak 192D	356	354	421	436	434	526	482	565
Patuanak	173	138	99	89	72	84	64	73
Pinehouse	612	682	820	922	1,038	1,076	978	1,052
Beauval	607	656	717	785	843	806	756	640
Local Study Area [3]	1,748	1,954	2,161	2,352	2,510	2,631	2,395	2,478
Northern Saskatchewan [4]	25,304	25,340	26,735	31,104	32,029	33,919	36,557	37,064
Saskatchewan	968,313	1,009,613	988,928	990,237	978,933	968,157	1,033,381	1,098,352

	Average Annual Change in Population (%)[1,2]						
	1982-1986	1987-1991	1992-1996	1997-2001	2002-2006	2007-2011	2012-2016
ERFN	6.1%	1.9%	1.2%	0.0%	3.6%	-2.1%	3.6%
La Plonge 192		-3.5%	2.9%	0.5%	2.5%	-3.7%	5.2%
Wapachewunak 192D	-0.1%	3.5%	0.7%	-0.1%	3.9%	-1.7%	3.2%
Patuanak	-4.4%	-6.4%	-2.1%	-4.2%	3.1%	-5.3%	2.7%
Pinehouse	2.2%	3.8%	2.4%	2.4%	0.7%	-1.9%	1.5%
Beauval	1.6%	1.8%	1.8%	1.4%	-0.9%	-1.3%	-3.3%
Local Study Area[3]	2.3%	2.0%	1.7%	1.3%	0.9%	-1.9%	0.7%
Northern Saskatchewan[4]	0.0%	1.1%	3.1%	0.6%	1.2%	1.5%	0.3%
Saskatchewan	0.8%	-0.4%	0.0%	-0.2%	-0.2%	1.3%	1.2%

Source: Statistics Canada 1992 , 1998, 2002, 2008, 2012, 2017, and 2022.

Footnotes:

1. Data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5, and in some cases, 10. Totals may not add-up due to rounding.
2. In addition to random rounding, area and data suppression has been adopted to further protect the confidentiality of individual respondents' personal information. Area and data suppression results in the deletion of all information for geographic areas with populations below a specified size. For example, areas with a population of less than 40 persons are suppressed. If the community searched has a population of less than 40 persons, only the total population counts will be available. Suppression of data can be due to poor data quality or to other technical reasons.
3. Local Study Area includes La Plonge 192, Wapachewunak 192D, Patuanak, Pinehouse Lake, and Beauval.
4. North Saskatchewan is defined as Census Division No.18.

Appendix 12-C2: Population Distribution by Age Group for 2016 and 2021 for the Local Study Area, Northern Saskatchewan, and Saskatchewan

	Total Population by Age Group 2021								
	ERFN	La Plonge 192, Indian reserve	Wapachewunak 192D, Indian reserve	Patuanak, Northern hamlet	Pinehouse, Northern village	Beauval, Northern village	Local Study Area[3]	Northern Saskatchewan[4]	Saskatchewan
	A = B + C	B	C	D	F	E	G = B + C + D + E + F	H	I
Total - Population	**720**	**145**	**575**	**65**	**1,015**	**685**	**2,485**	**35,990**	**1,132,505**
0 to 14 years	175	35	140	15	335	155	680	10,790	223,115
15 to 24 years	125	15	110	10	170	95	400	5,785	135,380
25 to 34 years	90	20	70	5	140	90	325	5,160	148,410
35 to 44 years	80	15	65	5	115	60	260	3,955	152,475
45 to 54 years	85	10	75	15	125	90	315	3,765	127,820
55 to 64 years	65	20	45	0	75	95	235	3,475	147,320
65 years and over	80	20	60	10	55	95	240	3,050	197,980

	Total Population by Age Group (%) 2021								
	ERFN	La Plonge 192	Wapachewunak 192D	Patuanak	Pinehouse	Beauval	Local Study Area[3]	Northern Saskatchewan[4]	Saskatchewan
Total - Population	**100.7%**	**96.7%**	**101.8%**	**86.7%**	**96.2%**	**107.0%**	**100.0%**	**97.1%**	**103.1%**
0 to 14 years	24.5%	23.3%	24.8%	20.0%	31.8%	24.2%	27.4%	29.1%	20.3%
15 to 24 years	17.5%	10.0%	19.5%	13.3%	16.1%	14.8%	16.1%	15.6%	12.3%
25 to 34 years	12.6%	13.3%	12.4%	6.7%	13.3%	14.1%	13.1%	13.9%	13.5%
35 to 44 years	11.2%	10.0%	11.5%	6.7%	10.9%	9.4%	10.5%	10.7%	13.9%
45 to 54 years	11.9%	6.7%	13.3%	20.0%	11.8%	14.1%	12.7%	10.2%	11.6%
55 to 64 years	9.1%	13.3%	8.0%	0.0%	7.1%	14.8%	9.5%	9.4%	13.4%
65 years and over	11.2%	13.3%	10.6%	13.3%	5.2%	14.8%	9.7%	8.2%	18.0%

	Total Population by Age Group 2016								
	ERFN	La Plonge 192, Indian reserve	Wapachewunak 192D, Indian reserve	Patuanak, Northern hamlet	Pinehouse, Northern village	Beauval, Northern village	Local Study Area[3]	Northern Saskatchewan[4]	Saskatchewan
	A = B + C	B	C	D	F	E	G = B + C + D + E + F	H	I
Total - Population	**715**	**150**	**565**	**75**	**1,055**	**640**	**2,485**	**37,065**	**1,098,350**
0 to 14 years	180	40	140	20	340	155	695	11,565	215,685
15 to 24 years	115	30	85	15	215	115	460	6,550	137,720
25 to 34 years	100	20	80	5	140	90	335	5,310	155,045
35 to 44 years	85	10	75	5	105	55	250	4,005	136,540
45 to 54 years	85	20	65	10	120	90	305	4,005	138,825
55 to 64 years	60	15	45	5	70	70	205	3,115	144,110
65 years and over	85	20	65	15	60	60	220	2,525	170,425

	Total Population by Age Group (%) 2016								
	ERFN	La Plonge 192	Wapachewunak 192D	Patuanak	Pinehouse	Beauval	Local Study Area[3]	Northern Saskatchewan[4]	Saskatchewan
Total - Population	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**
0 to 14 years	25.2%	26.7%	24.8%	26.7%	32.2%	24.2%	28.0%	31.2%	19.6%
15 to 24 years	16.1%	20.0%	15.0%	20.0%	20.4%	18.0%	18.5%	17.7%	12.5%
25 to 34 years	14.0%	13.3%	14.2%	6.7%	13.3%	14.1%	13.5%	14.3%	14.1%
35 to 44 years	11.9%	6.7%	13.3%	6.7%	10.0%	8.6%	10.1%	10.8%	12.4%
45 to 54 years	11.9%	13.3%	11.5%	13.3%	11.4%	14.1%	12.3%	10.8%	12.6%
55 to 64 years	8.4%	10.0%	8.0%	6.7%	6.6%	10.9%	8.2%	8.4%	13.1%
65 years and over	11.9%	13.3%	11.5%	20.0%	5.7%	9.4%	8.9%	6.8%	15.5%

Source: Statistics Canada 2017, 2022.

Footnotes:

1. Data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5, and in some cases, 10. Totals may not add-up due to rounding.

suppression results in the deletion of all information for geographic areas with populations below a specified size. For example, areas with a population of less than 40 persons are suppressed. If the community searched has a population of less than 40 persons, only the total population counts will be available. Suppression of data can be due to poor data quality or to other technical reasons.

3. Local Study Area includes La Plonge 192, Wapachewunak 192D, Patuanak, Pinehouse Lake, and Beauval.

4. North Saskatchewan is defined as Census Division No.18.

Appendix 12-C3

Population Age Structure by Gender for the Local Study Area, Northern Saskatchewan, and Saskatchewan, 2021

	Northern Saskatchewan[1,2,3,5]					Saskatchewan[1,2,5]					La Plonge 192, Indian reserve[1,2,5]					Wapachewunak 192D, Indian reserve[1,2,5]				
	Total	Men+ - NS	Women+ - NS	% Men+	% Women+	Total	Men+ - SK	Women+ - SK	% Men+	% Women+	Total	Men+ - La Plonge 192	Women+ - La Plonge 192	% Men+	% Women+	Total	Men+ - Wapachewunak 192D	Women+ - Wapachewunak 192D	% Men+	% Women+
Total Population	**35,990**	**17,840**	**18,150**			**1,132,505**	**563,120**	**569,385**			**145**	**70**	**80**			**575**	**280**	**290**		
0 to 4 years	3,495	1,720	1,770	-4.78	4.92	69,455	35,555	33,900	-3.14	2.99	10	5	5	-3.45	3.45	45	15	15	-2.61	2.61
5 to 9 years	3,415	1,680	1,735	-4.67	4.82	76,545	39,210	37,340	-3.46	3.30	15	5	5	-3.45	3.45	40	25	25	-4.35	4.35
10 to 14 years	3,885	2,000	1,885	-5.56	5.24	77,120	39,600	37,520	-3.50	3.31	10	5	10	-3.45	6.90	50	25	25	-4.35	4.35
15 to 19 years	3,170	1,615	1,555	-4.49	4.32	68,510	35,525	32,985	-3.14	2.91	5	5	5	-3.45	3.45	65	30	25	-5.22	4.35
20 to 24 years	2,615	1,390	1,230	-3.86	3.42	66,870	34,580	32,295	-3.05	2.85	10	5	0	-3.45	0.00	45	20	15	-3.48	2.61
25 to 29 years	2,555	1,275	1,275	-3.54	3.54	70,030	35,420	34,605	-3.13	3.06	10	5	5	-3.45	3.45	40	20	20	-3.48	3.48
30 to 34 years	2,605	1,225	1,380	-3.40	3.83	78,380	38,930	39,450	-3.44	3.48	10	5	5	-3.45	3.45	30	20	25	-3.48	4.35
35 to 39 years	2,070	960	1,115	-2.67	3.10	79,420	39,380	40,040	-3.48	3.54	10	5	5	-3.45	3.45	30	20	20	-3.48	3.48
40 to 44 years	1,885	880	1,005	-2.45	2.79	73,055	36,670	36,380	-3.24	3.21	5	0	5	0.00	3.45	35	20	20	-3.48	3.48
45 to 49 years	1,825	865	960	-2.40	2.67	65,075	32,425	32,655	-2.86	2.88	0	0	0	0.00	0.00	40	25	20	-4.35	3.48
50 to 54 years	1,940	970	970	-2.70	2.70	62,745	31,300	31,440	-2.76	2.78	10	5	5	-3.45	3.45	35	5	20	-0.87	3.48
55 to 59 years	1,850	880	975	-2.45	2.71	73,165	36,045	37,120	-3.18	3.28	10	5	5	-3.45	3.45	15	10	15	-1.74	2.61
60 to 64 years	1,625	810	810	-2.25	2.25	74,155	36,725	37,430	-3.24	3.31	10	5	5	-3.45	3.45	30	10	10	-1.74	1.74
65 to 69 years	1,220	640	580	-1.78	1.61	64,770	32,140	32,630	-2.84	2.88	5	5	5	-3.45	3.45	15	15	5	-2.61	0.87
70 to 74 years	840	450	385	-1.25	1.07	48,945	23,790	25,160	-2.10	2.22	5	5	0	-3.45	0.00	15	10	5	-1.74	0.87
75 to 79 years	500	245	255	-0.68	0.71	33,045	15,605	17,445	-1.38	1.54	5	0	5	0.00	3.45	15	0	10	0.00	1.74
80 to 84 years	295	140	155	-0.39	0.43	23,460	10,290	13,170	-0.91	1.16	0	0	0	0.00	0.00	5	5	10	-0.87	1.74
85 to 89 years	135	60	75	-0.17	0.21	16,165	6,290	9,870	-0.56	0.87	0	0	0	0.00	0.00	5	5	5	-0.87	0.87
90 to 94 years	60	30	25	-0.08	0.07	8,715	2,965	5,750	-0.26	0.51	0	0	0	0.00	0.00	0	0	0	0.00	0.00
95 to 99 years	10	0	5	0.00	0.01	2,435	625	1,810	-0.06	0.16	0	0	0	0.00	0.00	0	0	0	0.00	0.00
100 years +	0	0	0	0.00	0.00	450	60	385	-0.01	0.03	0	0	0	0.00	0.00	0	0	0	0.00	0.00

Population Age Structure by Sex for the Local Study Area, Northern Saskatchewan, and Saskatchewan, 2016

	Northern Saskatchewan[1,2,3,5]					Saskatchewan[1,2,5]					La Plonge 192, Indian reserve[1,2,5]					Wapachewunak 192D, Indian reserve[1,2,5]				
	Total	Male - NS	Female - NS	% Male	% Female	Total	Male - SK	Female - SK	% Male	% Female	Total	Male - La Plonge 192	Female - La Plonge 192	% Male	% Female	Total	Male - Wapachewunak 192D	Female - Wapachewunak 192D	% Male	% Female
Total Population	**37,065**	**18,640**	**18,425**			**1,098,355**	**545,785**	**552,565**			**145**	**70**	**80**			**565**	**280**	**290**		
0 to 4 years	3,850	1,960	1,890	-5.29	5.10	73,130	37,335	35,795	-3.40	3.26	15	10	5	-6.90	3.45	30	15	15	-2.65	2.65
5 to 9 years	4,165	2,165	1,995	-5.84	5.38	74,460	38,150	36,305	-3.47	3.31	10	0	5	0.00	3.45	50	25	25	-4.42	4.42
10 to 14 years	3,555	1,785	1,775	-4.82	4.79	68,095	34,920	33,175	-3.18	3.02	10	5	10	-3.45	6.90	50	25	25	-4.42	4.42
15 to 19 years	3,345	1,725	1,610	-4.65	4.34	67,655	34,680	32,980	-3.16	3.00	15	10	5	-6.90	3.45	55	30	25	-5.31	4.42
20 to 24 years	3,210	1,635	1,575	-4.41	4.25	70,060	36,070	33,990	-3.28	3.09	10	5	5	-3.45	3.45	35	20	15	-3.54	2.65
25 to 29 years	2,900	1,425	1,475	-3.84	3.98	77,525	39,290	38,235	-3.58	3.48	15	10	10	-6.90	6.90	40	20	20	-3.54	3.54
30 to 34 years	2,410	1,140	1,270	-3.08	3.43	77,520	38,610	38,915	-3.52	3.54	5	5	5	-3.45	3.45	40	20	25	-3.54	4.42
35 to 39 years	2,005	990	1,015	-2.67	2.74	71,590	35,940	35,650	-3.27	3.25	0	0	5	0.00	3.45	40	20	20	-3.54	3.54
40 to 44 years	2,000	960	1,040	-2.59	2.81	64,950	32,510	32,440	-2.96	2.95	5	5	5	-3.45	3.45	40	20	20	-3.54	3.54
45 to 49 years	1,965	950	1,010	-2.56	2.72	63,575	31,780	31,795	-2.89	2.89	10	5	0	-3.45	0.00	40	25	20	-4.42	3.54
50 to 54 years	2,040	985	1,050	-2.66	2.83	75,245	37,230	38,015	-3.39	3.46	10	0	10	0.00	6.90	25	5	20	-0.88	3.54
55 to 59 years	1,750	890	860	-2.40	2.32	76,195	38,070	38,130	-3.47	3.47	10	5	5	-3.45	3.45	25	10	15	-1.77	2.65
60 to 64 years	1,365	685	675	-1.85	1.82	67,915	33,935	33,985	-3.09	3.09	0	0	5	0.00	3.45	20	10	10	-1.77	1.77
65 to 69 years	1,060	585	480	-1.58	1.30	53,230	26,285	26,945	-2.39	2.45	10	5	0	-3.45	0.00	15	15	5	-2.65	0.88
70 to 74 years	630	325	305	-0.88	0.82	37,740	18,225	19,510	-1.66	1.78	5	5	0	-3.45	0.00	15	10	5	-1.77	0.88
75 to 79 years	425	225	200	-0.61	0.54	29,400	13,410	15,985	-1.22	1.46	5	0	5	0.00	3.45	10	0	10	0.00	1.77
80 to 84 years	250	125	120	-0.34	0.32	23,120	9,950	13,170	-0.91	1.20	0	0	0	0.00	0.00	15	5	10	-0.88	1.77
85 to 89 years	110	60	55	-0.16	0.15	16,280	6,305	9,975	-0.57	0.91	0	0	0	0.00	0.00	5	5	5	-0.88	0.88
90 to 94 years	40	20	25	-0.05	0.07	8,005	2,510	5,485	-0.23	0.50	0	0	0	0.00	0.00	5	0	0	0.00	0.00
95 to 99 years	0	0	0	0.00	0.00	2,290	525	1,760	-0.05	0.16	0	0	0	0.00	0.00	0	0	0	0.00	0.00
100 years +	5	0	0	0.00	0.00	370	50	325	0.00	0.03	0	0	0	0.00	0.00	0	0	0	0.00	0.00

Source: Statistics Canada, 2017, 2022.

Footnotes:

1. Data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5, and in some cases, 10. Totals may not add-up due to rounding.
2. In addition to random rounding, area and data suppression has been adopted to further protect the confidentiality of individual respondents' personal information. Area and data suppression results in the deletion of all information for geographic areas with populations below a specified size. For example, areas with a population of less than 40 persons are suppressed. If the community searched has a population of less than 40 persons, only the total population counts will be available. Suppression of data can be due to poor data quality or to other technical reasons.
3. North Saskatchewan is defined as Census Division No.18.
4. Local Study Area includes La Plonge 192, Wapachewunak 192D, Patuanak, Pinehouse Lake, and Beauval.

5. The 2021 Census disaggregates by gender. Census years prior to 2021 disaggregates by sex (male and female). Although sex and gender refer to two different concepts, the introduction of gender is not expected to have a significant impact on data analysis and historical comparability, given the small size of the transgender and non-binary populations. Given that the non-binary population is small, data aggregation to a two-category gender variable is sometimes necessary to protect the confidentiality of responses provided. In these cases, individuals in the category "non-binary persons" are distributed into the other two gender categories (men+ and women+) and are denoted by the "+" symbol (Statistics Canada 2022).
Gender refers to an individual's personal and social identity as a man, woman, or non-binary person (a person who is not exclusively a man or a woman). Gender includes the following concepts: (1) gender identity, which refers to the gender that a person feels internally and individually; (2) gender expression, which refers to the way a person presents their gender, regardless of their gender identity, through body language, aesthetic choices, or accessories (e.g., clothes, hairstyle, and makeup), which may have traditionally been associated with a specific gender. A person's gender may differ from their sex at birth, and from what is indicated on their current identification or legal documents, such as their birth certificate, passport, or driver's license. A person's gender may change over time. Some people may not identify with a specific gender (Statistics Canada 2022).

Population Age Structure by Gender for the Local Study Area, Northern Saskatchewan, and Saskatchewan, 2021

	Patuanak, Northern hamlet[1,2,5]					Pinehouse, Northern village[1,2,5]				
	Total	Men+ - Patuanak	Women+ - Patuanak	% Men+	% Women+	Total	Men+ - Pinehouse	Women+ - Pinehouse	% Men+	% Women+
Total Population	**65**	**25**	**40**			**1,015**	**495**	**515**		
0 to 4 years	0	0	0	0.00	0.00	110	50	60	-4.93	5.91
5 to 9 years	5	0	0	0.00	0.00	90	45	40	-4.43	3.94
10 to 14 years	5	0	5	0.00	7.69	135	70	65	-6.90	6.40
15 to 19 years	5	0	0	0.00	0.00	110	55	50	-5.42	4.93
20 to 24 years	5	5	5	-7.69	7.69	60	35	25	-3.45	2.46
25 to 29 years	5	0	5	0.00	7.69	75	35	40	-3.45	3.94
30 to 34 years	0	0	0	0.00	0.00	65	25	40	-2.46	3.94
35 to 39 years	5	0	0	0.00	0.00	60	25	35	-2.46	3.45
40 to 44 years	0	0	0	0.00	0.00	55	20	40	-1.97	3.94
45 to 49 years	5	0	0	0.00	0.00	50	20	25	-1.97	2.46
50 to 54 years	10	5	5	-7.69	7.69	75	40	30	-3.94	2.96
55 to 59 years	0	0	0	0.00	0.00	45	30	15	-2.96	1.48
60 to 64 years	0	0	0	0.00	0.00	30	15	15	-1.48	1.48
65 to 69 years	10	5	5	-7.69	7.69	15	10	15	-0.99	1.48
70 to 74 years	5	0	5	0.00	7.69	15	10	5	-0.99	0.49
75 to 79 years	5	0	5	0.00	7.69	15	5	10	-0.49	0.99
80 to 84 years	0	0	0	0.00	0.00	5	5	5	-0.49	0.49
85 to 89 years	0	0	0	0.00	0.00	5	0	0	0.00	0.00
90 to 94 years	0	0	0	0.00	0.00	0	0	0	0.00	0.00
95 to 99 years	0	0	0	0.00	0.00	0	0	0	0.00	0.00
100 years +	0	0	0	0.00	0.00	0	0	0	0.00	0.00

	Beauval, Northern village[1,2,5]					Local Study Area[1,2,4,5]				
	Total	Men+ - Beauval	Women+ - Beauval	% Men+	% Women+	Total	Men+ - LSA	Women+ - LSA	% Men+	% Women+
Total Population	**685**	**330**	**350**			**2,485**	**1,200**	**1,275**		
0 to 4 years	50	30	25	-4.38	3.65	215	100	105	-4.04	4.24
5 to 9 years	60	35	25	-5.11	3.65	210	110	95	-4.44	3.84
10 to 14 years	50	20	25	-2.92	3.65	250	120	130	-4.85	5.25
15 to 19 years	50	30	25	-4.38	3.65	235	120	105	-4.85	4.24
20 to 24 years	45	20	25	-2.92	3.65	165	85	70	-3.43	2.83
25 to 29 years	50	25	25	-3.65	3.65	180	85	95	-3.43	3.84
30 to 34 years	40	20	20	-2.92	2.92	145	70	90	-2.83	3.64
35 to 39 years	40	15	20	-2.19	2.92	145	65	80	-2.63	3.23
40 to 44 years	20	10	10	-1.46	1.46	115	50	75	-2.02	3.03
45 to 49 years	40	15	30	-2.19	4.38	135	60	75	-2.42	3.03
50 to 54 years	50	25	25	-3.65	3.65	180	80	85	-3.23	3.43
55 to 59 years	55	25	35	-3.65	5.11	125	70	70	-2.83	2.83
60 to 64 years	40	20	25	-2.92	3.65	110	50	55	-2.02	2.22
65 to 69 years	30	10	15	-1.46	2.19	75	45	45	-1.82	1.82
70 to 74 years	25	10	15	-1.46	2.19	65	35	30	-1.41	1.21
75 to 79 years	15	5	10	-0.73	1.46	55	10	40	-0.40	1.62
80 to 84 years	15	10	5	-1.46	0.73	25	20	20	-0.81	0.81
85 to 89 years	5	0	5	0.00	0.73	15	5	10	-0.20	0.40
90 to 94 years	10	10	5	-1.46	0.73	10	10	5	-0.40	0.20
95 to 99 years	0	0	0	0.00	0.00	0	0	0	0.00	0.00
100 years +	0	0	0	0.00	0.00	0	0	0	0.00	0.00

Population Age Structure by Sex for the Local Study Area, Northern Saskatchewan, and Saskatchewan, 2016

	Patuanak, Northern hamlet[1,2,5]					Pinehouse, Northern village[1,2,5]				
	Total	Male - Patuanak	Female - Patuanak	% Male	% Female	Total	Male - Pinehouse	Female - Pinehouse	% Male	% Female
Total Population	**75**	**35**	**40**			**1,050**	**535**	**515**		
0 to 4 years	10	0	10	0.00	13.33	95	60	40	-5.71	3.81
5 to 9 years	5	5	5	-6.67	6.67	140	80	60	-7.62	5.71
10 to 14 years	5	5	0	-6.67	0.00	105	45	60	-4.29	5.71
15 to 19 years	10	10	0	-13.33	0.00	110	50	55	-4.76	5.24
20 to 24 years	10	5	5	-6.67	6.67	110	55	55	-5.24	5.24
25 to 29 years	0	0	0	0.00	0.00	85	40	45	-3.81	4.29
30 to 34 years	5	0	5	0.00	6.67	65	30	35	-2.86	3.33
35 to 39 years	0	0	0	0.00	0.00	55	30	30	-2.86	2.86
40 to 44 years	5	0	5	0.00	6.67	50	25	30	-2.38	2.86
45 to 49 years	5	0	5	0.00	6.67	60	35	35	-3.33	3.33
50 to 54 years	5	0	5	0.00	6.67	55	30	25	-2.86	2.38
55 to 59 years	5	0	0	0.00	0.00	50	25	30	-2.38	2.86
60 to 64 years	5	5	0	-6.67	0.00	15	10	10	-0.95	0.95
65 to 69 years	5	0	5	0.00	6.67	30	15	15	-1.43	1.43
70 to 74 years	5	0	5	0.00	6.67	15	5	10	-0.48	0.95
75 to 79 years	0	0	0	0.00	0.00	15	5	5	-0.48	0.48
80 to 84 years	5	0	0	0.00	0.00	5	5	5	-0.48	0.48
85 to 89 years	0	0	0	0.00	0.00	0	0	0	0.00	0.00
90 to 94 years	0	0	0	0.00	0.00	0	0	0	0.00	0.00
95 to 99 years	0	0	0	0.00	0.00	0	0	0	0.00	0.00
100 years +	0	0	0	0.00	0.00	0	0	0	0.00	0.00

	Beauval, Northern village[1,2,5]					Local Study Area[1,2,4,5]				
	Total	Male - Beauval	Female - Beauval	% Male	% Female	Total	Male - LSA	Female - LSA	% Male	% Female
Total Population	**640**	**320**	**320**			**2,475**	**1,240**	**1,245**		
0 to 4 years	55	40	15	-6.25	2.34	205	125	85	-5.05	3.43
5 to 9 years	40	25	20	-3.91	3.13	245	135	115	-5.45	4.65
10 to 14 years	60	30	30	-4.69	4.69	230	110	125	-4.44	5.05
15 to 19 years	65	35	30	-5.47	4.69	255	135	115	-5.45	4.65
20 to 24 years	55	30	20	-4.69	3.13	220	115	100	-4.65	4.04
25 to 29 years	60	35	25	-5.47	3.91	200	105	100	-4.24	4.04
30 to 34 years	35	15	20	-2.34	3.13	150	70	90	-2.83	3.64
35 to 39 years	20	10	10	-1.56	1.56	115	60	65	-2.42	2.63
40 to 44 years	30	15	20	-2.34	3.13	130	65	80	-2.63	3.23
45 to 49 years	35	15	20	-2.34	3.13	150	80	80	-3.23	3.23
50 to 54 years	50	20	35	-3.13	5.47	145	55	95	-2.22	3.84
55 to 59 years	30	15	15	-2.34	2.34	120	55	65	-2.22	2.63
60 to 64 years	35	10	25	-1.56	3.91	75	35	50	-1.41	2.02
65 to 69 years	20	5	15	-0.78	2.34	80	40	40	-1.62	1.62
70 to 74 years	15	10	15	-1.56	2.34	55	30	35	-1.21	1.41
75 to 79 years	15	5	5	-0.78	0.78	45	10	25	-0.40	1.01
80 to 84 years	5	5	0	-0.78	0.00	30	15	15	-0.61	0.61
85 to 89 years	0	0	0	0.00	0.00	5	5	5	-0.20	0.20
90 to 94 years	0	0	0	0.00	0.00	5	0	0	0.00	0.00
95 to 99 years	0	0	0	0.00	0.00	0	0	0	0.00	0.00
100 years +	0	0	0	0.00	0.00	0	0	0	0.00	0.00

Appendix 12-C4: Indigenous Population Ratio in the Local Study Area, Northern Saskatchewan, and Saskatchewan, 2016 and 2021

	2021 Population [1,2]								
	EFRN	La Plonge 192, Indian reserve	Wapachewunak 192D, Indian reserve	Patuanak, Northern hamlet	Pinehouse, Northern village	Beauval, Northern village	Local Study Area[3]	Northern Saskatchewan[4]	Saskatchewan
	A = B + C	B	C	D	F	E	G = B + C + D + E + F	H	I
Total - Indigenous identity for the population in private households	**715**	**145**	**570**	**65**	**1,015**	**835**	**2,630**	**35,825**	**1,103,200**
Indigenous identity	710	145	565	60	960	765	2,495	30,890	187,885
Single Indigenous responses	700	140	560	60	955	500	2,215	30,530	184,435
First Nations (North American Indian)	680	125	555	50	315	115	1,160	25,115	121,175
Métis	25	15	10	10	635	375	1,045	5,410	62,800
Inuk (Inuit)	0	0	0	0	0	0	0	0	460
Multiple Indigenous responses	0	0	0	0	10	25	35	165	2,030
Indigenous responses not included elsewhere	0	0	0	0	0	0	0	200	1,425
Non-Indigenous identity	10	0	10	0	50	30	90	4,935	915,310

	2021 Proportions[1,2]								
	EFRN	La Plonge 192, Indian reserve	Wapachewunak 192D, Indian reserve	Patuanak, Northern hamlet	Pinehouse, Northern village	Beauval, Northern village	Local Study Area[3]	Northern Saskatchewan[4]	Saskatchewan
Total - Indigenous identity for the population in private households	**100.0%**	**96.7%**	**100.9%**	**86.7%**	**96.7%**	**150.5%**	**109.8%**	**97.2%**	**103.0%**
Indigenous identity	99.3%	96.7%	100.0%	80.0%	91.4%	137.8%	104.2%	83.8%	17.6%
Single Indigenous responses	97.9%	93.3%	99.1%	80.0%	91.0%	90.1%	92.5%	82.8%	17.2%
First Nations (North American Indian)	95.1%	83.3%	98.2%	66.7%	30.0%	20.7%	48.4%	68.2%	11.3%
Métis	3.5%	10.0%	1.8%	13.3%	60.5%	67.6%	43.6%	14.7%	5.9%
Inuk (Inuit)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Multiple Indigenous responses	0.0%	0.0%	0.0%	0.0%	1.0%	4.5%	1.5%	0.4%	0.2%
Indigenous responses not included elsewhere	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	0.1%
Non-Indigenous identity	1.4%	0.0%	1.8%	0.0%	4.8%	5.4%	3.8%	13.4%	85.5%

	2016 Population [1,2]								
	EFRN	La Plonge 192, Indian reserve	Wapachewunak 192D, Indian reserve	Patuanak, Northern hamlet	Pinehouse, Northern village	Beauval, Northern village	Local Study Area[3]	Northern Saskatchewan[4]	Saskatchewan
	A = B + C	B	C	D	F	E	G = B + C + D + E + F	H	I
Total - Indigenous identity for the population in private households	**715**	**150**	**565**	**75**	**1,050**	**555**	**2,395**	**36,850**	**1,070,555**
Indigenous identity	685	140	545	70	1,000	525	2,280	32,200	175,020
Single Indigenous responses	695	145	550	70	1,000	500	2,265	32,010	172,810
First Nations (North American Indian)	670	130	540	65	310	115	1,160	25,575	114,570
Métis	20	10	10	10	690	375	1,095	6,435	57,880
Inuk (Inuit)	0	0	0	0	0	0	0	0	360
Multiple Indigenous responses	0	0	0	0	0	25	25	135	1,305
Indigenous responses not included elsewhere	0	0	0	0	0	0	0	55	905
Non-Indigenous identity	20	0	20	0	55	30	105	4,650	895,535

	2016 Proportions[1,2]								
	EFRN	La Plonge 192, Indian reserve	Wapachewunak 192D, Indian reserve	Patuanak, Northern hamlet	Pinehouse, Northern village	Beauval, Northern village	Local Study Area[3]	Northern Saskatchewan[4]	Saskatchewan
Total - Indigenous identity for the population in private households	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**
Indigenous identity	95.8%	93.3%	96.5%	93.3%	95.2%	94.6%	95.2%	87.4%	16.3%
Single Indigenous responses	97.2%	96.7%	97.3%	93.3%	95.2%	90.1%	94.6%	86.9%	16.1%
First Nations (North American Indian)	93.7%	86.7%	95.6%	86.7%	29.5%	20.7%	48.4%	69.4%	10.7%
Métis	2.8%	6.7%	1.8%	13.3%	65.7%	67.6%	45.7%	17.5%	5.4%
Inuk (Inuit)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Multiple Indigenous responses	0.0%	0.0%	0.0%	0.0%	0.0%	4.5%	1.0%	0.4%	0.1%
Indigenous responses not included elsewhere	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%
Non-Indigenous identity	2.8%	0.0%	3.5%	0.0%	5.2%	5.4%	4.4%	12.6%	83.7%

Source: Statistics Canada 2017, 2022.

Footnotes:

1. Data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5, and in some cases, 10. Totals may not add-up due to rounding.

2. In addition to random rounding, area and data suppression has been adopted to further protect the confidentiality of individual respondents' personal information. Area and data suppression results in the deletion of all information for geographic areas with populations below a specified size. For example, areas with a population of less than 40 persons are suppressed. If the community searched has a population of less than 40 persons, only the total population counts will be available. Suppression of data can be due to poor data quality or to other technical reasons.

3. Local Study Area includes La Plonge 192, Wapachewunak 192D, Patuanak, Pinehouse Lake, and Beauval.

4. North Saskatchewan is defined as Census Division No.18.

Appendix 12-C5: Proportion of Population who are migrants within 1-year and 5-years, for the Local Study Area, Northern Saskatchewan, and Saskatchewan, 2016 and 2021

2021 Mobility Status								
	La Plonge 192, Indian reserve[1,2]	Wapachewunak 192D, Indian reserve[1,2]	Patuanak, Northern hamlet[1,2]	Pinehouse, Northern village[1,2]	Beauval, Northern village[1,2]	Local Study Area[1,2,3]	Northern Saskatchewan[1,2,4]	Saskatchewan[1,2]
Total - Mobility status 1 year ago - 25% sample data [5]	**140**	**565**	**60**	**995**	**825**	**2,585**	**35,155**	**1,090,215**
Non-movers	140	550	60	915	810	2,475	32,355	952,690
Movers	-	15	-	80	15	110	2,800	137,525
Non-migrants	-	-	-	45	10	55	1,870	87,445
Migrants	-	10	-	35	-	45	930	50,080
Internal migrants	-	10	-	35	-	45	920	43,570
Intraprovincial migrants	-	10	-	30	-	40	670	31,135
Interprovincial migrants	-	-	-	10	-	10	245	12,435
External migrants	-	-	-	-	-	-	10	6,510
Proportion								
Non-movers	100.0%	97.3%	100.0%	92.0%	98.2%	95.7%	92.0%	87.4%
Movers	0.0%	2.7%	0.0%	8.0%	1.8%	4.3%	8.0%	12.6%
Non-migrants	0.0%	0.0%	0.0%	4.5%	1.2%	2.1%	5.3%	8.0%
Migrants	0.0%	1.8%	0.0%	3.5%	0.0%	1.7%	2.6%	4.6%
Internal migrants	0.0%	1.8%	0.0%	3.5%	0.0%	1.7%	2.6%	4.0%
Intraprovincial migrants	0.0%	1.8%	0.0%	3.0%	0.0%	1.5%	1.9%	2.9%
Interprovincial migrants	0.0%	0.0%	0.0%	1.0%	0.0%	0.4%	0.7%	1.1%
External migrants	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%
Total - Mobility status 5 years ago - 25% sample data [6]	**130**	**525**	**65**	**900**	**775**	**2,395**	**32,355**	**1,034,525**
Non-movers	105	400	30	570	570	1,675	22,430	640,040
Movers	30	125	30	340	205	730	9,920	394,480
Non-migrants	15	75	10	235	85	420	4,725	180,065
Migrants	15	55	25	100	115	310	5,195	214,415
Internal migrants	15	55	25	100	115	310	5,015	172,905
Intraprovincial migrants	15	45	25	95	90	270	4,240	134,460
Interprovincial migrants	-	10	10	-	30	50	780	38,445
External migrants	-	-	-	-	-	-	180	41,505
Proportion								
Non-movers	80.8%	76.2%	46.2%	63.3%	73.5%	69.9%	69.3%	61.9%
Movers	23.1%	23.8%	46.2%	37.8%	26.5%	30.5%	30.7%	38.1%
Non-migrants	11.5%	14.3%	15.4%	26.1%	11.0%	17.5%	14.6%	17.4%
Migrants	11.5%	10.5%	38.5%	11.1%	14.8%	12.9%	16.1%	20.7%
Internal migrants	11.5%	10.5%	38.5%	11.1%	14.8%	12.9%	15.5%	16.7%
Intraprovincial migrants	11.5%	8.6%	38.5%	10.6%	11.6%	11.3%	13.1%	13.0%
Interprovincial migrants	0.0%	1.9%	15.4%	0.0%	3.9%	2.1%	2.4%	3.7%
External migrants	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%	4.0%

2016 Mobility Status								
	La Plonge 192, Indian reserve[1,2]	Wapachewunak 192D, Indian reserve[1,2]	Patuanak, Northern hamlet[1,2]	Pinehouse, Northern village[1,2]	Beauval, Northern village[1,2]	Local Study Area[1,2,3]	Northern Saskatchewan[1,2,4]	Saskatchewan[1,2]
Total - Mobility status 1 year ago - 25% sample data [5]	**145**	**560**	**70**	**1,030**	**555**	**2,360**	**36,110**	**1,055,820**
Non-movers	120	490	65	920	505	2,100	32,390	905,630
Movers	25	65	-	110	50	250	3,720	150,195
Non-migrants	10	40	10	85	35	180	2,415	89,005
Migrants	20	25	-	25	15	85	1,305	61,185
Internal migrants	20	25	-	25	10	80	1,275	49,930
Intraprovincial migrants	15	25	-	15	10	65	1,040	35,965
Interprovincial migrants	-	10	-	10	-	20	235	13,970
External migrants	-	-	-	-	-	-	25	11,255
Proportion								
Non-movers	82.8%	87.5%	92.9%	89.3%	91.0%	89.0%	89.7%	85.8%
Movers	17.2%	11.6%	0.0%	10.7%	9.0%	10.6%	10.3%	14.2%
Non-migrants	6.9%	7.1%	14.3%	8.3%	6.3%	7.6%	6.7%	8.4%
Migrants	13.8%	4.5%	0.0%	2.4%	2.7%	3.6%	3.6%	5.8%
Internal migrants	13.8%	4.5%	0.0%	2.4%	1.8%	3.4%	3.5%	4.7%
Intraprovincial migrants	10.3%	4.5%	0.0%	1.5%	1.8%	2.8%	2.9%	3.4%
Interprovincial migrants	0.0%	1.8%	0.0%	1.0%	0.0%	0.8%	0.7%	1.3%
External migrants	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	1.1%
Total - Mobility status 5 years ago - 25% sample data [6]	**135**	**530**	**65**	**955**	**495**	**2,180**	**32,915**	**998,200**
Non-movers	95	445	50	610	310	1,510	23,980	602,890
Movers	40	85	10	340	170	645	8,940	395,310
Non-migrants	10	45	10	245	125	435	5,700	201,450
Migrants	30	45	-	100	45	220	3,245	193,860
Internal migrants	30	45	-	95	45	215	3,130	147,360
Intraprovincial migrants	30	30	-	75	30	165	2,375	98,780
Interprovincial migrants	-	10	-	30	10	50	755	48,585
External migrants	-	-	-	-	-	-	115	46,500
Proportion								
Non-movers	70.4%	84.0%	76.9%	63.9%	62.6%	69.3%	72.9%	60.4%
Movers	29.6%	16.0%	15.4%	35.6%	34.3%	29.6%	27.2%	39.6%
Non-migrants	7.4%	8.5%	15.4%	25.7%	25.3%	20.0%	17.3%	20.2%
Migrants	22.2%	8.5%	0.0%	10.5%	9.1%	10.1%	9.9%	19.4%
Internal migrants	22.2%	8.5%	0.0%	9.9%	9.1%	9.9%	9.5%	14.8%
Intraprovincial migrants	22.2%	5.7%	0.0%	7.9%	6.1%	7.6%	7.2%	9.9%
Interprovincial migrants	0.0%	1.9%	0.0%	3.1%	2.0%	2.3%	2.3%	4.9%
External migrants	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	4.7%

Source: Statistics Canada 2017, 2022.

Footnotes:

1. Data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5, and in some cases, 10. Totals may not add-up due to rounding.
2. In addition to random rounding, area and data suppression has been adopted to further protect the confidentiality of individual respondents' personal information. Area and data suppression results in the deletion of all information for geographic areas with populations below a specified size. For example, areas with a population of less than 40 persons are suppressed. If the community searched has a population of less than 40 persons, only the total population counts will be available. Suppression of data can be due to poor data quality or to
3. Local Study Area includes La Plonge 192, Wapachewunak 192D, Patuanak, Pinehouse Lake, and Beauval.
4. North Saskatchewan is defined as Census Division No.18.

Appendix 12-C6: Population Projections for Saskatchewan Keewatin Yatthé Health Authority for 2018-2049

Years	Projection[1]								
	Low Growth	Medium Growth M1	Medium Growth M2	Medium Growth M3	Medium Growth M4	Medium Growth M5	High Growth	Slow-aging	Fast-aging
2018	11,139	11,139	11,139	11,139	11,139	11,139	11,139	11,139	11,139
2019	11,139	11,148	11,144	11,149	11,166	11,154	11,158	11,154	11,143
2020	11,132	11,154	11,147	11,154	11,189	11,166	11,177	11,167	11,141
2021	11,120	11,158	11,146	11,158	11,210	11,175	11,196	11,180	11,135
2022	11,103	11,159	11,143	11,158	11,229	11,183	11,215	11,192	11,126
2023	11,082	11,159	11,139	11,157	11,246	11,190	11,235	11,203	11,114
2024	11,057	11,156	11,132	11,153	11,260	11,194	11,253	11,212	11,098
2025	11,028	11,151	11,123	11,147	11,271	11,196	11,271	11,220	11,079
2026	10,998	11,145	11,114	11,140	11,282	11,198	11,290	11,228	11,060
2027	10,965	11,138	11,103	11,131	11,291	11,198	11,308	11,234	11,038
2028	10,929	11,129	11,091	11,121	11,298	11,197	11,326	11,241	11,014
2029	10,892	11,120	11,078	11,110	11,304	11,195	11,345	11,247	10,989
2030	10,855	11,111	11,065	11,099	11,310	11,194	11,364	11,254	10,964
2031	10,816	11,103	11,053	11,088	11,316	11,193	11,385	11,261	10,939
2032	10,778	11,095	11,041	11,077	11,322	11,193	11,407	11,270	10,913
2033	10,739	11,086	11,029	11,066	11,329	11,193	11,430	11,280	10,887
2034	10,700	11,079	11,018	11,055	11,335	11,194	11,455	11,291	10,861
2035	10,660	11,071	11,007	11,044	11,341	11,194	11,480	11,303	10,834
2036	10,619	11,064	10,996	11,033	11,347	11,195	11,506	11,316	10,806
2037	10,579	11,057	10,985	11,022	11,353	11,196	11,534	11,331	10,777
2038	10,537	11,049	10,975	11,011	11,358	11,196	11,562	11,347	10,747
2039	10,496	11,043	10,964	11,000	11,364	11,197	11,592	11,365	10,717
2040	10,454	11,037	10,955	10,990	11,370	11,199	11,624	11,386	10,685
2041	10,412	11,031	10,946	10,979	11,376	11,202	11,658	11,409	10,653
2042	10,369	11,026	10,936	10,968	11,382	11,205	11,692	11,434	10,619
2043	10,326	11,020	10,927	10,957	11,387	11,207	11,729	11,461	10,584
2044	10,280	11,012	10,916	10,944	11,391	11,208	11,764	11,487	10,546
2045	10,233	11,003	10,903	10,930	11,393	11,208	11,799	11,514	10,506
2046	10,184	10,993	10,890	10,913	11,393	11,206	11,834	11,540	10,463
2047	10,133	10,982	10,875	10,896	11,392	11,203	11,868	11,567	10,419
2048	10,082	10,969	10,858	10,877	11,389	11,199	11,902	11,593	10,374
2049	10,029	10,956	10,842	10,857	11,385	11,195	11,936	11,620	10,327

Source: Statistics Canada 2019a, Custom projections for Health Regions in Canada (2018-2043).

Average annual population change[2]	-0.34%	-0.05%	-0.09%	-0.08%	0.07%	0.02%	0.22%	0.14%	-0.24%
Cumulative population change[2]	-9.96%	-1.64%	-2.67%	-2.53%	2.21%	0.50%	7.16%	4.32%	-7.29%

Footnote:

1. These projections use the same methodology, assumptions and scenarios as in the Population Projections for Canada (2018 to 2068), provinces and territories (2018 to 2043), adapted to Health Regions (a description of the methodology and assumptions of these projections can be found here: https://www150.statcan.gc.ca/n1/pub/91-620-x/91-620-x2019001-eng.pdf.) The methods combine the use of historical data and the opinion of experts for each component of growth to develop future trajectories specific to each Health Regions. Generally, the same method has been used for all Health Regions. However, in Health Regions with small populations, where the counts of demographic events recorded annually are usually small, the past trends are often noisy, being very affected by random fluctuations. For this reason, some compromises were made in the less populated Health Regions (including Keewatin Yatthé), such as using the trends in both sex together instead of doing it for each sex separately, or keeping the age structure constant over time (for the projected changes in a given component of growth).

2. Average annual population change and cumulative population change calculated by InterGroup Consultants Ltd.

Appendix 12-C7: Population Projections for Saskatchewan Mamawetan Churchill River Health Authority for 2018-2049

Years	Projection[1]								
	Low Growth	Medium Growth M1	Medium Growth M2	Medium Growth M3	Medium Growth M4	Medium Growth M5	High Growth	Slow-aging	Fast-aging
2018	23,449	23,449	23,449	23,449	23,449	23,449	23,449	23,449	23,449
2019	23,651	23,673	23,669	23,679	23,709	23,678	23,695	23,687	23,659
2020	23,840	23,892	23,886	23,905	23,967	23,902	23,946	23,928	23,857
2021	24,019	24,111	24,101	24,130	24,225	24,127	24,203	24,173	24,049
2022	24,191	24,328	24,315	24,353	24,483	24,351	24,465	24,421	24,235
2023	24,354	24,543	24,526	24,574	24,740	24,573	24,731	24,671	24,414
2024	24,513	24,757	24,736	24,795	24,997	24,796	25,001	24,923	24,590
2025	24,664	24,969	24,944	25,013	25,253	25,017	25,274	25,177	24,760
2026	24,809	25,180	25,151	25,229	25,509	25,238	25,550	25,433	24,926
2027	24,950	25,390	25,357	25,444	25,765	25,459	25,830	25,691	25,087
2028	25,085	25,598	25,561	25,657	26,020	25,678	26,112	25,950	25,245
2029	25,216	25,806	25,764	25,870	26,276	25,899	26,398	26,212	25,399
2030	25,343	26,014	25,967	26,081	26,532	26,120	26,687	26,477	25,550
2031	25,468	26,222	26,170	26,294	26,790	26,343	26,981	26,746	25,699
2032	25,590	26,430	26,374	26,505	27,049	26,566	27,278	27,018	25,845
2033	25,709	26,638	26,577	26,716	27,308	26,789	27,579	27,294	25,989
2034	25,828	26,848	26,782	26,929	27,569	27,014	27,885	27,574	26,131
2035	25,946	27,061	26,989	27,144	27,833	27,242	28,197	27,861	26,273
2036	26,064	27,276	27,198	27,361	28,099	27,472	28,514	28,154	26,414
2037	26,181	27,493	27,410	27,580	28,368	27,705	28,838	28,454	26,554
2038	26,298	27,713	27,625	27,801	28,641	27,942	29,169	28,761	26,693
2039	26,415	27,935	27,841	28,025	28,916	28,181	29,507	29,077	26,830
2040	26,532	28,161	28,061	28,252	29,196	28,425	29,853	29,401	26,967
2041	26,649	28,390	28,284	28,481	29,479	28,673	30,206	29,733	27,102
2042	26,766	28,620	28,508	28,712	29,765	28,923	30,566	30,074	27,235
2043	26,882	28,854	28,736	28,946	30,055	29,177	30,935	30,426	27,366
2044	26,995	29,088	28,963	29,178	30,344	29,431	31,308	30,781	27,493
2045	27,105	29,321	29,190	29,411	30,634	29,685	31,685	31,141	27,617
2046	27,213	29,555	29,418	29,643	30,924	29,940	32,068	31,508	27,738
2047	27,318	29,789	29,645	29,875	31,215	30,196	32,456	31,880	27,855
2048	27,421	30,024	29,873	30,107	31,507	30,453	32,850	32,259	27,970
2049	27,521	30,258	30,101	30,338	31,799	30,710	33,249	32,643	28,081

Source: Statistics Canada 2019a, Custom projections for Health Regions in Canada (2018-2043).

Average annual population change[2]	0.52%	0.83%	0.81%	0.83%	0.99%	0.87%	1.13%	1.07%	0.58%
Cumulative population change[2]	17.37%	29.04%	28.37%	29.38%	35.61%	30.97%	41.79%	39.21%	19.75%

Footnote:

1. These projections use the same methodology, assumptions and scenarios as in the Population Projections for Canada (2018 to 2068), provinces and territories (2018 to 2043), adapted to Health Regions (a description of the methodology and assumptions of these projections can be found here: https://www150.statcan.gc.ca/n1/pub/91-620-x/91-620-x2019001-eng.pdf.) The methods combine the use of historical data and the opinion of experts for each component of growth to develop future trajectories specific to each Health Regions. Generally, the same method has been used for all Health Regions. However, in Health Regions with small populations, where the counts of demographic events recorded annually are usually small, the past trends are often noisy, being very affected by random fluctuations. For this reason, some compromises were made in the less populated Health Regions (including Keewatin Yatthé), such as using the trends in both sex together instead of doing it for each sex separately, or keeping the age structure constant over time (for the projected changes in a given component of growth).

2. Average annual population change and cumulative population change calculated by InterGroup Consultants Ltd.

Denison Mines

Wheeler River Project

Final Environmental Impact Statement

November 2024

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Appendix 12-D: Incident-Based Crime Statistics, by Detailed Violations, Police Services in Saskatchewan, 2016 to 2020

Incident-Based Crime Statistics, by Detailed Violations, Police Services in Saskatchewan[1 2 3 4 5]						
Detatchment	**Year**	**2016**	**2017**	**2018**	**2019**	**2020**
Pinehouse, Saskatchewan, Royal Canadian Mounted Police, rural	**Actual incidents**	486	545	442	655	597
	Rate per 100,000 population [6]	21,648	24,439	19,318	28,027	24,854
	Percentage change in rate [7]	46.9%	12.9%	-21.0%	45.1%	-11.3%
Beauval, Saskatchewan, Royal Canadian Mounted Police, rural	**Actual incidents**	1,279	1,305	1,257	1,078	1,322
	Rate per 100,000 population [6]	45,099	45,423	43,646	37,985	45,999
	Percentage change in rate [7]	15.9%	0.7%	-3.9%	-13.0%	21.1%
Saskatchewan	**Actual incidents**	153,479	149,351	147,141	151,199	144,085
	Rate per 100,000 population [6]	13,511	12,983	12,665	12,898	12,224
	Percentage change in rate [7]	4.6%	-3.9%	-2.5%	1.8%	-5.2%

Source: Statistics Canada 2019b. Table 35-10-0182-01 (Formerly CANSIM 252-0079). Incident-based crime statistics, by detailed violations, police services in Saskatchewan
https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3510018201

Footnotes:

1. For the period from 1998 to 2017 Incident-based Uniform Crime Reporting Survey (UCR2) data are not available for all respondents. In order to report this level of detail for police services still reporting to the Aggregate Uniform Crime Reporting Survey (UCR) over this time, a process of imputation was applied to derive counts for violations that do not exist on their own in the aggregate survey. For approximately 80% of the aggregate offence codes, there is a 1:1 mapping with a new incident-based violation code. For violations where this was not the case, such as the aggregate other Criminal Code category, it was necessary to estimate (impute) this figure using the distribution of other Criminal Code offences from existing Incident-based UCR2 respondents.

2. During the production of each year's crime statistics, data from the previous year are revised to reflect any updates or changes that have been received from the police services. For more information on the concepts, methods and quality of the data contained in this table, please contact the Canadian Centre for Justice Statistics at statcan.ccjcss-ccsjsc.statcan@canada.ca.

3. Police reported statistics may be affected by differences in the way police services deal with minor offences. In some instances, police or municipalities might chose to deal with some minor offences using municipal by-laws or provincial provisions rather than Criminal Code provisions. Counts are based on the most serious violation in the incident.

4. In January 2018, the Uniform Crime Reporting Survey (UCR) definitions of “founded” and “unfounded” criminal incidents were updated to reflect a more victim-centred approach for recording crimes that consider the complexities of certain offences such as sexual assault, family violence and intimate partner violence. Under the new reporting standards, specific offences may be more likely reported by police as founded rather than unfounded (or unsubstantiated), which would exclude them from police-reported crime rates and crime severity indices. Data for 2019 represent the first complete year of UCR data collected under the new reporting standards. As a result, for selected violations and police services, the actual proportion of incidents in 2019 that were classified as “not cleared” has increased. Use caution when comparing these data with prior years.

5. A high crime rate or Crime Severity Index (CSI) may indicate that a municipality is a geographical area that provides commercial business, human or public services, or entertainment for many people who reside outside, as well as inside, the municipality. As a result, these municipalities may have large part-time or temporary populations which are excluded from both their population bases and their crime rate and CSI calculations.

6. Population figures reflect only the permanent or resident population of a jurisdiction. Where a jurisdiction serves as the centre for commercial businesses, human or public services, or entertainment, it may have substantial “part-time” populations, e.g., tourists, cabin owners, commuters, students, and seasonal staff. These temporary populations, whose permanent residence is within another jurisdiction, are excluded from a jurisdiction’s population figures. This may be a factor to consider when examining the crime rate and Crime Severity Index for some municipalities.

7. This represents the year-over-year (current year over last year) percentage change in the rate of actual incidents.

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Final Environmental Impact Statement

November 2024

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Appendix 12-E1 - SGI Collision Rates for All Provincial Highways and Rural Municipalities in Saskatchewan (2011 to 2019)

	2011	2012	2013	2014	2015	2016	2017	2018	2019
Collision rate for all provincial highways (coll./Mvkm)	0.84	0.74	0.82	0.66	0.72	0.81	0.83	0.87	0.88
Collision rate for all rural municipalities (coll./Mvkm)	1.09	1.07	1.16	0.94	1.00	1.21	1.33	1.37	1.34

Source:

SGI. 2020. Traffic Collision Statistics (2011 to 2019)
https://www.sgi.sk.ca/news?cat=statistics&topic=collision-statistics&item=10
[Accessed July 21, 2021]

Appendix 12-E2 - SGI Traffic Collision Statistics for Hwy 165 in Saskatchewan (2011 to 2019)

Year	Control Section	Location	Length in km	ADT (veh/d)	Total Travel MvKm	Collisions: Property Damage	Personal Injury	Fatal	Total	Acc/ MvKm	Persons: Injured	Killed
			a	b	c	d	e	f	g	h	i	j
									=d+e+f	=g/c		
2019	165-00	Hwy 165 Section Not Known	0.0	0	0.00	0	0	0	0	0.00	0	0
	165-01	Jct Hwy 106 - Jct Hwy 2	94.8	32	1.11	2	0	0	2	1.80	0	0
	165-02	Jct Hwy 2 - Besnard Lake Rd.	55.6	190	3.85	1	0	0	1	0.26	0	0
	165-03	Besnard Lake Rd - Key Lake Rd	56.0	77	1.57	0	1	0	1	0.64	1	0
	165-04	Key Lake Rd - Jct Hwy 155	66.0	176	4.23	3	1	0	4	0.95	1	0
		Subtotal Hwy 165 excluding CS 165-01	177.6		9.65	4	2	0	6	0.62	2	0
		Subtotal Hwy 165 (all)	272.4		10.76	6	2	0	8	0.74	2	0
2018	165-01	Hwy 165 Section Not Known	0.0	0	0.00	1	0	0	1	0.00	0	0
	165-02	Jct Hwy 106 - Jct Hwy 2	94.8	32	1.11	1	1	0	2	1.80	2	0
	165-03	Jct Hwy 2 - Besnard Lake Rd.	55.6	190	3.85	3	0	0	3	0.78	0	0
	165-04	Besnard Lake Rd - Key Lake Rd	56.0	77	1.57	0	0	0	0	0.00	0	0
	165-05	Key Lake Rd - Jct Hwy 155	66.0	176	4.23	1	0	0	1	0.24	0	0
		Subtotal Hwy 165 excluding CS 165-01	177.6		9.65	5	0	0	5	0.52	0	0
		Subtotal Hwy 165 (all)	272.4		10.76	6	1	0	7	0.65	2	0
2017	165-00	Hwy 165 Section Not Known	0.0	0	0.00	0	0	0	0	0.00	0	0
	165-01	Jct Hwy 106 - Jct Hwy 2	94.8	34	1.18	1	1	0	2	1.69	1	0
	165-02	Jct Hwy 2 - Besnard Lake Rd.	55.6	213	4.32	1	2	0	3	0.69	2	0
	165-03	Besnard Lake Rd - Key Lake Rd	56.0	123	2.52	1	0	0	1	0.40	0	0
	165-04	Key Lake Rd - Jct Hwy 155	66.0	226	5.43	4	1	0	5	0.92	1	0
		Subtotal Hwy 165 excluding CS 165-01	177.6		12.27	6	3	0	9	0.73	3	0
		Subtotal Hwy 165 (all)	272.4		13.45	7	4	0	11	0.82	4	0
2016	165-00	Hwy 165 Section Not Known	0.0	0	0.00	1	0	0	1	0.00	0	0
	165-01	Jct Hwy 106 - Jct Hwy 2	94.8	34	1.18	1	0	0	1	0.85	0	0
	165-02	Jct Hwy 2 - Besnard Lake Rd.	55.6	21	4.32	3	2	1	6	1.39	5	1
	165-03	Besnard Lake Rd - Key Lake Rd	56.0	23	2.52	2	0	0	2	0.79	0	0
	165-04	Key Lake Rd - Jct Hwy 155	66.0	226	5.43	8	4	0	12	2.21	6	0
		Subtotal Hwy 165 excluding CS 165-01	177.6		12.27	14	6	1	21	1.71	11	1
		Subtotal Hwy 165 (all)	272.4		13.45	15	6	1	22	1.64	11	1
2015	165-00	Hwy 165 Section Not Known	0.0	0	0.00	1	0	0	1	0.00	0	0
	165-01	Jct Hwy 106 - Jct Hwy 2	94.8	37	1.28	2	0	0	2	1.56	0	0
	165-02	Jct Hwy 2 - Besnard Lake Rd.	55.6	213	4.32	3	1	0	4	0.93	4	0
	165-03	Besnard Lake Rd - Key Lake Rd	56.0	123	2.52	1	0	0	1	0.40	0	0
	165-04	Key Lake Rd - Jct Hwy 155	66.0	225	5.43	9	3	0	12	2.21	4	0
		Subtotal Hwy 165 excluding CS 165-01	177.6		12.27	14	4	0	18	1.47	8	0
		Subtotal Hwy 165 (all)	272.4		13.55	16	4	0	20	1.48	8	0
2014	165-00	Hwy 165 Section Not Known	0.0	0	0.00	0	0	0	0	0.00	0	0
	165-01	Jct Hwy 106 - Jct Hwy 2	94.8	44	1.53	3	2	0	5	3.27	2	0
	165-02	Jct Hwy 2 - Besnard Lake Rd.	55.6	200	4.06	2	0	0	2	0.49	0	0
	165-03	Besnard Lake Rd - Key Lake Rd	56.0	113	2.31	1	0	0	1	0.43	0	0
	165-04	Key Lake Rd - Jct Hwy 155	66.0	194	4.68	2	0	1	3	0.64	0	2
		Subtotal Hwy 165 excluding CS 165-01	177.6		11.05	5	0	1	6	0.54	0	2
		Subtotal Hwy 165 (all)	272.4		12.58	8	2	1	11	0.87	2	2
2013	165-00	Hwy 165 Section Not Known	0.0	0	0.00	1	0	0	1	0.00	0	0
	165-01	Jct Hwy 106 - Jct Hwy 2	94.8	44	1.52	1	0	0	1	0.66	0	0
	165-02	Jct Hwy 2 - Besnard Lake Rd.	55.6	213	4.32	3	1	0	4	0.93	1	0
	165-03	Besnard Lake Rd - Key Lake Rd	56.0	123	2.52	1	2	0	3	1.19	5	0
	165-04	Key Lake Rd - Jct Hwy 155	66.0	232	5.58	3	0	0	3	0.54	0	0
		Subtotal Hwy 165 excluding CS 165-01	177.6		12.42	8	3	0	11	0.89	6	0
		Subtotal Hwy 165 (all)	272.4		13.94	9	3	0	12	0.86	6	0
2012	165-00	Hwy 165 Section Not Known	0.0	0	0.00	0	1	0	1	0.00	1	0
	165-01	Jct Hwy 106 - Jct Hwy 2	94.8	44	1.53	1	0	0	1	0.65	0	0
	165-02	Jct Hwy 2 - Besnard Lake Rd.	55.6	200	4.06	2	1	1	4	0.99	5	1
	165-03	Besnard Lake Rd - Key Lake Rd	56.0	113	2.31	2	0	0	2	0.87	0	0
	165-04	Key Lake Rd - Jct Hwy 155	66.0	194	4.68	5	1	0	6	1.28	3	0
		Subtotal Hwy 165 excluding CS 165-01	177.6		11.05	9	3	1	13	1.18	9	1
		Subtotal Hwy 165 (all)	272.4		12.58	10	3	1	14	1.11	9	1
2011	165-01	Jct Hwy 106 - Jct Hwy 2	94.8	21	0.71	2	2	0	4	5.63	3	0
	165-02	Jct Hwy 2 - Besnard Lake Rd.	55.6	200	4.06	2	1	0	3	0.74	1	0
	165-03	Besnard Lake Rd - Key Lake Rd	56.0	113	2.31	0	0	0	0	0.00	0	0
	165-04	Key Lake Rd - Jct Hwy 155	66.0	193	4.65	5	0	0	5	1.08	0	0
		Subtotal Hwy 165 excluding CS 165-01	177.6		11.02	7	1	0	8	0.73	1	0
		Subtotal Hwy 165 (all)	272.4		11.73	9	3	0	12	1.02	4	0

Source:

SGI. 2020. Traffic Collision Statistics (2011 to 2019)

https://www.sgi.sk.ca/news?cat=statistics&topic=collision-statistics&item=10 [Accessed July 21, 2021]

Appendix 12-E3 - SGI Traffic Collision Statistics for Hwy 914 in Saskatchewan (2011 to 2019)

Year	Control Section	Location	Length in km	ADT (veh/d)	Total Travel MvKm	Collisions Property Damage	Personal Injury	Fatal	Total	Acc/ MvKm	Persons Injured	Killed
			a	b	c	d	e	f	g	h	i	j
									=d+e+f	=g/c		
2019	914-00	Hwy 914 Section Not Known	0.0	0	0.00	0	0	0	0	0.00	0	0
	914-01	Jct Hwy 165 - Pinehouse Lake	49.9	85	1.54	0	0	0	0	0.00	0	0
	914-02	Pinehouse Lake - Bridge (N. Abut)	25.2	90	0.83	0	0	0	0	0.00	0	0
	914-03	Churchill River - Key Lake	194.3	45	3.19	0	0	0	0	0.00	0	0
		Subtotal Hwy 914	269.4		5.56	0	0	0	0	0.00	0	0
2018	914-00	Hwy 914 Section Not Known	0.0	0	0.00	1	0	0	1	0.00	0	0
	914-01	Jct Hwy 165 - Pinehouse Lake	49.9	85	1.54	0	0	0	0	0.00	0	0
	914-02	Pinehouse Lake - Bridge (N. Abut)	25.2	90	0.83	0	0	0	0	0.00	0	0
	914-03	Churchill River - Key Lake	194.3	45	3.19	0	0	0	0	0.00	0	0
		Subtotal Hwy 914	269.4		5.56	1	0	0	1	0.18	0	0
2017	914-00	Hwy 914 Section Not Known	0.0	0	0.00	0	0	0	0	0.00	0	0
	914-01	Jct Hwy 165 - Pinehouse Lake	49.9	125	2.27	2	0	0	2	0.88	0	0
	914-02	Pinehouse Lake - Bridge (N. Abut)	25.2	90	0.83	0	0	0	0	0.00	0	0
	914-03	Churchill River - Key Lake	194.3	45	3.19	0	1	0	1	0.31	1	0
		Subtotal Hwy 914	269.4		6.29	2	1	0	3	0.48	1	0
2016	914-00	Hwy 914 Section Not Known	0.0	0	0.00	0	0	0	0	0.00	0	0
	914-01	Jct Hwy 165 - Pinehouse Lake	49.9	125	2.27	1	1	0	2	0.88	2	0
	914-02	Pinehouse Lake - Bridge (N. Abut)	25.2	90	0.83	1	0	0	1	1.20	0	0
	914-03	Churchill River - Key Lake	194.3	45	3.19	1	0	0	1	0.31	0	0
		Subtotal Hwy 914	269.4		6.29	3	1	0	4	0.64	2	0
2015	914-00	Hwy 914 Section Not Known	0.0	0	0.00	0	0	0	0	0.00	0	0
	914-01	Jct Hwy 165 - Pinehouse Lake	49.9	125	2.27	3	0	1	4	1.76	0	2
	914-02	Pinehouse Lake - Bridge (N. Abut)	25.2	90	0.83	0	0	0	0	0.00	0	0
	914-03	Churchill River - Key Lake	194.3	45	3.19	0	3	0	3	0.94	3	0
		Subtotal Hwy 914	269.4		6.29	3	3	1	7	1.11	3	2
2014	914-00	Hwy 914 Section Not Known	0.0	0	0.00	1	0	0	1	0.00	0	0
	914-01	Jct Hwy 165 - Pinehouse Lake	49.9	113	2.05	2	0	0	2	0.98	0	0
	914-02	Pinehouse Lake - Bridge (N. Abut)	25.2	90	0.83	0	0	0	0	0.00	0	0
	914-03	Churchill River - Key Lake	194.3	50	3.55	1	1	0	2	0.56	1	0
		Subtotal Hwy 914	269.4		6.43	4	1	0	5	0.78	1	0
2013	914-00	Hwy 914 Section Not Known	0.0	0	0.00	0	0	0	0	0.00	0	0
	914-01	Jct Hwy 165 - Pinehouse Lake	49.9	173	3.15	2	1	0	3	0.95	1	0
	914-02	Pinehouse Lake - Bridge (N. Abut)	25.2	90	0.83	2	0	0	2	2.41	0	0
	914-03	Churchill River - Key Lake	194.3	50	3.55	1	1	0	2	0.56	2	0
		Subtotal Hwy 914	269.4		7.53	5	2	0	7	0.93	3	0
2012	914-00	Hwy 914 Section Not Known	0.0	0	0.00	0	0	0	0	0.00	0	0
	914-01	Jct Hwy 165 - Pinehouse Lake	49.9	113	2.05	1	1	0	2	0.98	1	0
	914-02	Pinehouse Lake - Bridge (N. Abut)	25.2	90	0.83	0	0	0	0	0.00	0	0
	914-03	Churchill River - Key Lake	194.3	50	3.55	0	0	0	0	0.00	0	0
		Subtotal Hwy 914	269.4		6.43	1	1	0	2	0.31	1	0
2011	914-01	Jct Hwy 165 - Pinehouse Lake	49.9	113	2.05	2	0	0	2	0.98	0	0
	914-02	Pinehouse Lake - Bridge (N. Abut)	25.2	90	0.83	0	0	0	0	0.00	0	0
	914-03	Churchill River - Key Lake	194.3	50	3.55	3	1	0	4	1.13	2	0
		Subtotal Hwy 914	269.4		6.43	5	1	0	6	0.93	2	0

Source:

SGI. 2020. Traffic Collision Statistics (2011 to 2019)
https://www.sgi.sk.ca/news?cat=statistics&topic=collision-statistics&item=10
[Accessed July 21, 2021]

Denison Mines

Wheeler River Project

Final Environmental Impact Statement

November 2024

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Section 13: Engagement Database Summary Table – Economics

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
18-EN-ERFN-5.21	5	Workshop	2018-05-03	As part of the engagement program for the Wheeler River Project, Denison organized a workshop for English River First Nation at their Patuanak Reserve location for ERFN and Patuanak members to attend. The workshop aimed to gather community input in relation to road alignment options, treated effluent discharge locations, and mining methods. The meeting had been delayed many times and was held in the Health Clinic because there was a regional power outage.	English River First Nation	You're projecting to start production in 2025. What type of jobs – I'm looking at building capacity in the community and in the school. What can Denison do to build capacity in elementary and middle school students now so they're ready when you are in seven years? What other things besides geologists, can we shoot for?	Denison considered this in section: Existing Environment, Key Indicator: Employment and Training – Educational Attainment	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from a member of English River First Nation who attended a workshop in the year 2018. The record reference serves to describe the existing environment in terms of educational attainment in relation to employment and training. Denison has estimated a workforce of 300 people for the two-year Construction period. Each component of Construction will require workers with different types of skills and training depending on the task (e.g., road construction, wellfield drilling, erection of buildings, connection to services). During Operation, over 180 people are expected to be employed to operate the ISR wellfield and processing plant, as well as provide various supporting activities such as security, camp operations, operation of the water treatment, sewage and potable water plants, environmental monitoring, and maintenance of roads, equipment, and buildings. Total employment level of over 180 people is estimated to include 155 employees and 29 contracted. The anticipated workforce breakdown for Operation of the Project include the following types of positions: Foundation (82 jobs), Trades (35 jobs) Profession/Technical (46 jobs), Supervisory (21 jobs). Denison, through a Human Resource Development Plan, will initially prioritize Indigenous and non-Indigenous communities in the LSA in terms of employment and training opportunities (anticipated to be in institutions in northern Saskatchewan) and will work with the leadership of these communities to assist in determining hiring and training practices during all phases of the Project, which could include such items as on-the-job training and career counselling to help with advancement from foundational positions, advance sharing of job qualification requirements, clearly identifying training requirements and working with various training institutions to make sure such appropriate training is available, and creation of scholarship and support programs. Denison will negotiate with the Province of Saskatchewan to develop the Project's SLA and the Human Resource Development Agreement, which will outline measures in relation to socio-economic parameters related to the Project.
18-EN-ERFN-5.22	5	Workshop	2018-05-03	Same as above	English River First Nation	What about summer programs to get them thinking about working for Denison? Building a partnership between the school and Denison to build capacity within the students so when they do graduate there's a clear path towards employment?	Denison considered this in section: Existing Environment, Key Indicator: Employment and Training – Educational Attainment	The context in which this comment was used within the terrestrial section of the EIS serves as a local perspective, documented as coming from a member of English River First Nation who attended a workshop in the year 2018. The record reference serves to describe the existing environment in terms of educational attainment in relation to employment and training.

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
18-EN-ERFN-5.30	5	Workshop	2018-05-03	Same as above	English River First Nation	What are the prospects for small scholarships for some of our overachievers?	Denison considered this in section: Scope of Assessment, Key Indicators and Measurable Parameters	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from a member of English River First Nation who attended a workshop in the year 2018. The record reference serves to support educational attainment as a key indicator. Scholarships were not directly incorporated into the Economy VC as a KI, given the narrow focus and effect of scholarships, considering to the selected indicators. Denison, through a Human Resource Development Plan, will initially prioritize Indigenous and non-Indigenous communities in the LSA in terms of economic opportunities. Denison will negotiate with the Province of Saskatchewan to develop the Project's surface lease agreement and the Human Resource Development Agreement, which will outline measures in relation to socio-economic parameters related to the Project, which could include scholarships or other incentivized learning opportunities.
18-EN-ERFN-5.31	5	Workshop	2018-05-03	Same as above	English River First Nation	We created a scholarship with another company in honour of the Humboldt Broncos accident. We're open to something like that.	Denison considered this in section: Scope of Assessment, Key Indicators and Measurable Parameters	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from a member of English River First Nation who attended a workshop in the year 2018. The record reference serves to support the chosen key indicators and measurable parameters.
16-EN-ERFN-99.2	99	Meeting	2016-07-07	English River First Nation and Denison held their first introductory meeting. Discussed relationship development, procurement with ERFN businesses, and ERFN employment opportunities. Scheduled a follow-up meeting to be held in the community of Patuanak.	English River First Nation	ERFN businesses suited to support the Wheeler River project; Minetec Industrial Supply http://www.minetecsales.com/about-us/ (supply house catering to mining industry) Beauval General Store, Gas Bar & Restaurant, located at the Beauval Forks. Material for exploration camps, fuel and groceries.	Denison considered this in section: Existing Environment, Key Indicator: Business Opportunities – Local Businesses	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from a member of English River First Nation who attended a meeting in the year 2016. The record reference serves to describe the existing environment in terms of business opportunities.
16-EN-DesNd-101.1	101	Meeting	2016-09-26	Des Nedhe and Denison held an introductory meeting regarding relationship development and business and procurement opportunities in the future.	Des Nedhe	Interested in any future business opportunities that may be available as Denison advances their Wheeler River Project.	Denison considered this in section: Existing Environment, Key Indicator: Business Opportunities, Local Businesses	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming an individual at Des Nedhe, representing English River First Nation interests, who attended a meeting in the year 2016. The record reference serves to describe the existing environment in terms of business opportunities.
16-EN-VPL-105.7	105	Community Meeting	2016-09-07	Denison hosted a community meeting in Pinehouse Lake to introduce the company and the Wheeler River Project.	Village of Pinehouse Lake, Kineepik Métis Local #9, Pinehouse Business North	When it comes to input, one of the reasons we created PBN is for the ability to handle this. Work out jobs and contracts with PBN.	Denison considered this in section: Existing Environment, Key Indicator: Business Opportunities, Local Businesses	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual of the Village of Pinehouse/Kineepik Métis Local #9, who attended a community meeting in the year 2016. The record reference serves to describe the existing environment in terms of local businesses in relation to business opportunities.
16-EN-VB-107.12	107	Community Event	2016-12-06	Denison participated in a community meeting for a local co-management board in Beauval to introduce the	MLA - Athabasca, Northwest Communities Management	What is the potential of northern communities to invest? It's usually much easier at the startup of a junior company to allow that to happen. The other thing is a legacy – this is where we missed the boat in the past	Denison considered this in section:	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from a member the co-management board in Beauval who attended a community event in the year

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
				company and explain the Wheeler River Project.	Company, Sipishik Métis Local #37, Village of Beauval	with mining companies coming to the north, for the companies to consider setting up some sort of legacy for the north – some sort of infrastructure, or a fund. A good example is Mistik, a forestry company who set aside a stumpage fee that goes directly to the impacted community. You need to consider that, and it's much easier to do early, when you know a small fraction has to go to that fund, rather than later trying to convince the shareholders who might not be in favour of it. We run into that scenario with some of the established companies. I recommend you begin that sort of setaside for the north, for legacy purposes.	Existing Environment, Key Indicator: Business Opportunities, Local Businesses	2016. The record reference serves to describe the existing environment in terms of local businesses in relation to business opportunities.
16-EN-VB-107.15	107	Community Meeting	2016-12-06	Same as above	MLA - Athabasca, Northwest Communities Management Company, Sipishik Métis Local #37, Village of Beauval	This scenario has repeated itself so many times with indigenous communities being impacted by development, whatever the size and distance. The question in some minds is, we know you're not banging the table. If we do bang the table we had better come up with what we have in terms of assets and human resources, equipment capacities and capabilities. It's no use just to say we want a piece of the action. We need to plan those incremental pieces. We're trying to do that; other things are happening besides the Wheeler River project.	Denison considered this in section: Existing Environment, Key Indicator: Business Opportunities – Local Businesses	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from a member the co-management board in Beauval who attended a community meeting in the year 2016. The record reference serves to describe the existing environment in terms of local businesses in relation to business opportunities.
17-EN-VB-116.5	116	Meeting	2017-09-06	Denison and the leaders of Beauval met and an update on the Wheeler River Project was provided by Denison. Attendees discussed their interest in a formal Memorandum of Understanding regarding working together in the future.	Village of Beauval	Continue to work together to identify areas the community maybe able to support the project activities from a business development perspective.	Denison considered this in section: Scope of Assessment, Key Indicators and Measurable Parameters	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from Beauval leadership, who attended a meeting in the year 2017. The record reference serves to support the chosen key indicators and measurable parameters.
19-EN-VB-132.1	132	Meeting	2019-02-01	Denison and Beauval held a meeting, in which Denison provided an update on the Wheeler River Project, including the pending submission of the Project into the environmental assessment process.	Village of Beauval	The sizable construction crew required to meet the needs of the Wheeler project during the construction phase was going to be a difficult task for Beauval to take on. They would like to be involved to whatever extent possible and would need to start looking for ways of maximizing this involvement. Beauval was willing to work with Denison to prepare the community and be ready to maximize opportunities to the extent that he was able to do so.	Denison considered this in section: Existing Environment, Key Indicator: Business Opportunities, Local Businesses	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual from the Village of Beauval who attended a meeting in the year 2019. The record reference serves to describe the existing environment in terms of local businesses in relation to business opportunities.
19-LK-ERFNTrap-134.172	134	Site Visit	2019-10-29	Denison met with local land user and English River First Nation Trapper at the Wheeler River Project site location for a full-day to interview him regarding his knowledge of the area, including providing information and feedback on specifics pertaining to wildlife and wildlife movement patterns, fish and spawning areas, local lakes and	ERFN Trapper	Moose: The area to the north of the Wheeler River Project regional study area (from maps) has generally been better for moose than the local project area. The area east and north of Three Mile Lake, and Omnia winter tracking transects #11 and 4 (see Omnia Terrestrial Baseline Report, Figure 2.5-1; and image included below). He sees more caribou and less moose. He believes this is a natural change and moose are moving further south.	Denison considered this in section: Existing Environment, Key Indicator: Traditional Economy And in section: Assessment of Project Related Effects, Potential Project Related Effects,	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from ERFN Trapper who attended a site visit in the year 2019. The record reference serves to describe the existing environment in terms of the traditional economy and is then used in relation to potential effects in terms of the traditional economy.

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				lake names, recreational and commercial use, traditional food consumption, and specific aspects of the Wheeler River Project. ERFN Trapper provided his consent to Denison to use the information he provided in the environmental assessment. He reviewed the notes taken from the meeting, and provided his revisions / modifications to Denison on January 2, 2020.			Potential Effect 3 – Traditional Economy	
19-LK-ERFNTrap-134.224	134	Site Visit	2019-10-29	Same as above	ERFN Trapper	If the gate at Key Lake is removed or the road is redesigned to go around Key Lake allowing unimpeded access to the north, there would be lots of concerns about the increase in the number of people coming north into this area. However, many people can currently bypass the Key Lake gate and drive along the Fox Lake road. There is a bridge in place (near the south part of Fox Lake road) for access to a drilling camp and this bridge is over a fairly deep river. If this bridge came out, it would restrict access further north along the road. More people have quads these days.	Denison considered this in section: Cumulative Effects	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming ERFN Trapper who attended a site visit in the year 2019. The record reference serves to highlight information within the engagement database that is pertinent to cumulative effects with respect to changes in access.
20-EN-VB-382.7	382	Meeting	2020-12-09	Denison provided a presentation to the Village of Beauval on the 2020 field program for Wheeler River and Denison's responses to the COVID-19 global pandemic.	Village of Beauval	Will you have an agreement similar to the ones that Cameco and Orano have? Will you have employment and training targets?	Denison considered this in section: Existing Environment, Key Indicator: Employment and Training, Employment Rate	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual from the Village of Beauval who attended a meeting in the year 2020. The record reference serves to describe the existing environment in terms of employment rate in relation to employment and training. Denison will negotiate with the Province of Saskatchewan to develop the Project's SLA and the Human Resource Development Agreement, which will outline measures in relation to socio-economic parameters related to the Project. Denison, through a Human Resource Development Plan, will initially prioritize Indigenous and non-Indigenous communities in the LSA in terms of economic opportunities. Denison will negotiate with the Province of Saskatchewan to develop the Project's surface lease agreement and the Human Resource Development Agreement, which will outline measures in relation to socio-economic parameters related to the Project.
20-EN-VB-382.10	382	Meeting	2020-12-09	Same as above	Village of Beauval	Team Drilling and Northlands College have a drilling training program. Would you bring something like this to our region?	Denison considered this in section: Existing Environment, Key Indicator: Employment and Training, Educational Attainment	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual from the Village of Beauval who attended a meeting in the year 2020. The record reference serves to describe the existing environment in terms of educational attainment in relation to employment and training. Denison, through a Human Resource Development Plan, will initially prioritize Indigenous and non-Indigenous communities in the LSA in terms of economic opportunities. Denison will

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
								negotiate with the Province of Saskatchewan to develop the Project's surface lease agreement and the Human Resource Development Agreement, which will outline measures in relation to socio-economic parameters related to the Project.
21-EN-LLRIB-392.11	392	Meeting	2021-03-05	As a result of their request, Denison provided a presentation on the Wheeler River Project to the Lac La Ronge Indian Band Lands and Resources Subcommittee.	Lac La Ronge Indian Band	What about employment? If there are no underground workers then there will be less workers.	Denison considered this in section: Existing Environment, Key Indicator: Employment and Training, Unemployment Rate	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from a member of the Lac La Ronge Indian Band who attended a meeting in the year 2021. The record reference serves to describe the existing environment in terms of unemployment rate in relation to employment and training. Denison, through a Human Resource Development Plan, will initially prioritize Indigenous and non-Indigenous communities in the LSA in terms of economic opportunities. Denison will negotiate with the Province of Saskatchewan to develop the Project's surface lease agreement and the Human Resource Development Agreement, which will outline measures in relation to socio-economic parameters related to the Project.
21-EN-VPL-444.1	444	Virtual Meeting	2021-02-11	Denison hosted a virtual meeting for the municipality of Pinehouse Lake. The public meetings were focused on the Project generally, and did not seek input or comments on the distinct interests of the Métis in respect of the Project or Métis land use. This was expressly stated at the outset of each of the public meetings. Included in the discussion was an overview on the Valued Components for the Wheeler River Project, with a request to provide feedback to Denison via an online survey with specific questions pertaining to Valued Components.	Village of Pinehouse Lake	Does Denison have plans to have contracts with Northern Indigenous companies, especially those from impacted/rights bearing communities? Will there be contracts for northern businesses for the life of the mine?	Denison considered this in section: Scope of the Assessment, Key Indicators and Measurable Parameters And in section: Existing Environment, Key Indicator: Business Opportunities, Local Businesses	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual from Pinehouse who attended a virtual meeting in the year 2021. The record reference serves to support the chosen key indicators and measurable parameters and serves to describe the existing environment in terms of local businesses in relation to business opportunities. Denison's Indigenous Peoples Policy sets out priority for Indigenous employment and procurement (among other items). With respect to employment, as noted in the Economics section of the EIS, Residents of Saskatchewan's North (i.e., those resident in the northern administration district of Saskatchewan) are prioritized for employment as an expected condition of the Surface Lease Agreement, similarly for goods and services to service the Project. With respect to procurement, Denison has established an internal procurement policy approach. The approach requires that Denison consider businesses within the local study area first and the Northern Administrative District second, prior to looking elsewhere (southern Saskatchewan and/or outside of Saskatchewan) throughout all phases of the Project.
21-EN-VPL-444.16	444	Virtual Meeting	2021-02-11	Same as above	Village of Pinehouse Lake	Will there be opportunities for people from Pinehouse to be employed?	Denison considered this in section: Existing Environment, Key Indicator: Employment and Training, Employment Rate	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual from the Village of Pinehouse who attended a virtual meeting in the year 2021. The record reference serves to describe the existing environment in

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
								terms of employment rate in relation to employment and training. Denison, through a Human Resource Development Plan, will initially prioritize Indigenous and non-Indigenous communities in the LSA in terms of economic opportunities. Denison will negotiate with the Province of Saskatchewan to develop the Project's surface lease agreement and the Human Resource Development Agreement, which will outline measures in relation to socio-economic parameters related to the Project.
21-EN-VPL-444.17	444	Virtual Meeting	2021-02-11	Same as above	Village of Pinehouse Lake	As per the existing Human Resources Development Agreement that Cameco & Orano have (which they have failed to meet) is Denison Mines willing to commit to 53% RSN in its workforce once Wheeler River Operations Commence?	Denison considered this in section: Existing Environment, Key Indicator: Employment and Training, Employment Rate	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual from the Village of Pinehouse who attended a virtual meeting in the year 2021. The record reference serves to describe the existing environment in terms of employment rate in relation to employment and training. Denison will negotiate with the Province of Saskatchewan to develop the Project's Surface Lease Agreement and the Human Resource Development Agreement, which will outline measures in relation to socio-economic parameters related to the Project.
21-EN-VPL-444.21	444	Virtual Meeting	2021-02-11	Same as above	Village of Pinehouse Lake	Will Denison offer specific apprenticeship opportunities to Pinehouse residents?	Denison considered this in section: Existing Environment, Key Indicator: Employment and Training, Educational Attainment	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual from the Village of Pinehouse who attended a virtual meeting in the year 2021. The record reference serves to describe the existing environment in terms of educational attainment in relation to employment and training. Denison, through a Human Resource Development Plan, will initially prioritize Indigenous and non-Indigenous communities in the LSA in terms of employment and training opportunities (anticipated to be in institutions in northern Saskatchewan) and will work with the leadership of these communities to assist in determining hiring and training practices during all phases of the Project, which could include such items as on-the-job training and career counselling to help with advancement from foundational positions, advance sharing of job qualification requirements, clearly identifying training requirements and working with various training institutions to make sure such appropriate training is available, and creation of scholarship and support programs. Denison will negotiate with the Province of Saskatchewan to develop the Project's surface lease agreement and the Human Resource Development Agreement, which will outline measures in relation to socio-economic parameters related to the Project.
21-EN-VPL-444.22	444	Virtual Meeting	2021-02-11	Same as above	Village of Pinehouse Lake	Will Denison commit to ensure that technical opportunities are being offered to Pinehouse residents	Denison considered this in section:	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual from the Village of

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
						and that those training programs are hosted in the community where the trainees are fully supported?	Existing Environment, Key Indicator: Employment and Training, Educational Attainment	Pinehouse who attended a virtual meeting in the year 2021. The record reference serves to describe the existing environment in terms of educational attainment in relation to employment and training. Denison, through a Human Resource Development Plan, will initially prioritize Indigenous and non-Indigenous communities in the LSA in terms of employment and training opportunities (anticipated to be in institutions in northern Saskatchewan) and will work with the leadership of these communities to assist in determining hiring and training practices during all phases of the Project, which could include such items as on-the-job training and career counselling to help with advancement from foundational positions, advance sharing of job qualification requirements, clearly identifying training requirements and working with various training institutions to make sure such appropriate training is available, and creation of scholarship and support programs. Denison will negotiate with the Province of Saskatchewan to develop the Project's surface lease agreement and the Human Resource Development Agreement, which will outline measures in relation to socio-economic parameters related to the Project.
21-EN-VPL-444.23	444	Virtual Meeting	2021-02-11	Same as above	Village of Pinehouse Lake	Will Denison entertain a partnership for an industrial training centre in Pinehouse?	Denison considered this in section: Existing Environment, Key Indicator: Employment and Training, Educational Attainment	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual from the Village of Pinehouse who attended a virtual meeting in the year 2021. The record reference serves to describe the existing environment in terms of educational attainment in relation to employment and training.
21-EN-YOUTH-445.3	445	Virtual Meeting	2021-02-10	Denison provided a virtual presentation to the high schools in Ile a la Crosse, Beauval and Pinehouse about the Wheeler River Project. Included in the discussion was an overview on the Valued Components for the Wheeler River Project, with a request to provide feedback to Denison via an online survey with specific questions pertaining to Valued Components.	Village of Ile a la Crosse, Village of Pinehouse Lake, Village of Beauval	Considering we are educational institutions; will we be given workforce development plans for this project? In this way Northern Saskatchewan communities, and the appropriate educational institutions from the North, will have ample time to train Northerners to fill these upcoming positions.	Denison considered this in section: Existing Environment, Key Indicator: Employment and Training, Educational Attainment	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual from Pinehouse, Ile a la Crosse, or Beauval who attended a virtual meeting in the year 2021. The record reference serves to describe the existing environment in terms of educational attainment in relation to employment and training.
21-EN-SUR-446.7	446	Survey	2021-02-16	As part of engagement activities for the municipalities of Beauval, Ile a la Crosse and Pinehouse Lake, Denison prepared and shared an online survey which included information about Denison, the Wheeler River Project, and posed validation questions about the Valued Components being assessed as part of the environmental assessment process. A total of 68 responses	Village of Beauval, Village of Ile a la Crosse, Village of Pinehouse Lake	What is the percentage of employment going to be for northern people?	Denison considered this in section: Existing Environment, Key Indicator: Employment and Training, Employment Rate	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual from Pinehouse, Ile a la Crosse, or Beauval completed a survey in the year 2021. The record reference serves to describe the existing environment in terms of employment rate in relation to employment and training. Denison, through a Human Resource Development Plan, will initially prioritize Indigenous and non-Indigenous communities in the LSA in terms of economic opportunities. Denison will

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
				were received and 62 of the responses were considered complete, for a 91% completion rate. The information related to the Valued Components was incorporated into the assessment and questions asked on the surveys was incorporated into the overall engagement database.				negotiate with the Province of Saskatchewan to develop the Project's surface lease agreement and the Human Resource Development Agreement, which will outline measures in relation to socio-economic parameters related to the Project.
21-EN-SUR-446.8	446	Survey	2021-02-16	Same as above	Village of Beauval, Village of Ile a la Crosse, Village of Pinehouse Lake	Requirements for partnerships and use of Northern workforce.	Denison considered this in section: Existing Environment, Key Indicator: Employment and Training, Employment Rate	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual from Pinehouse, Ile a la Crosse, or Beauval completed a survey in the year 2021. The record reference serves to describe the existing environment in terms of employment rate in relation to employment and training.
21-EN-SUR-446.21	446	Survey	2021-02-16	Same as above	Village of Beauval, Village of Ile a la Crosse, Village of Pinehouse Lake	Denison Question: Why did you choose these valued components? Response: Economy is important for jobs/employment of northerners. Water, land and animals are all connected. We still use the land for livelihood.	Denison considered this in section: Existing Environment, Key Indicator: Traditional Economy	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual from Pinehouse, Ile a la Crosse, or Beauval completed a survey in the year 2021. The record reference serves to describe the existing environment in terms of the traditional economy.
21-EN-SUR-446.34	446	Survey	2021-02-16	Same as above	Village of Beauval, Village of Ile a la Crosse, Village of Pinehouse Lake	Denison Question: Based on what you know so far about the Wheeler Project, what aspects of the project could benefit, or work well for your community? Response: Employment for our people.	Denison considered this in section: Scope of the Assessment, Key Indicators and Measurable Parameters In section: Scope of the Assessment, Influence of Indigenous Knowledge, Local Knowledge, and Engagement In section: Existing Environment, Key Indicator: Employment and Training, Participation Rate In section: Assessment of Project-Related Effects, Potential Project-Related Effects In section: Scope of the Assessment, Valued Component Selection In section:	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual from Pinehouse, Ile a la Crosse, or Beauval completed a survey in the year 2021. The record reference serves to support the chosen key indicators and measurable parameters, and serves to describe the existing environment in terms of participation, unemployment, and employment rates in relation to employment and training.

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
							Existing Environment, Key Indicator: Employment and Training, Unemployment Rate And in section: Existing Environment, Key Indicator: Employment and Training, Employment Rate	
21-EN-SUR-446.35	446	Survey	2021-02-16	Same as above	Village of Beauval, Village of Ile a la Crosse, Village of Pinehouse Lake	Denison Question: Based on what you know so far about the Wheeler Project, what aspects of the project could benefit, or work well for your community? Response: Training and employment	Denison considered this in section: Existing Environment, Key Indicator: Employment and Training, Employment Rate And in section In section: Scope of the Assessment, Valued Component Selection	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual from Pinehouse, Ile a la Crosse, or Beauval completed a survey in the year 2021. The record reference serves to support the chosen key indicators and measurable parameters and serves to describe the existing environment in terms of employment rate in relation to employment and training.
21-EN-SUR-446.39	446	Survey	2021-02-16	Same as above	Village of Beauval, Village of Ile a la Crosse, Village of Pinehouse Lake	Denison Question: Based on what you know so far about the Wheeler Project, what aspects of the project could benefit, or work well for your community? Response: Potential jobs. That is it. All this fancy stuff is just for people hoping they will get work in a place where work is limited and scarce.	Denison considered this in section: Existing Environment, Key Indicator: Employment and Training, Unemployment Rate And in section In section: Scope of the Assessment, Valued Component Selection	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual from Pinehouse, Ile a la Crosse, or Beauval completed a survey in the year 2021. The record reference serves to support the chosen key indicators and measurable parameters and serves to describe the existing environment in terms of unemployment rate in relation to employment and training.
21-EN-SUR-446.40	446	Survey	2021-02-16	Same as above	Village of Beauval, Village of Ile a la Crosse, Village of Pinehouse Lake	Denison Question: Based on what you know so far about the Wheeler Project, what aspects of the project could benefit, or work well for your community? Response: Employment and contract opportunities	Denison considered this in section: Existing Environment, Key Indicator: Employment and Training, Unemployment Rate In section: Existing Environment, Key Indicator: Employment and Training, Employment Rate In section: Assessment of Project-Related Effects, Potential Project-Related Effects	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual from Pinehouse, Ile a la Crosse, or Beauval completed a survey in the year 2021. The record reference serves to support the chosen key indicators and measurable parameters, serves to describe the existing environment in terms of unemployment and employment rates in relation to employment and training, and serves to reiterate rationale for the chosen KIs in the context of potential project-related effects.

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
							And in section In section: Scope of the Assessment, Valued Component Selection	
21-EN-SUR-446.42	446	Survey	2021-02-16	Same as above	Village of Beauval, Village of Ile a la Crosse, Village of Pinehouse Lake	Denison Question: Based on what you know so far about the Wheeler Project, what aspects of the project could benefit, or work well for your community? Response: I think it would be good to bring jobs into community	Denison considered this in section: Scope of the Assessment, Key Indicators and Measurable Parameters In section: Scope of the Assessment, Influence of Indigenous Knowledge, Local Knowledge, and Engagement In section: Existing Environment, Key Indicator: Employment and Training, Unemployment Rate In section: Existing Environment, Key Indicator: Employment and Training, Participation Rate In section: Existing Environment, Key Indicator: Employment and Training, Employment Rate In section: Assessment of Project-Related Effects, Potential Project-Related Effects And in section: Scope of the Assessment, Valued Component Selection	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual from Pinehouse, Ile a la Crosse, or Beauval completed a survey in the year 2021. The record reference serves to support the chosen key indicators and measurable parameters, serves to describe the existing environment in terms of unemployment, employment, and participation rates in relation to employment and training, and serves to reiterate rationale for the chosen KIs in the context of potential project-related effects.
21-EN-SUR-446.52	446	Survey	2021-02-16	Same as above	Village of Beauval, Village of Ile a la Crosse, Village of Pinehouse Lake	Denison Question: Based on what you know so far about the Wheeler Project, what aspects of the project could benefit, or work well for your community? Response: The employment rates would rise	Denison considered this in section: Scope of the Assessment, Key Indicators and Measurable Parameters In section:	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual from Pinehouse, Ile a la Crosse, or Beauval completed a survey in the year 2021. The record reference serves to support the chosen key indicators and measurable parameters, serves to describe the existing environment in terms of unemployment rates in relation to

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
							Scope of the Assessment, Influence of Indigenous Knowledge, Local Knowledge, and Engagement In section: Assessment of Project-Related Effects, Potential Project-Related Effects In section: Scope of the Assessment, Valued Component Selection And in section: Existing Environment, Key Indicator: Employment and Training, Unemployment Rate	employment and training, and serves to reiterate rationale for the chosen KIs in the context of potential project-related effects.
21-EN-SUR-446.53	446	Survey	2021-02-16	Same as above	Village of Beauval, Village of Ile a la Crosse, Village of Pinehouse Lake	Denison Question: Based on what you know so far about the Wheeler Project, what aspects of the project could benefit, or work well for your community?) Response: I could make a lot of money and help my family.	Denison considered this in section: Scope of the Assessment, Key Indicators and Measurable Parameters In section: Scope of the Assessment, Influence of Indigenous Knowledge, Local Knowledge, and Engagement In section: Existing Environment, Key Indicator: Income, Total Personal Income In section: Existing Environment, Key Indicator: Income, Household Income And in section: Assessment of Project-Related Effects, Potential Project-Related Effects And in section In section:	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual from Pinehouse, Ile a la Crosse, or Beauval completed a survey in the year 2021. The record reference serves to support the chosen key indicators and measurable parameters, serves to describe the existing environment in terms of total personal income and household income, and serves to reiterate rationale for the chosen KIs in the context of potential project-related effects.

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
							Scope of the Assessment, Valued Component Selection	
21-EN-SUR-446.54	446	Survey	2021-02-16	Same as above	Village of Beauval, Village of Ile a la Crosse, Village of Pinehouse Lake	Denison Response: Based on what you know so far about the Wheeler Project, what aspects of the project could benefit, or work well for your community? Response: Employment for more northern people. there's quite a bit of people unemployed that would work hard and well at the mine site.	Denison considered this in section: Scope of the Assessment, Key Indicators and Measurable Parameters In section: Scope of the Assessment, Influence of Indigenous Knowledge, Local Knowledge, and Engagement In section: Existing Environment, Key Indicator: Employment and Training, Unemployment Rate And in section In section: Scope of the Assessment, Valued Component Selection	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual from Pinehouse, Ile a la Crosse, or Beauval completed a survey in the year 2021. The record reference serves to support the chosen key indicators and measurable parameters and serves to describe the existing environment in terms of unemployment rate in relation to employment and training.
21-EN-SUR-446.56	446	Survey	2021-02-16	Same as above	Village of Beauval, Village of Ile a la Crosse, Village of Pinehouse Lake	Denison Question: Based on what you know so far about the Wheeler Project, what aspects of the project could benefit, or work well for your community? Response: Job opportunities	Denison considered this in section: Existing Environment, Key Indicator: Employment and Training, Unemployment Rate And in section: Scope of the Assessment, Valued Component Selection	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual from Pinehouse, Ile a la Crosse, or Beauval completed a survey in the year 2021. The record reference serves to support the chosen key indicators and measurable parameters, and serves to describe the existing environment in terms of unemployment and employment rates in relation to employment and training.
21-EN-SUR-446.59	446	Survey	2021-02-16	Same as above	Village of Beauval, Village of Ile a la Crosse, Village of Pinehouse Lake	Denison Question: Based on what you know so far about the Wheeler Project, what aspects of the project could benefit, or work well for your community? Response: Employment, training, wellness	Denison considered this in section: Existing Environment, Key Indicator: Employment and Training, Unemployment Rate And in section: Scope of the Assessment, Valued Component Selection	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual from Pinehouse, Ile a la Crosse, or Beauval completed a survey in the year 2021. The record reference serves to support the chosen key indicators and measurable parameters, and serves to describe the existing environment in terms of unemployment and employment rates in relation to employment and training.

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
21-EN-SUR-446.60	446	Survey	2021-02-16	Same as above	Village of Beauval, Village of Ile a la Crosse, Village of Pinehouse Lake	Denison Question: Based on what you know so far about the Wheeler Project, what aspects of the project could benefit, or work well for your community? Response: Job opportunities, business opportunities	Denison considered this in section: Existing Environment, Key Indicator: Employment and Training, Unemployment Rate And in section: Scope of the Assessment, Valued Component Selection	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual from Pinehouse, Ile a la Crosse, or Beauval completed a survey in the year 2021. The record reference serves to describe the existing environment in terms of unemployment in relation to employment and training, and serves to support to selection of the chosen valued components.
21-EN-ERFN-447.3	447	Virtual Meeting	2021-03-31	Denison hosted a virtual meeting for English River First Nation (Patuanak, La Plonge and Urban Members). Included in the discussion was an overview on the Valued Components for the Wheeler River Project, with a request to provide feedback to Denison via an online survey with specific questions pertaining to Valued Components.	English River First Nation	Will Tron and Des Nedhe get opportunities to have contracts?	Denison considered this in section: Scope of the Assessment, Key Indicators and Measurable Parameters And in section: Existing Environment, Key Indicator: Business Opportunities, Local Businesses	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming a member of English River First Nation, who attended a virtual meeting in the year 2021. The record reference serves to support the chosen key indicators and measurable parameters, and serves to describe the existing environment in terms of local businesses in relation to business opportunities. Denison, through a Human Resource Development Plan, will initially prioritize Indigenous and non-Indigenous communities in the LSA in terms of economic opportunities. Denison will negotiate with the Province of Saskatchewan to develop the Project's surface lease agreement and the Human Resource Development Agreement, which will outline measures in relation to socio-economic parameters related to the Project.
21-EN-ERFN-447.4	447	Virtual Meeting	2021-03-31	Same as above	English River First Nation	Will local companies (Tron, Des Nedhe) and local community members get priority for contracts/employment? Will there be opportunities for negotiations between ERFN and Denison so our community members don't lose out on opportunities?	Denison considered this in section: Scope of the Assessment, Key Indicators and Measurable Parameters And in section: Existing Environment, Key Indicator: Business Opportunities, Local Businesses	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming a member of English River First Nation, who attended a virtual meeting in the year 2021. The record reference serves to support the chosen key indicators and measurable parameters and serves to describe the existing environment in terms of local businesses in relation to business opportunities, and serves to support the chosen key indicators and measurable parameters. Denison, through a Human Resource Development Plan, will initially prioritize Indigenous and non-Indigenous communities in the LSA in terms of economic opportunities. Denison will negotiate with the Province of Saskatchewan to develop the Project's surface lease agreement and the Human Resource Development Agreement, which will outline measures in relation to socio-economic parameters related to the Project.
21-EN-ERFN-447.13	447	Virtual Meeting	2021-03-31	Same as above	English River First Nation	Will Denison pay for schooling and training? Specifically trades/tickets. Will they give site specific training or training that can be transferrable?	Denison considered this in section: Existing Environment, Key Indicator: Employment and	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from member of English River First Nation who attended a virtual meeting in the year 2021. The record reference serves to describe the existing environment in

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
							Training, Educational Attainment	terms of educational attainment in relation to employment and training. Denison, through a Human Resource Development Plan, will initially prioritize Indigenous and non-Indigenous communities in the LSA in terms of employment and training opportunities (anticipated to be in institutions in northern Saskatchewan) and will work with the leadership of these communities to assist in determining hiring and training practices during all phases of the Project, which could include such items as on-the-job training and career counselling to help with advancement from foundational positions, advance sharing of job qualification requirements, clearly identifying training requirements and working with various training institutions to make sure such appropriate training is available, and creation of scholarship and support programs. Denison will negotiate with the Province of Saskatchewan to develop the Project's surface lease agreement and the Human Resource Development Agreement, which will outline measures in relation to socio-economic parameters related to the Project.
21-EN-ERFNSUR-456.6	456	Survey	2021-04-09	As part of engagement activities for English River First Nation, Denison prepared and shared an online survey which included information about Denison, the Wheeler River Project, and posed validation questions about the Valued Components being assessed as part of the environmental assessment process. A total of 23 responses were received. The information related to the Valued Components was incorporated into the assessment and questions asked on the surveys was incorporated into the overall engagement database.	English River First Nation	Denison Question: Based on what you know so far about the Wheeler Project, what aspects of the project could be challenging or cause concern for your community? Response: Members be 100% solely involved	Denison considered this in section: Existing Environment, Key Indicator: Employment and Training, Unemployment Rate And in section: Scope of the Assessment, Valued Component Selection	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from member of English River First Nation who completed a survey in the year 2021. The record reference serves to support the selection of the chosen valued components and serves to describe the existing environment in terms of unemployment rate in relation to employment and training.
21-EN-ERFNSUR-456.14	456	Survey	2021-04-09	Same as above	English River First Nation	Denison Question: Based on what you know so far about the Wheeler Project, what aspects of the project could be challenging or cause concern for your community? Response: Providing jobs	Denison considered this in section: Existing Environment, Key Indicator: Employment and Training, Unemployment Rate And in section: Scope of the Assessment, Valued Component Selection	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from member of English River First Nation who completed a survey in the year 2021. The record reference serves to support the selection of the chosen valued components and serves to describe the existing environment in terms of unemployment rate in relation to employment and training. Denison, through a Human Resource Development Plan, will initially prioritize Indigenous and non-Indigenous communities in the LSA in terms of economic opportunities. Denison will negotiate with the Province of Saskatchewan to develop the Project's Surface Lease Agreement and the Human Resource

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
								Development Agreement, which will outline measures in relation to socio-economic parameters related to the Project, including in those relation to employment and training opportunities.
21-EN-ERFN-474.5	474	Meeting	2021-06-30	Denison, its third party consultants for socioeconomic and health and wellness assessment (Intergroup) and the English River First Nation Lands & Resources Officer and the third party consultant for English River First Nation (Shared Value Solutions) held a meeting in which Denison provided an overview of the Wheeler River Project scope, and Intergroup provided an overview of the approach taken for the socioeconomic and wellness assessment for the Environmental Assessment.	English River First Nation	Can you integrate Indigenous land use into economic assessment? Find a value to put this into income? Fit within?	Denison considered this in section: Scope of the Assessment, Key Indicators and Measurable Parameters In section: Scope of the Assessment, Influence of Indigenous Knowledge, Local Knowledge, and Engagement In section: Assessment of Project-Related Effects, Potential Project-Related Effects And in section: Assessment of Project-Related Effects, Potential Project-Related Effects, Potential Effect 3 – Traditional Economy	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from member of English River First Nation who attended a meeting in the year 2021. The record reference serves to highlight dialogue contained within the engagement database that supported the selection of the traditional economy as a key indicator as part of the economic valued component. The record reference additionally serves to reiterate rationale for the chosen KIs in the context of potential project-related effects. The EIS considers the traditional economy as a key indicator as part of the economic valued component. The effect of Project-related activities on the traditional economy is measured as the change in the proportion of LSA residents participating in the traditional economy. See the Economics section of the EIS for more information.
22-EN-ERFN-618.20	618	Open House	2022-05-30	In collaboration with the Chief and Council of English River First Nation, Denison hosted an open house event at ERFN Patuanak Reserve, sharing information about the Wheeler River Project, the preliminary effects assessment of the Project, and proposed mitigation and monitoring. Denison advertised the event on the local radio, with posters around the community, on the local cable network, and through social media. Denison had a Dene translator available for attendees. Residents of the Hamlet of Patuanak were also advised about the open house and invited to attend. 31 attendees signed the sign in sheet. Information boards and area models were displayed, and staff Denison staff were available to answer questions. A survey was available for community members to complete,	English River First Nation	What is your plan for training and for young people? Are you going to hire people who don't have their Grade 12	Denison considered this in section: Existing Environment, Key Indicator: Employment and Training, Educational Attainment	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from member of English River First Nation who attended an open house in the year 2022. The record reference serves to describe the existing environment in terms of educational attainment in relation to employment and training. Foundational positions (i.e., Entry Level) (82 jobs) require Grade 12 education and in-house training programs, although a combination of skills and experience may be considered. These positions would include process plant operators, site services, drillers, and catering/janitorial staff. Denison, through a Human Resource Development Plan, will initially prioritize Indigenous and non-Indigenous communities in the LSA in terms of economic opportunities. Denison will negotiate with the Province of Saskatchewan to develop the Project's surface lease agreement and the Human Resource Development Agreement, which will outline measures in relation to socio-economic parameters related to the Project.

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
				and remaining available online for 2 weeks following the open house.				
22-EN-ERFN-618.21	618	Open House	2022-05-30	Same as above	English River First Nation	How will training for jobs be implemented?	Denison considered this in section: Existing Environment, Key Indicator: Employment and Training, Educational Attainment	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from member of English River First Nation who attended an open house in the year 2022. The record reference serves to describe the existing environment in terms of educational attainment in relation to employment and training. Denison, through a Human Resource Development Plan, will initially prioritize Indigenous and non-Indigenous communities in the LSA in terms of economic opportunities. Denison will negotiate with the Province of Saskatchewan to develop the Project's surface lease agreement and the Human Resource Development Agreement, which will outline measures in relation to socio-economic parameters related to the Project.
22-EN-ERFN-621.1	621	Meeting	2022-05-30	Denison hosted a meeting with the Chief and Council of English River First Nation, hosted in ERFN Patuanak, to share information about the Wheeler River Project, preliminary effects assessment of the Project, and proposed mitigation and monitoring. A representative from the Canadian Nuclear Safety Commission and from the Province of Saskatchewan were also in attendance.	English River First Nation	Work co-ops for youth and students? Something to plan for.	Denison considered this in section: Existing Environment, Key Indicator: Employment and Training, Educational Attainment	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from member of English River First Nation who attended an open house in the year 2022. The record reference serves to describe the existing environment in terms of educational attainment in relation to employment and training. Denison, through a Human Resource Development Plan, will initially prioritize Indigenous and non-Indigenous communities in the LSA in terms of employment and training opportunities (anticipated to be in institutions in northern Saskatchewan) and will work with the leadership of these communities to assist in determining hiring and training practices during all phases of the Project, which could include such items as on-the-job training and career counselling to help with advancement from foundational positions, advance sharing of job qualification requirements, clearly identifying training requirements and working with various training institutions to make sure such appropriate training is available, and creation of scholarship and support programs. Denison will negotiate with the Province of Saskatchewan to develop the Project's SLA and the Human Resource Development Agreement, which will outline measures in relation to socio-economic parameters related to the Project.
22-EN-ERFN-621.6, 22-EN-ERFN-621.9	621	Meeting	2022-05-30	Same as above	English River First Nation	Employment and training opportunities?	Denison considered this in section: Existing Environment, Key Indicator: Employment and Training, Employment Rate	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from member of English River First Nation who attended an open house in the year 2022. The record reference serves to describe the existing environment in terms of employment rate in relation to employment and training. Denison, through a Human Resource Development Plan, will initially prioritize Indigenous and non-Indigenous communities in

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
								the LSA in terms of economic opportunities. Denison will negotiate with the Province of Saskatchewan to develop the Project's surface lease agreement and the Human Resource Development Agreement, which will outline measures in relation to socio-economic parameters related to the Project
22-EN-SUR-652.4	652	Survey	2022-06-03	As part of engagement activities for English River First Nation, Beauval, and Pinehouse, Denison prepared and shared, both online and as a hardcopy during Spring Engagement meetings, a survey that asked a series of questions relating to the results of the environmental assessment. A total of 39 surveys were entirely or partially completed.	Unknown	Denison Question: Are there any topics that you would like to see including in monitoring plans? Response: Jobs given to community, better yet "communities", giving opportunity	Denison considered this in section: Existing Environment, Key Indicator: Employment and Training, Employment Rate	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual from English River First Nation, Beauval, or Pinehouse who completed a survey in the year 2022. The record reference serves to describe the existing environment in terms of employment rate in relation to employment and training.
22-EN-SUR-652.31	652	Survey	2022-06-03	Same as above	Unknown	Denison Question: Are there any topics of particular concern that Denison needs to pay special attention to? Response: Mostly providing jobs	Denison considered this in section: Existing Environment, Key Indicator: Employment and Training, Employment Rate	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual from English River First Nation, Beauval, or Pinehouse who completed a survey in the year 2022. The record reference serves to describe the existing environment in terms of employment rate in relation to employment and training. Denison, through a Human Resource Development Plan, will initially prioritize Indigenous and non-Indigenous communities in the LSA in terms of economic opportunities. Denison will negotiate with the Province of Saskatchewan to develop the Project's surface lease agreement and the Human Resource Development Agreement, which will outline measures in relation to socio-economic parameters related to the Project.
22-EN-SUR-652.32	652	Survey	2022-06-03	Same as above	Unknown	Denison Question: Are there any topics of particular concern that Denison needs to pay special attention to? Response: Jobs	Denison considered this in section: Existing Environment, Key Indicator: Employment and Training, Employment Rate	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual from English River First Nation, Beauval, or Pinehouse who completed a survey in the year 2022. The record reference serves to describe the existing environment in terms of employment rate in relation to employment and training. Denison, through a Human Resource Development Plan, will initially prioritize Indigenous and non-Indigenous communities in the LSA in terms of economic opportunities. Denison will negotiate with the Province of Saskatchewan to develop the Project's Surface Lease Agreement and the Human Resource Development Agreement, which will outline measures in relation to socio-economic parameters related to the Project, including in those relation to employment and training opportunities.
22-EN-SUR-652.33	652	Survey	2022-06-03	Same as above	Unknown	Denison Question: Are there any topics of particular concern that Denison needs to pay special attention to?	Denison considered this in section:	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual from English River First

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
						Response: Local employment is important to me.	Influence of Indigenous Knowledge, Local Knowledge, and Engagement on the Assessment. And in section: Existing Environment, Key Indicator: Employment and Training, Employment Rate.	Nation, Beauval, or Pinehouse who completed a survey in the year 2022. The record reference serves to describe the existing environment in terms of employment rate in relation to employment and training. Denison, through a Human Resource Development Plan, will initially prioritize Indigenous and non-Indigenous communities in the LSA in terms of economic opportunities. Denison will negotiate with the Province of Saskatchewan to develop the Project's Surface Lease Agreement and the Human Resource Development Agreement, which will outline measures in relation to socio-economic parameters related to the Project, including in those relation to employment and training opportunities.
22-EN-SUR-652.34	652	Survey	2022-06-03	Same as above	Unknown	Denison Question: Are there any topics of particular concern that Denison needs to pay special attention to? Response: To provide jobs.	Denison considered this in section: Existing Environment, Key Indicator: Employment and Training, Employment Rate.	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual from English River First Nation, Beauval, or Pinehouse who completed a survey in the year 2022. The record reference serves to describe the existing environment in terms of employment rate in relation to employment and training. Denison has estimated a workforce of 300 during the two-year Construction phase and 180 during the Operation phase. Residents and communities in the LSA will be given first priority for employment, training, and business opportunities, followed by residents and communities in the RSA.
22-EN-SUR-652.35	652	Survey	2022-06-03	Same as above	Unknown	Denison Question: Are there any topics of particular concern that Denison needs to pay special attention to? Response: The creation of jobs for northerners	Denison considered this in section: Influence of Indigenous Knowledge, Local Knowledge, and Engagement on the Assessment. In section: Existing Environment, Key Indicator: Employment and Training, Employment Rate. And in section: Existing Environment, Key Indicator: Employment and Training, Unemployment Rate.	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual from English River First Nation, Beauval, or Pinehouse who completed a survey in the year 2022. The record reference serves to describe the existing environment in terms of employment and unemployment rates in relation to employment and training. Denison, through a Human Resource Development Plan, will initially prioritize Indigenous and non-Indigenous communities in the LSA in terms of economic opportunities. Denison will negotiate with the Province of Saskatchewan to develop the Project's surface lease agreement and the Human Resource Development Agreement, which will outline measures in relation to socio-economic parameters related to the Project.
22-EN-SUR-652.36	652	Survey	2022-06-03	Same as above	Unknown	Denison Question: Are there any topics of particular concern that Denison needs to pay special attention to? Response: Employment for our young people.	Denison considered this in section: Influence of Indigenous Knowledge, Local Knowledge, and	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual from English River First Nation, Beauval, or Pinehouse who completed a survey in the year 2022. The record reference serves to describe the existing environment in terms of employment rate in relation to employment and training.

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
							Engagement on the Assessment. Andin section: Existing Environment, Key Indicator: Employment and Training, Employment Rate.	Denison, through a Human Resource Development Plan, will initially prioritize Indigenous and non-Indigenous communities in the LSA in terms of economic opportunities. Denison will negotiate with the Province of Saskatchewan to develop the Project's Surface Lease Agreement and the Human Resource Development Agreement, which will outline measures in relation to socio-economic parameters related to the Project, including in those relation to employment and training opportunities.
22-EN-SUR-652.37	652	Survey	2022-06-03	Same as above	Unknown	Denison Question: Are there any things missing that Denison should consider to reduce the effects of the Project to the environment? Response: Environmental Jobs	Denison considered this in section: Existing Environment, Key Indicator: Employment and Training, Unemployment Rate.	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual from English River First Nation, Beauval, or Pinehouse who completed a survey in the year 2022. The record reference serves to describe the existing environment in terms of unemployment rate in relation to employment and training.
22-EN-SUR-652.38	652	Survey	2022-06-03	Same as above	Unknown	Denison Question: Are there any topics that you would like to see including in monitoring plans? Response: environmental jobs	Denison considered this in section: Existing Environment, Key Indicator: Employment and Training, Unemployment Rate.	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual from English River First Nation, Beauval, or Pinehouse who completed a survey in the year 2022. The record reference serves to describe the existing environment in terms of unemployment rate in relation to unemployment and training.
22-EN-SUR-652.39	652	Survey	2022-06-03	Same as above	Unknown	Denison Question: Are there any topics that you would like to see including in monitoring plans? Response: Jobs given to community, better yet "communities", giving opportunity	Denison considered this in section: Existing Environment, Key Indicator: Employment and Training, Employment Rate.	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual from English River First Nation, Beauval, or Pinehouse who completed a survey in the year 2022. The record reference serves to describe the existing environment in terms of employment rate in relation to employment and training.
22-EN-SUR-652.41	652	Survey	2022-06-03	Same as above	Unknown	Denison Question: What additional information would be helpful for you to understand the Project and its potential impacts to people and the environment? Response: Jobs	Denison considered this in section: Existing Environment, Key Indicator: Employment and Training, Unemployment Rate.	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual from English River First Nation, Beauval, or Pinehouse who completed a survey in the year 2022. The record reference serves to describe the existing environment in terms of unemployment rate in relation to employment and training.
22-EN-SUR-652.42	652	Survey	2022-06-03	Same as above	Unknown	Denison Question: What additional information would be helpful for you to understand the Project and its potential impacts to people and the environment? Response: More opportunities for people with disabilities. Job coach for people with disabilities.	Denison considered this in section: Existing Environment, Key Indicator: Employment and Training, Unemployment Rate.	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual from English River First Nation, Beauval, or Pinehouse who completed a survey in the year 2022. The record reference serves to describe the existing environment in terms of unemployment rate in relation to employment and training. Denison, through a Human Resource Development Plan, will initially prioritize Indigenous and non-Indigenous communities in the LSA in terms of economic opportunities. Denison will negotiate with the Province of Saskatchewan to develop the Project's Surface Lease Agreement and the Human Resource Development Agreement, which will outline measures in relation

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
								to socio-economic parameters related to the Project, including in those relation to employment and training opportunities.
22-EN-SUR-652.43	652	Survey	2022-06-03	Same as above	Unknown	Denison Question: What additional information would be helpful for you to understand the Project and its potential impacts to people and the environment? Response: Hopefully jobs in the future.	Denison considered this in section: Existing Environment, Key Indicator: Employment and Training, Unemployment Rate.	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual from English River First Nation, Beauval, or Pinehouse who completed a survey in the year 2022. The record reference serves to describe the existing environment in terms of unemployment rate in relation to employment and training.
22-EN-SUR-652.44	652	Survey	2022-06-03	Same as above	Unknown	Denison Question: Are there any topics of particular concern that Denison needs to pay special attention to? Response: Hoping Denison will participate in northern communities in developing qualified participants.	Denison considered this in section: Existing Environment, Key Indicator: Employment and Training, Unemployment Rate.	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual from English River First Nation, Beauval, or Pinehouse who completed a survey in the year 2022. The record reference serves to describe the existing environment in terms of unemployment rate in relation to employment and training. Denison, through a Human Resource Development Plan, will initially prioritize Indigenous and non-Indigenous communities in the LSA in terms of economic opportunities. Denison will negotiate with the Province of Saskatchewan to develop the Project's surface lease agreement and the Human Resource Development Agreement, which will outline measures in relation to socio-economic parameters related to the Project.
22-EN-SUR-652.46	652	Survey	2022-06-03	Same as above	Unknown	Denison Question: What additional information would be helpful for you to understand the Project and its potential impacts to people and the environment? Response: For our younger generation, it would be great for the company to give out scholarships, to this industry.	Denison considered this in section: Existing Environment, Key Indicator: Employment and Training, Educational Attainment	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual from English River First Nation, Beauval, or Pinehouse who completed a survey in the year 2022. The record reference serves to describe the existing environment in terms of educational attainment in relation to employment and training.
22-EN-SUR-652.47	652	Survey	2022-06-03	Same as above	Unknown	Denison Question: What additional information would be helpful for you to understand the Project and its potential impacts to people and the environment? Response: Younger adults be involved and educate them. Courses	Denison considered this in section: Existing Environment, Key Indicator: Employment and Training, Educational Attainment	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual from English River First Nation, Beauval, or Pinehouse who completed a survey in the year 2022. The record reference serves to describe the existing environment in terms of educational attainment in relation to employment and training.
22-EN-VPL/ML9-623.3	623	Meeting	2022-06-02	Denison hosted a meeting with the Kineepik Métis Local and the Northern Village of Pinehouse Lake, hosted at the Pinehouse Gas Bar, to share information about the Wheeler River Project, preliminary effects assessment of the Project, and proposed mitigation and monitoring.	Kineepik Métis Local, Village of Pinehouse Lake	Need education and training model that fit within our community structure. A mix of western and traditional learning. Once a job posting goes up its too late, we need to know before hand, as partners we should and deserve to know before hand. To prioritize our people	Denison considered this in section: Existing Environment, Key Indicator: Employment and Training, Educational Attainment	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual from Pinehouse/Kineepik Métis Local #9 who attended a meeting in the year 2022. The record reference serves to describe the existing environment in terms of educational attainment in relation to employment and training. Denison, through a Human Resource Development Plan, will initially prioritize Indigenous and non-Indigenous communities in the LSA in terms of employment and training opportunities (anticipated to be in institutions in northern Saskatchewan) and will work with the leadership of these communities to assist in

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
								determining hiring and training practices during all phases of the Project.
22-EN-VPL/ML9-623.4	623	Meeting	2022-06-02	Same as above	Kineepik Métis Local, Village of Pinehouse Lake	What are the opportunities? A new (smaller, less impactful) method can reduce jobs for the community. We really need to get educated and learn about this kind of mining.	Denison considered this in section: Existing Environment, Key Indicator: Employment and Training, Employment Rate	The context in which this comment was used within the Economics section of the EIS serves as a local perspective, documented as coming from an individual from Pinehouse/Kineepik Métis Local #9 who attended a meeting in the year 2022. The record reference serves to describe the existing environment in terms of employment rate in relation to employment and training. Denison has estimated a workforce of 300 during the two-year Construction phase and 180 during the Operation phase. Residents and communities in the LSA will be given first priority for employment, training, and business opportunities, followed by residents and communities in the RSA. Denison, through a Human Resource Development Plan, will initially prioritize Indigenous and non-Indigenous communities in the LSA in terms of economic opportunities. Denison will negotiate with the Province of Saskatchewan to develop the Project's surface lease agreement and the Human Resource Development Agreement, which will outline measures in relation to socio-economic parameters related to the Project.

Denison Mines

Wheeler River Project

Final Environmental Impact Statement

November 2024

Powering PEOPLE, PARTNERSHIPS AND PASSION.

Appendix 13-B1: Labour Force Status for the Local Study Area (LSA), Northern Saskatchewan (RSA), and Saskatchewan, 2016 and 2021

	2021 Labour Force Status																							
	La Plonge 192, Indian Reserve[1,2,12]			Wapachewunak 192D, Indian Reserve[1,2,12]			Patuanak, Northern Hamlet[1,2,12]			Pinehouse, Northern Village[1,2,12]			Beauval, Northern Village[1,2,12]			LSA[1,2,3,12]			Northern Saskatchewan (RSA)[1,2,4,12]			Saskatchewan[1,2,12]		
	Total	Men+	Women+	Total	Men+	Women+	Total	Men+	Women+	Total	Men+	Women+	Total	Men+	Women+	Total	Men+	Women+	Total	Men+	Women+	Total	Men+	Women+
Total - Population aged 15 years and over[5]	**110**	**50**	**55**	**430**	**225**	**205**	**50**	**20**	**25**	**680**	**335**	**350**	**625**	**285**	**340**	**1,895**	**915**	**975**	**25,040**	**12,340**	**12,700**	**882,760**	**436,515**	**446,245**
In the labour force[5]	40	15	25	165	90	75	25	10	15	275	125	155	430	180	250	935	420	520	11,140	5,680	5,460	577,510	303,915	273,590
Employed[6]	40	15	25	125	65	60	20	10	10	225	95	130	360	155	205	770	340	430	9,020	4,460	4,555	528,900	277,285	251,620
Unemployed[7]	0	0	10	40	25	15	0	0	0	55	35	20	65	25	45	160	85	90	2,120	1,220	900	48,605	26,640	21,970
Not in the labour force[8]	60	35	30	270	135	125	20	10	10	405	205	200	195	105	95	950	490	460	13,895	6,660	7,240	305,250	132,595	172,660
Participation rate[9]	36.4%	30.0%	45.5%	38.4%	40.0%	36.6%	50.0%	50.0%	60.0%	40.4%	37.3%	44.3%	68.8%	63.2%	73.5%	49.3%	45.9%	53.3%	44.5%	46.0%	43.0%	65.4%	69.6%	61.3%
Employment rate[10]	36.4%	30.0%	45.5%	29.1%	28.9%	29.3%	40.0%	50.0%	40.0%	33.1%	28.4%	37.1%	57.6%	54.4%	60.3%	40.6%	37.2%	44.1%	36.0%	36.1%	35.9%	59.9%	63.5%	56.4%
Unemployment rate[11]	0.0%	0.0%	40.0%	24.2%	27.8%	20.0%	0.0%	0.0%	0.0%	20.0%	28.0%	12.9%	15.1%	13.9%	18.0%	17.1%	20.2%	17.3%	19.0%	21.5%	16.5%	8.4%	8.8%	8.0%

	2016 Labour Force Status																							
	La Plonge 192, Indian Reserve[1,2,12]			Wapachewunak 192D, Indian Reserve[1,2,12]			Patuanak, Northern Hamlet[1,2,12]			Pinehouse, Northern Village[1,2,12]			Beauval, Northern Village[1,2,12]			LSA[1,2,3,12]			Northern Saskatchewan (RSA)[1,2,4,12]			Saskatchewan[1,2,12]		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Total - Population aged 15 years and over[5]	**110**	**50**	**55**	**430**	**205**	**215**	**55**	**25**	**30**	**715**	**355**	**360**	**410**	**210**	**195**	**1,720**	**845**	**855**	**25,295**	**12,610**	**12,685**	**857,295**	**424,260**	**433,035**
In the labour force[5]	35	15	25	185	90	95	20	10	10	400	215	185	235	130	110	875	460	425	12,355	6,540	5,815	585,540	311,110	274,430
Employed[6]	35	15	20	145	65	85	20	10	0	305	160	145	185	105	85	690	355	335	9,420	4,660	4,755	544,095	286,330	257,760
Unemployed[7]	0	0	0	40	25	10	10	0	0	90	55	40	45	25	25	185	105	75	2,935	1,875	1,060	41,445	24,775	16,665
Not in the labour force[8]	70	35	35	240	115	120	30	15	15	315	140	180	175	85	90	830	390	440	12,940	6,070	6,870	271,760	113,155	158,605
Participation rate[9]	31.8%	30.0%	45.5%	43.0%	43.9%	44.2%	36.4%	40.0%	33.3%	55.9%	60.6%	51.4%	57.3%	61.9%	56.4%	50.9%	54.4%	49.7%	48.8%	51.9%	45.8%	68.3%	73.3%	63.4%
Employment rate[10]	31.8%	30.0%	36.4%	33.7%	31.7%	39.5%	36.4%	40.0%	0.0%	42.7%	45.1%	40.3%	45.1%	50.0%	43.6%	40.1%	42.0%	39.2%	37.2%	37.0%	37.5%	63.5%	67.5%	59.5%
Unemployment rate[11]	0.0%	0.0%	0.0%	21.6%	27.8%	10.5%	50.0%	0.0%	0.0%	22.5%	25.6%	21.6%	19.1%	19.2%	22.7%	21.1%	22.8%	17.6%	23.8%	28.7%	18.2%	7.1%	8.0%	6.1%

Source: Statistics Canada 2016a and 2021

Footnotes:

1) Data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5, and in some cases, 10. Totals may not add-up due to rounding.

2) In addition to random rounding, area and data suppression has been adopted to further protect the confidentiality of individual respondents' personal information. Area and data suppression results in the deletion of all information for geographic areas with populations below a specified size. For example, areas with a population of less than 40 persons are suppressed. If the community searched has a population of less than 40 persons, only the total population counts will be available. Suppression of data can be due to poor data quality or to other technical reasons.

3) Local Study Area (LSA) includes La Plonge 192, Wapachewunak 192D, Patuanak, Pinehouse Lake, and Beauval.

4) North Saskatchewan (RSA) is defined as Census Division No.18.

5) Refers to whether a person aged 15 years and over was employed unemployed or not in the labour force during the Census reference week.

6) "Employed" refers to persons 15 years and over, excluding institutional residents who, during the week prior to Census Day: "(a) Did any work at all at a job or business, that is, paid work in the context of an employer-employee relationship, or self-employment. This also includes persons who did unpaid family work, which is defined as unpaid work contributing directly to the operation of a farm, business or professional practice owned and operated by a related member of the same household; or (b) Had a job but were not at work due to factors such as their own illness or disability, personal or family responsibilities, vacation or a labour dispute. This category excludes persons not at work because they were on layoff or between casual jobs, and those who did not then have a job (even if they had a job to start at a future date)." (Source: 2021 Census Dictionary).

7) "Unemployed" refers to persons who, during the Census reference week, were without paid work or without self-employment work and were available for work and either: a) had actively looked for paid work in the past four weeks; or b) were on temporary lay-off and expected to return to their job; or c) had definite arrangements to start a new job in four weeks or less." (Source: 2021 Census

8) "Not in the labour force" refers to persons who, during the Census reference week, were neither employed nor unemployed. It includes students, homemakers, retired workers, seasonal workers in an 'off' season who were not looking for work, and persons who could not work because of a long-term illness or disability." (Source: 2021 Census Dictionary).

9) The "Participation Rate" refers to the number of people in the labour force during the Census reference week, as a percentage of the population 15 years and over. (Source: 2021 Census Dictionary).

10) The "Employment Rate" refers to the number of people employed during the Census reference week as a percentage of the total population 15 years and over. (Source: 2021 Census Dictionary).

11) The "Unemployment Rate" refers to the number of people unemployed during the Census reference week expressed as a percentage of the population in the labour force. (Source: 2021 Census Dictionary).

Appendix 13-B2: Labour Force Status for the Local Study Area (LSA), Northern Saskatchewan (RSA), and Saskatchewan, 2006 to 2021

	Participation Rate(1,2,3)					Employment Rate(1,2,4)					Unemployment Rate(1,2,5)				
	2006	2011	2016	2021	Avrg	2006	2011	2016	2021	Avrg	2006	2011	2016	2021	Avrg
English River First Nation and Patuanak															
La Plonge 192, Indian Reserve	47%	50%	32%	36%	41%	37%	44%	32%	36%	37%	22%	0%	0%	0%	6%
Wapachewunak 192D, Indian Reserve	36%	44%	43%	38%	40%	21%	38%	34%	29%	31%	41%	13%	22%	24%	25%
Patuanak, Northern Hamlet	42%	44%	36%	50%	43%	25%	44%	36%	40%	36%	60%	0%	50%	0%	28%
Pinehouse, Northern Village	46%	52%	56%	69%	56%	37%	42%	43%	58%	45%	22%	18%	23%	15%	19%
Beauval, Northern Village	58%	42%	57%	40%	49%	43%	35%	45%	33%	39%	25%	16%	19%	20%	20%
Total LSA(6)	**48%**	**47%**	**51%**	**49%**	**49%**	**35%**	**39%**	**40%**	**41%**	**39%**	**28%**	**15%**	**21%**	**17%**	**20%**
Northern Saskatchewan (RSA)(7)	**50%**	**47%**	**49%**	**44%**	**48%**	**40%**	**38%**	**37%**	**36%**	**38%**	**20%**	**18%**	**24%**	**19%**	**20%**
Saskatchewan	**68%**	**69%**	**68%**	**65%**	**68%**	**65%**	**65%**	**64%**	**60%**	**63%**	**6%**	**6%**	**7%**	**8%**	**7%**

Source: Statistics Canada 2006, 2011, 2016a, 2021.

Footnotes:

1) Data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5, and in some cases, 10. Totals may not add-up due to rounding.

2) In addition to random rounding, area and data suppression has been adopted to further protect the confidentiality of individual respondents' personal information. Area and data suppression results in the deletion of all information for geographic areas with populations below a specified size. For example, areas with a population of less than 40 persons are suppressed. If the community searched has a population of less than 40 persons, only the total population counts will be available. Suppression of data can be due to poor data quality or to other technical reasons.

3) The "Participation Rate" refers to the number of people in the labour force during the Census reference week, as a percentage of the population 15 years and over. (Source: 2021 Census Dictionary).
4) The "Employment Rate" refers to the number of people employed during the Census reference week as a percentage of the total population 15 years and over. (Source: 2021 Census Dictionary).
5) The "Unemployment Rate" refers to the number of people unemployed during the week Census reference week expressed as a percentage of the population in the labour force. (Source: 2021 Census Dictionary).
6) Local Study Area (LSA) includes La Plonge 192, Wapachewunak 192D, Patuanak, Pinehouse Lake, and Beauval.
7) North Saskatchewan (RSA) is defined as Census Division No.18.

Appendix 13-B3: Employment by Industry Sector for the Local Study Area (LSA), Northern Saskatchewan (RSA), and Saskatchewan, 2016 and 2021

	2021 Employment by Industry Sector								
	Local Study Area (LSA)(1,2,3,9)			Northern Saskatchewan (RSA)(1,2,4,9)			Saskatchewan(1,2,9)		
	Total	Men+	Women+	Total	Men+	Women+	Total	Men+	Women+
Total labour force population aged 15 years and over by Industry - NAICS(5)	**935**	**430**	**510**	**11,140**	**5,680**	**5,460**	**577,505**	**303,920**	**273,590**
Industry - not applicable(6)	80	35	30	1,045	600	450	14,000	7,290	6,715
All industry categories(7)	875	400	475	10,090	5,080	5,010	563,505	296,630	266,870
Agriculture; forestry; fishing and hunting (NAICS 11)	20	10	-	235	175	60	48,750	34,620	14,130
Mining; quarrying; and oil and gas extractions (NAICS 21)	70	60	-	725	635	95	18,555	16,035	2,515
Construction (NAICS 23)	55	45	-	745	650	90	44,130	38,640	5,490
Manufacturing (NAICS 31-33)	10	10	-	105	75	25	26,200	20,290	5,910
Retail Trade (NAICS 44-45)	130	50	85	1,130	535	595	61,480	30,005	31,475
Transportation and Warehousing (NAICS 48-49)	30	15	-	350	275	75	24,225	19,320	4,910
Educational Services (NAICS 61)	125	30	100	1,905	495	1,405	46,205	13,905	32,305
Health Care and Social Assistance (NAICS 62)	120	20	115	1,560	350	1,210	80,465	14,190	66,270
Accommodation and Food Services (NAICS 72)	55	15	45	480	220	255	32,705	14,110	18,595
Other Services (Except Public Administration)(NAICS 81)	-	10	-	170	105	70	25,825	12,800	13,025
Public Administration (NAICS 91)	140	75	60	1,600	915	685	39,210	19,420	19,795
Other (NAICS 22, 41, 51, 52, 53, 54, 55, 56, 71)(8)	90	15	70	1,100	655	445	115,745	63,275	52,455

	2016 Employment by Industry Sector								
	Local Study Area (LSA)(1,2,3,9)			Northern Saskatchewan (RSA)(1,2,4,9)			Saskatchewan(1,2,9)		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
Total labour force population aged 15 years and over by Industry - NAICS(5)	**880**	**455**	**420**	**12,355**	**6,540**	**5,815**	**585,540**	**311,105**	**274,430**
Industry - not applicable(6)	100	45	55	1,570	910	655	10,225	5,200	5,020
All industry categories(7)	785	415	365	10,790	5,630	5,160	575,310	305,905	269,410
Agriculture; forestry; fishing and hunting (NAICS 11)	25	25	-	240	220	20	51,255	36,820	14,440
Mining; quarrying; and oil and gas extractions (NAICS 21)	165	145	25	1,165	1,025	145	23,070	20,040	3,025
Construction (NAICS 23)	40	40	-	800	735	70	49,310	43,460	5,850
Manufacturing (NAICS 31-33)	-	10	-	150	120	30	26,710	21,000	5,710
Retail Trade (NAICS 44-45)	90	50	50	1,015	455	555	63,360	30,185	33,180
Transportation and Warehousing (NAICS 48-49)	15	20	10	445	325	120	24,755	19,385	5,370
Educational Services (NAICS 61)	150	30	130	1,895	530	1,365	45,360	13,670	31,690
Health Care and Social Assistance (NAICS 62)	90	-	80	1,660	290	1,370	72,625	11,285	61,335
Accommodation and Food Services (NAICS 72)	40	30	15	585	270	310	37,785	14,295	23,490
Other Services (Except Public Administration) (NAICS 81)	-	10	-	250	135	115	25,680	12,590	13,090
Public Administration (NAICS 91)	85	65	35	1,520	955	570	38,180	19,640	18,535
Other (NAICS 22, 41, 51, 52, 53, 54, 55, 56, 71)(8)	40	30	20	1,060	580	480	117,215	63,525	53,675

Source: Statistics Canada 2016a and 2021.

Footnotes:

1) Data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5, and in some cases 10. Totals may not add up due to rounding.

2) In addition to random rounding, area and data suppression has been adopted to further protect the confidentiality of individual respondents' personal information. Area and data suppression results in the deletion of all information for geographic areas with populations below a specified size. For example, areas with a population of less than 40 persons are suppressed. If the community searched has a population of less than 40 persons, only the total population counts will be available. Suppression of data can be due to poor data quality or to other technical reasons.

3) Local Study Area (LSA) includes La Plonge 192, Wapachewunak 192D, Patuanak, Pinehouse Lake, and Beauval.

4) North Saskatchewan (RSA) is defined as Census Division No.18.

5) Includes the experienced labour force which refers to persons aged 15 years and over who during the Census were employed and the unemployed who had last worked for pay or in self-employment prior to the Census.

6) Includes unemployed persons aged 15 years and over who have never worked for pay or in self-employment or who had last worked prior to January 1, 2015 or 2020.

7) Refers to the general nature of the business carried out in the establishment where the person worked. The data are produced according to the North American Industry Classification System (NAICS) 2017.

8) The data sets group Other Servicesas Utilities, Wholesale Trade, Information and Cultural Industries, Finance and Insurance, Real Estate and Rental and Leasing, Professional; Scientific and Technical Services, Management of Companies and Enterprises, Admin and Support; Waste Mgmt and Remediation, and Arts; Entertainment and Recreation. These categories have been collapsed in the table.

9) The 2021 Census disaggregates by gender. Census years prior to 2021 disaggregates by sex (male and female). Although sex and gender refer to two different concepts, the introduction of gender is not expected to have a significant impact on data analysis and historical comparability, given the small size of the transgender and non-binary populations. Given that the non-binary population is small, data aggregation to a two-category gender variable is sometimes necessary to protect the confidentiality of responses provided. In these cases, individuals in the category "non-binary persons" are distributed into the other two gender categories (men+ and women+) and are denoted by the "+" symbol (Statistics Canada 2021).
Gender refers to an individual's personal and social identity as a man, woman, or non-binary person (a person who is not exclusively a man or a woman). Gender includes the following concepts: (1) gender identity, which refers to the gender that a person feels internally and individually; (2) gender expression, which refers to the way a person presents their gender, regardless of their gender identity, through body language, aesthetic choices, or accessories (e.g., clothes, hairstyle, and makeup), which may have traditionally been associated with a specific gender. A person's gender may differ from their sex at birth, and from what is indicated on their current identification or legal documents, such as their birth certificate, passport, or driver's license. A person's gender may change over time. Some people may not identify with a specific gender (Statistics Canada 2021).

Appendix 13-B4: Employment by Industry Sector for the Local Study Area (LSA), Northern Saskatchewan (RSA), and Saskatchewan, 2006 to 2021

	La Plonge 192, Indian Reserve[1,2]				Wapachewunak 192D, Indian Reserve[1,2]				Patuanak, Northern Hamlet[1,2]				Pinehouse, Northern Village[1,2]			
	2006	2011	2016	2021	2006	2011	2016	2021	2006	2011	2016	2021	2006	2011	2016	2021
Total labour force population aged 15 years and over by Industry - North American Industry Classification System (NAICS) 2012 - 25% sample data[5]	**45**	**45**	**40**	**45**	**130**	**160**	**185**	**165**	**30**	**25**	**20**	**25**	**295**	**365**	**400**	**275**
Industry - NAICS2012 - not applicable[6]	10	0	10	10	10	15	15	20	0	0	0	0	25	45	55	20
All industry categories[7]	**45**	**40**	**35**	**40**	**120**	**145**	**170**	**150**	**25**	**20**	**25**	**25**	**270**	**325**	**340**	**260**
11 Agriculture; forestry; fishing and hunting	0	0	10	0	10	10	0	10	0	0	0	0	10	0	0	0
21 Mining; quarrying; and oil and gas extraction	0	10	0	0	15	25	25	0	0	10	0	0	35	90	110	30
22 Utilities	0	0	0	0	0	0	0	10	0	0	10	0	10	0	10	0
23 Construction	0	10	0	0	15	10	15	10	0	0	0	10	30	20	25	20
31-33 Manufacturing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41 Wholesale trade	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44-45 Retail trade	0	0	10	10	10	10	20	15	0	0	10	0	30	25	25	40
48-49 Transportation and warehousing	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	10
51 Information and cultural industries	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0
52 Finance and insurance	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
53 Real estate and rental and leasing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0
54 Professional; scientific and technical services	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55 Management of companies and enterprises	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56 Administrative and support; waste management and remedia	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	10
61 Educational services	10	0	0	10	15	15	30	30	0	0	0	0	60	45	60	50
62 Health care and social assistance	0	0	0	10	10	10	15	15	0	0	10	0	35	60	45	40
71 Arts; entertainment and recreation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
72 Accommodation and food services	0	0	0	10	10	0	10	0	0	0	0	0	10	10	20	10
81 Other services (except public administration)	10	0	0	0	10	0	0	0	0	0	0	0	0	10	0	0
91 Public administration	10	10	0	10	35	45	35	55	10	0	0	10	25	40	30	30

	Beauval, Northern Village[1,2]				LSA[1,2,3]				Northern Saskatchewan (RSA)[1,2,4]				Saskatchewan[1,2]		
	2006	2011	2016	2021	2006	2011	2016	2021	2006	2011	2016	2021	2006	2011	2016
Total labour force population aged 15 years and over by Industry - North American Industry Classification System (NAICS) 2012 - 25% sample data[5]	**335**	**230**	**235**	**425**	**835**	**825**	**880**	**935**	**11,275**	**11,590**	**12,355**	**11,140**	**524,305**	**562,310**	**585,540**
Industry - NAICS2012 - not applicable[6]	30	0	20	30	75	60	100	80	1,055	860	1,570	1,045	6,825	7,590	10,225
All industry categories[7]	**300**	**220**	**215**	**400**	**760**	**750**	**785**	**875**	**10,220**	**10,730**	**10,790**	**10,090**	**517,475**	**554,715**	**575,310**
11 Agriculture; forestry; fishing and hunting	25	0	15	10	45	10	25	20	375	200	240	235	60,210	51,360	51,255
21 Mining; quarrying; and oil and gas extraction	45	30	30	40	95	165	165	70	975	1,030	1,165	725	19,055	22,985	23,070
22 Utilities	0	0	0	0	10	0	20	10	105	100	95	100	5,040	5,330	5,395
23 Construction	25	10	0	15	70	50	40	55	660	700	800	745	29,940	42,975	49,310
31-33 Manufacturing	10	0	0	10	10	0	0	10	440	300	150	105	29,865	26,460	26,710
41 Wholesale trade	0	0	0	0	0	0	0	0	95	115	105	95	19,100	21,135	20,480
44-45 Retail trade	15	0	25	65	55	35	90	130	920	990	1,015	1,130	56,730	60,940	63,360
48-49 Transportation and warehousing	15	25	15	20	25	25	15	30	395	400	445	350	24,460	25,390	24,755
51 Information and cultural industries	10	0	0	0	20	0	0	0	110	80	90	85	11,975	10,900	10,005
52 Finance and insurance	0	0	0	10	0	0	0	10	105	90	95	75	18,705	21,120	20,155
53 Real estate and rental and leasing	10	0	0	10	10	0	10	10	95	120	90	85	6,570	7,445	7,650
54 Professional; scientific and technical services	0	0	0	10	0	0	0	10	100	190	165	110	19,020	23,520	25,250
55 Management of companies and enterprises	0	0	0	0	0	0	0	0	10	0	10	0	635	575	1,340
56 Administrative and support; waste management and remedia	0	0	10	30	0	10	10	40	275	345	310	425	14,455	13,425	16,395
61 Educational services	55	35	60	35	140	95	150	125	1,590	1,605	1,895	1,905	40,315	43,995	45,360
62 Health care and social assistance	30	45	20	55	75	115	90	120	1,390	1,350	1,660	1,560	58,405	65,450	72,625
71 Arts; entertainment and recreation	0	0	0	10	0	0	0	10	110	130	100	125	9,395	9,825	10,545
72 Accommodation and food services	15	15	10	35	35	25	40	55	710	515	585	480	34,580	34,085	37,785
81 Other services (except public administration)	10	0	0	0	30	10	0	0	290	175	250	170	25,695	25,445	25,680
91 Public administration	35	25	20	35	115	120	85	140	1,480	2,300	1,520	1,600	33,315	42,335	38,180

Source: Statistics Canada 2006, 2011, 2016a, and 2021.

Footnotes:

1) Data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5, and in some cases 10. Totals may not add up due to rounding.

2) In addition to random rounding, area and data suppression has been adopted to further protect the confidentiality of individual respondents' personal information. Area and data suppression results in the deletion of all information for geographic areas with populations below a specified size. For example, areas with a population of less than 40 persons are suppressed. If the community searched has a population of less than 40 persons, only the total population counts will be available. Suppression of data can be due to poor data quality or to other technical reasons.

3) Local Study Area (LSA) includes La Plonge 192, Wapachewunak 192D, Patuanak, Pinehouse Lake, and Beauval.

4) North Saskatchewan (RSA) is defined as Census Division No.18.

5) Includes the experienced labour force which refers to persons aged 15 years and over who during the Census were employed and the unemployed who had last worked for pay or in self-employment prior to the Census.

6) Includes unemployed persons aged 15 years and over who have never worked for pay or in self-employment or who had last worked prior to January 1, 2005, 2010, 2015, or 2020.

7) Refers to the general nature of the business carried out in the establishment where the person worked. The data are produced according to the North American Industry Classification System (NAICS) 2017.

Appendix 13-B5: Educational Attainment for the population 15 years of age and older for the Local Study Area (LSA), Northern Saskatchewan (RSA), and Saskatchewan, 2016 and 2021

	2021 Educational Attainment for the Population 15 Years of Age and Older																							
	La Plonge 192, Indian Reserve[1,2,3,9]			Wapachewunak 192D, Indian Reserve[1,2,3,9]			Patuanak, Northern Hamlet[1,2,3,9]			Pinehouse, Northern Village[1,2,3,9]			Beauval, Northern Village[1,2,3,9]			LSA[1,2,3,4,9]			Northern Saskatchewan (RSA)[1,2,3,5,9]			Saskatchewan[1,2,3,9]		
	Total	Men+	Women+	Total	Men+	Women+	Total	Men+	Women+	Total	Men+	Women+	Total	Men+	Women+	Total	Men+	Women+	Total	Men+	Women+	Total	Men+	Women+
Total Population 15 and Over by Highest Certificate, Diploma or Degree[6]	**110**	**50**	**55**	**430**	**225**	**205**	**50**	**20**	**25**	**680**	**335**	**350**	**625**	**285**	**340**	**1,895**	**915**	**975**	**25,040**	**12,340**	**12,700**	**882,760**	**436,515**	**446,245**
Less than High School Certificate	35	15	20	185	105	80	25	10	15	350	190	160	180	105	70	775	425	345	11,795	6,475	5,320	159,815	89,275	70,540
High School Certificate or Equivalent[7]	25	15	10	170	95	75	10	10	10	195	90	105	195	75	120	595	285	320	6,490	2,935	3,550	284,345	146,000	138,345
Apprenticeship or Trades Certificate or Diploma	15	10	10	35	20	10	-	-	-	35	20	15	75	55	25	160	105	60	1,795	1,310	485	84,485	61,685	22,800
Post-Secondary Non-University Certificate or Diploma[8]	25	-	15	25	10	15	10	-	10	60	20	40	120	30	90	240	60	170	2,435	895	1,545	143,610	50,720	92,890
University Certificate or Diploma Below the Bachelor's Level	-	-	-	-	-	-	-	-	-	10	-	10	10	-	10	20	-	20	510	135	375	29,260	11,355	17,905
University Degree at Bachelor Level or Above	-	-	-	25	-	20	-	-	-	35	10	25	50	15	30	110	25	75	2,015	595	1,425	181,255	77,485	103,770

	2016 Educational Attainment for the Population 15 Years of Age and Older																							
	La Plonge 192, Indian Reserve[1,2,3,9]			Wapachewunak 192D, Indian Reserve[1,2,3,9]			Patuanak, Northern Hamlet[1,2,3,9]			Pinehouse, Northern Village[1,2,3,9]			Beauval, Northern Village[1,2,3,9]			LSA[1,2,3,4,9]			Northern Saskatchewan (RSA)[1,2,3,5,9]			Saskatchewan[1,2,3,9]		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Total Population 15 and Over by Highest Certificate, Diploma or Degree[6]	**105**	**50**	**55**	**425**	**210**	**220**	**55**	**25**	**25**	**715**	**355**	**360**	**410**	**215**	**195**	**1,710**	**855**	**855**	**25,295**	**12,605**	**12,690**	**857,295**	**424,265**	**433,035**
Less than High School Certificate	40	25	20	195	110	90	25	15	10	370	200	165	120	70	40	750	420	325	12,865	6,945	5,920	177,210	96,680	80,530
High School Certificate or Equivalent[7]	20	10	10	125	60	70	10	10	10	155	75	85	115	55	60	425	210	235	5,195	2,250	2,955	261,210	133,730	127,480
Apprenticeship or Trades Certificate or Diploma	25	15	-	40	25	15	10	10	-	55	40	10	50	40	10	180	130	35	2,080	1,495	585	89,440	64,100	25,340
Post-Secondary Non-University Certificate or Diploma[8]	10	10	10	35	15	15	10	-	10	80	20	60	70	30	45	205	75	140	2,810	1,180	1,630	146,770	51,240	95,530
University Certificate or Diploma Below the Bachelor's Level	-	-	-	10	-	-	-	-	-	-	-	10	-	10	10	10	10	20	475	110	365	28,195	10,790	17,405
University Degree at Bachelor Level or Above	10	-	-	30	-	25	10	-	-	50	20	30	45	-	40	145	20	95	1,865	630	1,230	154,480	67,730	86,745

Source: Statistics Canada 2016a and 2021.

Footnotes:

1) Statistics Canada data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5 and in some cases, 10. Totals may not add up due to rounding.
2) In addition to random rounding, area and data suppression has been adopted to further protect the confidentiality of individual respondents' personal information. Area and data suppression results in the deletion of all information for geographic areas with populations below a specified size. For example, areas with a population of less than 40 persons are suppressed. If the community searched has a population of less than 40 persons, only the total population counts will be available. Suppression of data can be due to poor data quality or to other technical reasons.
3) Educational attainment data for 2016 and 2021 were derived from 30% data. However, on Indian reserves and in remote communities, Statistics Canada attempts to obtain data from 100% of the population.
4) Local Study Area (LSA) includes La Plonge 192, Wapachewunak 192D, Patuanak, Pinehouse Lake, and Beauval.
5) North Saskatchewan (RSA) is defined as Census Division No.18.
6) "Highest certificate, diploma or degree" refers to the highest certificate, diploma or degree the individual has completed based primarily on time spent" in-class." For high school graduates, a university education is considered to be a higher level of education than a college diploma, while a college education is considered to be a higher level of education than a trade. Although some trades requirements may take as long or longer to complete than a given college or university program, the majority of time acquiring trade certification may be on-the-job, as opposed to being in a classroom.
7) "High school certificate or equivalent" includes persons who have graduated from a secondary school or equivalent. Excludes persons with a postsecondary certificate, diploma or degree.
8) "Postsecondary non-university certificate or diploma" includes non-degree-granting institutions such as community colleges, CEGEPs, private business colleges and technical institutes.

Appendix 13-B6: Educational Attainment for the population 15 years of age and older for the Local Study Area (LSA), Northern Saskatchewan (RSA), and Saskatchewan, 2006 to 2021

	Census Year	Total population 15 years and over[1,2]	No certificate, diploma or degree[1,2]	High school certificate or equivalent[1,2]	Apprenticeship or trades certificate or diploma[1,2]	College, CEGEP or other non-university certificate or diploma[1,2]	University certificate or diploma below the bachelor level[1,2]	University certificate, diploma or degree[1,2]
La Plonge 192, Indian Reserve	2006	90	60	20	10	10	0	10
	2011	80	35	25	10	10	0	10
	2016	105	40	20	25	10	0	10
	2021	110	35	25	15	25	0	0
Wapachewunak 192D, Indian Reserve	2006	370	235	50	45	25	10	15
	2011	365	190	120	10	25	0	20
	2016	425	195	125	40	35	10	30
	2021	430	185	170	35	25	0	25
Patuanak, Northern Hamlet	2006	55	35	20	0	0	0	0
	2011	45	25	15	0	0	0	0
	2016	55	25	10	10	10	0	10
	2021	50	25	10	10	10	0	0
Pinehouse, Northern Village	2006	630	445	75	15	40	10	40
	2011	710	430	165	30	50	10	35
	2016	715	370	155	55	80	0	50
	2021	680	350	195	35	60	10	35
Beauval, Northern Village	2006	585	270	105	60	90	10	40
	2011	540	295	100	90	20	0	35
	2016	410	120	115	50	70	0	45
	2021	625	180	195	75	120	10	50
LSA[3]	**2006**	**1,730**	**1,045**	**270**	**130**	**165**	**30**	**105**
	2011	**1,740**	**975**	**425**	**140**	**105**	**10**	**100**
	2016	**1,710**	**750**	**425**	**180**	**205**	**10**	**145**
	2021	**1,895**	**775**	**595**	**170**	**240**	**20**	**110**
Northern Saskatchewan (RSA)[4]	**2006**	**22,365**	**13,055**	**3,500**	**1,880**	**1,915**	**710**	**1,300**
	2011	**24,795**	**13,640**	**4,625**	**2,320**	**2,025**	**695**	**1,485**
	2016	**25,295**	**12,865**	**5,195**	**2,080**	**2,810**	**475**	**1,865**
	2021	**25,040**	**11,795**	**6,490**	**1,795**	**2,435**	**510**	**2,015**
Saskatchewan	**2006**	**766,235**	**231,730**	**205,495**	**86,310**	**111,770**	**32,180**	**98,755**
	2011	**812,505**	**200,430**	**228,755**	**98,820**	**127,295**	**32,780**	**124,425**
	2016	**857,295**	**177,210**	**261,210**	**89,440**	**146,770**	**28,195**	**154,480**
	2021	**882,760**	**159,815**	**284,345**	**84,485**	**143,610**	**29,260**	**181,255**

Source: Statistics Canada 2006, 2011, 2016a, and 2021.

Footnotes:

1) Statistics Canada data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5 and in some cases, 10. Totals may not add up due to rounding.

2) In addition to random rounding, area and data suppression has been adopted to further protect the confidentiality of individual respondents' personal information. Area and data suppression results in the deletion of all information for geographic areas with populations below a specified size. For example, areas with a population of less than 40 persons are suppressed. If the community searched has a population of less than 40 persons, only the total population counts will be available. Suppression of data can be due to poor data quality or to other technical reasons.

3) Local Study Area (LSA) includes La Plonge 192, Wapachewunak 192D, Patuanak, Pinehouse Lake, and Beauval.

4) North Saskatchewan (RSA) is defined as Census Division No.18.

Appendix 13-B7: Average Total Income of Individuals for the Local Study Area (LSA), Northern Saskatchewan (RSA), and Saskatchewan, 2015 and 2020

	2020 Average Total Income of Individuals																							
	La Plonge 192, Indian Reserve[1,2,3,4]			Wapachewunak 192D, Indian R[1,2,3,4]			Patuanak, Northern Hamlet[1,2,3,4]			Pinehouse, Northern Village[1,2,3,4]			Beauval, Northern Village[1,2,3,4]			LSA[1,2,3,4,5,6]			Northern Saskatchewan (RSA)[1,2,3,4,7]			Saskatchewan[1,2,3,4]		
	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity
Average Total Income in 2020 Among Recipients [8]	$0	$0	$0	$31,200	$30,700	$60,000	$0	$0	$0	$39,400	$36,800	$76,000	$49,600	$48,800	$56,000	$41,222	$39,611	$63,778	$40,320	$35,480	$62,100	$53,050	$40,720	$55,050
Total - Total income groups in 2020 for the population aged 15 years and over in private households	-	-	-	435	425	-	-	-	-	680	640	40	625	565	60	1,740	1,630	100	25,040	20,835	4,205	882,760	128,795	753,965
Without total income	-	-	-	50	50	-	-	-	-	80	80	-	35	30	-	165	160	-	2,505	2,400	105	37,340	11,960	25,385
With total income	-	-	-	380	375	-	-	-	-	600	560	35	585	535	55	1,565	1,470	90	22,530	18,435	4,100	845,420	116,840	728,585
Under $10,000	-	-	-	65	65	-	-	-	-	70	65	10	30	30	-	165	160	10	3,440	3,140	305	71,145	16,095	55,045
$10,000 to $19,999	-	-	-	65	65	-	-	-	-	95	90	-	35	35	-	195	190	-	3,355	3,040	320	93,490	16,575	76,915
$20,000 to $29,999	-	-	-	100	100	-	-	-	-	140	140	-	120	110	-	360	350	-	4,260	3,820	445	128,145	22,290	105,860
$30,000 to $39,999	-	-	-	65	65	-	-	-	-	60	60	-	100	90	-	225	215	-	2,905	2,465	445	104,575	15,870	88,705
$40,000 to $49,999	-	-	-	25	25	-	-	-	-	60	60	-	90	85	-	175	170	-	2,255	1,770	490	96,540	12,190	84,350
$50,000 to $59,999	-	-	-	15	15	-	-	-	-	55	55	-	55	50	-	125	120	-	1,590	1,285	315	80,300	9,480	70,815
$60,000 to $69,999	-	-	-	15	15	-	-	-	-	35	30	-	20	20	-	70	65	-	1,175	875	300	63,775	6,485	57,290
$70,000 to $79,999	-	-	-	10	-	-	-	-	-	15	15	-	55	55	-	80	70	-	855	575	280	48,655	4,865	43,795
$80,000 to $89,999	-	-	-	10	-	-	-	-	-	25	20	10	-	-	-	35	20	10	585	340	245	38,510	3,610	34,900
$90,000 to $99,999	-	-	-	10	10	-	-	-	-	15	10	10	20	-	-	45	20	10	600	360	240	30,590	2,825	27,770
$100,000 and over	-	-	-	10	10	-	-	-	-	30	15	15	50	50	-	90	75	15	1,495	765	730	89,685	6,555	83,130

	2015 Average Total Income of Individuals																							
	La Plonge 192, Indian Reserve[1,2,3,4]			Wapachewunak 192D, Indian R[1,2,3,4]			Patuanak, Northern Hamlet[1,2,3,4]			Pinehouse, Northern Village[1,2,3,4]			Beauval, Northern Village[1,2,3,4]			LSA[1,2,3,4,5,6]			Northern Saskatchewan (RSA)[1,2,3,4,7]			Saskatchewan[1,2,3,4]		
	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity
Average Total Income in 2015 Among Recipients [8]	$0	$0	$0	$29,199	$27,568	$69,121	$0	$0	$0	$37,864	$35,536	$68,605	$44,972	$44,640	$0	$37,464	$35,785	$68,734	$31,971	$25,961	$60,580	$49,409	$32,976	$51,838
Total - Total income groups in 2015 for the population aged 15 years and over in private households	-	-	-	425	410	15	-	-	-	710	670	45	405	375	30	1,540	1,455	90	25,295	21,240	4,050	857,295	117,330	739,970
Without total income	-	-	-	45	45	-	-	-	-	90	85	-	20	20	-	155	150	-	2,530	2,435	100	34,760	11,405	23,355
With total income	-	-	-	380	365	15	-	-	-	625	580	45	385	355	30	1,390	1,300	90	22,760	18,815	3,950	822,540	105,925	716,620
Under $10,000	-	-	-	105	105	-	-	-	-	140	130	-	65	60	-	310	295	-	7,070	6,750	325	106,475	27,765	78,715
$10,000 to $19,999	-	-	-	100	100	-	-	-	-	135	135	-	90	80	-	325	315	-	4,435	3,975	455	117,515	19,560	97,955
$20,000 to $29,999	-	-	-	60	60	-	-	-	-	85	80	-	45	45	-	190	185	-	2,860	2,440	420	108,430	14,615	93,815
$30,000 to $39,999	-	-	-	40	40	-	-	-	-	55	55	-	35	25	-	130	120	-	2,035	1,675	365	95,735	11,650	84,090
$40,000 to $49,999	-	-	-	10	10	-	-	-	-	50	50	-	20	20	-	80	80	-	1,495	1,125	370	88,575	8,880	79,700
$50,000 to $59,999	-	-	-	20	15	-	-	-	-	30	30	-	10	10	-	60	55	-	1,050	710	345	70,625	6,320	64,310
$60,000 to $69,999	-	-	-	-	10	-	-	-	-	30	20	-	25	20	-	55	50	-	870	530	335	53,855	4,520	49,335
$70,000 to $79,999	-	-	-	15	10	-	-	-	-	20	15	-	15	20	-	50	45	-	605	360	245	41,680	3,360	38,320
$80,000 to $89,999	-	-	-	10	-	-	-	-	-	15	10	-	20	20	-	45	30	-	530	270	260	34,295	2,670	31,625
$90,000 to $99,999	-	-	-	10	-	-	-	-	-	25	20	-	10	10	-	45	30	-	525	315	215	26,075	1,990	24,085
$100,000 and over	-	-	-	20	15	-	-	-	-	45	40	-	45	40	-	110	95	-	1,285	670	615	79,280	4,605	74,670

Source: Statistics Canada 2016a and 2021.

Footnotes:

1) Data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5, and in some cases 10. Totals may not add up due to rounding.

2) In addition to random rounding, area and data suppression has been adopted to further protect the confidentiality of individual respondents' personal information. Area and data suppression results in the deletion of all information for geographic areas with populations below a specified size. For example, areas with a population of less than 40 persons are suppressed. If the community searched has a population of less than 40 persons, only the total population counts will be available. Suppression of data can be due to poor data quality or to other technical reasons.

3) Income variables do not account for inflation.

4) Personal income variables were derived from 25% sample data. However, on Indian Reserves and in remote communities, attempts are made to obtain data from 100% of the population.

5) Local Study Area (LSA) includes La Plonge 192, Wapachewunak 192D, Patuanak, Pinehouse Lake, and Beauval. However, data is not available for La Plonge 192 and Patuanak.

6) Local Study Area (LSA) average total income in 2015 among recipients is calculated based on the weighted average of Number of income recipients and Average total income of the Indian Reserves, hamlet, and villages where data available.

7) North Saskatchewan (RSA) is defined as Census Division No.18.

8) Total income (i.e. personal income) refers to the total money income received during the calendar year prior to the Census year. Sources of income are: wages and salaries, net farm income; net non-farm income from unincorporated business and/or professional practice; child benefits; Old Age Security pension and Guaranteed Income Supplement; benefits from Canada Pension Plan or Quebec Pension Plan; benefits from Employment Insurance; other income from government sources; dividends, interest on bonds, deposits and savings certificates and other investment income; retirement pensions, superannuation and annuities, including those from RRSPs and RRIFs; and other money income. Not included in all Census years as total income: income tax refunds, lump sum inheritance payments, gambling revenue, lump sum insurance policy settlements, capital gains or losses, receipts from the sale of property or belongings, loan repayments, property tax rebates or refunds of pension contributions. For the 2016 Census the reference period is the calendar year 2015 for all income variables.

Appendix 13-B8: Average Total Income of Individuals for the Local Study Area (LSA), Northern Saskatchewan (RSA), and Saskatchewan, 2005 to 2020

	La Plonge 192, Indian Reserve[1,2,3,4,9]			Wapachewunak 192D, Indian Reserve[1,2,3,4,9]			Patuanak, Northern Hamlet[1,2,3,4,9]			Pinehouse, Northern Village[1,2,3,4,9]		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Average Total Income Among Recipients[8]												
2005	$0	$0	$0	$17,257	$19,941	$14,494	$0	$0	$0	$21,765	$24,307	$19,430
2010	$0	$0	$0	$25,392	$27,163	$23,259	$0	$0	$0	$25,627	$30,993	$20,711
2015	$0	$0	$0	$29,199	$31,698	$26,853	$0	$0	$0	$37,864	$43,588	$32,158
2020	$0	$0	$0	$31,200	$29,400	$33,200	$0	$0	$0	$39,400	$38,800	$40,000
Total - Total income groups with income for the population aged 15 years and over in private households												
2005	-	-	-	345	175	170	-	-	-	540	260	280
2010	-	-	-	335	185	150	-	-	-	640	310	335
2015	-	-	-	380	185	195	-	-	-	625	310	315
2020	-	-	-	430	230	205	-	-	-	680	335	350

	Beauval, Northern Village[1,2,3,4,9]			LSA[1,2,3,4,5,6,9]			Northern Saskatchewan (RSA)[1,2,3,4,7,9]			Saskatchewan[1,2,3,4,9]		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Average Total Income Among Recipients[8]												
2005	$25,286	$27,334	$23,347	$21,913	$24,251	$19,657	$20,804	$22,398	$19,213	$31,616	$38,038	$25,476
2010	$29,210	$31,875	$27,181	$26,772	$30,251	$23,555	$26,604	$28,612	$24,599	$40,798	$48,611	$33,119
2015	$44,972	$47,942	$41,842	$37,464	$41,631	$33,247	$31,971	$34,485	$29,519	$49,409	$58,791	$40,184
2020	$49,600	$52,400	$47,200	$41,042	$40,816	$41,178	$40,320	$39,640	$40,960	$53,050	$60,250	$46,080
Total - Total income groups with income for the population aged 15 years and over in private households												
2005	500	240	255	1,385	675	705	20,420	10,200	10,220	728,960	356,330	372,630
2010	490	210	275	1,465	705	760	22,145	11,060	11,080	776,195	384,730	391,470
2015	385	195	185	1,390	690	695	22,760	11,240	11,525	822,545	407,840	414,705
2020	625	285	340	1,735	850	895	$25,040	$12,340	$12,700	$882,760	$436,515	$446,245

Source: Statistics Canada 2006, 2011, 2016a, and 2021.

Footnotes:

1) Data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5, and in some cases 10. Totals may not add up due to rounding.

2) In addition to random rounding, area and data suppression has been adopted to further protect the confidentiality of individual respondents' personal information. Area and data suppression results in the deletion of all information for geographic areas with populations below a specified size. For example, areas with a population of less than 40 persons are suppressed. If the community searched has a population of less than 40 persons, only the total population counts will be available. Suppression of data can be due to poor data quality or to other technical reasons.

3) Income variables do not account for inflation.

4) Personal income variables were derived from 25% sample data. However, on Indian Reserves and in remote communities, attempts are made to obtain data from 100% of the population.

5) Local Study Area (LSA) includes La Plonge 192, Wapachewunak 192D, Patuanak, Pinehouse Lake, and Beauval. However, data is not available for La Plonge 192 and Patuanak.

6) Local Study Area (LSA) average total income among recipients is calculated based on the weighted average of number of income recipients and average employment income of the Indian Reserves, hamlet, and villages where data available.

7) North Saskatchewan (RSA) is defined as Census Division No.18.

8) Total income (i.e. personal income) refers to the total money income received during the calendar year prior to the Census year. Sources of income are: wages and salaries, net farm income; net non-farm income from unincorporated business and/or professional practice; child benefits; Old Age Security pension and Guaranteed Income Supplement; benefits from Canada Pension Plan or Quebec Pension Plan; benefits from Employment Insurance; other income from government sources; dividends, interest on bonds, deposits and savings certificates and other investment income; retirement pensions, superannuation and annuities, including those from RRSPs and RRIFs; and other money income. Not included in all Census years as total income: income tax refunds, lump sum inheritance payments, gambling revenue, lump sum insurance policy settlements, capital gains or losses, receipts from the sale of property or belongings, loan repayments, property tax rebates or refunds of pension contributions. For the 2021 Census, for example, the reference period is the calendar year 2020 for all income variables.

Appendix 13-B9: Median Total Income of Individuals for the Local Study Area (LSA) Communities, Northern Saskatchewan (RSA), and Saskatchewan, 2015 and 2020

	2020 Median Total Income of Individuals																				
	La Plonge 192, Indian Reserve[1,2,3,4]			Wapachewunak 192D, Indian Reserve[1,2,3,4]			Patuanak, Northern Hamlet[1,2,3,4]			Pinehouse, Northern Village[1,2,3,4]			Beauval, Northern Village[1,2,3,4]			Northern Saskatchewan (RSA)[1,2,3,4,5]			Saskatchewan[1,2,3,4]		
	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity
Number of total income recipients aged 15 years and over in private households - 25% sample data	-	-	-	385	375	10	-	-	-	595	560	40	590	535	55	22,530	18,430	4,100	845,420	116,840	728,585
Median Total Income in 2020 Among Recipients[6]	-	-	-	**$23,800**	**$23,800**	-	-	-	-	**$29,400**	**$28,600**	**$87,000**	**$40,400**	**$40,400**	**$42,000**	**$30,600**	**$27,600**	**$51,600**	**$42,400**	**$32,000**	**$44,400**

	2015 Median Total Income of Individuals																				
	La Plonge 192, Indian Reserve[1,2,3,4]			Wapachewunak 192D, Indian Reserve[1,2,3,4]			Patuanak, Northern Hamlet[1,2,3,4]			Pinehouse, Northern Village[1,2,3,4]			Beauval, Northern Village[1,2,3,4]			Northern Saskatchewan (RSA)[1,2,3,4,5]			Saskatchewan[1,2,3,4]		
	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity
Number of total income recipients aged 15 years and over in private households - 25% sample data	-	-	-	380	365	15	-	-	-	625	580	45	385	355	30	22,765	18,810	3,955	822,540	105,920	716,615
Median Total Income in 2015 Among Recipients[6]	-	-	-	**$19,779**	**$19,733**	**$56,192**	-	-	-	**$24,224**	**$22,624**	**$66,816**	**$29,240**	**$29,128**		**$19,817**	**$17,278**	**$50,527**	**$38,232**	**$23,553**	**$40,414**

Source: Statistics Canada 2016a and 2020.

Footnotes:
1) Data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5, and in some cases 10. Totals may not add up due to rounding.
2) In addition to random rounding, area and data suppression has been adopted to further protect the confidentiality of individual respondents' personal information. Area and data suppression results in the deletion of all information for geographic areas with populations below a specified size. For example, areas with a population of less than 40 persons are suppressed. If the community searched has a population of less than 40 persons, only the total population counts will be available. Suppression of data can be due to poor data quality or to other technical reasons.
3) Income variables do not account for inflation.
4) Personal income variables were derived from 25% sample data. However, on Indian Reserves and in remote communities, attempts are made to obtain data from 100% of the population.
5) North Saskatchewan (RSA) is defined as Census Division No.18.
6) Total income (i.e. personal income) refers to the total money income received during the calendar year prior to the Census year. Sources of income are: wages and salaries, net farm income; net non-farm income from unincorporated business and/or professional practice; child benefits; Old Age Security pension and Guaranteed Income Supplement; benefits from Canada Pension Plan or Quebec Pension Plan; benefits from Employment Insurance; other income from government sources; dividends, interest on bonds, deposits and savings certificates and other investment income; retirement pensions, superannuation and annuities, including those from RRSPs and RRIFs; and other money income. Not included in all Census years as total income: income tax refunds, lump sum inheritance payments, gambling revenue, lump sum insurance policy settlements, capital gains or losses, receipts from the sale of property or belongings, loan repayments, property tax rebates or refunds of pension contributions. For the 2016 Census the reference period is the calendar year 2015 for all income variables. For the 2021 Census the reference period is the calendar year 2020 for all income variables.

Appendix 13-B10: Household Income for the Local Study Area (LSA), Northern Saskatchewan (RSA), and Saskatchewan, 2015 and 2020

	2020 Household Income																							
	La Plonge 192, Indian Reserve(1,2,3,4)			Wapachewunak 192D, Indian Reserve(1,2,3,4)			Patuanak, Northern Hamlet(1,2,3,4)			Pinehouse, Northern Village(1,2,3,4)			Beauval, Northern Village(1,2,3,4)			LSA(1,2,3,4,5,6)			Northern Saskatchewan (RSA)(1,2,3,4,7)			Saskatchewan(1,2,3,4)		
	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity
Average Income in 2020 for Private Households (Before Taxes)(8)	**$0**	**$0**	**$0**	**$67,000**	**$66,500**	**$0**	**$0**	**$0**	**$0**	**$88,000**	**$87,000**	**$100,000**	**$99,000**	**$100,000**	**$95,000**	**$87,282**	**$86,793**	**$96,667**	**$86,800**	**$82,300**	**$106,000**	**$99,800**	**$87,500**	**$102,200**
Total Number of Private Households with Income in 2020(9)	-	-	-	180	175	-	-	-	-	270	250	15	295	265	30	745	690	45	10,475	8,530	1,945	449,580	73,655	375,925
Under $10,000	-	-	-	20	20	-	-	-	-	-	-	-	-	-	-	20	20	-	305	290	10	7,390	1,880	5,505
$10,000 to $19,999	-	-	-	10	10	-	-	-	-	10	10	-	-	-	-	20	20	-	445	400	40	12,795	2,985	9,805
$20,000 to $29,999	-	-	-	30	30	-	-	-	-	25	25	-	-	-	-	55	55	-	930	800	135	35,710	6,310	29,400
$30,000 to $39,999	-	-	-	15	15	-	-	-	-	20	20	-	-	-	-	35	35	-	845	745	100	32,035	6,355	25,685
$40,000 to $49,999	-	-	-	20	20	-	-	-	-	10	10	-	-	-	-	30	30	-	910	760	145	34,165	6,400	27,755
$50,000 to $59,999	-	-	-	10	10	-	-	-	-	20	20	-	25	25	-	55	55	-	820	710	115	33,330	6,290	27,035
$60,000 to $69,999	-	-	-	25	25	-	-	-	-	25	25	-	25	25	-	75	75	-	805	690	110	32,480	5,760	26,725
$70,000 to $79,999	-	-	-	10	10	-	-	-	-	15	10	-	45	40	-	70	60	-	715	585	125	30,315	5,160	25,155
$80,000 to $89,999	-	-	-	10	15	-	-	-	-	20	15	10	-	-	-	30	30	10	620	505	115	28,320	4,520	23,800
$90,000 to $99,999	-	-	-	-	10	-	-	-	-	10	10	-	20	-	-	30	20	-	570	435	140	25,725	3,785	21,940
$100,000 and over	-	-	-	35	35	-	-	-	-	95	85	10	125	110	-	255	230	10	3,510	2,605	905	177,315	24,195	153,120

	2015 Household Income																							
	La Plonge 192, Indian Reserve(1,2,3,4)			Wapachewunak 192D, Indian Reserve(1,2,3,4)			Patuanak, Northern Hamlet(1,2,3,4)			Pinehouse, Northern Village(1,2,3,4)			Beauval, Northern Village(1,2,3,4)			LSA(1,2,3,4,5,6)			Northern Saskatchewan (RSA)(1,2,3,4,7)			Saskatchewan(1,2,3,4)		
	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity
Average Income in 2015 for Private Households (Before Taxes)(8)	**$0**	**$0**	**$0**	**$60,621**	**$59,779**	**$0**	**$0**	**$0**	**$0**	**$88,965**	**$89,427**	**$85,190**	**$98,027**	**$103,761**	**$0**	**$83,412**	**$84,517**	**$85,190**	**$71,111**	**$63,370**	**$106,767**	**$93,942**	**$75,155**	**$97,253**
Total Number of Private Households with Income in 2015(9)	-	-	-	180	175	10	-	-	-	265	235	30	180	165	20	625	575	60	10,230	8,410	1,825	432,625	64,830	367,790
Under $10,000	-	-	-	-	20	-	-	-	-	10	10	-	-	-	-	10	30	-	775	765	20	11,605	4,005	7,595
$10,000 to $19,999	-	-	-	25	25	-	-	-	-	30	20	-	30	25	10	85	70	10	1,180	1,110	70	25,710	5,955	19,760
$20,000 to $29,999	-	-	-	25	30	-	-	-	-	15	15	-	-	10	-	40	55	-	1,145	1,045	95	33,620	6,230	27,395
$30,000 to $39,999	-	-	-	25	15	-	-	-	-	25	10	-	25	15	-	75	40	-	955	850	100	35,345	6,380	28,970
$40,000 to $49,999	-	-	-	20	20	-	-	-	-	25	25	-	-	10	-	45	55	-	845	730	125	33,595	5,870	27,720
$50,000 to $59,999	-	-	-	20	20	-	-	-	-	20	15	-	-	-	-	40	35	-	715	600	115	31,285	4,585	26,700
$60,000 to $69,999	-	-	-	10	10	10	-	-	-	25	15	10	15	10	10	50	35	30	610	460	150	30,150	4,290	25,860
$70,000 to $79,999	-	-	-	15	10	-	-	-	-	20	15	10	10	-	-	45	25	10	515	425	95	27,360	3,630	23,730
$80,000 to $89,999	-	-	-	-	10	-	-	-	-	15	10	-	10	-	-	25	20	-	475	360	115	25,860	3,495	22,365
$90,000 to $99,999	-	-	-	10	10	-	-	-	-	10	10	10	-	-	-	20	20	10	425	290	135	23,115	2,900	20,215
$100,000 and over	-	-	-	35	25	-	-	-	-	80	75	-	80	75	-	195	175	-	2,585	1,775	810	154,980	17,490	137,495

Source: Statistics Canada 2016a and 2021.

Footnotes:

1) Data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5, and in some cases 10. Totals may not add up due to rounding.

2) In addition to random rounding, area and data suppression has been adopted to further protect the confidentiality of individual respondents' personal information. Area and data suppression results in the deletion of all information for geographic areas with populations below a specified size. For example, areas with a population of less than 40 persons are suppressed. If the community searched has a population of less than 40 persons, only the total population counts will be available. Suppression of data can be due to poor data quality or to other technical reasons.

3) Income variables do not account for inflation.

4) Household income variables were derived from 25% sample data. However, on Indian Reserves and in remote communities, attempts are made to obtain data from 100% of the population.

5) Local Study Area (LSA) includes La Plonge 192, Wapachewunak 192D, Patuanak, Pinehouse Lake, and Beauval. However, data is not available for La Plonge 192 and Patuanak.

6) Local Study Area (LSA) average total income among recipients is calculated based on the weighted average of Number of income groups with income and Average household income of the Indian Reserves, hamlet, and villages where data available.

7) North Saskatchewan (RSA) is defined as Census Division No.18.

8) Household Income refers to Total Income, or income from all sources. Total income is the total money income received during the calendar year prior to the Census year. Sources of income are: wages and salaries, net farm income; net non-farm income from unincorporated business and/or professional practice; child benefits; Old Age Security pension and Guaranteed Income Supplement; benefits from Canada Pension Plan or Quebec Pension Plan; benefits from Employment Insurance; other income from government sources; dividends, interest on bonds, deposits and savings certificates and other investment income; retirement pensions, superannuation and annuities, including those from RRSPs and RRIFs; and other money income. Not included in all Census years as total income: income tax refunds, lump sum inheritance payments, gambling revenue, lump sum insurance policy settlements, capital gains or losses, receipts from the sale of property or belongings, loan repayments, property tax rebates or refunds of pension contributions. For the 2016 Census the reference period is the calendar year 2015 for all income variables. For the 2021 Census the reference period is the calendar year 2020 for all income variables.

9) Private household refers to a person or a group of persons (other than foreign residents) who occupy the same dwelling and do not have a usual place of residence elsewhere in Canada. It may consist of a family group (census family) with or without other persons, of two or more families sharing a dwelling, of a group of unrelated persons, or of one person living alone. Household members who are

Appendix 13-B11: Household Income for the Local Study Area (LSA), Northern Saskatchewan (RSA), and Saskatchewan, 2005, 2010, 2015, and 2020

	La Plonge 192, Indian Reserve(1,2,3,4)	Wapachewunak 192D, Indian Reserve(1,2,3,4)	Patuanak, Northern Hamlet(1,2,3,4)	Pinehouse, Northern Village(1,2,3,4)	Beauval, Northern Village(1,2,3,4)	LSA(1,2,3,4,5,6)	Northern Saskatchewan (RSA)(1,2,3,4,7)	Saskatchewan(1,2,3,4)
Average Income for Private Households (Before Taxes)(8)								
2005	$0	$41,344	$0	$48,476	$51,224	$47,903	$45,871	$59,455
2010	$0	$53,020	$0	$67,652	$57,539	$60,237	$59,283	$77,317
2015	$0	$60,621	$0	$88,965	$98,027	$83,231	$71,111	$93,942
2020	$0	$67,000	$0	$88,000	$99,000	$86,243	$86,800	$99,800
Household income of private households								
2005	-	145	-	240	245	630	9,250	387,145
2010	-	155	-	240	245	640	9,935	409,575
2015	-	185	-	265	180	630	10,235	432,620
2020	-	180	-	265	235	680	10,475	449,580

Source: Statistics Canada 2006, 2011, 2016a, and 2021.

Footnotes:

1) Data have been subjected to a confidentiality procedure known as random rounding whereby values are rounded either up or down to a multiple of 5, and in some cases 10. Totals may not add up due to rounding.
2) In addition to random rounding, area and data suppression has been adopted to further protect the confidentiality of individual respondents' personal information. Area and data suppression results in the deletion of all information for geographic areas with populations below a specified size. For example, areas with a population of less than 40 persons are suppressed. If the community searched has a population of less than 40 persons, only the total population counts will be
3) Income variables do not account for inflation.
4) Personal income variables were derived from 25% sample data. However, on Indian Reserves and in remote communities, attempts are made to obtain data from 100% of the population.
5) Local Study Area (LSA) includes La Plonge 192, Wapachewunak 192D, Patuanak, Pinehouse Lake, and Beauval. However, data is not available for La Plonge 192 and Patuanak.
6) Local Study Area (LSA) average total income among recipients is calculated based on the weighted average of number of income groups with income and Average household income of the Indian Reserves, hamlet, and villages where data available.
7) North Saskatchewan (RSA) is defined as Census Division No.18.
8) Total income (i.e. personal income) refers to the total money income received during the calendar year prior to the Census year. Sources of income are: wages and salaries, net farm income; net non-farm income from unincorporated business and/or professional practice; child benefits; Old Age Security pension and Guaranteed Income Supplement; benefits from Canada Pension Plan or Quebec Pension Plan; benefits from Employment Insurance; other income from government sources; dividends, interest on bonds, deposits and savings certificates and other investment income; retirement pensions, superannuation and annuities, including those from RRSPs and RRIFs; and other money income. Not included in all Census years as total income: income tax refunds, lump sum inheritance payments, gambling revenue, lump sum insurance policy settlements, capital gains or losses, receipts from the sale of property or belongings, loan repayments, property tax rebates or refunds of pension contributions. For the 2021 Census, for example, the reference period is the calendar year 2020 for all income variables.

Appendix 13-B12: Total Income Sources for the Local Study Area (LSA), Northern Saskatchewan (RSA), and Saskatchewan, 2015 and 2020

	2020 Total Income Sources																							
	La Plonge 192, Indian Reserve(6)			Wapachewunak 192D, Indian Reserve(6)			Patuanak, Northern Hamlet(6)			Pinehouse, Northern Village(6)			Beauval, Northern Village(6)			LSA(3,4,6)			Northern Saskatchewan (RSA)(5,6)			Saskatchewan(6)		
	Total	Male	Female	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity
Number of employment income recipients aged 15 years and over in private households - 25% sample data	0	0	0	190	180	10	0	0	0	345	315	30	425	385	35	960	880	75	12,665	9,680	2,985	622,685	73,275	549,415
Number of government transfers recipients aged 15 years and over in private households - 25% sample data	0	0	0	370	365	0	0	0	0	570	540	30	530	485	45	1470	1390	75	21,330	17,735	3,595	751,480	108,395	643,085
Employment Income (1)	-	-	-	48.0%	47.0%	80.0%	-	-	-	53.2%	48.0%	90.0%	61.6%	61.6%	60.0%	55.9%	53.7%	87.5%	56.8%	51.3%	70.8%	65.8%	59.5%	66.4%
Government Transfer Payments (2)	-	-	-	47.6%	48.8%	0.0%	-	-	-	44.0%	49.6%	7.0%	34.8%	35.6%	28.0%	41.6%	44.5%	7.0%	36.2%	44.8%	14.0%	17.8%	33.5%	16.0%
Other	-	-	-	4.4%	4.2%	20.0%	-	-	-	2.8%	2.4%	3.0%	3.6%	2.8%	12.0%	2.5%	1.7%	5.5%	7.0%	3.9%	15.2%	16.4%	7.0%	17.6%

	2015 Total Income Sources																							
	La Plonge 192, Indian Reserve(6)			Wapachewunak 192D, Indian Reserve(6)			Patuanak, Northern Hamlet(6)			Pinehouse, Northern Village(6)			Beauval, Northern Village(6)			LSA(3,4,6)			Northern Saskatchewan (RSA)(5,6)			Saskatchewan(6)		
	Total	Male	Female	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity	Total	Indigenous identity	Non-Indigenous identity
Number of employment income recipients aged 15 years and over in private households - 25% sample data	0	0	0	220	210	15	0	0	0	440	400	45	315	295	20	975	905	80	13,830	10,575	3,255	636,950	72,005	564,945
Number of government transfers recipients aged 15 years and over in private households - 25% sample data	0	0	0	330	320	0	0	0	0	520	495	20	325	290	30	1175	1105	50	19,080	16,715	2,360	549,500	85,515	463,980
Employment Income (1)	-	-	-	71.7%	70.2%	99.1%	-	-	-	76.7%	73.6%	99.0%	78.4%	79.1%	-	76.1%	74.6%	99.0%	71.9%	67.6%	80.6%	73.4%	73.6%	73.4%
Government Transfer Payments (2)	-	-	-	25.1%	27.0%	0.0%	-	-	-	19.7%	22.0%	3.0%	15.8%	15.2%	-	20.1%	21.7%	3.0%	21.8%	28.6%	7.8%	10.5%	19.9%	9.6%
Other	-	-	-	3.2%	2.8%	0.9%	-	-	-	3.6%	4.4%	0.0%	5.8%	5.7%	-	3.7%	3.7%	0.0%	6.3%	3.8%	11.6%	16.1%	6.5%	17.0%

Source: Statistics Canada 2016a and 2021.

Footnotes:

1) Employment income - All income received as wages salaries and commissions from paid employment and net self-employment income from farm or non-farm unincorporated business and/or professional practice during the reference period. For the 2016 Census the reference period is the calendar year 2015 for all income variables. For the 2021 Census the reference period is the calendar year 2020 for all income

2) Government transfers - All cash benefits received from federal provincial territorial or municipal governments during the reference period. It includes: Old Age Security pension Guaranteed Income Supplement Allowance or Allowance for the Survivor; Retirement disability and survivor benefits from Canada Pension Plan and Québec Pension Plan; Benefits from Employment Insurance and Québec parental insurance plan; Child benefits from federal and provincial programs; Social assistance benefits; Workers' compensation benefits; Working income tax benefit; Goods and services tax credit and harmonized sales tax credit; Other income from government sources. For the 2016 Census the reference period is the calendar year 2015 for all income variables.

3) Local Study Area (LSA) includes La Plonge 192, Wapachewunak 192D, Patuanak, Pinehouse Lake, and Beauval. However, data is not available for La Plonge 192 and Patuanak.

4) Local Study Area (LSA) Employment income and government transfer payments are calculated based on the weighted average of number of employment income and government transfers receipents of the Indian Reserves, hamlet, and villages where data available.

5) North Saskatchewan (RSA) is defined as Census Division No.18.

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Final Environmental Impact Statement

November 2024

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ASSESSMENT OF ACCIDENTS AND MALFUNCTIONS - TECHNICAL SUPPORTING DOCUMENT FOR THE WHEELER RIVER PROJECT

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EXECUTIVE SUMMARY

Proposed Project

The Denison Wheeler River Project (Wheeler or the Project) is a proposed uranium mine and processing plant in northern Saskatchewan, Canada. The Project is located in a relatively undisturbed area of the boreal forest about 4 km off of Highway 914 and approximately 35 km north-northeast of the Key Lake uranium operation. The deposit will be mined via In Situ Recovery (ISR) that involves injecting a low-pH mining solution into the uranium deposit through a series of cased drill holes (injection wells) and subsequently pumping the uranium-rich solution to surface through recovery wells. Once on surface, the uranium rich mining solution recovered from the wellfield will be pumped to the on-site processing plant. Inside the processing plant a relatively simple precipitation process will be used to separate the uranium from the mining solution. Once separated, the uranium will be dried, packaged and trucked off site, destined for eventual use in a nuclear power plant. The main phases of the Project are construction, operation, decommissioning, and post-decommissioning. Construction would last for approximately three years; production activities would commence following commissioning of the facilities and would last 15 years with a production rate of up to 12 M lbs U3O8 per year. Decommissioning is expected to last for five years and post-decommissioning a further 15 years.

Scope and Objective

The scope of this assessment includes consideration of potential accidents and malfunctions within the context of the key Project components that define the Project scope for the purposes of the Environmental Assessment.

The objective of the assessment is to evaluate the potential human health or biophysical environmental effects resulting from radiological and conventional accidents and malfunctions in consideration of proposed environmental protection measures.

Assessment Methodology The assessment of accidents and malfunctions is designed to provide a clear definition of the potential Project-associated hazards that fall outside the range of "typical" day-to-day events and to provide a framework for quantifying the risks associated with these hazards.

The four basic steps in the process of risk assessment for the accidents and malfunctions assessment are as follows:

- Hazard identification / bounding scenario: the identification of physical situations with the potential for harming the human health or biophysical environment. In this study, "Hazards" and "Accidents and Malfunctions" are used interchangeably. The hazards are identified for several potential events, such as releases of chemical and radiological constituents, fires, and explosions. Identification of bounding scenarios involve initial screening of the hazard scenarios and selection of bounding scenarios that encompass the risk of scenarios screened in each category. This completion of this step was documented Wheeler River ISR Project Hazard Identification Report (Appendix A). Section 5.0 describes the selected bounding scenarios.

- Assessment of probabilities: the estimation of the probability of occurrence of the scenario occurring within a specific time period or in specified circumstances. Section 7.0 includes the assessment of probabilities. This section considers the existing preventive and mitigative measures (provided in Section 4.0) put in place to manage the risk.

- Assessment of potential effects: the identification of the effects of a hazard on human health or biophysical environment. Section 8.0 includes the assessment of potential effects.

- Risk estimation and ranking: the estimation of the consequences of a scenario and the probability with which it is likely to occur; that is, risk is the product of consequence and probability (risk = consequence × probability of occurrence). Section 9.0 provides summary and risk estimation for the selected bounding scenarios.

For reference, the temporal and spatial extents of the assessment are as follows:

- The temporal extent of the evaluation includes all mine and mill life-cycle phases – construction, operations, decommissioning, and post-decommissioning.

- The spatial extent of the evaluation includes the Project site and the site access road. Three off-site scenarios, involving a release to water (Scenarios 1 and 2) and ground (Scenario 7) that would have the potential to affect a temporary community of interest camp along the mine-related transportation route were also considered. These scenarios were developed with the Denison team and reflected the result of and input from Denison's interested party engagement activities. It is noted that the primary transportation route for the Project includes approximately 380 km of publicly accessible gravel highway (110 km of Highway 165 and 270 km of Highway 914). Focussing the assessment on the locations of interest to Interested Parties along the route is a practical means by which to conduct the assessment. The accident and malfunctions scenarios described herein, related to transportation of Project-related goods and services at the locations of interest, can generally be interpreted as being representative of similar locations along the transport route.

<u>Hazard Identification and Screening</u>

A total of 70 hazard scenarios were identified and evaluated.

Five of the hazard scenarios characterized as high-risk, three of which are recommended for further assessment. The two high-risk scenarios that were not recommended for further detailed assessment are associated with occupational fatalities for the site preparation activities. These scenarios have not been advanced since it is assumed that the Denison health and safety program will be "best practice" and therefore in these cases the risk is considered ALARP (as low as reasonably practical).

Twenty-one of the scenarios evaluated were characterized as moderate-risk scenarios. Of these twenty-three, nineteen of the moderate-risk scenarios were deemed to represent a tolerable level of risk in consideration of proposed safeguards and design features that reduce the risk level to ALARP. Four moderate / ALARP-moderate scenarios require further detailed assessment for more accurate characterization of risk. The four moderate risk scenarios that are subsequently assessed in more detail are associated with a contaminant release to the environment whose potential effects maybe may be more far reaching than can adequately assessed by the screening assessment and therefore additional more quantitative evaluation is appropriate.

The balance of the scenarios evaluated, 44, were characterized as low-risk scenarios, based on low likelihood of occurrence and/or consequence in consideration planned existing safeguards and design features. Low-risk scenarios are not carried forward for more detailed analysis as they are adequately characterized by the screening process.

<u>Bounding Scenarios</u>

As indicated above, six hazard scenarios were selected as bounding scenarios for more detailed risk analysis (Table ES-1). Herein, a bounding scenario is used to represent an event whose potential consequences are considered to represent those associated with other accident and malfunction scenarios; or, alternatively, the potential consequences of scenarios that are bounded by another are expected to fit within the envelope of those associated with the bounding scenario. Utilizing the bounding scenario approach makes it possible to avoid duplication in the evaluation process while at the same time ensuring the evaluation is completed in a conservative manner.

Table ES-1: Bounding Scenarios Identified for Further Assessment by the Hazard Identification Process

No.	Potential Accident or malfunction	Project Phase	Potential Effect Pathway
1	Vehicle accident including rollover, collision, run off road	Op	Aquatic release of radioactivity
2	Vehicle accident including rollover, collision, run off road	Co / Op / De	Aquatic release of fuel, hazardous chemicals and reagents
3	Loss of freeze capacity	Op	Loss of freeze wall and secondary underground containment
4	Failure of freeze wall	Op	Loss secondary underground containment and groundwater contamination
5	Process vessel and piping system failure	Op	Release of radon from storage tank
6	Facility fire / explosion	Op	Release of radioactivity and uranium concentrate powder to atmosphere
7	Vehicle accident including rollover, collision, run off road	Co / Op / De	Terrestrial release of radioactivity and chemicals

Notes: Red and yellow shading indicates high and moderate risk scenarios, respectively. "Effect Pathway" describes nature of the event and therefore the nature of the assessment of consequence. C = Construction, O = Operation, and De = Decommissioning.

Assessment of Potential Effects of the Bounding Scenarios

Detailed assessment of the seven bounding scenarios was considered in terms of both probability and consequence to determine an overall level of risk. The results of the assessment are summarized in Table ES-2. As can be seen, the more rigorous assessment has shown that the risk of the selected bounding scenarios is low to moderate. No high-risk scenarios have been identified.

Table ES2 Bounding Scenarios Probability, Consequence, and Risk Ranking

No.	Potential Accident /or Malfunction	Potential Effect pathway	Probability	Effect Severity	Overall Risk Rating[1]
1	Vehicle accident including rollover, collision, run off road	Aquatic release of radioactivity	Highly unlikely	Moderate	Low
2	Vehicle accident including rollover, collision, run off road	Aquatic release of fuel, hazardous chemicals and reagents	Unlikely	Moderate	Low
3	Loss of freeze capacity	Loss of freeze wall and secondary underground containment	Highly unlikely	Major	Moderate
4	Failure of freeze wall	Loss secondary underground containment and groundwater contamination	Highly unlikely	Major	Moderate
5	Process vessel and piping system failure	Release of radon from storage tank	Likely	Minor	Low
6	Facility fire / explosion	Release of radioactivity and uranium concentrate powder to atmosphere	Highly unlikely	Moderate	Low
7	Vehicle accident including rollover, collision, run off road	Terrestrial release of radioactivity and chemicals	Unlikely	Minor	Low

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Abbreviations

Acronym	Definition
ac	aqueous
AEGL	Acute Exposure Guideline Level
ALARP	As low as reasonably practicable
ALOHA	Areal Locations of Hazardous Atmospheres
ARF	airborne release fraction
ATSDR	Agency for Toxic Substances and Disease Registry
CNSC	Canadian Nuclear Safety Commission
DOE	Department of Energy
DR	damage ratio
EPA	Environmental Protection Agency
ERA	environmental risk assessment
ERAP	Emergency Response Assistance Plans
ERPG	Emergency Response Planning Guideline
GEIS	Generic Environmental Impact Statement
HDPE	high density polyethylene
ISR	In Situ Recovery
LPF	leak path factor
MAR	material at risk
NPAG	non-potentially acid generating
NRC	Nuclear Regulatory Commission
OECD	Organisation for Economic Co-operation and Development
PAC	Protective Action Criteria
PAHs	polyaromatic hydrocarbons
Project	Wheeler River Project
RF	respirable fraction
REGDOC	Regulatory Document
TDG	Transportation of Dangerous Goods
TEEL	Temporary Emergency Exposure Limit
UOC	uranium ore concentrate
WTP	Water treatment plant

Units of Measure

Units	Definition
%	percent
µg/L	micrograms per litre
µm	micrometre
Bq/g	becquerels per gram
Bq/L	becquerels per litre
cm	centimetre
cm/s	centimetres per second
g/cm^3	grams per cubic centimetre
g/m^3	grams per cubic metre
g/s	grams per second
gal	imperial gallon
GBq	giga-becquerels
GBq/h	giga-becquerels per hour
kg	kilogram
kg/d	kilograms per tonne
kg/m^3	kilograms per cubic metre
kg/t	kilograms per tonne
h	hour
ha	hectare
km	kilometre
km^2	square kilometres
km/h	kilometres per hour
L	litre
$L/(m^2/s)$	litres per square metre per second
L/s	litres per second
m	metre
m/s	metres per second
m^2	square metres
m^3	cubic metres
m^3/d	cubic metres per day
m^3/hr	cubic metres per hour

Units	Definition
m^3/s	cubic metres per second
m^3/yr	cubic metres per year
masl	metres above sea level
mg/L	milligrams per litre
mg/m^3	milligrams per cubic metre
MBq	mega-becquerels
MBq/h	mega-becquerels per hour
mil	millimetre
min	minute
mm	millimetre
mm/°C/day	millimetres per degree day
mm/yr	millimetres per year
ppm	parts per million
t	tonne
t/d	tonnes per day
t/h	tonnes per hour
uswg	U S Water Gallon

1.0 INTRODUCTION

EcoMetrix Incorporated (EcoMetrix) was retained by Denison Mines Corp. (Denison) to complete the accidents and malfunctions (A&M) assessment for the Wheeler River Project as part of the environmental assessment process. The Project is a proposed in-situ recovery (ISR) uranium operation in Saskatchewan. This report details that assessment.

1.1 Overall Scope and Objective of the Assessment

The scope of this assessment includes consideration of potential accidents and malfunctions within the context of the key Project components that define the Project scope for the purposes of the Environmental Assessment.

The objective of the assessment is to evaluate the potential human health or biophysical environmental effects resulting from radiological and conventional accidents and malfunctions in consideration of proposed environmental protection measures.

1.2 Background Information

The Denison Wheeler River Project (Wheeler or the Project) is a proposed uranium mine and processing plant in northern Saskatchewan, Canada. The Project is located in a relatively undisturbed area of the boreal forest about 4 km off of Highway 914 and approximately 35 km north-northeast of the Key Lake uranium operation. The deposit will be mined via ISR that involves injecting a low-pH mining solution into the uranium deposit through a series of cased drill holes (injection wells) and subsequently pumping the uranium-rich solution to surface through recovery wells. Once on surface, the uranium rich mining solution recovered from the wellfield will be pumped to the on-site processing plant. Inside the processing plant a relatively simple precipitation process will be used to separate the uranium from the mining solution. Once separated, the uranium will be dried, packaged and trucked off site, destined for eventual use in a nuclear power plant. The main phases of the Project are construction, operation, decommissioning and post-decommissioning. Construction would last for approximately three years, production activities would commence following commissioning of the facilities and would last 15 years with a production rate of up to 12 M lbs U_3O_8 per year. Decommissioning is expected to last for five years and post-decommissioning a further 15 years.

Further Project-related information is provided in **Section 2.0**, Project Information.

1.3 Regulatory Context to the A&M Assessment

For the purpose of this assessment, accidents and malfunctions refer to events or conditions that are not part of any activity or normal operation of the Project as proposed by Denison Mines Corp. (Denison). This is consistent with the definition of an accident as described in REGDOC 3.6, "… *any unintended event, including operating errors, equipment failures, and other mishaps, the consequences, or potential consequences of which are significant from the point of* *view of protection or safety*" (CNSC 2021). Despite rigorous planning and the implementation of best practices and preventative measures, the potential exists for accidents and malfunctions to occur during any Project phase. If such unplanned events or conditions occur, adverse effects on human health or the biophysical environmental could result if not addressed or responded to in an appropriate manner.

Federal guidance concerning the assessment of accidents and malfunctions is provided in Canadian Nuclear Safety Commission (CNSC) REGDOC-2.9.1: Environmental Protection: Environmental Principles, Assessments and Protection Measures (CNSC 2020). Specific considerations regarding the scope of such assessments are described in REGDOC-2.9.1, which indicates that the Environmental Impact Statement should provide an assessment of potential health and environmental effects resulting from postulated radiological and conventional malfunctions and/or accidents. The Environmental Impact Statement should also include any mitigation measures such as monitoring, contingency, clean up, or restoration work in the surrounding environment that would be required during or immediately following the postulated malfunction and accident scenarios (CNCS 2020).

Section 5.4 of the Transportation of Dangerous Goods Regulations (Government of Canada 2021) sets out the requirements for the loading and securing of dangerous goods to prevent damage to the container or to the means of transport that could lead to an accidental release. Sections 8 of the Transportation of Dangerous Goods Regulations is relevant to accidental release and accidental release reporting requirements.

The provincial mandate is less specific than that provided within CNSC REGDOC-2.9.1. Both the technical proposal guidelines (Government of Saskatchewan 2014a) and the guidelines for the preparation of the terms of reference (Government of Saskatchewan 2014b) that have been prepared by the Environmental Assessment Branch of the Ministry of Environment under the Saskatchewan Environmental Assessment Act make reference to addressing effects associated with accidents and malfunctions that may occur during all Project phases within the Environmental Impact Statement submission. Denison has included these commitments in the Project's Terms of Reference (Denison 2019).

1.4 Report Format

Following this introductory section, the remainder of this report is organized as follows:

- **Section 2.0**: provides Project-related information;
- **Section 3.0**: describes the methodology for the accidents and malfunctions assessment;
- **Section 4.0**: presents general considerations and context for the accident and malfunctions assessment;
- **Section 5.0**: provides the description of the bounding scenarios identified through the initial hazards identification and screening process (see Appendix A);
- **Section 6.0**: provides the chemical, occupational, and radiological benchmarks used to facilitate the quantitative assessment of identified bounding scenarios;

- **Section 7.0**: presents the assessment of probabilities of the bounding scenarios;
- **Section 8.0**: presents the assessment of the potential effects of the bounding scenarios on the environment;
- **Section 9.0**: provides a summary of the overall estimate of risks from bounding accidents and malfunctions scenarios.
- **Section 10.0**: provides a list of references cited in this report.

The detailed hazard identification evaluation that was completed in support of this assessment is provided in **Appendix A**. The hazard identification evaluation is used to identify a comprehensive list of potential accident and malfunction scenarios that may occur in consideration of Project-related work processes and activities, screen these scenarios as to potential risks and, based on this screening, recommend scenarios that could pose a relative high risk that should be carried forward for more detailed consideration. It is noted that the hazard identification evaluation focusses on risks to the human health or biophysical environment.

2.0 PROJECT INFORMATION

2.1 Project Location

The Project would be located in northern Saskatchewan about 4 km off of Highway 914 and approximately 35 km north-northeast of the Key Lake uranium operation (**Figure 2-1**).

The Project site plan and the facility layout are shown in **Figure 2-2** and **Figure 2-3**, respectively.

Figure 2-1: Location of the Wheeler River Project Site in Saskatchewan

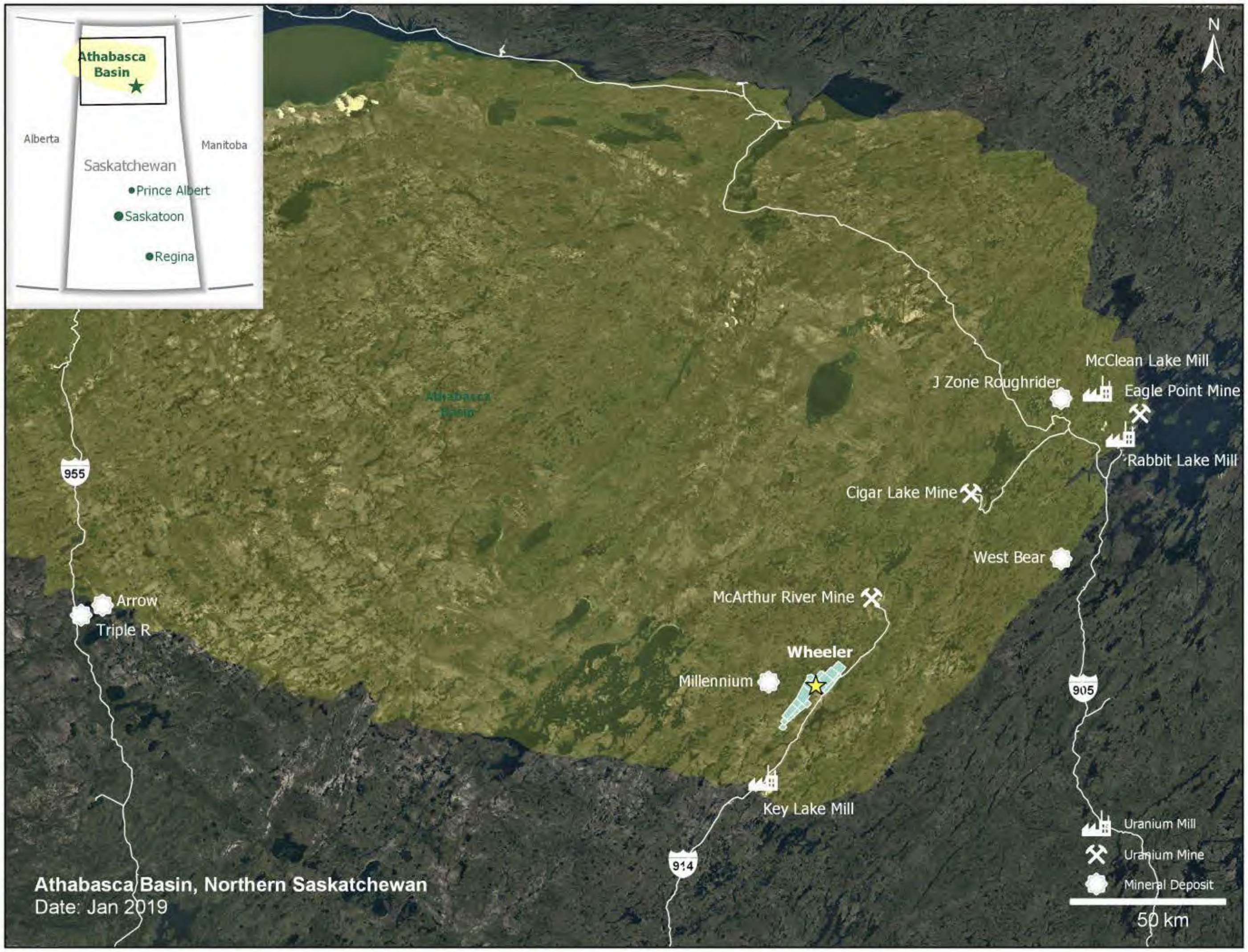


Figure 2-2: Wheeler River Project Site Plan Overview

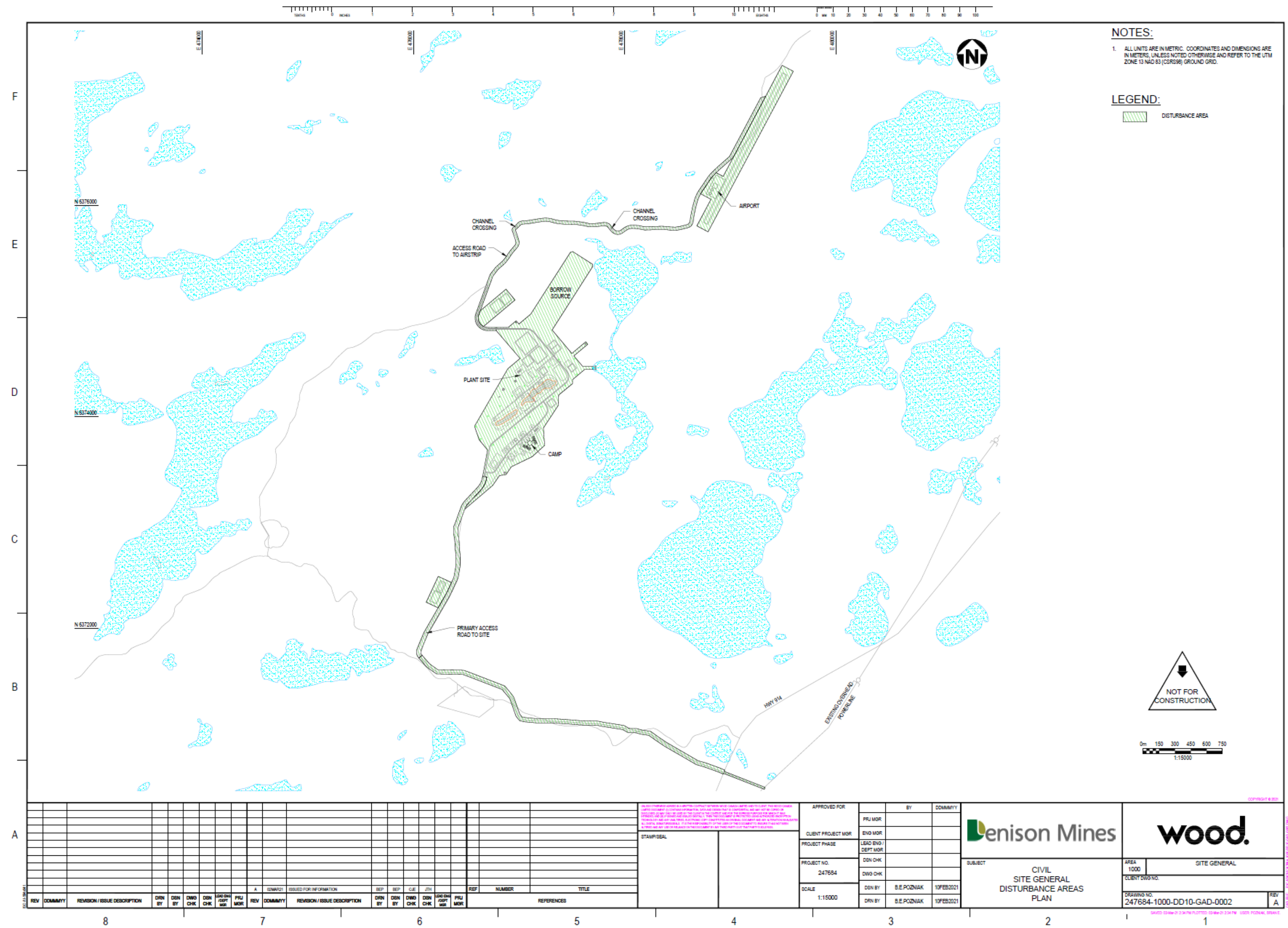
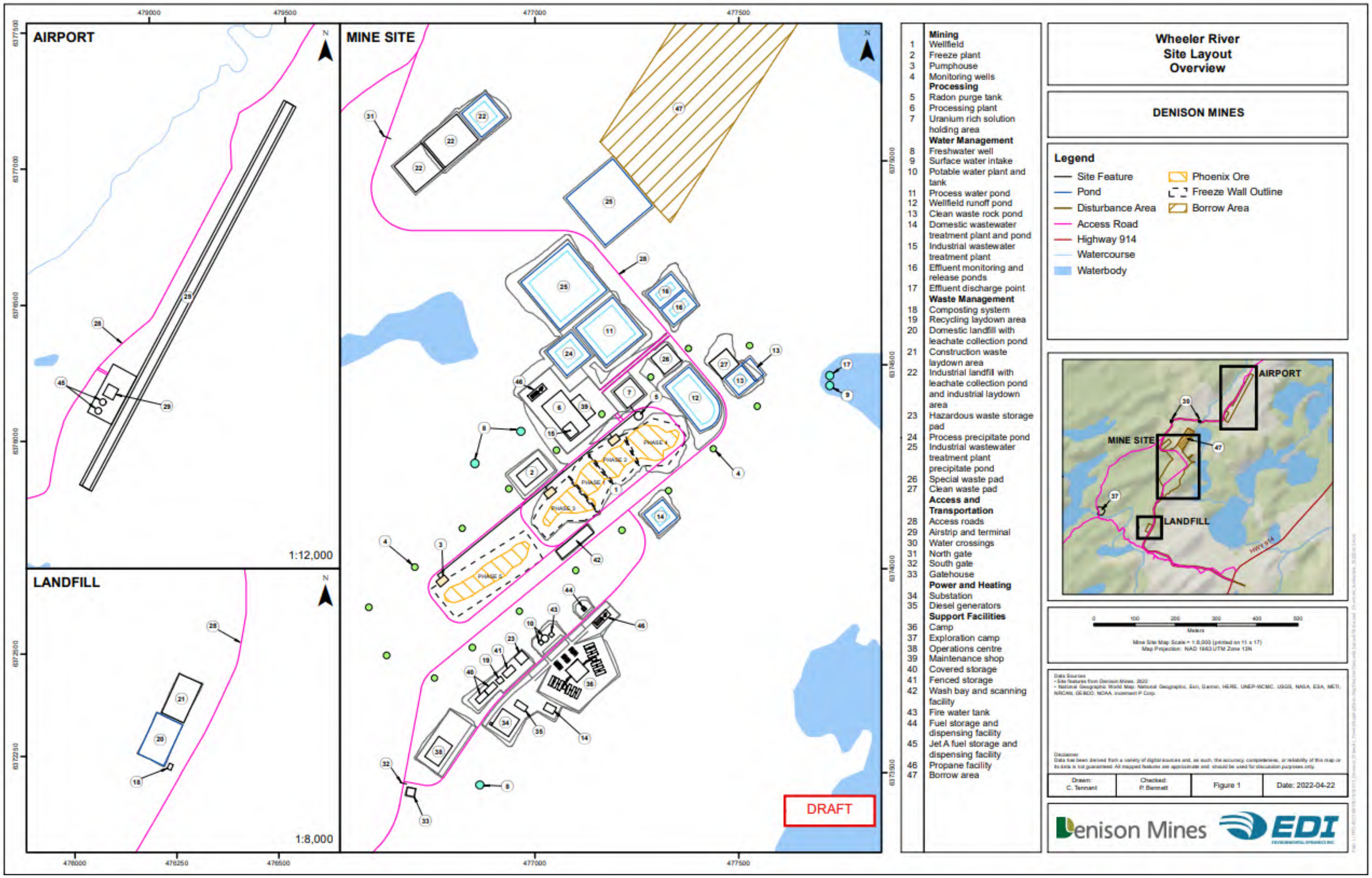


Figure 2-3: Wheeler River Project Facility Layout



2.2 Project Details and Components

As indicated in **Section 1.2**, the Project includes four principal phases: construction, operations, decommissioning and post-decommission. These project phases are summarized in **Table 2-1**.

Table 2-1: Key Wheeler River Project Phases Description

Phase	Duration	Description
Construction	3 years	• Development of access roads and air strip • Site preparation and earthworks; clearing, levelling, and grading of the Project Area • Power generation – generators • Installation of main substation and distribution of power around site • Wellfield and freeze hole drilling; ground freezing • Batch plant operation (concrete); crusher at borrow area • Development of surface infrastructure (camp, operations centre, plants, ponds, pads, and support facilities) • Waste management (composting, domestic and industrial landfill operation, recycling) • Water management (including treatment and site runoff) • Groundwater supply • Surface water withdrawal • Fuel management (e.g., propane for comfort heating; vehicle and aircraft fuel) • On-site and off-site operation of vehicles and transport of materials • Air transportation for workers • Regulatory site inspections • Engagement – site visit from Interested Parties
Operation	15 years	• Operation of the ISR wellfield • Wellfield and freeze wall drilling • Operation and expansion of freeze wall • Batch plant operation (grout and cement); crusher at borrow area • Expansion of pond and pads • Operation of the processing plant and production of uranium concentrate • Water withdrawal from groundwater or surface water body • Management of surface water (including seepage and site runoff) • Water treatment, both domestic and industrial

Phase	Duration	Description
		• Water release to surface water body • Waste management (composting, domestic and industrial landfill operation, recycling) • Hazardous waste management (temporary storage, handling, and off-site transportation) • Storage and disposal of drill waste rock, process precipitates, and industrial wastewater treatment plant precipitates • On-site and off-site operation of vehicles and transport of materials • Power supply – primarily power from the grid, also generators and back-up generators • Package and transport of nuclear substances • Fuel management (e.g., propane for comfort heating; vehicle and aircraft fuel) • Air transportation for workers • Progressive decommissioning and reclamation • Regulatory site inspections • Engagement – site visit from Interested Parties
Decommissioning	5 years	• Site water management, treatment, and release • Mining horizon remediation and thawing of freeze wall • Process water treatment and release • Closure of ISR and freeze wells and related infrastructure • Decontamination of surface facilities and injection, recovery, and monitoring wells • Asset removal (including site power transmission lines and electrical infrastructure) • Demolition and disposal of non-salvageable surface infrastructure and materials • Remediation of contaminated areas (wellfield, pads, ponds, domestic wastewater treatment location, and process plant area) • Power generation – generators • Waste management (composting and landfill operation) • Decommissioning of landfills; hazardous materials management (temporary storage and off-site disposal) • On-site and off-site operation of vehicles and transport of materials • Reclamation of disturbed areas • Regulatory site inspections

Phase	Duration	Description
		• Engagement – site visit from Interested Parties
Post-Decommissioning	15 years	• Environmental monitoring • Regulatory site inspections • Engagement – site visit from Interested Parties

Further to the description of Project phases provided in Table 2-1, key project details and components are highlighted in Table 2-2 and in the report subsections that follow.

Table 2-2: Key Wheeler River Project Details and Components

Item	Details
Access Road	A seven-kilometer section of road from highway 914 to the Wheeler site and a five-kilometer section of the road from the Wheeler site to the airstrip.
Air Strip	A 1,600 m long airstrip is positioned in a natural and relatively flat valley to the northeast of the Wheeler site including a terminal building and two double-walled Jet A fuel tanks.
Site Works	Site works includes site preparation, construction, equipment installation and decommissioning activities.
Orebody and Wellfield	The Phoenix deposit, the highest-grade undeveloped uranium deposit in the world, is geologically situated at or immediately above the unconformity between the Athabasca Basin sandstone and older basement rocks, approximately 400 metres below surface. The ISR wellfield is a group of wells, installed and completed in an area of uranium mineralized within the Phoenix deposit. The wellfield includes the piping and pumping systems, as well as monitoring wells.
Freeze Wall	The freeze wall would be established by drilling parallel cased holes from surface, anchoring into the impermeable basement rock and would be constructed to surround the mining horizon, from bedrock to surface. The freeze wall would be established in stages, consistent with the mining schedule. The freeze plant will be constructed on surface based on a modular design for easy installation and operation.
Processing Plant	The processing plant includes pH adjustment, impurities removal, uranium precipitation, uranium concentrate dewatering/drying and packaging, and mining solution refortification.
Accommodation Facility	The accommodation facility will be sized to accommodate a peak load of about 100-150 individuals during operations.
Operations Centre	The operations complex will be a standalone, multi-functional building that will serve the administrative, technical, and maintenance needs of the site.
Security Houses and Truck Scales	The security and truck scale buildings will be modular, prefabricated units that will be manufactured off-site and shipped to site for installation and commissioning.
Wash Bay and Scanning Facility	A wash bay will be available to clean items, equipment and vehicles that may have been in contact with potential contaminants.

Item	Details
Power Supply	Primary Power Supply to the site will be provided via an approximate 5 km extension tap from the existing 138 kV overhead transmission line that runs along Highway 914. Emergency diesel generator will serve as the back-up power supply.
Site Runoff Management	The site runoff management will include the runoff from waste pads and clean waste rock pads and other site runoff.
Fresh Water Supply and Distribution	Fresh water will be sourced from either a shallow groundwater well or an intake from a nearby surface water body to supply the fire water system, potable water, processing plant, wash bay, and temporary batch plant.
Potable Water Treatment Plant	Potable water will be generated on site by a prefabricated modularized (40 ft shipping container) potable Water Treatment Plant (WTP) comprised of a treatment plant, a 2,000 L storage tank, and a bottle filling station.
Sewage Treatment Plant	The sewage treatment plant will be a modular facility comprised of two heated and insulated units (likely containers), a holding tank, ancillary filtration, ancillary treatment process equipment, and sludge handling system.
Water Treatment Plant	The WTP will be designed to treat any contaminated water removed from the ISR process (e.g., backwash of sand filters, bleed solution), runoff collected from the waste pad, and any other contact water such as water from the wash bay and process sumps. The WTP will be located inside of the processing plant.
Landfill and Compost	The inert non-hazardous wastes such as wood and plastics will be disposed in an on-site landfill and food waste will be composted.
Waste Pad and Ponds	the waste pad is expected to contain mineralized drill cuttings from wellfield development, solid impurities (mainly iron and/or radium) removed from the uranium rich mining solution, and dewatered reject solids from the sewage and water treatment processes.
Clean Waste Pad and Ponds	Clean waste rock will be stored on an unlined pad and can be used for road or concrete construction.
Hazardous Substance Storage and Dispensing	Hazardous substance storage will include liquid Fuel Storage and Dispensing Facility, propane facility, and other hazardous substances including sulphuric acid, hydrogen peroxide, sodium hydroxide, barium chloride and flocculants

2.2.1 Access Road

Mainland access to the site will be from Highway 914. An assessment of several routes was completed and considered factors such as: safety, environment (total disturbance), capital costs and risk. In addition, specific workshops were held in the Indigenous and non-Indigenous communities to capture community input into the final route selection. After the engagement process and using community input, the preferred route was selected and incorporated into the current Project design. A seven-kilometer (7 km) section of road will be constructed from the highway to the Wheeler site and a five kilometer (5 km) long road will also be constructed from the Wheeler site to the airstrip; the total road length is twelve kilometers (12 km). Additional site roads will include a service loop to the camp and a short service road to the runoff pond and the potential treated effluent discharge point. The development of the access road options considered distance from waterbodies among other factors. Denison anticipates the need for installation of two water crossings over the Icelander River along the section of the road from the Wheeler site to the airstrip.

2.2.2 Airstrip

A 1,600 m long airstrip is proposed to be positioned in a natural and relatively flat valley to the northeast of the Wheeler site. The magnetic headings are 03/21, which is similar to both the Collins Bay airport and Key Lake airstrip. The runway has been designed to accommodate the aircraft presently used by existing mining operations in northern Saskatchewan to transport personnel into and out of site. The approach line to the airstrip from the southwest clears the Wheeler surface facilities by 500 m. An airstrip terminal building and two double-walled Jet A fuel tanks, to provide site service to aircraft as required, will be constructed near the airstrip. The airstrip and terminal will not be connected to the substation; a small diesel genset will be used to provide terminal building services, communications, and runway lighting.

2.2.3 Site Works

The site works associated with the implementation of the Project include:

- Site preparation.
- Road construction.
- Installation of piping.
- Building construction.
- Construction of ponds and pads.
- Installation of process equipment.
- Construction of utility systems.
- Batch plant operation.
- Mining horizon remediation.
- Decontamination.
- Asset removal.
- Demolition and disposal.
- Reclamation.

2.2.4 Orebody and Wellfield

Several areas of uranium mineralization amendable to ISR have been defined at Wheeler, with the most prominent area being the Phoenix deposit. Phoenix is the highest-grade undeveloped uranium deposit in the world. It is geologically situated at or immediately above the unconformity between the Athabasca Basin sandstone and older basement rocks, approximately 400 metres below surface.

The ISR wellfield is a group of wells, installed and completed in an area of uranium mineralized (**Figure 2-3**). The Wheeler wellfield will consist of a combination of injection and recovery wells, potentially in the general arrangement of one recovery well in the centre surrounded by 6 to 8 injection wells. At surface, the spacing between the recovery well and each injection well is anticipated to be roughly 10 metres apart, with certain areas requiring closer spacing (approximately 5 meters) or further spacing (approximately 15 metres). With these configuration options, the final wellfield for Phoenix is expected to include approximately 310 wells over a 90 m x 900 m area.

Wellfield piping system will transport the mining solution to and from the processing plant. The flow rates and pressures of the individual well lines will be monitored in the pumphouses. This data will be transmitted to the processing plant for remote monitoring through a master control system. Through the master control system, operators will be capable of controlling pumphouse production lines remotely.

Double-walled high-density polyethylene (HDPE), or equivalent, piping will be used in the wellfields and will be designed and selected to meet design operating and environmental conditions. The lines from the processing plant, pumphouses, and individual well lines will be freeze protected and secured to minimize pipe movement.

Based on the current designs for the Project, approximately three pumphouses will be needed. A pumphouse is a small building or container on surface where pipes from injection and recovery wells are operated and flows of mining solution are monitored.

Pumphouses will contain pumps and equipment that will distribute the mining solution to the injection wells, as well as collect the uranium rich mining solution from the recovery wells. Each pumphouse will be connected to two production trunk lines. One of the trunk lines will be used for receiving mining solution from the processing plant, and the other will be used for returning uranium rich mining solution back to the processing plant. Each pumphouse will include a manifold, valves, flow meters, pressure meters, and instrumentation, as required, to fully operate, monitor and control the process. Pumphouse control monitoring systems enable operators to individually adjust each recovery or injection well as well as allow for sampling. Operators can also use the master control system in the processing plant to remotely control pumphouse production lines.

2.2.5 Freeze Wall

At Wheeler site, the very low permeability basement rock below the uranium deposit serves as a natural aquitard; however, the sandstone hosting the uranium deposit is permeable and groundwater can flow horizontally through the deposit. To achieve containment at Wheeler, the uranium deposit will be surrounded by an engineered freeze wall from the basement rock to surface, isolating the uranium from regional groundwater movement.

The freeze wall will be established by drilling parallel cased holes from surface, anchoring into the impermeable basement rock, spaced approximately 6 m apart. A total of over 300 freeze holes are planned for the Wheeler River Project. The ground will be frozen from surface down to the low permeability basement rock to create a continuous wall around the mining area which is completely contained from the surrounding regional groundwater. Once the drill holes have been installed, a low temperature brine solution will be circulated through the cased holes to remove heat from the ground, ultimately freezing the natural groundwater. While the freeze wall is expected to be several metres thick, it will be developed around the uranium deposit, to ensure the uranium deposit itself does not freeze.

Each section of the freeze wall will require approximately twelve months to be established. The freeze wall will remain in place until mining is complete and into the decommissioning phase until remediation is completed. After decommissioning, once the refrigeration is turned off, it will take a minimum of twelve months for the freeze wall to thaw depending on how long the freeze wall was active and actual ground conditions encountered.

To supply the cold brine, a freeze plant will be constructed on surface based on a modular design for easy installation and operation. Each chiller unit produces about 300 tons of refrigeration (TR) and contains an ammonia compressor, which is run by a 1,000 hp motor. The brine distribution system is handled by a surface brine mixing tank that can move brine to the freeze holes at 300 m^3/hr. The freeze plant capacity is expected to be scaled up throughout the mining phases based on refrigeration requirements, from two chiller units at the start of Phase 1, to a total of six units at Phase 5 of mining and beyond to the decommissioning phase.

2.2.6 Processing Plant

The processing plant will house the tanks and equipment to fully process uranium rich mining solution recovered from the ISR wellfield into uranium concentrate and refortify the mining solution for continued use in the ISR wellfield. The processing plant will also contain filtration systems, bulk chemical storage, process solution storage tanks, and a control room.

Bulk storage tanks for the processing chemicals, such as sulphuric and/or hydrochloric acid, sodium hydroxide, and hydrogen peroxide, will be located outside the processing plant building. The storage tanks will sit inside appropriately designed and sized concrete secondary containment basins.

The uranium bearing solution will be pumped from the wellfield pumphouse(s) to the processing plant and pumped through the following circuits:

- Radon purge tank: When the uranium bearing solution comes to surface, radon gas will naturally move out of solution and into the atmosphere. To keep worker radiation exposure ALARA, a radon purge tank will be used to remove this initial volume of radon before the solution enters the processing plant. The radon purge tank will vent radon from the uranium bearing solution to the air outside of the plant.

- Uranium bearing solution holding area: the ISR mining and subsequent processing of uranium will not always occur at the same rates. Additionally, there will be times when parts of the processing plant are down for routine maintenance. For these reasons, Denison has incorporated a UBS holding area into the current design of the processing plant. It will be a controlled area where UBS can be safely stored on surface, prior to processing. The UBS holding area will be adjacent to the processing plant and under a fabric tension building system. The fabric tensioned roof will help to keep precipitation from entering the uranium bearing solution. The volume of the UBS holding area is anticipated to be 5,000 m^3. The area will be contained by a double composite liner system with leak detection

- Process precipitate removal – Uranium bearing solution will be pumped to a process precipitate removal circuit where the pH of the solution will be adjusted to allow for precipitation of impurities such as iron hydroxides, radium-226, thorium-230, and other metals, collectively referred to as process precipitates. Removal of process precipitates will be done by adding chemicals including hydrogen peroxide, barium chloride, sulphuric acid, flocculant, and lime. Once the impurities have precipitated out of the UBS, the solution is routed to the yellowcake precipitation circuit. Process precipitates removed at this step will be pumped or placed into totes and moved to the process precipitate storage area. The precipitates will contain approximately 2- 3% uranium and will be removed and processed at an offsite facility as part of the decommissioning phase.

- Yellowcake precipitation – Upon completion of the process precipitate removal step, the remaining solution will be further refined by reagent addition and pH adjustments in agitated tanks to precipitate yellowcake. The final step of yellowcake precipitation occurs through a thickener that provides time for dewatering of the uranium oxide precipitates. The precipitated uranium will accumulate at the bottom of the thickener and the remaining solution will rise to the top. The precipitated uranium will be transferred to the yellowcake dewatering, drying, and packaging area and the remaining solution will be transferred to the industrial wastewater treatment circuit.

- Yellowcake dewatering, drying, and packaging – Moisture from the precipitated uranium will be removed through filtering then conveyed through enclosed conveyor to the dryer where any remaining moisture will be evaporated. Any water collected from the drying process will be condensed and reused in the plant for reagents preparation. Denison is evaluating the use of either low temperature dryers or calciners for the drying step in the processing plant. Calcining allows for further removal of impurities from the produced yellowcake to meet certain purchasers' requirements. Once the moisture is removed from the yellowcake product, the yellowcake is packaged into 55 gallon steel drums via gravity.

2.2.7 Accommodation Facility

Located to the southeast of the wellfield, the proposed accommodations facility is anticipated to be a turnkey building manufactured offsite and assembled and commissioned on-site. The building's design will be sized to accommodate a peak load of about 100 to 150 individuals during operations; however, due to its modularized design, additional modules can be easily installed should additional beds be required in the future.

The facility will include a central services complex with:

- Kitchen with food preparation area and serving area;
- Dining room;
- Camp office;
- Commissary;
- Recreation area; and
- Exercise facilities.

2.2.8 Operations Centre

The operations complex is planned to be a standalone, multi-functional building that will serve the administrative, technical, and maintenance needs of the site. The building is proposed to be a two-story pre-engineered structure with total usable space of 38,000 ft^2: 27,000 ft^2 on the first floor and 11,000 ft^2 on the second floor.

The first floor will house the two-story shops, dry space, and warehouses. The shops will include three full-sized maintenance bays, with one being equipped as a welding bay. Areas of the operations centre will be designed to have containment and sumps as required. Change areas (dries) will be provided, with contamination control and suitable wash spaces for each, including laundry facilities. The warehouse has two receiving doors adjacent to the shops. Office spaces will also be provided in these areas for warehouse and procurement staff as well as maintenance supervisors.

The second floor will have administrative space with offices, a boardroom, meeting rooms, lunchroom, and washrooms.

Additional facilities include:

- Medical or nursing station with waiting area;
- Parking space for emergency response vehicles;
- Space for storage of mine rescue/emergency response gear and supplies;
- Laboratory facilities;
- Training room; and
- Mechanical and electrical services rooms.

2.2.9 Security Houses and Truck Scales

Access to the property will be controlled by both a north and south security gate. The main, south gate security house will be staffed as required and be equipped with an 80-tonne weigh scale that is hard-wired into the shack. The security and truck scale buildings are planned to be modular, prefabricated units that will be manufactured off-site and shipped to site for installation and commissioning. The south gate facilities will have appropriate power and communications capability. The north gate will be a simple locked gate.

2.2.10 Wash Bay and Scanning Facility

A wash bay will be constructed to clean items, equipment and vehicles that may have been in contact with potential contaminants. Contaminated water from wash bay will be collected in a sump tank and routed to the water treatment plant for treatment and discharge. Radiological clearance scanning required for any items, equipment and vehicles leaving the site will be conducted in the same building.

2.2.11 Power Supply

Site infrastructure anticipated to draw power from the provincial power grid, includes the camp buildings, operations buildings, the ISR precipitation plant, and the freeze plants.

- Primary Power Supply - Electrical service to Wheeler will be provided via an approximate 5 km extension tap from the existing 138 kV overhead transmission line that runs along Highway 914. Power transmission to the site (e.g., assessment, obtaining necessary permits, and construction) will be led by SaskPower and is not considered part of this Project.

- Back-up Power Supply - To provide electrical service during times of utility outages, emergency diesel generator will be installed in strategic locations to service the site and maintain essential functions. The generators will be used to maintain power to the processing plant and the accommodations facility, as well as to maintain other essential services as required.

2.2.12 Site Runoff Management

Water will be collected from the waste pond (which collected runoff from the waste pad) and the processing plant terrace and then directed to the water treatment plant. Runoff for the small clean waste rock pile may be collected into a settling pond to remove total suspended solids if necessary. Other site runoff collection needs will be examined and identified as needed; conceptually the strategy runoff management strategy is to ensure all waters potentially influenced by site aspects are diverted in into the site water management system and only released to the environment when their quality is appropriate to do so.

2.2.13 Fresh Water Supply and Distribution

A freshwater distribution system will be designed to provide fresh water to the fire water system (freshwater tank, two electric fire water pumps, and a back-up diesel fire water pump for on-site fire suppression needs), the potable WTP, the processing plant, wash bay and temporary batch plant (required during construction phase). Fresh water will be sourced from either a shallow groundwater well or an intake from a nearby surface water body.

2.2.14 Potable Water Treatment Plant

Potable water will be treated on site by a prefabricated modularized (40 ft shipping container) potable WTP comprised of a treatment plant, a 2,000 L storage tank, and a bottle filling station. Potable water will be piped to the camp, the operations centre, and the processing plant to provide water for safety showers and eyewash stations. Other locations, such as the airstrip terminal, gate houses and satellite lunch trailers (during construction) will receive bottled water as required.

Ultrafiltration or reverse osmosis with UV filtration are proposed. Chlorination will be needed prior to distribution. The modular plant will be capable of all necessary processes and will contain required HVAC and lighting. The potable WTP will be placed on a concrete pad and will generate 1.4 m^3/hr (33 m^3) of potable water per day based on 300 L per person per day.

2.2.15 Sewage Treatment Plant

Domestic wastewater and sewage were assumed to be generated at the rate of 300 L per person per day. Sewage will either be collected in septic tanks and transported by a vacuum truck or piped directly to the on-site sewage treatment plant. The sewage treatment plant will be a modular facility comprised of two heated and insulated units (likely containers), a holding tank, ancillary filtration, ancillary treatment process equipment, and sludge handling system. Denison may investigate options to dispose of treated sewage underground or through a septic field. Alternatively, the sewage treatment plant will generate effluent suitable for discharge to local surface water. Treated effluent will first be discharged to surface testing ponds where the water quality will be checked to ensure it meets regulatory limits. Reject solids from the treatment process will be collected, dewatered, and stored on the waste pad on site prior to permanent disposal.

2.2.16 Water Treatment Plant

The Wheeler WTP will be designed to treat any contaminated water removed from the ISR process (e.g., backwash of sand filters, bleed solution), runoff collected from the waste pad, and any other contact water such as water from the wash bay and process sumps. The WTP will be located inside of the processing plant.

It is Denison's intent to incorporate treated water back into the mining water balance as make-up water in the processing plant, to the extent possible. Any excess treated water from the WTP will be pumped to appropriately sized holding ponds. The holding ponds will be sized to hold effluent for a period of 24 hours for testing before discharge to the environment.

Treated water in the ponds will be monitored prior to release to a surface water body or injected into groundwater via deep well injection. All treated effluent released to surface water will meet federal and provincial regulatory discharge limits.

2.2.17 Landfill, Recycling and Compost Management

- Domestic Waste Landfill - Denison plans to construct, operate, monitor and decommission a domestic landfill on site. A waste management plan will be developed for the Project which will detail how each type of waste generated on site will be managed. In general, only inert non-hazardous wastes such as wood and plastics will be suitable for disposal in the on-site landfill. The domestic landfill will have a composite liner system with leachate collection.

- Industrial Waste Landfill - Denison plans to construct, operate, monitor and decommission an industrial landfill on site. A waste management plan will be developed for the Project which will detail how each type of waste generated on site will be managed. The industrial landfill will be designed to accept industrial wastes generated at site including waste with chemical and/or radiological contamination. The landfill will have a double composite liner system with leak detection between the composite liners and leachate collection system above the primary, or upper composite liner.

- Composter - Denison plans to operate an composter for food waste. A contained and partially automated composter, such as the Brome composting system, is the preferred option.

2.2.18 Waste Pad and Ponds

During operation, the special waste pad is expected to contain primarily mineralized core and cuttings from wellfield development.

Special waste from drilling activities is defined as uranium containing materials that cannot be disposed of in the clean waste pile. Special waste will be determined by Denison geologists based on ore zone intersection expectations and probe reading taken during wellfield drilling activities. Based on the current wellfield and freeze wall design, approximately 150 m^3 of special waste rock will be generated.

Denison will examine opportunities to reprocess the mineralized core and cuttings generated during wellfield development. This may be done by placing the material in tanks with mining solution or place the material underground into the leaching zone (at the tail end of a well's production) to complete the leaching underground.

The special waste pad may be used to temporarily store other materials that may be radioactive (e.g., contaminated soil) prior to disposal in the industrial landfill.

The special waste pad is estimated to be 2,500 m^2 in size and will be constructed with a double composite liner system with leak detection capabilities. Any contact water coming off the special waste pad will be directed to the wellfield runoff pond.

2.2.19 Clean Waste Pad and Ponds

Clean waste rock will be generated from the sandstone cuttings from drilling activities. This includes the drilling of the injection and recovery wells to create the ISR wellfield and the drilling of freeze holes to create the freeze wall. Clean waste rock will be stored on an unlined pad and can be used for road or concrete construction. A pond may be constructed beside the pad to collect runoff if required.

2.2.20 Hazardous Substance Storage and Dispensing

- Fuel Storage and Dispensing Facility - Fuel consumption at Wheeler may be limited to back-up power supply, auxiliary vehicles (i.e., ATVs and snowmobiles), miscellaneous equipment (i.e., portable pumps), and freight and personnel transportation to site. Tanker trucks will deliver diesel and gasoline to the site on an as-needed basis. Fuels will be stored in approved, above-ground, 25,000 L double-walled storage tank(s) equipped with secondary containment in accordance with provincial regulations and standards.

- Propane Facility - Propane may be used as a primary or backup means to support the camp kitchen, the incinerator, and to heat the buildings. The propane facility will be sized to meet the needs of the site activities and will a feature a storage tank (assumed to be 30,000 uswg), vaporizers, a propane bottle fill station, and a propane bottle weigh station. Propane will be delivered to site on an as needed basis.

- Other Hazardous Substances - Sulphuric acid, hydrogen peroxide, sodium hydroxide, barium chloride and flocculants are the main chemicals anticipated to be used in the processing plant and in mining. Bulk storage tanks for the processing chemicals, such as sulphuric and/or hydrochloric acid, sodium hydroxide, and hydrogen peroxide, will be located outside the processing plant. The storage tanks will sit inside appropriately designed and sized concrete secondary containment. The secondary containment for each applicable chemical system will be physically separated from the containment basins for other chemical systems.

2.3 Project Timeline

The Project timeline, and therefore the timeline over which potential accident and malfunction scenarios has been considered, is summarized in **Table 2-1**. The full life cycle of the Project is anticipated to be 38 years

3.0 ASSESSMENT METHODOLOGY

The methodology by which the accident and malfunction assessment has been carried out is described below.

For reference, the temporal and spatial extents of the assessment are as follows:

- The temporal extent of the evaluation includes all mine and mill life-cycle phases – construction, operations, decommissioning, and post-decommissioning.
- The spatial extent of the evaluation includes the Project site and the site access road. In addition, three off-site scenarios, involving a release to water (Scenarios 1 and 2) and ground (Scenario 7) that would have the potential to affect a community of interest along the mine-related transportation route were also considered. These scenarios were developed with the Denison team and reflected the result of and input from Denison's Interested Party engagement activities.

3.1 Overview

The assessment of accidents and malfunctions is designed to provide a clear definition of the potential Project-associated hazards that fall outside the range of "typical" day-to-day events and to provide a framework for quantifying the risks associated with these hazards.

The four basic steps in the process of risk assessment for the accidents and malfunctions assessment are as follows:

- Hazard identification and identification of bounding scenarios: Includes the identification of physical situations with the potential for harming the human health or biophysical environment. In this study, "Hazards" and "Accidents and Malfunctions" are used interchangeably. Hazard scenarios were identified using a systematic approach with consideration of the existence of sources of hazards and initiating events for each project component and activity. The hazards were identified for several potential events, such as releases of chemical and radiological constituents, fires, and explosions. Hazard scenarios were screened qualitatively for the perceived effects and probability of occurrence as well as the potential risk using a risk matrix approach (**Section 3.2.2**). Project information, experience from similar projects, particularly those located in Northern Saskatchewan, and professional judgment were used for this initial screening. Among the high or moderate-risk scenarios, bounding scenarios were selected. The bounding scenarios encompass the effects of other scenarios screened for each Project component and activity. The subsequent analysis focussed on these bounding scenarios. **Section 5.0** describes the selected bounding scenarios. The detailed methods and the complete list of identified scenarios are provided in the Wheeler River ISR Project Hazard Identification Report (**Appendix A**).

- Assessment of probabilities: Includes the estimation of the probability of occurrence of the selected bounding scenario occurring within a specific time period or in specified circumstances. **Section 7.0** describes the assessment of probabilities for each bounding scenario.

- Assessment of potential effects: Includes the quantitative evaluation of the potential effects of a selected bounding scenario to the human health or biophysical environment. **Section 8.0** includes the assessment of potential effects for each bounding scenario.

- Risk estimation and ranking: Includes the estimation of the combination of the effects of a scenario and the probability with which it is likely to occur; that is, risk is the product of consequence and probability (risk = consequence × probability of occurrence). Risk was evaluated using the risk matrix presented in risk matrix approach (**Section 3.2.2**). **Section 9.0** provides the overall risk estimation for the selected bounding scenarios.

3.2 Hazard Identification

As indicated above, the Wheeler River ISR Project Hazard Identification Report is provided in **Appendix A**. The hazard identification process is used to identify a comprehensive list of potential accident and malfunction scenarios that may occur in consideration of Project-related work processes and activities, screen these scenarios as to potential risks and, based on this screening, recommend scenarios that could pose a relative high risk that should be carried forward for more detailed consideration. The hazard identification evaluation focusses on risks to the human health or biophysical environment. An overview of the hazard identification process and the results of the hazard identification evaluation are provided below.

3.2.1 Scope and Applicability

As described in **Section 1.2**, Regulatory Context, there are regulatory drivers that require the potential effects of accidents and malfunctions related to the Project components and activities be assessed. The first step in the assessment of accidents and malfunctions is the completion of the hazard identification.

The objective of the hazard identification process is to identify all Project-related scenarios that have the potential to present a risk to the human health or biophysical environment. The hazard identification process includes a screening assessment of potential scenarios to identify those that require more detailed assessment in terms of probability and consequence. The initial screening evaluation is applied to a given scenario by qualitatively evaluating consequence severity and likelihood to determine an overall risk ranking. The evaluations of the probabilities and severity of the consequences, as well as the characterization of the risk of the selected scenarios, are included in the assessment of accidents and malfunctions.

Consistent with the overall accidents and malfunctions assessment, the scope of the hazard identification process included consideration of all Project phases (i.e., Construction, Operations, Decommissioning, and Post-decommissioning) and the Project site and associated access road to its junction with Highway 914, as well as at locations of interest to Interested Parties along the mine-related transportation route. It is noted that the primary transportation route for the Project includes approximately 380 km of publicly accessible gravel highway (110 km of Highway 165 and 270 km of Highway 914). Focussing the assessment on the locations of interest to Interested Parties along the route is a practical means by which to conduct the assessment. The accident and malfunctions scenarios described herein, related to transportation of Project-related goods and services at the locations of interest, can generally be interpreted as being representative of similar locations along the transport route.

Generally, the evaluation focused on potential human health or biophysical environmental risks associated with Project components and activities. It is noted that some hazards related to worker safety were identified; however, worker safety (i.e., risks and consequences) is beyond the scope of this assessment.

3.2.2 Process Hazards Analysis

The hazard identification process is a systematic approach to identify possible hazards in a work process. A hazard can be defined as a physical condition that has the potential for causing damage to people, property, or the environment (e.g., fire, explosion, release of chemicals, or radioactivity). Potential nodes for hazard identification are selected through the review of the Project-related components. A node is a Project component that represents a physical system or activity with the potential to present a risk to the human health or biophysical environment. Hazard scenarios are developed on consideration of these nodes.

The hazard identification for each node involves the consideration of the sources of hazard (e.g., presence of hazardous materials), hazardous situations (e.g., height or extreme heat), and initiating events (e.g., natural causes, technical failure, or human error) that in combination present a risk to the human health or biophysical environment. A screening evaluation is applied to a given scenario by qualitatively evaluating consequence severity and probability to determine a risk level.

While there are standards and regulatory documents (e.g., REGDOC-2.4.2, Safety Analysis, Probabilistic Safety Assessment (PSA) for Reactor Facilities (CNSC 2014)) that govern the assessment of the probability of the hazard scenarios for nuclear reactors, no such documents exist for non-reactor facilities. The focus of these documents is design-basis and beyond design-basis accidents that affect the integrity of the reactor core. The annual probability of releases from these accidents can be 1×10^{-6} and lower, while the consequence of these accidents could be very severe. In contrast, the probability of accidents and malfunctions at non-reactor facilities such as mines and process plants can be higher, as derived from the operating experience of similar installations. The International Atomic Energy Agency's TECDOC-1267 (IAEA 2002) states that while a plant-specific qualitative risk analysis should be conducted for a nuclear reactor facility, for non-nuclear facilities hazard identification and screening, evaluation of selected accident scenarios, and a combination of qualitative and quantitative analysis should be conducted. This document does not prescribe what probabilities should be considered.

On a scale of increasing likelihood, scenarios are categorized as highly unlikely, unlikely, likely, very likely, and almost certain as follows:

1. highly unlikely: ≤ 1 occurrence in 1,000 years;
2. unlikely: ≤ 1 occurrence in 100 years and > 1 occurrence in 1,000 years;
3. likely: ≤ 1 occurrence in 10 years and > 1 occurrence in 100 years;
4. very likely: ≤ 1 occurrence in 1 year and > 1 occurrence in 10 years; and
5. almost certain: > 1 occurrence in 1 year.

On a scale of increasing severity, scenarios are categorized as none, minor, moderate, major, and catastrophic as follows:

1. none: no human health or biophysical environmental consequences;
2. minor: short-term (less than one month) minor effect on small area or minor first aid injuries with no lost time;
3. moderate: reversible or repairable effect (less than one year) off site or reversible injuries with lost time;
4. major: extended-range, long-term effect off site (e.g., 10 years) or severe injuries with long lasting effects and/or disability; and
5. catastrophic: long-lasting with long-lasting or irreversible environmental effects, fatalities or multiple disabilities.

The resulting risk levels are defined according to the matrix shown in **Figure 3-1**.

For the purpose of the assessment, risks are identified as being low (coloured green in the matrix) where the screening evaluation considers the risk as generally being acceptable, as the likelihood of these scenarios can be effectively managed through application of planned controls and/or the consequence would be low in magnitude. Low-risk scenarios have a severity of none to moderate with the likelihood ranging from highly unlikely to almost certain.

Risks are identified as being moderate (i.e., coloured yellow in the matrix) where the screening evaluation considers the risk as generally being tolerable. In some cases, a moderate-risk scenario can encompass the risk of several screened scenarios for each effect category (e.g., toxic release, fire). In these cases, a moderate-risk scenario can be carried forward as a bounding scenario for more detailed analysis. Moderate-risk scenarios have a consequence of minor to catastrophic, with the likelihood ranging from highly unlikely to almost certain. In many cases, risk-reduction activities would reduce the risk associated with these scenarios to as low as reasonably practicable (ALARP). Under this condition, the risk may be characterized as tolerable.

Risks are identified as being high (coloured red in the matrix) where the screening evaluation considers the risk as generally being unacceptable. High-risk scenarios have major to catastrophic severity with the likelihood ranging from unlikely to almost certain. As the evaluation of the risk at this hazard identification stage is qualitative and is associated with some uncertainty, the hazard scenarios identified as high risk were advanced for further detailed assessment so that a more fulsome evaluation of risk and potential management activities can be considered.

Figure 3-1: Hazard Analysis Risk Matrix

Likelihood		Consequence Severity				
		1	2	3	4	5
		None	Minor	Moderate	Major	Catastrophic
5	Almost certain	Low	Moderate	Moderate	High	High
4	Very likely	Low	Low	Moderate	High	High
3	Likely	Low	Low	Moderate	Moderate	High
2	Unlikely	Low	Low	Low	Moderate	High
1	Highly unlikely	Low	Low	Low	Moderate	Moderate

3.2.3 Evaluation of Project Components and Activities

Based on the review of Project-related information provided in Section 2.2, the following key Project components and activities were identified and selected as nodes for hazard identification process. They form the basis of consideration of potential accident and malfunction scenarios:

1. Site works.
2. Drilling of wells.
3. Access road / land transportation.
4. Air strip / air transportation.
5. Operation of the freeze plant.
6. Maintenance of the freeze wall.
7. Production facility (operation of the processing plant).

8. Clean waste rock pads.
9. Special and mineralized waste rock pads.
10. Precipitates disposal area.
11. Wastewater treatment system.
12. Ponds and retention berms.
13. Electrical system and power plant.
14. Fire protection system.
15. Hazardous waste management system.

In consideration of sources of hazards and initiating events and as described in more detail in the hazard identification analysis (**Appendix A**), a total of 69 hazard scenarios were identified and evaluated.

Following the screening evaluation outlined in **Section 3.2.2**, five high risk scenarios were identified, three of which were recommended for further assessment. The two that were not carried forward involve occupational health and safety hazards and are beyond the scope of this current analysis.

Twenty-three of the scenarios evaluated were characterized as moderate-risk scenarios. Of these twenty-three, nineteen of the moderate-risk scenarios were deemed to represent a tolerable level of risk in consideration of proposed safeguards and design features that reduce the risk level to ALARP. Four moderate / ALARP-moderate scenarios were identified as requiring further detailed assessment for more accurate characterization of risk. The four moderate risk scenarios that are subsequently assessed in more detail beginning in **Section 5.0** are associated with a contaminant release to the environment whose potential effects maybe may be more far reaching than can adequately assessed by the screening assessment and therefore additional more quantitative evaluation was deemed appropriate.

The balance of the scenarios evaluated, 41, were characterized as low-risk scenarios, based on low likelihood of occurrence and/or consequence in consideration planned existing safeguards and design features. Low-risk scenarios are not carried forward for more detailed analysis as they are adequately characterized by the screening process.

3.2.4 Bounding Scenarios

From the initial screening process detailed in the hazard identification report (**Appendix A**), seven hazard scenarios have been selected as bounding scenarios for more detailed risk analysis (**Table 3-1**). Herein, a bounding scenario is used to represent an event whose potential consequences are considered to represent those associated with other accident and malfunction scenarios; or, alternatively, the potential consequences of scenarios that are bounded by another are expected to fit within the envelope of those associated with the bounding scenario. Utilizing the bounding scenario approach makes it possible to avoid duplication in the evaluation process while at the same time ensuring the evaluation is completed in a conservative manner.

This further assessment includes the quantification of the probability and consequences of each of these selected scenarios. For the seven identified bounding scenarios, a general description of the hypothetical event, the release characterization (e.g., contaminants, quantities), the probabilities of the events, and their potential effects on the human health and biophysical environment are provided. This more in-depth process results in more a representative characterization of the risk of these scenarios, as the estimation of the risk in the hazard identification report (**Appendix A**) was preliminary and completed at the screening level (i.e., qualitative).

Table 3-1: Bounding Scenarios Identified for Further Assessment by the Hazard Identification Process

No.	Potential Accident or Malfunction	Project Phase	Potential Effect Pathway
1	Vehicle accident including rollover, collision, run off road	Op	Aquatic release of radioactivity
2	Vehicle accident including rollover, collision, run off road	Co / Op / De	Aquatic release of fuel, hazardous chemicals and reagents
3	Loss of freeze capacity	Op	Loss of freeze wall and secondary underground containment
4	Failure of freeze wall	Op	Loss secondary underground containment and groundwater contamination
5	Process vessel and piping system failure	Op	Release of radon from storage tank
6	Facility fire / explosion	Op	Release of radioactivity and uranium concentrate powder to atmosphere
7	Vehicle accident including rollover, collision, run off road	Co / Op / De	Terrestrial release of radioactivity and chemicals

Notes:
"Co" is construction
"Op" is operations
"De" is Decommissioning
Red and yellow shading indicates high and moderate risk scenarios, respectively. "Effect Pathway" describes nature of the event and therefore the nature of the assessment of consequence.

The detailed assessment of the bounding scenarios is presented in the subsequent sections of this report (**Section 6.0**, **Section 7.0** and **Section 8.0**). The detailed assessment of bounding scenarios involves the quantification of the probability and the consequence(s) of the scenario.

The assessment of the probability requires the identification of the probability of the initiating events leading to the hazard scenario and the conditional probability of any of the associated events within the casual event chain.

The consequence assessment (e.g., the assessment of the fate and transport of a chemical or radiological release) of the scenario includes the characterization of the source terms when there is potential for the release of radioactivity and hazardous materials into the environment. The fate and transport of the released materials and the exposure to the receptors are then evaluated to quantify the severity of the consequences of the scenario.

4.0 GENERAL CONSIDERATIONS FOR THE ACCIDENT AND MALFUNCTIONS ASSESSMENT

Over the past four decades of global commercial nuclear facility operation, the probability and severity of accidents has been markedly lower than those in related industrial operations (OECD 2010). This can be attributed to the rigorous regulatory framework and well-developed plans and procedures for safe operation of nuclear facilities, including uranium mining and milling operations. The experience gained from the accidents that have occurred has resulted in improved engineered safety features and operating procedures, and the probability that similar accidents might occur in the future is considered low.

It is the intention of Denison to develop and operate the Project activities in a manner that mitigates potential adverse effects on the human health or biophysical environment to the extent that is possible. Denison would verify that all the work to be completed during the Project meets, or exceeds, the regulatory requirements stipulated by the CNSC and other regulatory authorities. Denison is committed to setting high standards for various aspects of its operations that will serves to mitigate potential Project-related effects, including those that may be associated with postulated accident and malfunction scenarios. In practice these standards would be upheld through adherence to corporate health, safety, environmental, and quality policies as manifested in various Project-related programs including, but not necessarily limited to:

- Quality Management Program;
- Occupational Health and Safety Program;
- Radiation Protection Program;
- Environmental Protection Program;
- Emergency Preparedness and Response Program;
- Fire Safety Program;
- Maintenance Program; and
- Wellfield and Surface Water Program.
- Within the aforementioned programs, detailed plans and procedures would be developed for the Project that would be site specific and in accordance with corporate policies, including:
- a radiation protection plan;
- a spill and emergency response plan;

- a traffic and transportation plan;
- a travel management plan;
- process monitoring and operational procedures;
- wellfield development and control procedures;
- security procedures;
- environmental monitoring procedures;
- personnel training procedures;
- regular and preventive inspection and testing procedures; and
- surface water and flood management procedures.

Together, these plans and procedures, and the work instructions that they contain, would be implemented throughout the life of the Project and help to mitigate the likelihood of occurrence of accident and malfunction scenarios. Project design features and considerations are the first line of defence in this regard. Examples of proposed design features and considerations are highlighted below:

- The processing plant will be designed with expert consideration of potential environmental and health and safety effects to mitigate interactions to the extent possible.
- The floor of the process plant will be graded as required and sumps will be installed to collect any spills.
- Ventilation in the processing plant will be designed with the ALARA principle in mind to provide sufficient worker protection and monitoring systems will be in place to ensure worker health and safety.
- Dust control and good housekeeping practices throughout the processing plant will also form a critical component of the Radiation Protection Management Plan developed for the Project.
- The processing plant exhaust, mainly from drying and packaging areas, will be directed through a stack and released outside of the building.
- The stack height will be designed based on results of air dispersion modelling to be an appropriate height for optimal dispersion.

- Bulk storage tanks for the processing chemicals, such as sulphuric and/or hydrochloric acid, sodium hydroxide, and hydrogen peroxide, will be located outside the processing plant.

- The storage tanks will sit inside appropriately designed and sized concrete secondary containment basins. The secondary containment basin for each applicable chemical system will be physically separated from the containment basins for other chemical systems.

- Each one of these materials will be stored, handled, recycled or disposed of in an appropriate manner and meet the requirements of the *Hazardous Substances and Waste Dangerous Goods Regulations (Government of Saskatchewan 2000)*.

- No fuels, oils or other hazardous substances will be stored within 100 m of any water body and no equipment maintenance or re-fuelling will be conducted within 100 m of a water body.

- Denison will maintain an up-to-date record of the various hazardous substances on site and will maintain Material Safety Data Sheets and appropriate procedures for spill management, handling and clean up in an accessible location.

- Fuel storage and distribution infrastructure will be constructed in accordance with applicable legislation requirements (e.g., *Hazardous Substances and Waste Dangerous Goods Regulations*) (*Government of Saskatchewan 2000*). Stationary and mobile equipment will be fueled with a fuel-dispensing truck.

- Ventilation in the pumphouses will be designed with the ALARA principle in mind to provide sufficient worker protection from potential radon and radon progeny exposure.

- Monitoring systems will be in place to ensure these mitigation measures are meeting design specifications.

- Double-walled high-density polyethylene (HDPE), or equivalent, piping will be used in the wellfields and will be designed and selected to meet design operating and environmental conditions.

- The lines from the processing plant, pumphouses, and individual well lines will be freeze protected and secured to minimize pipe movement.

- Groundwater monitoring wells will be installed at various depths and locations in and around the wellfield. The monitoring wells will allow for both groundwater sample collection and measurement of groundwater level.

- After an injection, recovery, or monitoring well has been completed, and before it is made operational, a mechanical integrity testing of the well casing will be completed to ensure the installation has been successful and the well is functioning as designed. Well casings that fail integrity tests will be repaired before the well is placed into service.

- At Wheeler, the very low permeability basement rock below the uranium deposit serves as a natural aquitard.
- The site access route was selected with consideration of distance from water bodies.
- Water will be collected from the waste pond (which collected runoff from the waste pad) and the processing plant terrace and then directed to the water treatment plant.
- The waste pad will be double lined, with leak detection capabilities and an associated monitoring program to ensure containment.
- Fuels will be stored in approved, above-ground, double-walled storage tank(s) equipped with secondary containment in accordance with provincial regulations and standards.
- Fuel storage and fuelling activities will be located at least 100 m from waterbodies.

5.0 DESCRIPTION OF THE BOUNDING SCENARIOS

A description of each of the seven bounding scenarios identified by the hazard evaluation screening process is presented below. For each scenario, a general description of the event is provided and then, as all of the postulated scenarios are associated with releases to the environment, the characterization of the release (e.g., contaminants, quantities) is described. The probabilities of the events and their potential and effects on the human health or biophysical environment are considered in **Section 7.0** and **Section 8.0**, respectively.

5.1 Bounding Scenario 1: Traffic Accident and Aquatic Release of Radioactivity

Vehicular access to the Project site would be via an access road from Provincial Highway 914 that leads to the Wheeler site. The access road would be used primarily to transport equipment and supplies to and from the Project, as well as the trucking of the uranium concentrate. Personnel would be typically flown to and from the site.

The access road is roughly 12 km long, 5 km of which is from highway 914 to the Wheeler site with the remaining 7 km from Wheeler site to the airstrip. Additional site roads would include a service loop to the camp and short service roads to other site features to facilitate access. Denison anticipates the need for installation of two water crossings in the Icelander River drainage upstream of Whitefish Lake along the section of the road from the Wheeler site to the airstrip. **Figure 5-1** shows the location of the water crossings along the access road.

Figure 5-1: Location of the Water Crossings Along Access Road

No trucks transporting uranium concentrate are expected to travel along the portion of the access road from the Wheeler site to the airstrip; however, Jet Fuel A will be transported to the airstrip along this portion of the road.

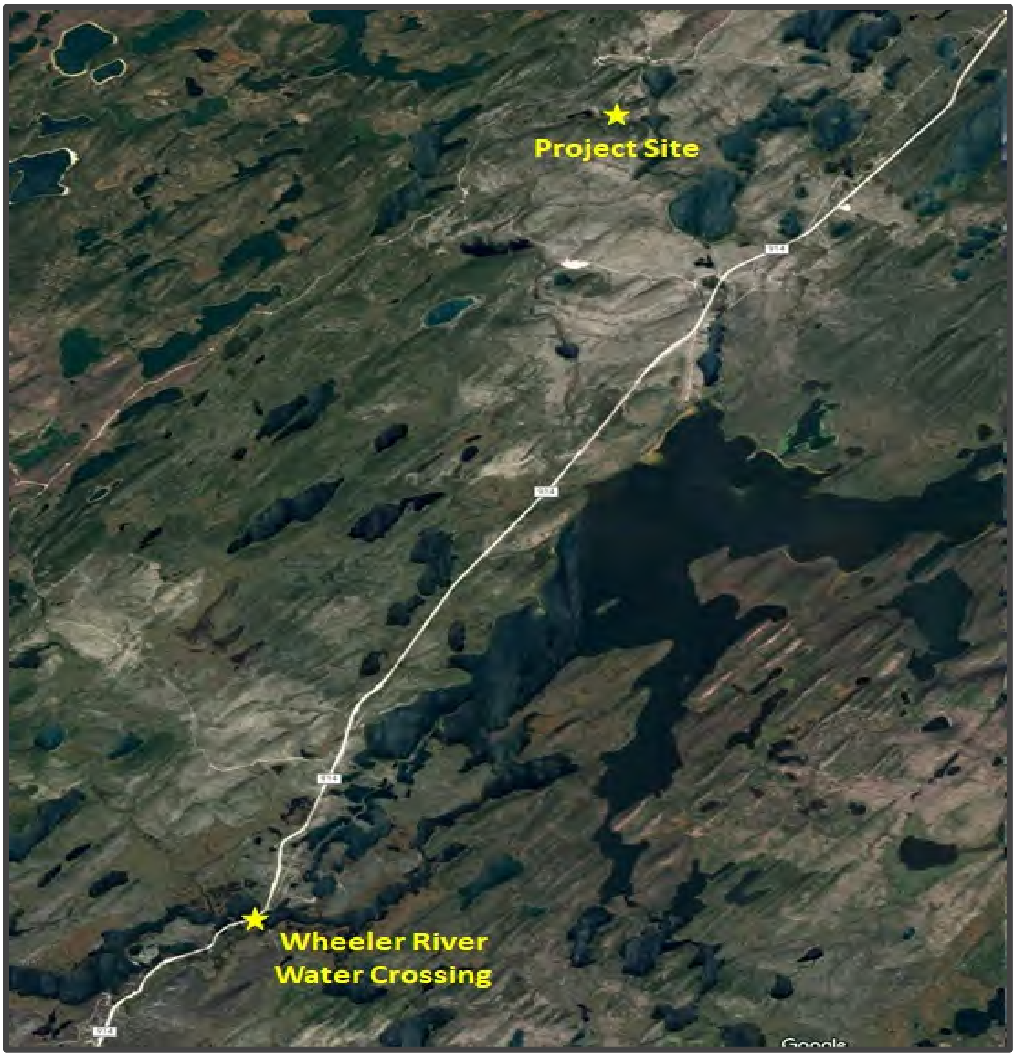
The portion of the access road between Highway 914 and the Wheeler site is not within 100 m of any waterbody at any location; therefore, an accidental release of hazardous substances, including uranium concentrate, to surface water is not expected along this portion of the road. Highway 914 crosses the Wheeler River 10 km southwest of the access road junction. **Figure 5-2** shows the location of the water crossings along Highway 914. The length of the bridge over the river at this crossing is approximately 100 m. The width of the river at the crossing is approximately 20 m. The crossing is equipped with guardrails along the entire length of the bridge. A traffic accident, collision, rollover, or run-off at or near the bridge could potentially result in a release of uranium concentrate into the surface water at this location. The flow direction at the Wheeler River water crossing is towards the northeast and towards Russell Lake. This location was the focus the evaluation as it represents an important location to resource users in the study area. The scenario provides an example of the consequences of such releases to local receptors—that is, the results of the assessment of the releases at this location would be expected to be generally representative of crossings along the transport route because the key endpoint in the assessment is overall risk, as defined for the assessment process as probability multiplied by consequence. Appendix B to this report describes water crossings along the Project-related transportation route on Highway 914 south from the Project site to its junction with Highway 165, and Highway 165 east to Highway 2 and west to Highway 155. While the specific conditions at these crossings may differ in size or nature, the results of the analysis presented can generally be applied more broadly as indicated above. The approach used is consistent with past practice for comparable assessments for uranium projects in the province.

The flow rates for the stream crossings and Wheeler River south of Russell Lake are provided in the table below (**Table 5-1**).

Table 5-1: Flow Rates for the stream crossings and Wheeler River south of Russell Lake

Location	Minimum Flow (L/s)	Average Flow (L/s)	Maximum Flow (L/s)
Water Crossing 1 - Inflow to Whitefish Lake from Kratchkowsky Lake	204	357	769
Water Crossing 2 - Inflow to Whitefish Lake from LA-9	494	917	2,132
Hydrometric Station 06DA005 - Wheeler River South of Russell Lake (https://wateroffice.ec.gc.ca/index_e.html)	10,900	17,340	24,670

Figure 5-2: Location of the Wheeler River Along Highway 914



For reference, the calcined (heated strongly to remove impurities) uranium concentrate would be packed into standard 205 L (55 gal) steel drums for shipping. The gross weight of each drum is between 430 kg and 450 kg. It is projected that there would be 35 to 40 drums packaged per mill operating day, requiring an average number of one trip per day. In uranium concentrate, the short-lived decay products of uranium-238 (i.e., thorium-234; protactinium-234m; protactinium-234, which has a relative concentration of 0.16% of uranium-238; and uranium-234) and uranium-235 (i.e., thorium-231) are assumed to be in equilibrium with their respective parents as it considers both uranium and its decay products. The radioactive equilibrium exists when a radionuclide decays at the same rate at which it is being produced by its parent decay. The activities of these radionuclides in uranium concentrate can be derived using the branching ratios as shown in the following table (**Table 5-2**). The branching ratio for a decay is the fraction of particles which decay by an individual decay mode with respect to the total number of particles which decay. These fractions are used to calculate the activity concentration of radionuclides in uranium concentrate.

Table 5-2: Radionuclides in Uranium Concentrate

Radionuclide	Half-Life	Branch Percentage
Uranium-238	$4.47 \times 10^{+09}$ yr	NA
Thorium-234	24.1 d	100% uranium-238
Protactinium-234m	1.16 min	100% uranium-238
Protactinium-234	6.7 h	0.16% uranium-238
Uranium-234	$2.45 \times 10^{+05}$ yr	100% uranium-238
Uranium-235 (4.6% of uranium-238)	$7.04 \times 10^{+08}$ yr	NA
Thorium-231	1.063 d	100% uranium-235

From other studies conducted for uranium mills in northern Saskatchewan, the particle size distribution for three uranium concentrate calcined samples were measured using a Beckman Coulter LS Particle Size Analyzer. **Table 5-3** provides a summary of particle size distribution information for these studies.

Table 5-3: Uranium Concentrate Particle Size Distribution[1]

Calcined Samples (three samples)		
Size Category (µm)	**Average Size (µm)**	**Percentage**
<5	2.5	4.0
5-15	8.6	14.7
15-25	19	46.1
25-35	30	32.8
35-55	44	2.5

The solubility of the calcined uranium used herein is based on testing of samples from the McClean Lake Operation that were analyzed over 72 or 24 hour periods. The Organisation for Economic Cooperation and Development (OECD) Guideline for Testing of Chemicals; Water Solubility (adopted 27.07.95; OECD 1995), flask method, was followed for these tests. The results are shown in Table 5-4. Bulk and particle densities of UOC were considered at 2.1 and 9.6 g/cm^3. Based on the solubility data from the McClean Lake samples, a solution of about 0.125 g of UOC in 250 mL of water will lead to a uranium concentration of 4,800 µg/L.

[1] This information was obtained from Cameco Corporation during the assessment accidents and malfunctions for Millennium Mine project.

Table 5-4: Solubility of Calcined Uranium Concentrate

Sample Source	Sample No.	Estimated Solubility (g/L) by Test Duration		
		24 h	48 h	72 h
McClean Lake (calcined)[2]	1	0.0035	0.0045	0.0046
	2	0.0060	0.0071	0.0067
	3	0.0053	0.0062	0.0090
	4	0.0038	0.0036	0.0039
	5	0.0070	0.0068	0.0064
	16 to 20 (average)	0.003 to 0.008 (0.005)	-	-

5.1.1 Release Characterization

The performance of drums similar to those proposed to be used for uranium concentrate shipment during transportation accident scenarios was determined by McSweeney et al. (2004). The authors concluded that, based on drum deformations performed in a previous analysis, if a drum experienced a crush force of 100,000 lbs, then the deformation of the drum would cause the lid to detach from the drum. Using this drum failure mechanism, and assuming the drums weigh 450 kg and are arranged four across in the truck, at a speed of 48 km/h the front 25% of the drums would fail, at 60 km/h to 97 km/h 55% would fail, at 145 km/h 75% would fail, and at ≥ 193 km/h all would fail.

Given that the speed of the truck is likely between 60 km/h to 97 km/h km/h, it was concluded that less than 55% of the drums would fail upon a traffic accident scenario. Assuming 40 drums in one shipment per day, each shipment would have approximately 40,000 lb of uranium concentrate:

40 drums x 450 kg/drum = 18,000 kg uranium concentrate = 40,000 lb

If 55% of this amount is released, the total release weight would be approximately 22,000 lb of uranium concentrate. The short-term dissolved release rate was estimated using solubility data. Solubility of calcined UOC was considered at an average value of 4,800 µg/L over the first 72 hours, which is the average solubility of McClean Lake UOC samples. It was assumed that such concentrations applied to a cross section of water defined by the lateral footprint of the spill (i.e., the total 20 m of the Wheeler River crossing) and a water column depth of 10 cm.

The water velocity was assumed to be 0.72 m/s. At an average depth of 1.2 m, the total flow rate is 17.3 m^3/s:

[2] This information was obtained from Cameco Corporation during the assessment accidents and malfunctions for Millennium Mine project.

$$20 \text{ m} \times 1.2 \text{ m} \times 0.72 \text{ m/s} = 17.3 \text{ m}^3\text{/s}.$$

The dissolution rate is calculated as 6.9 g/s:

$$20 \text{ m} \times 0.1 \text{ m} \times 0.72 \text{ m/s} \times 4.8 \text{ g/m}^3 = 6.9 \text{ g/s}.$$

Long-term concentrations were also estimated to account for transfer of the settled uranium from sediment to water. The long-term release rate is based on the concentration estimated for sediment pore-water quality. It was assumed that such concentrations applied to a cross section of water defined by the lateral footprint of the spill and a water column depth of 10 cm.

5.2 Bounding Scenario 2: Traffic Accident and Aquatic Release of Fuel and Hazardous Chemicals

Bounding Scenario 2 is similar to Bounding Scenario 1, except it potentially results in the release of chemicals or fuel such as diesel, gasoline, propane, hydrogen peroxide, sulphuric acid, and sodium hydroxide at the bridge over the Wheeler River. As with Scenario 1, this location was also the focus the evaluation as it represents an important location to resource users in the study area, but the results of the analysis presented can generally be applied more broadly to water crossings along the transport route from an overall risk perspective.

The information related to the fuel and chemicals transported to the site is summarized in **Table 5-5**.

It was conservatively assumed that a volume equivalent to the entire cargo of a shipment would be released during an event. Based on the available project information, the following is assumed:

- Diesel and Jet Fuel A (30 m^3 or 30,000 L release): The released diesel forms a sheen on top of water with a thickness of approximately 1 micron (i.e., micrometre; µm). While as much as 15% of the diesel would dissolve in the water column (NOAA 2006, 2020), up to 30% would evaporate from the surface of water (Silver and Mackay 1984). The rest of the fuel, which is predominantly heavier components, would stay afloat or be adsorbed into shallow sediments along the river bank and downstream near-shore lake areas.

- Gasoline (30 m^3 release): The released gasoline forms a sheen on top of water with a thickness of approximately 1 µm. While as much as 25% of the gasoline would dissolve in the water column, up to 70% would evaporate from the surface of water (Silver and Mackay 1984). The rest of fuel, which is predominantly heavier components, would stay afloat or be adsorbed into shallow sediments along the river bank and downstream near-shore lake areas.

- Propane (11,000 gallons or 41.58 m^3 release): The released propane would evaporate quickly and be released to the atmosphere with no measurable residue.

- Sulphuric acid (25 m^3 release): Sulphuric acid is completely dissolved in water resulting in low pH of affected waterbodies. It is assumed the entire volume of sulphuric acid mixes with water.
- Sodium hydroxide (25 m^3 release): Sodium hydroxide is completely dissolved in water resulting in high pH of affected waterbodies. It is assumed the entire volume of sodium hydroxide mixes with water.
- Hydrogen peroxide (~18 m^3 release): Hydrogen peroxide and water are miscible liquids; thus, upon release, the entire volume of hydrogen peroxide mixes with water.

Table 5-5: Chemicals Transported to The Site

Item	Annual Consumption, m^3	Truck Travel per year
Diesel Fuel	7,991	266
Jet A Fuel	195	10
Gasoline	163	6
Propane	4,740	114
Sulphuric Acid	15,417	617
Sodium hydroxide 50%	21	1
Hydrogen peroxide 70%	0.97 to 1.61	216
Total	NA	1,220

5.3 Bounding Scenario 3: Loss of Freeze Capacity to the Freeze Wall

The freeze wall is expected to be several metres thick as it is developed around the uranium deposit. The freeze wall provides full secondary containment of mining fluids within the mining zone and no fluids will be able to migrate across this barrier to the surrounding groundwater environment. Primary containment of mining fluids is achieved by the control of the mining solutions through inward hydraulic gradient created by the recovery wells pumps.

If freezing capacity is lost, the freeze wall would eventually thaw, and secondary containment lost. If this occurs the mining fluid could migrate into the local groundwater environment and cause the contamination. The scale of contamination is difficult to predict as there are large uncertainties associated with the amount of mining fluid that would migrate, the hydraulic conductivity of the thawed freeze wall, the static head, and other geological factors.

The freeze wall will require 14 months to be established. The freeze wall will be in place throughout the operations phase. After decommissioning once the refrigeration is turned off, it will take a minimum of 1 year for the freeze wall to thaw depending on how long the freeze wall was active and actual ground conditions encountered. This freeze and thaw time frame is very large compared with the time required to repair and establish the freeze capacity. Interruption of the freeze capacity due to mechanical failure of the freeze plant is not perceived to be a major concern, as there is low risk that such an event would result in the migration of mining fluids beyond secondary containment. For reference, intermittent artificial ground freezing has been shown to effectively maintain desired structural stability and hydraulic sealing while also providing a significant operational energy savings (Alzoubi et al. 2017). Intermittent freezing can be used as an analogue to temporary loss of freezing capacity and provides confirmation that temporary loss of freezing capacity would not likely present a substantial environmental concern.

5.4 Bounding Scenario 4: Failure of the Freeze Wall

In this scenario, the structural stability and hydraulic sealing of the freeze wall is compromised in its entirety. It is envisioned that such a scenario could result due to earth movement during major events such as earthquakes. Events such as surficial landslides and/or floods would not cause damage to the freeze wall to its full depth (~ 350 m below surface) that would result in freeze wall failure. The subsistence or response of rock mass to loss of volume at the mining area as uranium ore is removed could result in localized effects. The 3D strip numerical model predicted that stresses and displacements did not show instability in the altered sandstone or basement rock at the location that a freeze wall would been placed around the Phoenix Deposit boundary (RESPEC, 2021).

In the case of the complete failure of the freeze, groundwater and mining fluids within the mining theatre could migrate beyond the compromised section of the freeze wall. This migration process is likely to be very slow. The low temperature of the formation in and around the compromised section of the freeze wall would most likely cause the fluids to freeze and seal or partially seal the opening, further reducing the rate of contamination. The scale of any migration and resulting contamination of the local groundwater environment is difficult to predict as there are large uncertainties associated with the amount of mining fluid that would migrate, the hydraulic conductivity of the thawed freeze wall, the static head, and other hydrogeological / geological factors.

Shallow crevasses can form during earthquake-induced landslides, lateral spreads, or from other types of ground failures, but faults do not open up during an earthquake and surficial cracks which are the results of surficial land settlement are not likely of the depth (USGS 2021) that would pose a risk relative to the mining fluid. Moreover, shallow geological deformities such as crevasses and cracks are typically associated with earthquakes of large magnitudes (6+) – such magnitude earthquakes have not occurred in the past 500 years in area in which the Wheeler site is located (Government of Canada, 2021).

5.5 Bounding Scenario 5: Process System and Piping Failure

Large quantities of radon gas can be dissolved in the lixiviant (mining solution) returning from the mining horizon to the surface. The portion of the total dissolved radon in lixiviant which is above the solution's saturation value is released when encountering atmospheric pressures and temperatures (Brown, 2008). In order to prevent the release of radon in the working environment, atmospheric tanks and vessels are covered and maintained at negative pressure via ventilation systems. Under normal operating conditions, radon is vented from the processing building to the atmosphere through a stack at an appropriate height so as to maximize dispersion and minimize potential exposures at the ground surface. If the piping system, or vessels, such as a thickener tank failure, the dissolved radon is released inside the processing plant.

This accident scenario assumes a vessel or pipe leak that releases a portion of the thickener inside the processing building. In 2009, the NRC issued NUREG–1910, "Generic Environmental Impact Statement (GEIS) for In-Situ Leach Uranium Milling Facilities." (US NRC 2009). In the GEIS, the potential environmental impacts from the postulated accidents involving the operation of an ISR facility located in four geographic regions of the western United States were assessed. One of the scenarios assessed was the release of radon from failed or leaked thickener. The assessment assumed 20% of the contents of the thickener is released inside the processing building (US NRC 2009). Typical radon concentrations in circulating lixiviant (mining solution) ranges from 300 to 7,000 Bq/l (Brown 2008). GEIS used a concentration of approximately 4,000 Bq/l for its assessment.

Denison is planning to include a radon purge tank downstream of well field where most of radon in lixiviant (mining solution) will be released. The activity concentration of radon in the solution downstream of the purge tank before entering the processing building is estimated at 3,700 to 7,400 Bq/L[3]. This concentration range is consistent with the concentrations used by GEIS.

It should be noted that, despite potentially large quantities of the gas being evolved, it is fresh radon, and the progeny equilibrium factors are typically quite low. Most of the gas is released within the first few process areas, wherever first exposed to atmospheric pressure.

The capacity of the thickener at Wheeler ISR is 800 m^3. Assuming a release equivalent to 20% of the contents of the thickener, and a radon concertation of 4,000 Bq/l, the amount of radon released inside the processing plant would be:

$$800\ m^3 \times 0.2 \times 4{,}000\ Bq/l \times 1{,}000\ l/m^3 = 6.4 \times 10^8\ Bq.$$

5.6 Bounding Scenario 6: Facility Fire and / or Explosion

This scenario involves fire and explosion within the processing plant. The most credible event with potential for release of radioactivity is the explosion of the uranium concentrate dryer.

[3] Memorandum from Mehran Monabbatti, Steve Brown, Kim Theobald, Paul Kirby [IEC] to Janna Switzer and Xavier Lu Dac [Denison] dated December 2, 2021.

A fire or explosion that originates from the dryer could potentially release a large amount of uranium to the atmosphere.

For reference, it is acknowledged that this accident scenario could result in significant worker injuries and/or fatalities; therefore, this is the reason that it was rated as "catastrophic" from a consequence perspective in the hazard identification screening evaluation (see Appendix A). The more detailed evaluation of the scenario as presented herein as Bounding Scenario 6 focuses on the release of uranium to the atmosphere. Protections afforded to workers in the processing plant are assumed to be ALARP and, therefore from this perspective, there is no additional analysis specific to a potential worker fatality that could be considered further within the assessment.

5.6.1 Release Characterization

The quantification of uranium release from the uranium concentrate dryer followed the widely accepted methodology proposed by the United States (US) Department of Energy (DOE) to estimate source terms (USDOE 1994).

According to the USDOE, the airborne source term is typically estimated by the following five-component linear equation:

$$\text{source term} = MAR \times DR \times ARF \times RF \times LPF$$

where:

MAR = Material at risk is the amount of chemical or radionuclide available to be acted on by a given physical stress. For facilities, processes, and activities, the MAR is a value representing some maximum quantity of chemical present or reasonably anticipated for the process or structure being analyzed.

DR = Damage ratio is the fraction of the MAR actually affected by the initiating event(s) (i.e., accident-generated conditions). The DR is estimated based upon engineering analysis of the response of structural materials and materials of construction for containment to the type and level of stress or force generated by the event. These estimates often include a degree of conservatism due to simplification of phenomena to obtain a useable model.

ARF = Airborne release fraction, or airborne release rate for continuous release, is the coefficient used to estimate the amount of a chemical released or suspended in air as an aerosol or gas and thus available for transport due to physical stresses from a specific accident.

RF = Respirable fraction is the fraction of airborne chemical particles that can be transported through air and inhaled into the human respiratory system. The RF is commonly assumed to include particles of 10 µm aerodynamic equivalent diameter or less. Other definitions of "respirable particles" have been presented by various groups at different times, but for the present purposes 10 µm and smaller particles were considered respirable. For gaseous chemicals, the RF is 1.

LPF = Leak path factor is the fraction of the chemical or radionuclide transported through some confinement deposition or filtration mechanism. There can be many LPFs for some accident conditions (e.g., the fraction transported from the package, such as a shipping container, to the enclosure; the fraction leaked from the enclosure to the operating area around the enclosure or room; or the fraction leaked from the room to the building–atmosphere interface).

Background information on source term parameters for the fire scenario are summarized as follows:

- *MAR:*
  - The material at risk is the uranium content of the dryer. The content is estimate at 2,000 kg of uranium concentrate with the dryer.
  - MAR = 2,000 kg of uranium concentrate
- *DR:*
  - An explosion within the dryer can potentially affect the entire content of the dryer. Thus, the DR was assumed at 1.
- *ARF:*
  - The US DOE (US DOE 1994) suggests the value of $7.6x10^{-2}$ for ARF for unshielded blast effects from detonations and large volume, confined deflagrations.
- *RF:*
  - The US DOE (US DOE 1994) suggests the value of 0.14 for RF for unshielded blast effects from detonations and large volume, confined deflagrations.
- *LPF:*
  - Since the postulated accident scenario involves the explosion inside the dryer, much of the uranium concentrate will be trapped inside the damaged dryer. It was assumed that 90% of the content of the dryer is trapped. Thus, the LPF would be 0.1.

Based on the above the scenario source term is calculated as:

$2,000 \times 1 \times 7.6x10^{-2} \times 0.14 \times 0.1 = 2$ kg uranium concentrate

It should be noted that the above estimated value is based on a number of assumptions involving the content of uranium concentrate within the dryer and LPF for the explosion inside the dryer. In the GEIS (US NRC 2009), the potential environmental impacts from the postulated dryer explosion were assessed. This assessment used a number of conservative assumptions and estimated the source term for a dryer explosion at 1 kg of uranium concentrate.

5.7 Bounding Scenario 7: Traffic Accident and Terrestrial Release of Radioactivity, Fuel and Hazardous Chemicals

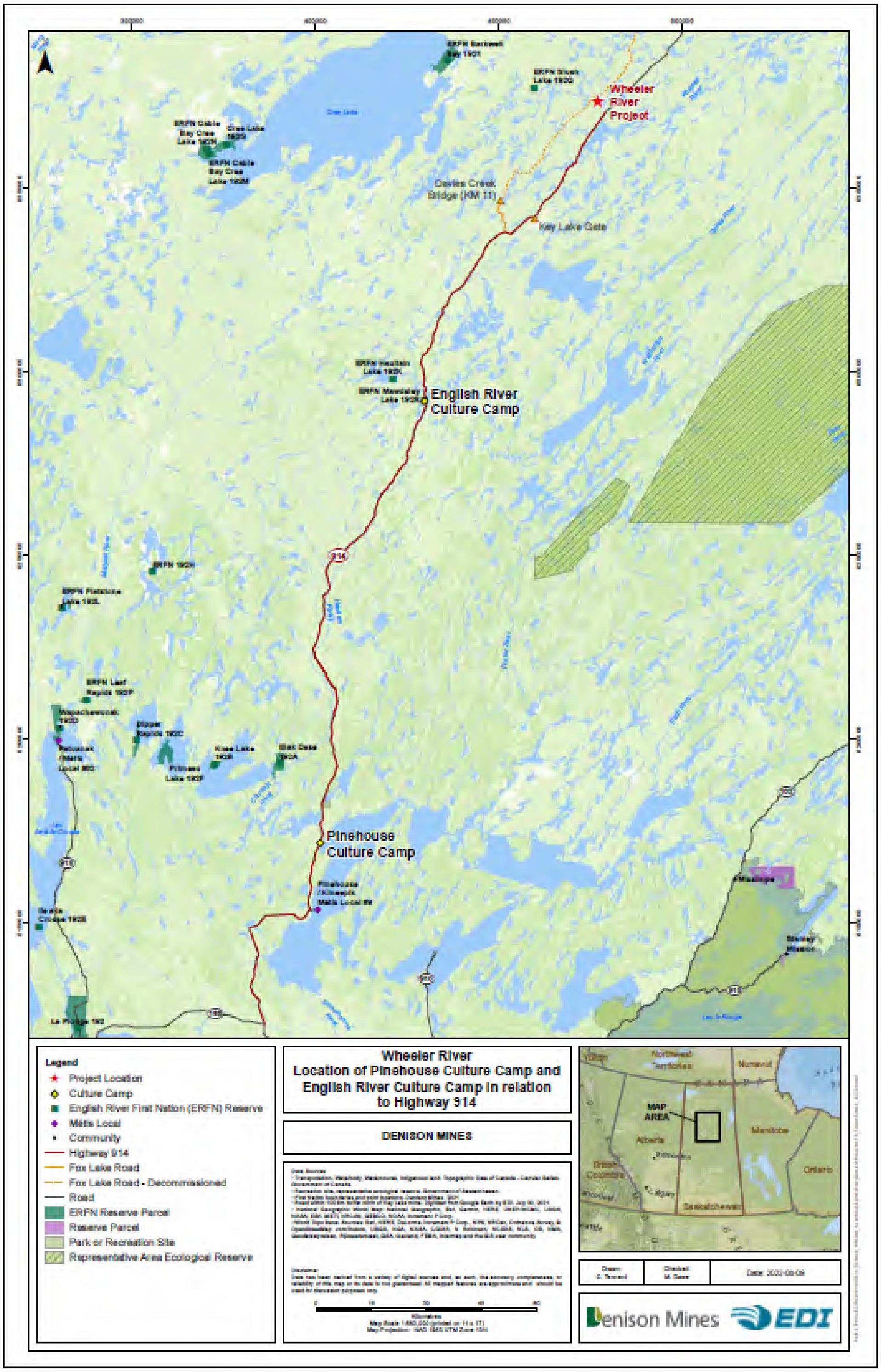
Bounding Scenario 7 is similar to Bounding Scenarios 1and 2 comprising a release of hazardous materials; however, this release is postulated to occur at an off-site location and the release is to ground and not water.

Based on engagement with Interested Parties two release locations have been assumed to provide the scenario some context. Generically, the events can be treated in a similar fashion as the probability and consequence are expected to be the same. The first location corresponds to km 160 of Hwy 914 which is the location of a cultural camp that has been established by the English River First Nations. The second location is at km 67 of Hwy 914 that is a gathering location for the Kineepik Metis Local associated with the Northern Village of Pinehouse. The locations of these camps are shown on **Figure 5-3**.

For reference and as described in **Section 5.2** for such a scenario, it was conservatively assumed that a volume equivalent to the entire cargo of a shipment would be released during an event. The information related to the fuel and chemicals transported to the site is summarized in **Table 5-5**. Based on the available project information, the following is assumed:

- Diesel and Jet Fuel A (30 m^3 or 30,000 L release).
- Gasoline (30 m^3 release).
- Propane (11,000 gallons or 41.58 m^3 release).
- Sulphuric acid (25 m^3 release).
- Sodium hydroxide (25 m^3 release).
- Hydrogen peroxide (~18 m^3 release).

Figure 5-3: Location of Terrestrial Release Along Highway 914



6.0 CHEMICAL, OCCUPATIONAL, AND RADIOLOGICAL BENCHMARKS

The following subsections define relevant benchmarks that are utilized to assess the potential effects of the postulated accident and malfunction scenarios. The benchmarks presented are specific to the bounding scenarios that have been described in **Section 5.0** and are given for the atmospheric and aquatic environments. The benchmarks are specifically selected with consideration of the expected interactions of the bounding scenarios with the environment for the following:

- Uranium
  - atmospheric environment
  - aquatic and terrestrial environment
- Radioactivity
  - aquatic and terrestrial environment
- Radon
  - atmospheric and terrestrial environment
- Sulphuric acid and sodium hydroxide
  - aquatic environment (pH).

6.1 Uranium

6.1.1 Non-Radioactivity

Atmospheric Environment

The Agency for Toxic Substances and Disease Registry (ATSDR) provides evaluations of toxicity for numerous agents, including uranium. In its 2013 report "Toxicological Profile for Uranium" (USHHS 2013), the ATSDR reports that "natural and depleted uranium have the identical chemical effect on your body. The health effects of natural and depleted uranium are due to chemical effects and not to radiation." The 2013 report by ATSDR further notes that "neither the National Toxicology Program, International Agency for Research on Cancer, nor the Environmental Protection Agency have classified natural uranium or depleted uranium with respect to carcinogenicity."

UNSCEAR (2017) indicates that the relative importance of chemical and radiological toxicities of uranium depend on a number of factors – notably, the degree of enrichment of uranium-234 and uranium-235. The chemical toxicity from uranium exposure is mainly associated with damage to the kidneys and is assumed not to occur below a threshold concentration. Thus, while uranium is a radioactive substance, for natural and depleted uranium, the risks from intake of uranium are related to its chemical toxicity, and the potential for such effects are the basis for the hazard and risk assessments described in this report.

Exposure limits for emergency scenarios are defined by a hierarchy of threshold concentrations. These include the Emergency Response Planning Guideline (ERPG), and Temporary Emergency Exposure Limit (TEEL) (USDOE 2016). TEELs are intended for use until ERPGs are adopted for chemicals and have similar definitions as the corresponding ERPG levels.

ERPGs are intended to be a planning tool to help anticipate human adverse effects on the general public caused by toxic chemical exposure. These are only available for a one-hour exposure duration and are not designed for hypersensitive individuals.

- ERPG-1 The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing other than mild transient adverse health effects or perceiving a clearly defined, objectionable odour.

- ERPG-2 The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair an individual's ability to take protective action.

- ERPG-3 The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing life-threatening health effects.

The most commonly used benchmarks for emergency release scenarios are from ERPG-2. ERPG values developed by the American Industrial Hygiene Association are included in Table 6-1. These values were taken from the Protective Action Criteria (PAC) tables (USDOE 2016).

Table 6-1: Emergency Response Planning Guidelines for Uranium Oxide and Uranium Concentrate

Chemical	ERPG-2	ERPG-3
Uranium oxide	10 mg/m^3	30 mg/m^3
Uranium concentrate	10 mg/m^3	50 mg/m^3

ERPG = Emergency Response Planning Guideline.

Aquatic Environment

A maximum acceptable concentration of 0.02 mg/L (i.e., 20 µg/L) is established for total natural uranium in drinking water. The guideline is based on the chemical toxicity of naturally occurring uranium (Health Canada 2019).

Canadian Water Quality Guidelines for Uranium (total recoverable, unfiltered) for the protection of aquatic life are 15 µg/L and 33 µg/L for long-term exposure and short-term exposure, respectively (CCME 2011).

The water quality guidelines for drinking and protection of aquatic life are not developed for emergency situations; however, they can be conservatively used during transient situations following an accident.

6.1.2 Radioactivity

Aquatic Environment

Radiation Protection Regulations, SOR/2000-203, governs the annual effective dose equivalent limits for individual members of the public exposed to the radioactivity resulting from industrial activities such as uranium mining and process plant buildings. The effective dose limit for the general public is 1 mSv per calendar year (Government of Canada 2021).

The assessment of effects on ecological receptors from exposure to radioactive constituents involves the estimation of the combined (total) dose that a receptor may receive from radionuclides taken into the body as well as from exposure to radiation fields in the external environment. In addition, it is standard practice to take into account differences in the effects of alpha, beta and gamma radiation. Radiation effects on biota depend not only on the absorbed dose, but also on the relative biological effectiveness (RBE) of the particular radiation (i.e., alpha, beta or gamma radiation). For example, alpha particles can produce observable damage at lower absorbed doses than gamma radiation. Thus, in order to estimate the potential harm to non-human biota from a given absorbed dose, the absorbed dose is multiplied by an appropriate radiation weighting factor. This in turn is derived from an experimentally determined RBE. In this assessment, the terms “RBE” and “radiation weighting factor” are used interchangeably. It should be noted that uncertainty remains concerning the most appropriate RBE values for assessing risks to non-human biota. The RBE values depend on the radiation quality, the biota under consideration, the endpoint being considered and the reference photon energies. The RBE values selected to develop protection criteria should correspond to the endpoint being protected (e.g., health of a population). For this assessment, an RBE of 2 was used for “low beta” and an RBE of 10 was used for alpha components, to represent their greater relative effectiveness (CSA Group 2012).

The Canadian Standard N288.6 which addresses Environmental Risk Assessments at Class I Nuclear Facilities and Uranium Mines and Mills (CSA 2012) recommends an RBE of 10 to be applied to the component of internal dose from alpha emitters. This assessment will follow this recommendation. The Standard also recommends that radiation dose benchmarks for quantitative effects assessment should follow UNSCEAR (2008), i.e., 100 µGy/h for terrestrial biota and 400 µGy/h for aquatic biota. Therefore, the benchmarks used in the assessment are 2.4 mGy/d for terrestrial biota and 9.6 mGy/d for aquatic biota. The prescribed limit for the general public is 1 mSv per calendar year.

6.2 Radon

6.2.1 Radioactivity

The maximum amount of radiation people are allowed to receive in the workplace is regulated. The Canadian Nuclear Safety Commission sets a limit of 50 mSv in a single year and 100 mSv over 5 years (a 20 mSv per year average). The limit for a pregnant worker, once pregnancy has been declared, is 4 mSv for the remainder of the pregnancy (CNSC 2021). The prescribed limit for the general public is 1 mSv per calendar year (CNSC 2021).

6.3 Sulphuric Acid Sodium Hydroxide

Aquatic Environment

Canadian Water Quality Guideline for pH for the Protection of Aquatic Life is 6.5-9 for long-term exposure. No guideline for short-term exposure is available (CCME 1987).

7.0 ASSESSMENT OF PROBABILITIES OF THE BOUNDING SCENARIOS

The probabilities of the seven identified bounding scenarios are characterized below.

7.1 Bounding Scenario 1: Traffic Accident and Aquatic Release of Radioactivity

Principal Traffic risk mitigation measures include:

- traffic control measures, such as the speed limit;
- travel management plans;
- spill and emergency response planning; and
- driver training.

Despite these risk control measures, a residual probability of accidents occurring remains. The probability of occurrence of a transportation accident and sequence of events resulting in release of hazardous materials is the key factor for quantifying the transportation risk. Statistical data for transportation accidents are available for general transportation, as well as the transportation of hazardous materials. General transportation accident statistics are commonly presented as the number of accidents per million kilometres or million miles of transport vehicle travelled. Specific hazardous materials transportation accident statistics are commonly presented as the number of accidents per million ton-miles or million tonne-kilometres of materials transported.

Hazardous material transportation accident statistics are generally more relevant for risk assessment studies such as this; however, the statistical datasets for hazardous material transportation are less reliable. Data regarding the total volume and mass transported by various modes of transportation are maintained by shipping companies and in most cases are only available to regulatory agencies such as Transport Canada. Publicly available information is reported on a lump sum basis. In addition, the statistical breakdown for transportation routes is not readily available and the route data, particularly for road transportation, are maintained by road transport companies and are not publicly available. With the above in mind, general transportation accident statistics have been used herein to characterize accident probability.

In Canada, the statistics related to the transportation and road accidents are primarily collected and maintained by federal and provincial government agencies including Transport Canada (2019) and its branches (such as the Canada Transportation Safety Board), the Saskatchewan Ministry of Highways and Infrastructure, and Saskatchewan Government Insurance (SGI 2018). These statistics indicate that average accident rates for Canada and Saskatchewan were 1.2 and

0.89 per one million kilometres travelled, respectively. Statistics more localized to the Project site indicate that average accident rate was1.75 per one million kilometres travelled for Highway 914. This value was used for the calculations.

In the case of the accident scenario envisioned, calcined uranium concentrate would be packed into standard 205 L (45 gal) steel drums for shipping. It is projected that there would be about 40 drums packaged per mill operating day (Wheeler River project description documentation). It was also assumed that a traffic accident on the bridge or within 40 m from either side of the bridge has the potential for release to the Wheeler River.

Using the transportation route lengths and the transportation accident rates estimated above and assuming one trips per day for 330 days per year, the annual probability of traffic accidents involving uranium concentrate along Highway 914 and in the vicinity of the Wheeler River crossing (i.e., considering a 40 m buffer at each side of the bridge, total of 40+40+20=100 m = 0.1 km) are estimated as:

for release to water: $330 \times 1.75 \times 0.1 / 1{,}000{,}000 = 5.78 \times 10^{-05}$

The above probabilities were calculated using Saskatchewan Government Insurance statistics for Highway 914.

According to the probability ratings described in **Section 3.2.2**, the probability that this accident and malfunction scenario would occur is highly unlikely.

7.2 Bounding Scenario 2: Traffic Accident, Aquatic Release of Fuel, and Hazardous Chemicals

Traffic risk mitigation measures for this Bounding Scenario 2 are the same those presented for Bounding Scenario 1. The annual probability of traffic accidents involving fuel or chemicals along Highway 914 and in the vicinity of the Wheeler River crossing (i.e., considering 40 m buffer at each side of the bridge, total of 40+40+20=100 m = 0.1 km), assuming 1,220 trips per year for 330 days per year, are estimated as:

for release to ground: $1{,}220 \times 1.75 \times 0.1 / 1{,}000{,}000 = 2.14 \times 10^{-03}$

The above probabilities were calculated using Saskatchewan Government Insurance statistics for Highway 914.

According to the probability ratings described in **Section 3.2.2**, the probability that this accident and malfunction scenario would occur is unlikely.

7.3 Bounding Scenario 3: Loss of Freeze Capacity

In **Section 5.3** it was argued that a loss of freeze capacity resulting in freeze wall failure and the subsequent release of mining fluids from the mining theatre into the local / regional groundwater environment was very unlikely. Accordingly, and based on professional judgement, a nominal value of $1x10^{-7}$ was assigned as the annual probability of this scenario.

According to the probability ratings described in **Section 3.2.2**, the probability that this accident and malfunction scenario would occur is highly unlikely.

7.4 Bounding Scenario 4: Failure of the Freeze Wall

In **Section 5.4**, it was noted that a strong earthquake with magnitude larger than 6 would have the potential to damage the freeze wall and result in the release of mining fluids from the mining theatre into the local / regional groundwater environment. A review of seismicity at the Wheeler site indicates that the probability of occurrence of an earthquake with this magnitude is very unlikely and is less than 10^{-4} per year.

According to the probability ratings described in **Section 3.2.2**, the probability that this accident and malfunction scenario would occur is highly unlikely.

7.5 Bounding Scenario 5: Process System and Piping Failure

The following principal mitigating measures would be in place to reduce the probability of a release from process piping and vessels:

- visual inspections;
- regular and preventive inspection, testing, and maintenance programs;
- emergency response planning; and
- full containment of processing plant.

A spill of uranium bearing solution and subsequent release of radon gas from the released solution could occur as a result of the following events:

- overflow of storage or process vessels and thickener;
- leaks or rupture in thickener;
- failure of valves or other piping system components.
- failure of the pumps; and

- failure of other process components, such as screens and filters.

Average probabilities of failures for different components in the solvent extraction unit were based on the information provided by the Center for Chemical Process Safety of the American Institute of Chemical Engineers (AIChE-CCPS 1989) and are shown in **Table 7-1**.

Table 7-1: Average Failure Probability for Solvent Extraction Process Equipment

Equipment with Potential for a Major Spill or Fire	Failure Rate (all modes)(per year)
Vessels (i.e., atmospheric and metallic) (assuming 2 thickeners containing uranium rich solvents)	10^{-3}
Piping (i.e., metal; straight section and connection) (assuming 100 sections)	10^{-4} per item
Pumps (e.g., motor driver and pressure-centrifugal) (assuming 2 pumps)	10^{-2}

Source: Center for Chemical Process Safety (AIChE - CCPS 1989)

If it is assumed that the plant is in 8,250 hours per year, this would result in a annual failure probability of 3.2×10^{-02} under this scenario, as shown below.

$$10^{-3}\times2+10^{-4}\times100 + 10^{-2}\times2 = 3.2 \times 10^{-02}$$

According to the probability ratings described in **Section 3.2.2**, the probability that this accident and malfunction scenario would occur is likely.

7.6 Bounding Scenario 6: Facility Fire and / or Explosion

The average annual probability of the occurrence of a furnace explosion, which is used as an analogue for Bounding Scenario 6, as provided by Chemical Process Safety of the American Institute of Chemical Engineers (AIChE-CCPS 1989) is 4×10^{-4}.

According to the probability ratings described in **Section 3.2.2**, the probability that this accident and malfunction scenario would occur is highly unlikely.

7.7 Bounding Scenario 7: Traffic Accident, Terrestrial Release of Radioactivity, Fuel, and Hazardous Chemicals

Traffic risk mitigation measures for Bounding Scenario 7 are the same those presented for Bounding Scenarios 1 and 2. The annual probability of traffic accidents involving radioactivity, fuel or chemicals along Highway 914 and within one kilometer near the designated locations assuming 1,220 trips per year for fuels and chemicals and for 330 trips per year for uranium, are estimated as:

$$(1{,}220+330) \text{ x } 1.75 \text{ x } 1 \text{ / } 1{,}000{,}000 = 2.71 \times 10^{-03}$$

The above probabilities were calculated using Saskatchewan Government Insurance statistics for Highway 914.

According to the probability ratings described in **Section 3.2.2**, the probability that this accident and malfunction scenario would occur is unlikely.

7.8 Summary of Probabilities

The probabilities for the bounding scenarios are summarized below in **Table 7-2**. Recall that the potential effects (i.e., overall risks) associated with the bounding scenarios are a function of both probability and consequence and therefore these probabilities are considered along with scenario consequences to predict effects in **Section 8.0**.

Table 7-2: Probabilities of Bounding Scenarios

No.	Potential Accidents or malfunctions	Project Phase	Potential Effects Pathway	Calculated Annual Probability	Probability Characterization
1	Vehicle accident including rollover, collision, run off road	Op	Aquatic release of radioactivity	5.77×10^{-05}	Highly unlikely
2	Vehicle accident including rollover, collision, run off road	Co / Op / De	Aquatic release of fuel, hazardous chemicals and reagents	2.14×10^{-03}	Unlikely
3	Loss of freeze capacity	Op	Release of mining liquid to the local / regional groundwater environment	$1x10^{-7}$	Highly unlikely
4	Failure of freeze wall	Op	Release of mining liquid to the local / regional groundwater environment	10^{-4}	Highly unlikely
5	Process vessel and piping system failure	Op	Release of radon from storage tank	3×10^{-02}	Likely
6	Facility fire / explosion	Op	Release of radioactivity and uranium concentrate powder to atmosphere	$4x10^{-4}$	Highly unlikely
7	Vehicle accident including rollover, collision, run off road	Co / Op / De	Terrestrial release of radioactivity and chemicals	2.71×10^{-03}	Unlikely

Notes: Co is construction; Op is operations; De is decommissioning.

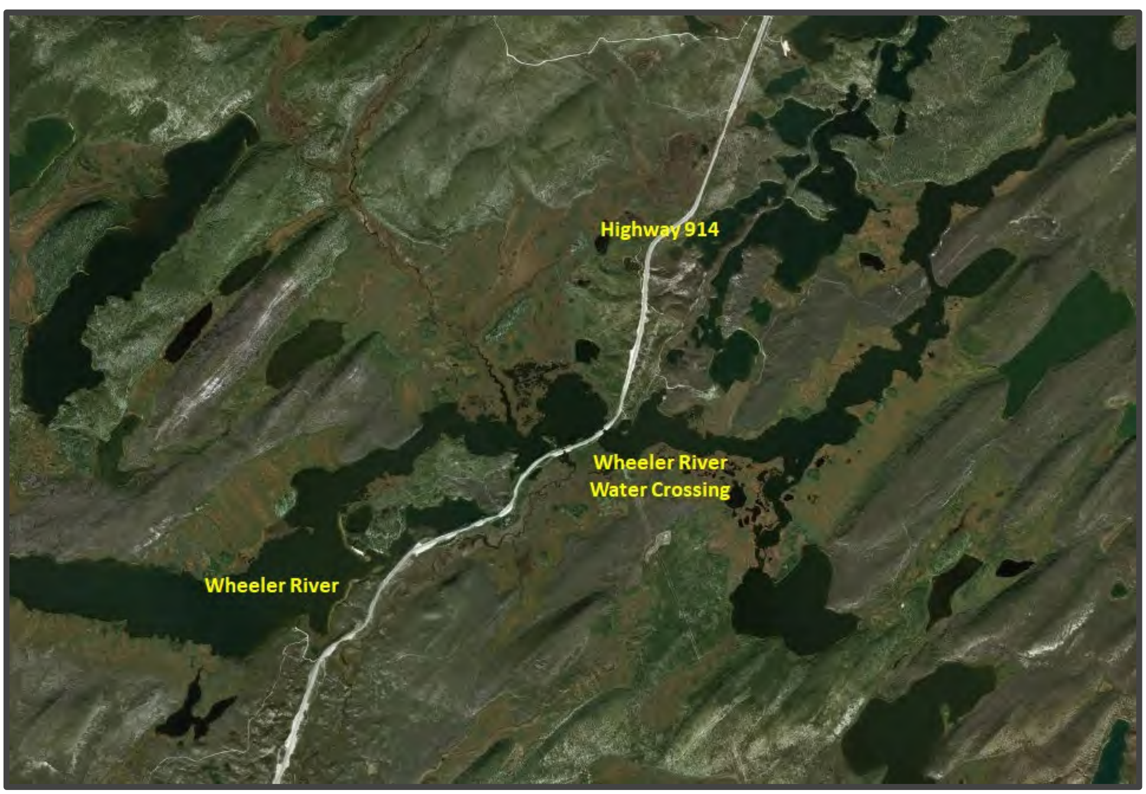
8.0 ASSESSMENT OF POTENTIAL EFFECTS FROM BOUNDING SCENARIOS

The assessment of potential effects associated with each of the identified bounding scenarios is presented below.

8.1 Bounding Scenario 1: Traffic Accident and Aquatic Release of Radioactivity

The Wheeler River runs approximately 10 km south of the Wheeler site from the southwest towards northeast and drains to Russel Lake. Provincial Highway 914 crosses the Wheeler River 10 km southwest of the site access road junction. This is the crossing where it is assumed that a hypothetical truck accident would occur (**Figure 8-1**). The river width at the crossing measures about 20 m. The closest hydrometric gauging station is station number 06DA005 (at Wheeler River South of Russell Lake). The river flows considered for this assessment are 5th percentile annual flow of 10.9 m^3/s (minimum flow), the average annual flow of 17.3 m^3/s (average flow), and the 95th percentile annual flow of 24.67 m^3/s (maximum flow). Corresponding river depths for these flow conditions are 0.8, 1.2, and 1.7 m, respectively.

Figure 8-1: The Wheeler River crossing location



Uranium Concentrates Fate and Transport Results

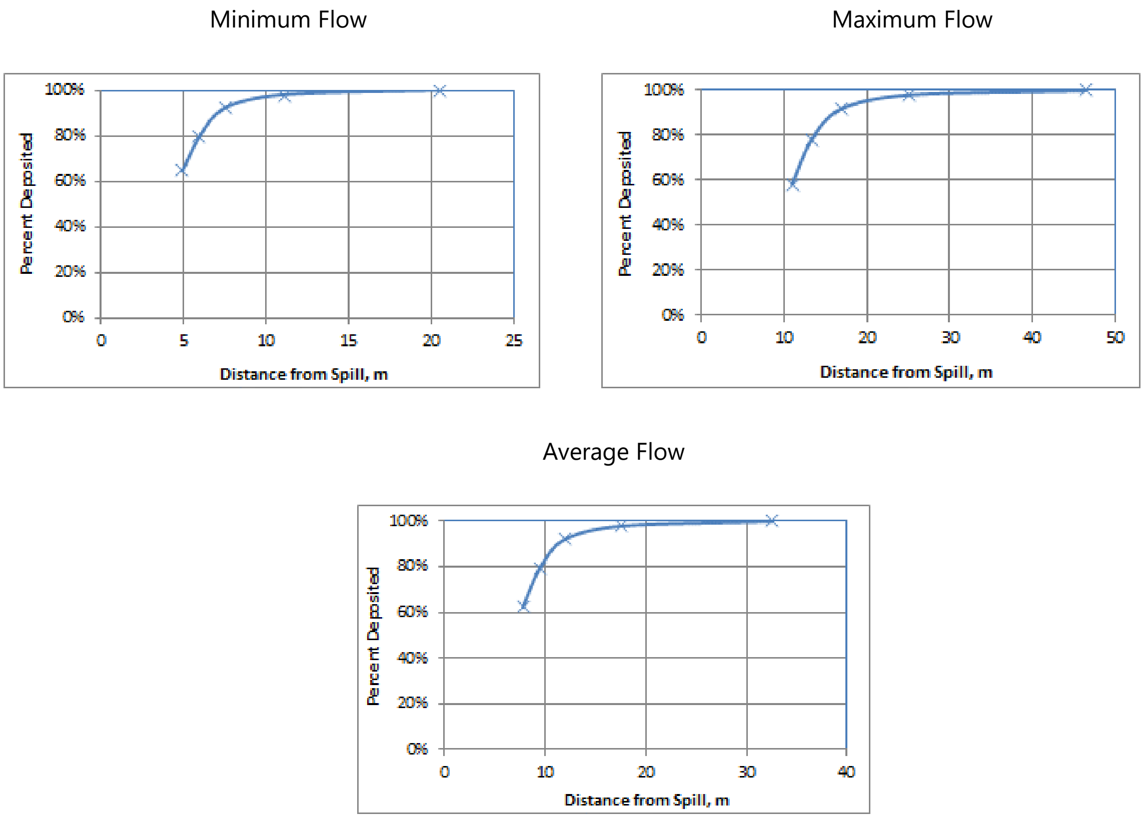
Sediment concentrations were estimated through calculation of the distance travelled by uranium concentrate after a spill, and the area impacted.

Figure 8-2 illustrates the implication of this distribution of uranium concentrate mass for any clean-up planning. The results indicate that most (98% of the mass) of the uranium concentrate will settle within a short distance of the release, even under high flow conditions in the Wheeler River (i.e., within ~20 m of the release point) due to a relatively slow water velocity (<0.8 m/s). This indicates that the hypothetical release would be confined to a small area and it is expected that it could be effectively recovered. Under high flow conditions (i.e., worst-case), the maximum estimated distance for the deposition of particulates <5 µm is approximately 46 m from the crossing.

For the purposes of the current assessment, it was assumed that 95% of the solids that settle within 15 m of the spill site are potentially recoverable through remedial activities. Sediment quality results are shown in **Table 8-1** for post remediation conditions. The results presented in the table are a summary of the three flow conditions for predicted sediment concentrations in the Wheeler River. In general, using the results of the assessment, the minimum predicted uranium concentrates concentrations in the river sediments occurred under high flow conditions, where the smaller particles (<5 µm) are deposited over a larger area.

Porewater quality within the impacted sediment of the Wheeler River was estimated based on weighted-average sediment concentrations and using a sediment-to-water partition coefficient of 3.5 m^3/kg. The results are shown in **Table 8-1**. During minimum flow conditions, the impacted volume is smaller resulting in a higher sediment concentration; whereas, higher flow conditions on the other hand, result in a greater footprint and hence lower concentrations. Concentrations post-cleanup may not follow the same trend since the clean-up is limited to a distance of 15 m and, while higher concentrated sediment in the vicinity of spill will be cleaned, sediments with lower concentrations further downstream will not, resulting in a higher overall concentration in the high flow conditions.

Figure 8-2: Distribution of Deposited Uranium Concentrate by Distance Downstream of the Wheeler River Crossing



Note: The horizontal scale is not the same for all figures.

Table 8-1: Estimated Post-Remediation Sediment and Porewater Quality Downstream of the Wheeler River Crossing

Flow	Affected Distance (m)	Average Sediment Concentration (µg/g)	Porewater Concentration (µg/L)
Minimum	21	3,461	12
Average	33	3,309~~2,535~~	12~~9~~
Maximum	47	2,535~~3,309~~	9~~12~~

Water concentrations for the three flows were estimated for short and long-term concentrations using information on uranium solubility and porewater concentrations, respectively. The results are shown in **Table 8-2**. The short-term period for the Wheeler River is estimated at about a week regardless of whether settling is taken into account.

Table 8-2: Estimated Water Quality Downstream of the Wheeler River crossing (µg/L)

Duration	Mixing in 5% of River Flow			Mixing in 25% of River Flow			Mixing in 100% of River Flow		
	Min Q	Mean Q	Max Q	Min Q	Mean Q	Max Q	Min Q	Mean Q	Max Q
Short-term†	56,747	37,831	26,705	11,349	7,566	5,341	2,837	1,892	1,335
Long-term*	n/a	n/a	n/a	n/a	n/a	n/a	0.39	0.188	0.173

Notes:

† Estimated at one week

* Post remediation

Q is flow

n/a- mixing in 5% and 25% is not relevant for long-term concentrations

Exposure Assessment

The assessment of effects to ecological receptors is made by comparing exposure estimates to the relevant toxicological / radiological benchmarks. For example, intake (or dose) estimates are compared to non-radiological Toxicity Reference Values (TRVs) and to dose rate guidelines for radionuclides to assess the risks of adverse health effects for each of the ecological receptors. For people, the estimated exposure is compared to the drinking water quality guidelines. The adverse effects on the water quality are transient, and the accumulation of contaminants through the food chain is not expected for the accident scenarios. Therefore, the only credible exposure pathway for the human receptors is drinking water.

It should be noted that for ecological health effects are considered on a population-level as opposed to an individual-level. Estimation of population level impacts is a complex issue and involves some level of scientific judgement.

The results of water and sediment quality predictions were used to assess exposures of ecological species to uranium.

In general, the approach taken for estimating the exposure of radiological and non-radiological contaminants to non-human biota is to model the intake of a contaminant by the biota (in mg/d or Bq/d) and then use a transfer factor or TF (d/kg) to obtain a body or flesh concentration where necessary. Many toxicity values for non-radiological contaminants are expressed as intake rates rather than tissue residues. Therefore, the assessment of non-radiological and radiological contaminants can be carried out in parallel with the flesh concentrations being important for estimating internal radiological dose; and intakes are used for assessment of non-radiological contaminants.

The comparison of intake (or dose) estimates to TRVs or dose rate guidelines is usually undertaken by the calculation of screening index (SI) values, also referred to as hazard quotients or HQs. The SI values provide an integrated description of the potential hazard, the exposure (or dose) response relationship and the exposure evaluation. This approach is widely used as a key line of evidence in ecological assessments, particularly in screening-type assessments (EC, 2012).

The acute exposure to all aquatic species, with the exception of benthic invertebrates was assessed. Since an acute TRV is not available for benthic invertebrates and they are exposed to both sediments and water, benthic invertebrate exposure was considered to be chronic.

In the assessment of population-level effects on benthic invertebrates, one of the key considerations in this predictive assessment is the scale of the impact. As discussed by U.S. EPA (2003), if the area is large, the effects will be diluted. However, if the area is small, the affected population or community may be too insignificant to prompt stakeholder concern or action. For this assessment, population-level impacts are judged to occur if more than 5% of a lake is affected or 0.2 hectares in river systems.

The results of the water quality predictions were used to assess exposures of a human receptor to chemical uranium as well as radionuclides. For a short-term assessment, the estimated uranium concentration in water was compared to the appropriate water quality benchmark and the estimated radiological dose was compared to the reference dose.

For the assessment of the exposure following a spill in a river, the focus is placed on the estimated concentration following mixing in the entire river flow under average conditions.

Table 8-3 provides estimated concentration and intake, calculated SI values for each receptor selected for assessment in the Wheeler River for average flow conditions for exposure to a spill of uranium concentrate. As seen from the table, the SI values for short-term water and sediment concentrations are above the reference value of 1; these are examined further below. The results of the ecological risk assessment indicate short-term ingestion of contaminated water resulting from an accident would not result in potential risks to grouse, vole or deer. No additional exceedance is observed under low or high flow conditions.

<u>Sediment:</u> Concentrations in post-remediation conditions (95% cleanup within 15 m of spill) are expected to exceed the benchmark. Spilled uranium concentrate would spread over approximately 10.3 m in the average flow condition, covering an area of approximately 824 m^2 (10.3x80=824 m^2 = 0.084 ha). These results indicate that a spill of uranium concentrate could potentially affect the benthic invertebrate populations following a spill, but the spatial extent would be limited.

Water: In the determination of the evaluation of the potential impact, a comparison was made between the results of the estimated short-term water quality and the guideline. The concentration of 1,892 µg/L is greater than 33 µg/L. This indicates that there may be some aquatic species that are affected, but the effects are transient the water concertation quickly drops to long-term level of 0.19 µg/L.

Table 8-3: Consequences on Ecological Receptors for Average Flow in the Wheeler River

Receptor	Exposure					SI (based on)		
	Concentration, mg/kg	Intake, mg/kg.d	Internal Dose	External Dose	Equivalent Dose, mGy/d	Concentration	Intake	Dose
Water-short term	1.892	-	-	-	-	57.3	-	-
Water-long term	0.00019	-	-	-	-	0.005	-	-
Sediment- dw	8449	-	-	-	-	4	-	-
Grouse	0.076	457	1.95E-05	-	1.95E-05	-	0.86	<0.001
Vole	3.97E-06	0.38	1.88E-06	-	1.88E-06	-	0.033	<0.001
Deer	2.55E-03	0.113	0.0012	-	0.001	-	0.01	0.018

Benchmarks: Water, mg/L: 0.033 (short-term);TRVs: 0.043, 0.17 and 0.73 (95^{th}, 90^{th} and 80^{th} protection levels)
Sediment, mg/kg dw: 2,296 (benthic invertebrates)
Intake, mg/kg.d: 160 (grouse), 11.4 (vole, deer)
Dose, mGy/d: 2.4
Grey shading exceeds benchmark
dw is dry weight

Based on the above assessment, and in consideration of the consequence scale described in **Section 3.2.2**, Process Hazards Analysis, the severity of the consequences of this accident and malfunction scenario is judged to be moderate.

8.2 Bounding Scenario 2: Traffic Accident and Aquatic Release of Fuel and Hazardous Chemicals

For the purpose of assessing the potential effects on the aquatic environment from a release of fuels and hazardous chemicals, as described in Section 5.2, the release of diesel fuel was chosen as a representative scenario, rather than other chemicals, such as acids and bases. Through the hazard identification screening process (see **Appendix A**), the overall risk of the release of acids and bases was characterized as "moderate" and "ALARP" and, as such, consistent with the scenario screening assessment methodology was not carried forward for further evaluation. Rather, since the release of organic compounds (such as diesel) would have the potential for downstream transport as a compound in liquid phase distinct from that of the water in the receiving environment. In this sense, it produces a greater challenge of potential contamination over a larger spatial extent and timespan than the release of acid, while coincidentally necessitates the need for /opportunity for proactive response and clean-up. In contrast, the released acids and bases dissolve in water relatively quickly and effects to local biota can be expected to be experienced on a more local basis and over a shorter timeframe. There is little likely mitigation that can be applied in that scenario and, therefore, the risk mitigation measures are limited to those that prevent accidents or reduce the probability to ALARP.

Fuel Spill

Amongst the fuels considered for this scenario, the consequences of the release of gasoline and solvents are bounded by the consequences associated with the release of diesel fuel. Both gasoline and solvents are lighter with higher vapour pressure; therefore, they have a shorter half-life in the aquatic environment and have a lesser tendency for adsorption to sediments and suspended solids in the water column.

Diesel fuel is considered a non-persistent oil, as it will lose 40% of its volume due to evaporation within 48 hours of an accidental release, even in cold weather. Small diesel spills (i.e., 2 to 20 m^3) will usually evaporate and disperse within a day or less in the aquatic environment; thus, seldom is there any oil on the surface for responders to recover (NOAA, 2020). With a specific gravity between 0.82 and 0.88, diesel fuel is much lighter than water, so it is not possible for diesel to sink and accumulate on the seafloor as pooled or free oil unless adsorption occurs with sediment. Diesel dispersed in the water column can adhere to fine-grained suspended sediments that can then settle out and get deposited on the seafloor. This process is more likely to occur near river mouths where fine-grained sediment is carried in by rivers. This process is not likely to result in measurable sediment contamination for small spills (NOAA 2020). The residual diesel is completely degraded within one to two months; therefore, surface water cleanup for small-scale diesel spills is not likely feasible.

Nevertheless, the unplanned release of diesel still poses a threat to aquatic organisms and particularly birds if they if they are exposed. Fish, aquatic invertebrates, and aquatic vegetation that come in direct contact with a diesel spill may be killed. However, small spills in open water are so rapidly diluted that fish kills are unlikely events unless the spill is in confined, shallow water. Diesel spills can affect water-associated birds by direct contact. Mortality is caused by ingestion during preening.

The theoretical maximum size of 1 µm diesel fuel sheen that can be created by a 30 m^3 spill is $3 \times 10^{+07}$ m^2; however, due to evaporation and dissolution of the majority of the spilled diesel, the size the affected area is much smaller, particularly in a slow-moving surface waterbody. The average water flow rate in the Icelander at station SA-5 is approximately 0.917 m^3/s and when considering the width of the river (i.e., 10 m) and the depth of less than 1 m, the average water velocity is less than 9 cm/s. The spill would quickly reach downstream water bodies (an unnamed lake and Whitefish Lake) where the water velocity would dramatically decrease. At this point, a spill would travel less than 1 km in a day. Considering the lifetime of diesel fuel, the diesel sheen cannot travel beyond 2 km from the bridge on the access road. Thus, the affected areas would be limited to areas downstream to Whitefish Lake. McGowan Lake, to the south of Whitefish Lake, would not be affected in long term (beyond 2 or 3 days). The effects under this scenario are transient, and some adverse effects to aquatic biota and birds may be expected; however, irreversible population level effects are not expected.

Based on the above, and in consideration of the consequence scale described in **Section 3.2.2**, Process Hazards Analysis, the severity of the consequences of this accident and malfunction scenario is judged to be moderate.

8.3 Bounding Scenario 3: Loss of Freeze Capacity

In **Section 7.3**, it was indicated that the probability of groundwater contamination due to the loss of freeze capacity is highly unlikely. In a very unlikely case of groundwater contamination, establishing an exposure pathway from deep contaminated groundwater to a surface water is associated with a large uncertainty. In addition, fate and transport of mine fluids cannot be easily quantified. However, it is recognized that, in a very unlikely case of contamination, remediation at the depth of mining horizon is very difficult and spread of contamination could potentially result in effects severity that can be characterized as major per the consequence scale described in **Section 3.2.2**, Process Hazards Analysis. Accordingly, Denison has put great effort into ensure that the structural stability of freeze wall is maintained, and the freeze plant is maintained in good working order.

8.4 Bounding Scenario 4: Failure of the Freeze Wall

In **Section 5.4**, it was indicated that the failure of the freeze wall is only possible due to a large magnitude (6+) earthquake which is a very low probability event at the Wheeler site. In addition, it was discussed that a small fracture in freeze wall may be sealed due to freezing of the intruding groundwater or mining fluid. In this case only small amount of contaminated fluid may leave the mining horizon.

Similar to the previous scenario discussed in **Section 8.3**, establishing an exposure pathway from deep contaminated groundwater to a surface water is associated with a large uncertainty. In addition, fate and transport of mine fluids cannot be easily quantified. It is also noted that the groundwater monitoring and freeze wall thickness monitoring would help detecting the loss of freeze capacity. In the highly unlikely event of failure of freeze wall, mitigation measures including pumping both within the freeze wall/CSW and outside the freeze wall could be employed. However, it is recognized that, in a very unlikely case of contamination, remediation at the depth of mining horizon is very difficult and spread of contamination could potentially result in effects severity that can be characterized as major per the consequence scale described in **Section 3.2.2**, Process Hazards Analysis.

8.5 Bounding Scenario 5: Process System and Piping Failure

The assessment of the accidental release of uranium-rich solution in a processing plant was completed by US NRC (2009). The analysis considered the source terms similar to the source term calculated in **Section 5.5**. The analysis was conducted for a number of wind speeds, stability classes, release durations, and receptor distances. For receptor distances of 100 and 500 m, doses from this scenario were calculated to be less than 0.25 and 0.01 mSv, respectively (US NRC 2009). Both of these doses are less than 25 percent of the annual dose limit for the public of 1 mSv.

There could be external doses from the spill to workers exposed to the released radon, but offsite receptors further than 500 m would be too far away to experience any effects. The assessment also indicated that the dose to the unprotected worker staying inside the processing plant during the spill could exceed the 50 mSv dose limit specified by CNSC if workers did not leave the area quickly after the spill. Denison ensures that the process designed to include control measures to reduce the exposure to both workers and members of the public as low as achievable. The measures would ensure that the processing plant is adequately ventilated, and that spills or leaks are detected by loss of system pressure, observation, or flow imbalance. Emergency response and spill response plans will include procedure for workers protection, personnel protection equipment, and procedures to evaluate exposures during a spill.

Based on the above, and in consideration of the consequence scale described in **Section 3.2.2**, Process Hazards Analysis, the severity of the consequences of this accident and malfunction scenario is judged to be minor.

8.6 Bounding Scenario 6: Facility Fire and / or Explosion

The assessment of the accidental release of uranium powder in the processing plant due to dryer explosion was completed by US NRC (2009). The analysis considered the source terms similar to the source term calculated in **Section 5.6**. Using the release amount of 1 kg inside the processing plant, the dose to offsite receptor at 200 m was calculated to be less than CNSC public dose limit of 1 mSv. The analyses also indicated that the dose to a worker in a full-face-piece powered air-purifying respirator who stays in the area would be 88 mSv, which exceeds the annual worker dose limit of 50 mSv.

Denison would ensure that the design of the plant includes control measures to reduce the exposure to both workers and members of the public to levels that are as low as achievable. The measures would ensure that the processing plant is adequately ventilated. Emergency response and spill response plans will include procedures for worker protection, personnel protection equipment (particularly respiratory equipment), as well as procedure to evaluate exposures during a release of uranium powder.

In the unlikely event of an unmitigated accidental release of uranium due to a dryer explosion, doses to the workers could have a moderate effect, but doses to members of the public would have only a minor effect.

Based on the above, and in consideration of the consequence scale described in **Section 3.2.2**, Process Hazards Analysis, the severity of the consequences of this accident and malfunction scenario is predicted to be moderate.

8.7 Bounding Scenario 7: Traffic Accident, Terrestrial Release of Radioactivity, Fuel, and Hazardous Chemicals

Compared with release to surface water, terrestrial release of hazardous materials are easier to manage due to less mobility of the released materials with the soil and potentially groundwater.

There are several provisions considered to ensure that the effects of terrestrial release of hazardous materials are as low as practicable. In additions to transportation mitigations listed for Scenarios 1 and 2, additional provisions include:

- The Transportation of Dangerous Goods (TDG) Act (Government of Canada 1992) outlines the requirements for entities that transport dangerous goods to establish Emergency Response Assistance Plans (ERAP). ERAPs list specialized personnel and equipment needed for responding to an incident. It is expected that the contractor who is responsible for transportation of uranium concentrate, fuel, and hazardous chemicals develop the ERAP.
- Transport Canada CANUTEC which is the Canadian Transport Emergency Centre operated by the Transportation of Dangerous Goods (TDG) Directorate of Transport Canada serves as a national advisory service that assists emergency response personnel in handling dangerous goods emergencies on a 24/7 basis.
- Limiting the wildlife access to the spill location.
- Speedy clean up to a pre-determined level.
- Preventing runoff and release to surface water.
- Preventing penetration to groundwater.

It is also noted that Highway 914 (as well as Highway 165also along the Project transport route) is a gravel highway that receives regular year-round maintenance, including grading, dust suppression, and snow removal in the winter. Highway 914 also has seasonal posted speed limits and weight restrictions. These factors were also considered within the context of the evaluation of this bounding scenario.

In a series of experiments during a study contracted by the USDOE, Simmons and Keller (2005) showed that the penetration rate of spilled liquid into soil depends on many factors, including slope, soil permeability, soil wettability, surface roughness, and initial moisture content of soil. In this study, experimental results were fitted into the Green-Ampt model (Simmons and Keller 2005). The results showed that, for most cases, the penetration rates ranged from 0.07 centimetres per second (cm/s) to 0.1 cm/s for silt loam and sandy soils (air porosity of 30% to 45%) with slopes of 2.4% and 4.8%. In most experiments, the final moisture content of 60% was reached after the front head of the spills disappeared. Given that the porosity of the areas around the transportation route are likely to be greater in consideration of regional soil conditions, this penetration rate of 0.1 cm/s is expected to be a conservative value for this assessment. At this penetration rate, a pool of released liquid with a depth of 30 cm would have penetrated the ground surface in 300 s (i.e., 5 minutes).

Assuming that the liquid content of the soil (water + diesel) increases from 20% to 60% for the maximum diesel release of 30 m3, approximately 75 m3 of the soil could be contaminated, as calculated below:

- 60% – 20% = 40% of additional liquid; and
- 30 m^3 / 0.4 = 75 m^3 of soil.

If the soil is completely saturated following the spill (from 20% to 100% liquid content), for the maximum diesel release of 30 m^3, 37.5 m^3 of the soil could be contaminated:

- 100% – 20% = 80% of additional liquid; and
- 30 m^3 / 0.8 = 37.5 m^3 of soil.

Based on the above discussion on water penetration rate, a conservative penetration time of 15 minutes was made. Based on this assumption, the maximum depth of contamination could be 90 cm (for penetration rate of 0.1 cm/s):

- depth = 900 s × 0.1 cm/s = 90 cm = 0.9 m.

For the penetration rate of 0.07 cm/s over 15 min, the depth of contamination could be 63 cm:

- depth = 900 s × 0.07 cm/s = 63 cm = 0.63 m.

The surface area affected by the spill can be calculated as follows:

- area = 75 m^3 / 0.9 m= 83 m^2, (60% saturation and depth of 0.9 m);
- area = 37.5 m^3 / 0.63 m = 60 m^2, (100% saturation and depth of 0.63 m);
- area = 75 m^3 / 0.63 m = 119 m^2, (60% saturation and depth of 0.63 m); and
- area = 37.5 m^3 / 0.9 m = 42 m^2, (100% saturation and depth of 0.9 m).

From the above calculation, the size of affected area would range from about 42 m^2 to 119 m^2. Shallow groundwater flow is generally affected by local-scale topography, which is represented by level to gently rolling plains around the transportation route. There is a potential for groundwater contamination within the area of soil contamination.

The velocity of groundwater at this location can be calculated as follows:

- V= K × I/n, where V is groundwater velocity, K is horizontal hydraulic conductivity, I is the horizontal hydraulic gradient, and n is the effective porosity.

Assuming that porosity is 0.45, hydraulic conductivity ranges from 7 × 10^{-5} m/s to 1 × 10^{-7} m/s, and hydraulic gradient ranges from 0.02 to 0.1, a range of groundwater velocity can be calculated as follows:

- Vmax = 7 × 10-5 m/s × 0.1 / 0.45 = 1.5 × 10-5 m/s.
- Vmin = 1 × 10-7 m/s × 0.02 / 0.45 = 4.4 × 10-9 m/s.

The wide range of the calculated velocities is a result of variation of soil conditions and the slope of the surface. Studies by Ledezma-Villanueva et al. (2015) and Berry and Burton (1997) show that residual contamination in soil and groundwater is degraded within 75 days. The distance that the groundwater can travel under these extreme (i.e., conservative) conditions ranges from 0.03 m to 100 m:

- Dmin = 1.5 * 10-5 m/s x 75 days x 24 x 3600 = ~ 100 m
- Dmax = 4.4*10-9 m/s x75 days x 24 x 3600 = ~0.03 m

As highlighted by the calculation, during this time period, no major migration of groundwater is expected. Thus, the contamination of soil and shallow groundwater is expected to be limited to a small area near the release location, given that release site remediation would occur well within the 75 day window.

During the cold season when the soil is frozen, no penetration of spilled material is expected. Therefore, no soil or groundwater contamination is expected. However, due to large spread of the released materials, the remediation is expected to take longer.

Based on the provisions in place and in consideration of the consequence scale described in **Section 3.2.2**, Process Hazards Analysis, the severity of the consequences of this accident and malfunction scenario is judged to be minor.

8.8 Summary of Consequence Severity

The severity of consequences for the bounding scenarios are summarized below in **Table 8-4**.

Table 8-4: Probabilities of Bounding Scenarios

No.	Potential Accidents or malfunctions	Project Phase	Potential Effects Pathway	Consequence Severity Characterization
1	Vehicle accident including rollover, collision, run off road	Op	Aquatic release of radioactivity	Moderate
2	Vehicle accident including rollover, collision, run off road	Co / Op / De	Aquatic release of fuel, hazardous chemicals and reagents	Moderate
3	Loss of freeze capacity	Op	Release of mining liquid to the local / regional groundwater environment	Major
4	Failure of freeze wall	Op	Release of mining liquid to the local / regional groundwater environment	Major
5	Process vessel and piping system failure	Op	Release of radon from storage tank	Minor
6	Facility fire / explosion	Op	Release of radioactivity and uranium concentrate powder to atmosphere	Moderate
7	Vehicle accident including rollover, collision, run off road	Co / Op / De	Terrestrial release of radioactivity and chemicals	Minor

Notes: Co is construction; Op is operations; De is decommissioning.

9.0 RISK ESTIMATION - SUMMARY

The results of the risk assessment of the bounding accident and malfunction scenarios are summarized in **Table 9-1**. As described in **Section 3.0**, the more in-depth risk evaluation for the bounding scenarios has been provided as this process results in more a representative characterization of the risk of these scenarios. The preliminary screening level assessment (see **Appendix A**) had deemed these scenarios as potentially posing a higher level of risk to the environment and a more detailed assessment was undertaken.

As can be seen, the more rigorous assessment has shown that the risk of the selected bounding scenarios is low to moderate. No high-risk scenarios have been identified.

The results combine the analysis of both probability (**Section 7.0**) and consequence of effect (**Section 8.0**) for each bounding scenario to identify an overall risk rating according to the risk ranking framework presented in **Section 3.2.2**, **Figure 3-1**. The difference between the risk ranking presented below and the original risk screening process (**Section 3.0**, **Appendix A**) is that the risk ratings below were assigned based on the quantitative assessment of these accident and malfunction scenarios.

The overall risk ratings indicate that the traffic accident scenarios releasing uranium concentrate (Scenario 1) and chemicals (Scenario 2), failure of process vessel and piping systems (Scenario 5), a facility fire or explosion (Scenario 6) and a terrestrial release of radioactivity and chemicals have a low risk (Scenario 7).

The overall risk associated with the loss of freeze capacity and the failure of the freeze wall (Scenarios 3 and 3) have been determined to be major; though, highly unlikely from solely a probability perspective.

Overall, low to moderate risk scenarios are deemed to represent a tolerable level of risk in consideration of proposed safeguards and design features that reduce the risk level to ALARP.

Table 9-1 Bounding Scenarios Probability, Consequence, and Overall Risk Rating

No.	Potential Accident /or Malfunction	Potential Effect pathway	Probability	Effect Severity	Overall Risk Rating[1]
1	Vehicle accident including rollover, collision, run off road	Aquatic release of radioactivity	Highly unlikely	Moderate	Low
2	Vehicle accident including rollover, collision, run off road	Aquatic release of fuel, hazardous chemicals and reagents	Unlikely	Moderate	Low
3	Loss of freeze capacity	Loss of freeze wall and secondary underground containment	Highly unlikely	Major	Moderate
4	Failure of freeze wall	Loss secondary underground containment and groundwater contamination	Highly unlikely	Major	Moderate
5	Process vessel and piping system failure	Release of radon from storage tank	Likely	Minor	Low
6	Facility fire / explosion	Release of radioactivity and uranium concentrate powder to atmosphere	Highly unlikely	Moderate	Low
7	Vehicle accident including rollover, collision, run off road	Terrestrial release of radioactivity and chemicals	Unlikely	Minor	Low

[1] Based on Figure 3-1.

10.0 REFERENCES

AIChE (American Institute of Chemical Engineers). 1989. Guidelines for Process Equipment Reliability Data, with Data Tables. February 1989. ISBN 978-0-8169-0422-8.

Alzoubi, M. A., A. P. Sasmito, A. Madiseh, and F. P. Hassani. 2017. Intermittent Freezing Concept for Energy Saving in Artificial Ground Freezing Systems, Energy Procedia 142 (2017) 3920–3925.

Berry, K.A.T. and D.L. Burton. 1997. Natural attenuation of diesel fuel in heavy clay soil. Can. J. Soil. Sci. 77: 469–477.

Brown, S. 2008. The New Generation of Uranium in Situ Recovery Facilities: Design Improvements Should Reduce Radiological Impacts Relative to First Generation Uranium Solution Mining Plants, WM 08 Conference, February 25 - March 1, 2008, Phoenix, AZ Abstract #8414.

CCME (Canadian Council of Ministers of the Environment). 2011. Canadian Water Quality Guidelines for the Protection of Aquatic Life, Uranium. Available at **https://ccme.ca/en/res/uranium-en-canadian-water-quality-guidelines-for-the-protection-of-aquatic-life.pdf**

CCME. 1987. Canadian Water Quality Guidelines for the Protection of Aquatic Life, pH.

CNSC (Canadian Nuclear Regulatory Commission). 2000. Radiation Protection Regulations, SOR/2000-203.

CNSC (Canadian Nuclear regulatory Commission). 2014. REGDOC-2.4.2, Safety Analysis Probabilistic Safety Assessment (PSA) for Reactor Facilities, Version 2. Available at **https://www.nuclearsafety.gc.ca/eng/pdfs/regulatory-documents/regdoc2-4-2/REGDOC-2.4.2_Probabilistic_Safety_Assessment_(PSA)_for_Reactor_Facilities_Version_2.pdf**

CNSC. 2020. REGDOC 2.9.1, Environmental Principles, Assessments and Protection Measures, Version 1.2. September 2020. ISBN 978-0-660-06255-6. Available at **http://nuclearsafety.gc.ca/eng/pdfs/REGDOCS/REGDOC-2-9-1-Environmental-Principles-Assessments-and-Protection-Measures-eng.pdf**

CNSC. 2021. REGDOC 3.6, Environmental Principles, Assessments and Protection Measures, Version 1.2. April 2021. Available at **https://nuclearsafety.gc.ca/eng/acts-and-regulations/regulatory-documents/published/html/regdoc3-6/index.cfm#:~:text=Regulatory%20document%20REGDOC%E2%80%913.6%2C%20Glossary,annual%20reports%20and%20guidance%20documents**.

CSA Group (Canadian Standards Association Group). 2012. N288.6-12 - Environmental Risk Assessments at Class I Nuclear Facilities and Uranium Mines and Mills. N288.6-12. Published 2012, reaffirmed 2017.

Denison Mines Corp. 2020. Wheeler River Project, Provincial Technical Proposal and Federal Project, Description.

Denison Mines Corp. 2019. Wheeler River Project, Terms of Reference. May 2019.

Environment Canada (EC). 2012. Federal Contaminated Sites Action Plan (FCSAP). Ecological Risk Assessment Guidance. March, 2012.

Government of Canada. 2021. Earthquake map of Canada. Available at: https://earthquakescanada.nrcan.gc.ca/historic-historique/caneqmap-en.php

Government of Canada. 1992. Transportation of Dangerous Goods Act. Available at: https://laws-lois.justice.gc.ca/PDF/T-19.01.pdf

Government of Saskatchewan. 2014a. A Guide to Assessing Projects and Preparing Proposals Under the Environmental Assessment Act. June 2014.

Government of Saskatchewan. 2014b. A Guide to Developing the Terms of Reference for a Proposed Project (or Development) under *The Environmental Assessment Act*. June 2014.

Government of Saskatchewan. 2020. The Hazardous Substances and Waste Dangerous Goods Regulations.

Health Canada. 2019. Guidelines for Canadian Drinking Water Quality, Guideline Technical Document, Uranium.

IAEA (International Atomic Energy Agency). 2002. Procedures for conducting probabilistic safety assessment for non-reactor nuclear facilities, IAEA-TECDOC-1267, January 2002, ISSN 1011–4289. Available at **https://www.pub.iaea.org/MTCD/Publications/PDF/te_1267_prn.pdf**

Ledezma-Villanueva, A. J. M. Adame-Rodríguez, I.A. O'Connor-Sánchez, J.F. Villarreal-Chiu and E.T. Aréchiga-Carvajal. Biodegradation kinetic rates of diesel-contaminated sandy soil samples by two different microbial consortia. Ann. Microbiol. (2016) 66:197–206.

McSweeney, T.I., S.J. Maheras, and S.B. Ross. 2004. Radioactive Materials Transport Accident Analysis. Proceedings of 14th International Symposium on the Packaging and Transportation of Radioactive Materials (PATRAM 2004), Berlin, Germany, September 20-24, 2004. Paper # 274.

NOAA (National Oceanic and Atmospheric Administration). 2006. Small Diesel Spills (500-5,000 gallons). Last updated 28 April 2020. Available at: **https://response.restoration.noaa.gov/sites/default/files/Small-Diesel-Spills.pdf**

NOAA (National Oceanic and Atmospheric Administration). 2020. Small Diesel Spills (500-5,000 gallons). **Last updated 28 April 2020.** Available at: **Small Diesel Spills (500-5,000 gallons) (noaa.gov)** https://response.restoration.noaa.gov/resources/oil-fact-sheets-spill-responders

OECD (Organisation for Economic Cooperation and Development). 1995. Guideline for Testing of Chemicals; Test No. 105: Water Solubility. Available at **https://www.oecd-ilibrary.org/docserver/9789264069589-en.pdf?expires=1630007874&id=id&accname=guest&checksum=B68BFF37F20C3420EADBE269E4B29450**

RESPEC. 2021. External Memorandum – Results of a Geomechanical Study Investigating the Influence of Uranium Extraction on Mining-Cavity Stability for the Wheeler River Uranium Project. Prepared for Denison Mines Corporation. May 10, 2021.

SGI (Saskatchewan Government Insurance). 2019. 2018 Saskatchewan Traffic Collisions Report, Regina, SK, Canada S4P 0J9. Available at https://www.sgi.sk.ca/documents/625510/627017/3528+-+SGI+TSP+TAIS+Report+SECURED.pdf/804862db-853d-4a8a-bfc3-7aa86e914ffcSilver W, and D. Mackay. 1984. Evaporation rate of spills of hydrocarbons and petroleum mixtures, Environ. Sci. Technol. 1984, 18, 11, 834–840.

Simmons, C. S. and J. M. Keller. 2005. Liquid Spills on Permeable Soil Surfaces: Experimental Confirmations, A report Prepared for the U.S. Department of Energy, PNNL-15408 400403909; TRN: US200618%%300, PNNL-15408, Available at **https://www.pnnl.gov/main/publications/external/technical_reports/pnnl-15408.pdf**

SRK Consulting. 2018. Prefeasibility Study Report for the Wheeler River Uranium Project Saskatchewan, Canada.

Transport Canada (TC). Transportation of dangerous Goods Regulations. SOR/2019-101.

Transport Canada (TC). 2019. Transport Canada Overview and Comprehensive Reports 2019.

USDOE. 1994. DOE Handbook, Airborne Release Fractions/Rates and Respirable Fractions for Non-reactor Nuclear Facilities.

USDOE (United States Department of Energy). 2016. DOE Handbook, Temporary Emergency Exposure Limits for Chemicals: Methods and Practice, DOE-HDBK-1046-2016.

US EPA (U.S. Environmental Protection Agency). 2003. Generic Ecological Assessment Endpoints (GEAEs) for Ecological Risk Assessment. October. EPA/630/P-02/004F

USGS (United States Geological Survey). 2021. Earthquakes hazards program. Available at: **https://www.usgs.gov/programs/earthquake-hazards/earthquakes**

USHHS (United States Department of Health and Human Services). 2013. Toxicological Profile for Uranium. Agency for Toxic Substances and Disease Registry. February 2013. Available at **https://www.atsdr.cdc.gov/ToxProfiles/tp150.pdf**

US NRC (United States Nuclear Regulatory Commission). 2004. NUREG-1805, Fire Dynamics Tools (FDTs): Quantitative Fire Hazard Analysis Methods for the U.S. Nuclear Regulatory Commission Fire Protection Inspection Program. Final Report. December 2004. Prepared for Division of System Safety and Analysis Office of Nuclear Reactor Regulation U.S. Nuclear Regulatory Commission Washington, DC 20555-0001. Available at **https://www.nrc.gov/docs/ML0432/ML043290075.pdf**

US NRC (Unite States Nuclear Regulatory Commission). 2009. Generic Environmental Impact Statement for In-Situ Leach Uranium Milling Facilities. Final Report. NUREG-1910, Vol. 1.

UNSCEAR (United Nations Scientific Committee on the Effects of Atomic Radiation). 2017.

WHO (World Health Organization). 2014. Health Effects of Particulate Matter, WHO Regional Office for Europe.

APPENDIX A - HAZARD IDENTIFICATION FOR THE ACCIDENTS AND MALFUNCTIONS ASSESSMENT – WHEELER RIVER PROJECT

Ecometrix | Environmental INTELLIGENCE

WHEELER RIVER ISR PROJECT - HAZARD IDENTIFICATION REPORT

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WHEELER RIVER ISR PROJECT - HAZARD IDENTIFICATION REPORT

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FOREWORD

EcoMetrix Incorporated (EcoMetrix) was retained by Denison Mines Corp. (Denison) to complete the accidents and malfunctions assessment for the Wheeler River Project (Wheeler or the Project) as part of the environmental assessment process. The Project is a proposed in-situ recovery (ISR) uranium operation in Saskatchewan. This current memorandum details the initial Hazard Identification (HI) process that has been completed to support that assessment. The HI is used to identify potential hazard scenarios, screen those scenarios as to potential environmental risks and, based on this screening, recommend scenarios that should be carried forward for more detailed consideration.

This HI informed an accidents and malfunctions (A&M) workshop that was completed on March 18, 2021, with representatives of Denison to gain further insights regarding potential scenarios, mitigation strategies and screening outcomes. This current report incorporates information provided in that workshop, as well as Project-related information that has come to light since that time.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

The Denison Wheeler River Project (Wheeler or the Project) is a proposed uranium mine and processing plant in northern Saskatchewan, Canada. The Project is located in a relatively undisturbed area of the boreal forest about 4 km off of Highway 914 and approximately 35 km north-northeast of the Key Lake uranium operation. The deposit will be mined via ISR that involves injecting a low-pH mining solution into the uranium deposit through a series of cased drill holes (injection wells) and subsequently pumping the uranium-rich solution to surface through recovery wells. Once on surface, the uranium rich mining solution recovered from the wellfield will be pumped to the on-site processing plant. Inside the processing plant a relatively simple precipitation process will be used to separate the uranium from the mining solution. Once separated, the uranium will be dried, packaged and trucked off site, destined for eventual use in a nuclear power plant. The main phases of the Project are construction, operation, decommissioning, and post-decommissioning. Construction would last for approximately three years; production activities would commence following commissioning of the facilities and would last 15 years with a production rate of up to 12 M lbs U3O8 per year. Decommissioning is expected to last for five years and post-decommissioning a further 15 years.

Ecometrix Incorporated (Ecometrix) was retained by Denison to complete the accidents and malfunctions (A&M) assessment for the Wheeler River Project as part of the environmental assessment process. The Project is a proposed in-situ recovery (ISR) uranium operation in Saskatchewan. This current memorandum details the initial Hazard Identification (HI) process that has been completed to support that assessment. The HI is used to identify potential hazard scenarios, screen those scenarios as to potential environmental risks and, based on this screening, recommend scenarios that should be carried forward for more detailed consideration.

This HI informed an accidents and malfunctions workshop that was completed om March 18, 2021 with representatives of Denison to gain further insights regarding potential scenarios, mitigation strategies and screening outcomes. This current report incorporates information provided in that workshop.

1.1 Scope and Applicability of the Hazard Identification

The regulations governing the Environmental Impact Statement (EIS) requires that the impacts of A&M related to the various project components be assessed. As a step towards the assessment of A&M, an HI needs to be completed. The objective of HI is to identify those A&M scenarios that have the potential to present a risk to the biophysical environment. The HI also includes a screening assessment that determines those scenarios that require more detailed quantitative assessment as to their probabilities and severity of consequences. This detailed quantitative assessment is documented in a stand-alone A&M Assessment Report, that is an appendix to the main Environmental Impact Statement (EIS).

The scope of the HI included consideration of all project phases: construction; operation; decommissioning and post-decommissioning. The spatial extent of the evaluation included the

Project site and the site access road to its junction with Highway 914, as well as at locations of interest to Interested Parties along the mine-related transportation route.

Generally, the evaluation focused on potential human health or biophysical environmental risks associated with Project components and activities. It is noted that some hazards related to worker safety were identified; however, worker safety (risks and consequences) is beyond the scope of this assessment.

1.2 Information Sources

Project related information that has been used to complete this evaluation is the most recent information available as provided by Denison, as of the publication of this report.

2.0 HAZARD ANALYSIS

The HI evaluation was performed to identify hazard scenarios associated with the Project that may result in consequences to human health or the biophysical environment. The hazard scenarios were subsequently assessed at a screening level as to potential risks to human health or the biophysical environment, and to identify scenarios that should be carried forward for more detailed evaluation.

2.1 Methodology

The hazard identification process is a systematic approach to identify possible hazards in a work process. A hazard can be defined as a physical condition that has the potential for causing damage to people, property, or the environment (e.g., fire, explosion, release of chemicals, or radioactivity). Potential nodes for hazard identification are selected through the review of the Project-related components. A node is a Project component that represents a physical system or activity with the potential to present a risk to the human health or biophysical environment. Hazard scenarios are developed on consideration of these nodes.

The hazard identification for each node involves the consideration of the sources of hazard (e.g., presence of hazardous materials), hazardous situations (e.g., height or extreme heat), and initiating events (e.g., natural causes, technical failure, or human error) that in combination present a risk to the human health or biophysical environment. A screening evaluation is applied to a given scenario by qualitatively evaluating consequence severity and probability to determine a risk level.

While there are standards and regulatory documents (e.g., REGDOC-2.4.2, Safety Analysis, Probabilistic Safety Assessment (PSA) for Reactor Facilities (CNSC 2014)) that govern the assessment of the probability of the hazard scenarios for nuclear reactors, no such documents exist for non-reactor facilities. The focus of these documents is design-basis and beyond design-basis accidents that affect the integrity of the reactor core. The annual probability of releases from these accidents can be $1x10^{-6}$ and lower, while the consequence of these accidents could be very severe. In contrast, the probability of accidents and malfunctions at non-reactor facilities such as mines and process plants can be higher, as derived from the operating experience of similar installations. The International Atomic Energy Agency's TECDOC-1267 (IAEA 2002) states that while a plant-specific qualitative risk analysis should be conducted for a nuclear reactor facility, for non-nuclear facilities hazard identification and screening, evaluation of selected accident scenarios, and a combination of qualitative and quantitative analysis should be conducted. This document does not prescribe what probabilities should be considered.

On a scale of increasing likelihood, scenarios are categorized as highly unlikely, unlikely, likely, very likely, and almost certain as follows:

1. highly unlikely: ≤ 1 occurrence in 1,000 years;

2. unlikely: ≤ 1 occurrence in 100 years and > 1 occurrence in 1,000 years;
3. likely: ≤ 1 occurrence in 10 years and > 1 occurrence in 100 years;
4. very likely: ≤ 1 occurrence in 1 year and > 1 occurrence in 10 years; and
5. almost certain: > 1 occurrence in 1 year.

On a scale of increasing severity, scenarios are categorized as none, minor, moderate, major, and catastrophic as follows:

1. none: no human health or biophysical environmental consequences;
2. minor: short-term (less than one month) minor effect on small area or minor first aid injuries with no lost time;
3. moderate: reversible or repairable effect (less than one year) off site or reversible injuries with lost time;
4. major: extended-range, long-term effect off site (e.g., 10 years) or severe injuries with long lasting effects and/or disability; and
5. catastrophic: long-lasting with long-lasting or irreversible environmental effects, fatalities or multiple disabilities.

The resulting risk levels are defined according to the matrix shown in **Figure 2-1**.

For the purpose of the assessment, risks are identified as being low (coloured green in the matrix) where the screening evaluation considers the risk as generally being acceptable, as the likelihood of these scenarios can be effectively managed through application of planned controls and/or the consequence would be low in magnitude. Low-risk scenarios have none to moderate severity with likelihood ranging from highly unlikely to almost certain.

Risks are identified as being moderate (coloured yellow in the matrix) where the screening evaluation considers the risk as generally being tolerable. Moderate-risk scenarios have minor to catastrophic severity with likelihood ranging from highly unlikely to almost certain. In many cases, risk reduction activities will reduce the risk associated with these scenarios to As Low as Reasonably Practicable (ALARP) and therefore these scenarios are characterized as tolerable.

Risks are identified as being high (coloured red in the matrix) where the screening evaluation considers the risk as generally being unacceptable. High-risk scenarios have major to catastrophic severity with likelihood ranging from unlikely to almost certain. As the evaluation of the risk at this hazard identification stage is qualitative and is associated with some uncertainty, the hazard scenarios identified as high risk are advanced for further detailed assessment so that a more fulsome evaluation of risk and potential management activities can be considered.

Likelihood / Probability		**Consequence Severity**				
		1	**2**	**3**	**4**	**5**
		None	**Minor**	**Moderate**	**Major**	**Catastrophic**
5	**Almost Certain**					
4	**Very Likely**					
3	**Likely**					
2	**Unlikely**					
1	**Highly Unlikely**					

Figure 2-1: Hazard Analysis Risk Matrix

2.2 Evaluation of Project Components and Activities (Process Nodes)

The following nodes were considered in the HI evaluation:

1. Site works, including
    - Site preperation.
    - Road construction.
    - Istallation of piping.
    - Building construction.
    - Constrution of ponds and pads.
    - Installtion of process equipment.
    - Constrution of utility systems.
    - Batch plnt operation.
    - Decomissioning of wells.
    - Demlition of buildings.
    - Removal of rocess equipment.
    - Closure of landfill.
2. Drilling of wells.
3. Access road / land transportation.
4. Air strip / air transportation.
5. Operation of the freeze plant.
6. Maintenace of the freeze wall.

7. Production facility (operation of the processing plant).
8. Clean waste rock pads.
9. Special and mineralized waste rock pads.
10. Precipitates disposal area.
11. Wastewater treatment system.
12. Ponds and retention berms.
13. Electrical system and power plant.
14. Fire protection system.
15. Hazardous waste management system.

3.0 EVALUATION OF PROJECT COMPONENTS AND ACTIVITIES (PROCESS NODES)

For each of the identified process nodes, hazard identification evaluations are shown in **Table 3-1** through **Table 3-16**. In each case, the evaluation considers consequence(s), existing safeguards and design features, and the qualitative evaluation of likelihood and severity of consequences.

The following notations are provided in support of the HI tables:

- As it pertains to Project phase:
  - "Co" is Construction;
  - "Op" is Operations;
  - "De" is Active Decommissioning; and
  - "PD" is Post-Active Decommissioning.
- "L" is Likelihood;
- "S" is Severity of the consequences; and,
- "RR" is Risk Ranking.

With consideration of the sources of hazard and initiating events, a total of 70 hazard scenarios were identified and evaluated.

Three of the hazard scenarios characterized as high-risk were recommended for further assessment. An addition four moderate / ALARP-moderate scenarios require further detailed assessment for more accurate characterization of the risk.

Twenty-one of the scenarios evaluated were characterized as moderate-risk scenarios. Generally, the moderate-risk scenarios were deemed to represent a tolerable level of risk in consideration of proposed safeguards and design features that reduce the risk level to ALARP. The four moderate-risk scenarios that are subsequently assessed in more detail are associated with a contaminant release to the environment, which may have potential effects that are more far reaching than can adequately be assessed by the screening assessment. As such, a more quantitative evaluation was deemed appropriate.

The remaining scenarios evaluated (44) were characterized as low-risk scenarios based on low likelihood of occurrence and/or low consequence in consideration of planned existing safeguards and design features. Low-risk scenarios were not carried forward for more detailed analysis as they were considered to be adequately characterized by the screening process.

Site Works - Summary – Nine potential scenarios have been identified. Risks have been characterized as low to moderate as it concerns environmental risks. No scenarios carried forward for quantitative assessment.

Table 3-1: Hazard Identification Evaluation – Site Works

ID#	Accident / Malfunction	Phase	Consequence	Existing Safeguards / Design Features	L	S	RR / Significance	Screening Decision / Rationale
1.1	Fall / slip	Co / Op / De	Occupational major injuries	Occupational health and safety plan Personnel training and orientation Personal protection equipment	5	3	ALARP, moderate	Best practice in worker health and safety program resulting in ALARP, no further assessment
1.2	Fall / slip	Co / Op / De	Occupational fatalities	Occupational health and safety plan Personnel training and orientation Personal protection equipment	2	5	ALARP, High	Best practice in worker health and safety program resulting in high but ALARP, no further assessment
1.3	Refuelling accident	Co / Op / De	Hydrocarbon release	Occupational health and safety plan Personnel training and orientation Personal protection equipment Spill management and response Secondary containment	4	2	Low	Overall risk level is low, minor consequence event, no further assessment
1.4	Fuel storage failure	Co / Op / De	Hydrocarbon release	Occupational health and safety plan Personnel training and orientation Personal protection equipment Spill management and response Secondary containment	1	3	Low	Overall risk level is low, highly unlikely event, no further assessment
1.5	Fuel storage and transfer fire and explosion	Co / Op / De	Occupational major injuries	Occupational health and safety plan Personnel training and orientation Personal protection equipment Fire safety plan and firefighting system	2	3	Low	Overall risk level is low, unlikely event, no further assessment
1.6	Fuel storage and transfer fire and explosion	Co / Op / De	Occupational fatalities	Occupational health and safety plan Personnel training and orientation Personal protection equipment Fire safety plan and firefighting system	1	5	ALARP, moderate	Best practice in worker health and safety program resulting in ALARP, no further assessment
1.7	Vehicle and construction equipment accident	Co / Op / De	Occupational major injuries	Occupational health and safety plan Personnel training and orientation Preventive and routine maintenance Onsite traffic control (speed limits, signage)	4	2	ALARP, moderate	Best practice in worker health and safety program resulting in ALARP, no further assessment
1.8	Vehicle and construction equipment accident	Co / Op / De	Occupational fatalities	Occupational health and safety plan Personnel training and orientation Preventive and routine maintenance Onsite traffic control	2	5	ALARP, High	Best practice in worker health and safety program resulting in high but ALARP, no further assessment
1.9	Vehicle accident	Co / Op / De	Hazardous materials spill	Occupational health and safety plan Personnel training and orientation Preventive and routine maintenance Onsite traffic control (speed limits, signage) Spill management and response	4	2	Low	Overall risk level is low, minor consequence event, no further assessment

Notes: "Co" is construction
"Op" is operations
"De" is Decommissioning
"L" is likelihood

"S" is severity
"RR" is risk ranking

Wellfield - Summary – Three potential scenarios have been identified. Risks have been characterized as low to moderate as it concerns environmental risks. No scenarios carried forward for quantitative assessment.

Table 3-2: Hazard Identification Evaluation – Drilling

ID#	Accident / Malfunction	Phase	Consequence	Existing Safeguards / Design Features	L	S	RR / Significance	Screening Decision / Rationale
2.1	Drilling mud spill	Co / Op	Material spill to ground, including contaminated drill muds	Occupational health and safety plan Personnel training and orientation Personal protection equipment Spill management and response Primary and secondary containment for drilling mud	4	2	Low	Overall risk level is low, minor consequence event (assumes containment and clean up), no further assessment
2.2	Piping failure in the well field	Co / Op	Loss of lixiviant (mining solution), UBS, and/or regents to ground	Occupational health and safety plan Personnel training and orientation Personal protection equipment Spill management and response Secondary containment via freeze wall	2	3	Low	Overall risk level is low, moderate consequence event (assume localized event to ground where clean up is possible prior to groundwater contamination), no further assessment
2.3	Surface flood	Co / Op	Potential for groundwater contamination	Lined collection points Site grading to collection areas Collection pond sized to accommodate PMP	2	2	Low	Overall risk level is low, minor consequence event, no further assessment
2.4	Well casing yield and/or damage	Co / Op	Loss of lixiviant (mining solution) into the groundwater within freeze wall containment	Occupational health and safety plan Personnel training and orientation Personal protection equipment Spill management and response **Secondary containment via freeze wall**	2	3	Low	Overall risk level is low, moderate consequence event (assume localized event to groundwater where cleanup is possible), no further assessment

Notes: "Co" is construction
"Op" is operations
"De" is Decommissioning
"L" is likelihood
"S" is severity
"RR" is risk ranking

Access Road / Land Transportation - Summary – Eight potential scenarios have been identified. Risks have been characterized as low to high as it concerns environmental risks. Two scenarios carried forward for quantitative assessment.

Table 3-3: Hazard Identification Evaluation – Access Road / Land Transportation (shaded rows are those recommended for further assessment)

ID#	Accident / Malfunction	Phase	Consequences	Existing Safeguards / Design Features	L	S	RR / Significance	Screening Decision / Rationale
3.1	Vehicle accident including rollover, collision, run off road	Op	Aquatic release of radioactivity	Occupational health and safety plan Personnel training and orientation Traffic control measures Travel management plan Spill management and emergency response plan	3	5	High	Further Assessment Recommended
3.2	Vehicle accident including rollover, collision, run off road	Co / Op / De	Terrestrial release of radioactivity	Occupational health and safety plan Personnel training and orientation Traffic control measures Travel management plan Spill management and emergency response plan	3	4	ALARP, moderate	Best practice in terrestrial spill containment and cleanup resulting in ALARP, no further assessment
3.3	Vehicle accident including rollover, collision, run off road	Co / Op / De	Aquatic release of fuel, hazardous chemicals and reagents	Occupational health and safety plan Personnel training and orientation Traffic control measures Travel management plan Spill management and emergency response plan	3	4 / 5 (see Screening Decision / Rationale)	ALARP, moderate High (see Screening Decision / Rationale)	Further Assessment Recommended As seen in the "S" column, two consequence screening rankings were provided and consequently, two overall risk screening ranking are also provided. Acids and bases (chemicals and reagents) released to the aquatic environment are likely to dissolve relatively quickly and effects to local biota can be expected to be experienced on a local basis and over a shorter timeframe resulting in the screening consequence score of "major" (4) and an overall risk screening ranking of "moderate". There is little likely that mitigation can be applied in that scenario and, therefore, the risk mitigation measures are limited to those that prevent accidents or reduce the probability to ALARP (thus the overall ranking of "ALARP, moderate"). The release of organic compounds (such as diesel) would have the potential for downstream transport as a compound in liquid phase distinct from that of the water and, in this sense, this release produces a greater challenge of potential contamination over a relatively large spatial extent and timespan. For this reason, a screening consequence score of "catastrophic" (5) and an overall risk ranking of "high" was given. Per the rationale provided above, the "high" overall risk release of diesel fuel case was chosen as the representative case for Scenario 3.3 and carried forward for further assessment.
3.4	Vehicle accident including rollover, collision, run off road	Co / Op / De	Terrestrial release of fuel, hazardous chemicals and reagents	Occupational health and safety plan Personnel training and orientation Traffic control measures Travel management plan Spill management and emergency response plan	3	4	ALARP, moderate	Best practice in terrestrial spill containment and cleanup resulting in ALARP; Further Assessment Recommended to address interested party concerns (includes consideration of radioactivity)
3.5	Vehicle fire	Co / Op / De	Terrestrial release of hydrocarbons and fuel	Occupational health and safety plan Personnel training and orientation Travel management plan Spill and emergency response plan Spill management and emergency response plan	1	4	ALARP, moderate	Best practice in terrestrial spill containment and cleanup resulting in ALARP, no further assessment

ID#	Accident / Malfunction	Phase	Consequences	Existing Safeguards / Design Features	L	S	RR / Significance	Screening Decision / Rationale
3.6	Vehicle fire	Co / Op / De	Release of radioactivity to air	Occupational health and safety plan Personnel training and orientation Travel management plan Spill and emergency response plan Spill management and emergency response plan	1	4	ALARP, moderate	Overall moderate (ALARP) risk, highly unlikely event. Reversible and transient effect. No further assessment
3.7	Vehicle fire	Co / Op / De	Atmospheric release of particulate and combustion by-products	Occupational health and safety plan Personnel training and orientation Travel management plan Spill management and emergency response plan Fire safety plan and firefighting systems Ambient air monitoring	1	3	Low	Overall low risk, highly unlikely event. Reversible and transient effect. No further assessment
3.8	Vehicle – Wildlife collision	Co / Op / De	Wildlife fatality	Occupational health and safety plan Personnel training and orientation Traffic control measures Travel management plan	4	2	Low	Overall low risk, Individual (not population) level minor effect, reversible and nonsignificant effect, no further assessment

Notes: “Co” is construction
“Op” is operations
“De” is Decommissioning
“L” is likelihood
“S” is severity
“RR” is risk ranking

Airstrip - Summary – Four potential scenarios have been identified. Risks have been characterized as low to moderate as it concerns environmental risks. No scenarios carried forward for quantitative assessment.

Table 3-4: Hazard Identification Evaluation – Airstrip

ID#	Accident / Malfunction	Phase	Consequence	Existing Safeguards / Design Features	L	S	RR / Significance	Screening Decision / Rationale
4.1	Fuel storage failure	Co / Op / De	Hydrocarbon release	Occupational health and safety plan Personnel training and orientation Storage inspection, maintenance Secondary containment Spill and emergency response plan	1	3	Low	Overall risk level is low, highly unlikely event, no further assessment
4.2	Refuelling accident	Co / Op / De	Hydrocarbon release	Occupational health and safety plan Personnel training and orientation Secondary containment Spill and emergency response plan	4	2	Low	Overall risk level is low, minor consequence event, no further assessment
4.3	Plane de-icing chemical release	Co / Op / De	Terrestrial release of reagent; possible aquatic release of reagent	Personnel training Containment Spill and emergency response plan	3	2	Low	Overall risk level is low, minor consequence event, no further assessment
4.4	Air plane crash	Co / Op / De	Occupational major injuries / fatality Atmospheric release of particulate and combustion by-products Release of hydrocarbons and fuel Damage to mine infrastructure structure	Travel management plan Air traffic control Spill and emergency response plan Fire safety plan and firefighting systems Personnel training	1	5	ALARP, moderate	Highly unlikely event, best practice in air traffic control resulting in ALARP, no further assessment
4.5	Ground vehicle – air plane collision	Co / Op / De	Occupational major injuries / fatality Atmospheric release of particulate and combustion by-products Release of hydrocarbons and fuel Damage to mine infrastructure structure	Travel management plan Air traffic control Ground traffic control Spill and emergency response plan Fire safety plan and firefighting systems Personnel training	1	5	ALARP, moderate	Highly unlikely event, best practice in air / ground traffic control resulting in ALARP, no further assessment

Notes: “Co” is construction
“Op” is operations
“De” is Decommissioning
“L” is likelihood
“S” is severity
“RR” is risk ranking

Freeze plant - Summary – Five potential scenarios have been identified. Risks have been characterized as low to high as it concerns environmental risks. One scenario is carried forward for quantitative assessment.

Table 3-5: Hazard Identification Evaluation – Freeze plant (shaded rows are those recommended for further assessment)

ID#	Accident / Malfunction	Phase	Consequence	Existing Safeguards / Design Features	L	S	RR / Significance	Screening Decision / Rationale
5.1	Ammonia storage and piping failure	Co / Op	Material spill	Occupational health and safety plan Personnel training and orientation Storage inspection, maintenance Secondary containment Spill and emergency response plan	3	2	Low	Overall risk level is low, minor consequence event, no further assessment
5.2	Loss of freeze capacity within the freeze plant or a select portion of the freeze wall injection system	Op	Short-term consequences unlikely as once established melting of wall will occur over months. If not rectified over longer-term there would be loss of tertiary containment within the ISR well field	Primary (hydraulic control) and secondary (double wall well construction) containment measures in the ISR well field Freeze wall monitoring Monitoring wells outside of the freeze wall – temp, pressure Perimeter pumping wells within and without the freeze wall that can be used to capture and recycle mining solutions or to inject neutralizing solution Back up power Spill and emergency response plan	1	3 to 4	Low to Moderate (ALARP) (for classification regarded as Moderate)	Potential limited loss of containment of lixiviant (mining solution) outside mining chamber with small spatial extent - Further Assessment Recommended. Denison does not believe a leak would occur, nor that such a leak in this scenario would have an effect that would extend spatially to a material extent; however, public perception of a potential loss of containment is of high concern and should assessed. In practice, the mechanical failure of refrigeration system can be addressed and mitigated well before the thawing of the freeze wall which would take months.
5.3	Cooling line break	Co / Op	Release of brine below ground and potential for groundwater contamination	Occupational health and safety plan Personnel training and orientation Inspection and maintenance Remote monitoring system Spill and emergency response plan	2	4	ALARP, moderate	Unlikely event, best practice resulting in ALARP, no further assessment
5.4	Cooling line break	Co / Op	Release of brine on surface – potential for ground and groundwater contamination	Occupational health and safety plan Personnel training and orientation Inspection and maintenance Remote monitoring system Pipes in trenches and secondary containment Spill and emergency response plan	2	2	Low	Overall risk level is low, minor consequence event with appropriate response and mitigation, no further assessment
5.5	Pumps failure	Co / Op	Release of brine on surface - potential for surface and groundwater contamination	Occupational health and safety plan Personnel training and orientation Inspection and maintenance Remote monitoring system No open drain from pumphouse Spill and emergency response plan	2	2	Low	Overall risk level is low, minor consequence event with appropriate response and mitigation, no further assessment

Notes: "Co" is construction
"Op" is operations
"De" is Decommissioning
"L" is likelihood
"S" is severity
"RR" is risk ranking

Freeze wall - Summary – One potential scenario has been identified. Risks have been characterized as moderate as it concerns environmental risks. One scenario is carried forward for quantitative assessment.

Table 3-6: Hazard Identification Evaluation – Freeze wall (shaded rows are those recommended for further assessment)

ID#	Accident / Malfunction	Phase	Consequence	Existing Safeguards / Design Features	L	S	RR / Significance	Screening Decision / Rationale
6.1	Failure of freeze wall due to seismic event / geotechnical instability resulting in physical damage to freeze wall and loss of integrity of freeze wall injection system	Op	Loss of primary and tertiary underground containment and groundwater contamination	Freeze wall monitoring Redundancy in design Monitoring wells outside of the freeze wall – temp, pressure Perimeter pumping wells within and without the freeze wall that can be used to capture and recycle mining solutions or to inject neutralizing solution Back up power Spill and emergency response plan	1	4	Moderate	Loss of containment of lixiviant (mining solution) outside mining chamber - Further Assessment Recommended

Notes: "Co" is construction
"Op" is operations
"De" is Decommissioning
"L" is likelihood
"S" is severity
"RR" is risk ranking

Production Plant - Summary – Seven potential scenarios have been identified. Risks have been characterized as low to high as it concerns environmental risks. Two scenarios are carried forward for quantitative assessment.

Table 3-7: Hazard Identification Evaluation – Production Plant (shaded rows are those recommended for further assessment)

ID#	Accident / Malfunction	Phase	Consequence	Existing Safeguards / Design Features	L	S	RR / Significance	Screening Decision / Rationale
7.1	Process vessel and piping system failure	Op	Release of sulphuric acid	Occupational health and safety plan Personnel training and orientation Inspection and maintenance Spill and emergency response plan Secondary containment Process sumps Production building is contained	3	2	Low	Overall low risk, minor consequence event, no further assessment
7.2	Process vessel and piping system failure	Op	Release of hydrogen peroxide and potential for fire	Occupational health and safety plan Personnel training and orientation Inspection and maintenance Spill and emergency response plan Secondary containment Process sumps Production building is contained	3	2	Low	Overall low risk, minor consequence event, no further assessment
7.3	Process vessel and piping system failure	Op	Release of magnesium hydroxide	Occupational health and safety plan Personnel training and orientation Inspection and maintenance Spill and emergency response plan Secondary containment Process sumps Production building is contained	3	2	Low	Overall low risk, minor consequence event, no further assessment
7.4	Process vessel and piping system failure, Thickener overflow	Op	Release of aqueous solution	Occupational health and safety plan Personnel training and orientation Inspection and maintenance Spill and emergency response plan Secondary containment Process sumps Production building is contained Detectable signs of exposure e.g., irritation	3	2	Low	Overall low risk, minor consequence event, no further assessment. ALARP
7.5	Process vessel and piping system failure	Op	Release of acidic fume from storage tank	Occupational health and safety plan Personnel training and orientation Inspection and maintenance Availability of respirators Emergency response plan will implement medical response to acute exposure to acidic fumes. Ambient monitoring Building ventilation	3	2	Low	Overall low risk, minor consequence event, no further assessment
7.6	Process vessel and piping system failure	Op	Release of radon from storage tank	Occupational health and safety plan Personnel training and orientation Inspection and maintenance	3	3	Moderate	Overall moderate risk, moderate consequence event - Further Assessment Recommended

ID#	Accident / Malfunction	Phase	Consequence	Existing Safeguards / Design Features	L	S	RR / Significance	Screening Decision / Rationale
				Emergency response plan Ambient monitoring Building ventilation				
7.7	Facility fire / explosion	Op	Release of radioactivity and yellowcake powder to atmosphere	Occupational health and safety plan Personnel training and orientation Inspection and maintenance Fire safety plan and firefighting systems Emergency response plan Ambient air monitoring	2	5	High	Further Assessment Recommended. It is also noted that this scenario could be an outcome of many initiating events – the specific details associated with the event will be determined based on the most current inventory of combustible and flammable materials associated with the production plant when the analysis is completed.
7.8	Process containment and gas cleaning and filtration system failure	Op	Release of yellowcake powder to atmosphere	Inspection, testing, and maintenance program Ambient air monitoring	3	4	ALARP, moderate	The consequence is bounded by scenario 7.7.

Notes: "Co" is construction
"Op" is operations
"De" is Decommissioning
"L" is likelihood
"S" is severity
"RR" is risk ranking

Clean Waste Rock Pads - Summary – Four potential scenarios have been identified. Risks have been characterized as low as it concerns environmental risks. No scenarios are carried forward for quantitative assessment.

Table 3-8: Hazard Identification Evaluation – Clean Waste Rock Pads

ID#	Accident / Malfunction	Phase	Consequence	Existing Safeguards / Design Features	L	S	RR / Significance	Screening Decision / Rationale
8.1	Stockpile slope failure	Co / Op /De	Release of material into surrounding environment	Personnel training and orientation Inspection and maintenance	1~~2~~	2	Low	Overall low risk, **highly** unlikely event due to small extent of stockpiles, no further assessment
8.2	Stockpile erosion	Co / Op /De	Release of materials into the environment	Personnel training and orientation Inspection and maintenance Single-lined pad Inspection and maintenance	2	3	Low	Overall low risk, unlikely event, no further assessment
8.3	Uncontrolled leachate / seepage release through runoff	Co / Op /De	Release of materials into the surface water	Personnel training and orientation Single-lined pad Inspection and maintenance Ambient monitoring Surface water management Spill management	1	2	Low	Low risk, highly unlikely event, no further assessment
8.4	Uncontrolled leachate / seepage release through lining failure	Co / Op /De	Release of materials into the groundwater	Personnel training and orientation Single-lined pad Inspection and maintenance Groundwater monitoring Spill response plan	2	3	Low	Overall low risk, unlikely event, no further assessment

Notes: "Co" is construction
"Op" is operations
"De" is Decommissioning
"L" is likelihood
"S" is severity
"RR" is risk ranking

Special / Specialized Waste Containment - Summary – Two potential scenarios have been identified. Risks have been characterized as low to moderate as it concerns environmental risks. No scenarios are carried forward for quantitative assessment.

Table 3-9: Hazard Identification Evaluation –Special / Specialized Waste Rock Pads

ID#	Accident / Malfunction	Phase	Consequence	Existing Safeguards / Design Features	L	S	RR / Significance	Screening Decision / Rationale
9.1	Loss of containment from storage vessels (barrels) resulting in uncontrolled leachate release	Co / Op /De	Release of contaminants into the surface water	Personnel training and orientation Double lined with leak detection/collection Inspection and maintenance Ambient monitoring Surface water management Spill management	1	3	Low	Overall low risk, **highly** unlikely event, no further assessment
9.2	Loss of containment from storage vessels (barrels)resulting in uncontrolled leachate release	Co / Op /De	Release of contaminants into the groundwater	Personnel training and orientation Double lined with leak detection/collection Inspection and maintenance Groundwater monitoring Spill response plan	1	4	ALARP, moderate	Best management practice results in ALARP, highly unlikely event, no further assessment

Notes: “Co” is construction
“Op” is operations
“De” is Decommissioning
“L” is likelihood
“S” is severity
“RR” is risk ranking

Gypsum (clean) Precipitates Disposal Area - Summary – Five potential scenarios have been identified. Risks have been characterized as low as it concerns environmental risks. No scenarios are carried forward for quantitative assessment.

Table 3-10: Hazard Identification Evaluation – Gypsum (clean) Precipitates Disposal Area

ID#	Accident / Malfunction	Phase	Consequence	Existing Safeguards / Design Features	L	S	RR / Significance	Screening Decision / Rationale
10.1	Precipitates erosion	Co / Op /De	Release of contaminants into surrounding environment	Personnel training and orientation Single-lined pad Inspection and maintenance	1	2	Low	Overall low risk, highly unlikely event, no further assessment
10.2	Uncontrolled leachate / seepage release through runoff	Co / Op /De	Release of contaminants into the environment	Personnel training and orientation Single-lined pad Inspection and maintenance Surface water monitoring Surface water management Spill management and response plan	1	2	Low	Overall low risk, highly unlikely event, no further assessment
10.3	Uncontrolled leachate / seepage release through lining failure	Co / Op /De	Release of contaminants into the surface water	Personnel training and orientation Single-lined pad Inspection and maintenance Surface water monitoring Surface water management Spill management and response plan	1	2	Low	Overall low risk, highly unlikely event, no further assessment
10.4	Uncontrolled leachate / seepage release through lining failure	Co / Op /De	Release of contaminants into the groundwater	Personnel training and orientation Single-lined pad Inspection and maintenance Groundwater monitoring Spill management and response plan	1	3	Low	Overall low risk, highly unlikely event, no further assessment
10.5	Wind erosion	Co / Op /De	Atmospheric release of contaminants	Personnel training and orientation Erosion control measures Inspection and maintenance Ambient air monitoring Response plan	1	3	Low	Overall low risk, highly unlikely event, no further assessment

Notes: "Co" is construction
"Op" is operations
"De" is Decommissioning
"L" is likelihood
"S" is severity
"RR" is risk ranking

Iron (contaminated) Precipitates Disposal Area - Summary – Five potential scenarios have been identified. Risks have been characterized as low to moderate as it concerns environmental risks. No scenarios are carried forward for quantitative assessment.

Table 3-11: Hazard Identification Evaluation – Iron (contaminated) Precipitates Disposal Area

ID#	Accident / Malfunction	Phase	Consequence	Existing Safeguards / Design Features	L	S	RR / Significance	Screening Decision / Rationale
11.1	Precipitates erosion	Co / Op /De	Release of contaminants into surrounding environment	Personnel training and orientation Double lined with leak detection/collection Inspection and maintenance	1	3	Low	Overall low risk, highly unlikely event, no further assessment
11.2	Uncontrolled leachate / seepage release through runoff	Co / Op /De	Release of contaminants into the environment	Personnel training and orientation Double lined with leak detection/collection Inspection and maintenance Surface water monitoring Surface water management Spill management and response plan	1	5	ALARP, moderate	Best management practice results in ALARP, highly unlikely event, no further assessment
11.3	Uncontrolled leachate / seepage release through lining failure	Co / Op /De	Release of contaminants into the surface water	Personnel training and orientation Double lined with leak detection/collection Inspection and maintenance Surface water monitoring Surface water management Spill management and response plan	1	5	ALARP, moderate	Best management practice results in ALARP, highly unlikely event, no further assessment
11.4	Uncontrolled leachate / seepage release through lining failure	Co / Op /De	Release of contaminants into the groundwater	Personnel training and orientation Double lined with leak detection/collection Inspection and maintenance Groundwater monitoring Spill management and response plan	1	5	ALARP, moderate	Best management practice results in ALARP, highly unlikely event, no further assessment
11.5	Wind erosion	Co / Op /De	Atmospheric release of contaminants	Personnel training and orientation Erosion control measures Inspection and maintenance Ambient air monitoring Response plan	1	3	Low	Overall low risk, highly unlikely event, no further assessment

Notes: "Co" is construction
"Op" is operations
"De" is Decommissioning
"L" is likelihood
"S" is severity
"RR" is risk ranking

Wastewater Treatment System - Summary – Three potential scenarios have been identified. Risks have been characterized as low to moderate as it concerns environmental risks. No scenarios are carried forward for quantitative assessment.

Table 3-12: Hazard Identification Evaluation – Wastewater Treatment System

ID#	Accident / Malfunction	Phase	Consequence	Existing Safeguards / Design Features	L	S	RR / Significance	Screening Decision / Rationale
12.1	Equipment / piping failure	Op / De	Contaminant and radioactivity release	Occupational health and safety plan Personnel training and orientation Piping design pressure higher than pumps shutoff pressure Inspection and maintenance Process monitoring Spill management and response	2	3	Low	Overall low risk in consideration of best management practice, containment of the piping within the ditches
12.2	Effluent clarifier overflow	Op / De	Contaminant and radioactivity release	Occupational health and safety plan Personnel training and orientation Inspection and maintenance Process monitoring Secondary containment Spill management and response	2	3	ALARP, low	Best management practice results in ALARP, no further assessment
12.3	Equipment and control system failure	Op / De	Release of reagents, Environmental contamination	Occupational health and safety plan Personnel training and orientation Inspection and maintenance Process monitoring Recirculation of off-spec water to the process Spill management and response	2	3	Low	Low risk, unlikely event, no further assessment

Notes: "Co" is construction
"Op" is operations
"De" is Decommissioning
"L" is likelihood
"S" is severity
"RR" is risk ranking

Ponds and Retention Berms - Summary – Five potential scenarios have been identified. Risks have been characterized as low to moderate as it concerns environmental risks. No scenarios are carried forward for quantitative assessment.

Table 3-13: Hazard Identification Evaluation – Ponds and Retention Berms

ID#	Accident / Malfunction	Phase	Consequence	Existing Safeguards / Design Features	L	S	RR / Significance	Screening Decision / Rationale
13.1	Pond overtopping	Op / De	Contaminant and radioactivity release	Personnel training and orientation Inspection and maintenance Surface water management Ponds designed for PMP/PMF Spill and emergency response plan Monitoring	2	3	Low	Overall low risk, unlikely event, no further assessment
13.2	Ponds containment or embankment failure	Op / De	Contaminant and radioactivity release	Personnel training and orientation Inspection and maintenance Surface water management Ponds designed for PMP/PMF Spill and emergency response plan Monitoring	1	5	ALARP, moderate	Best engineering practice in maintenance and inspection of the containment systems and berms. No further assessment
13.3	Ponds lining failure and leakage	Op / De	Contaminant and radioactivity release to groundwater	Personnel training and orientation Inspection and maintenance Groundwater monitoring Response plan	3	3	ALARP, moderate	Overall moderate risk, likely event with moderate consequence. Overall risk considered ALARP given engineering design and other safeguards. No further assessment recommended.
13.4	Surface flooding	Op / De	Contaminant and radioactivity release	Personnel training and orientation Inspection and maintenance Surface water management Ponds designed for PMP/PMF Spill and emergency response plan Monitoring	1	3	Low	Overall low risk, highly unlikely event, no further assessment
13.5	Wildlife entering pond	Op/De	Exposure to contaminants, drowning	Wildlife management plan Inspection Fencing	1	2	Low	Overall low risk, highly unlikely event, no further assessment

Notes: "Co" is construction
"Op" is operations
"De" is Decommissioning
"L" is likelihood
"S" is severity
"RR" is risk ranking

Electrical System and Power Plant - Summary – Three potential scenarios have been identified. Risks have been characterized as low to moderate as it concerns environmental risks. No scenarios are carried forward for quantitative assessment.

Table 3-14: Hazard Identification Evaluation – Electrical System and Power Plant

ID#	Accident / Malfunction	Phase	Consequence	Existing Safeguards / Design Features	L	S	RR / Significance	Screening Decision / Rationale
14.1	Substation transformer leak	Co / Op / De	Release of mineral oil and potential for groundwater contamination	Personnel training and orientation Inspection and maintenance Spill and emergency response plan Secondary containment	3	2	Low	Overall low risk, minor consequence event, no further assessment
14.2	Transformer, turbine, generator fire / explosion	Co / Op / De	Occupational major injuries	Personnel training and orientation Occupational health and safety program Personal protection equipment Inspection and maintenance Emergency response plan Fire safety plan and firefighting systems	2	3	ALARP, low	Best practice in worker health and safety program resulting in ALARP, no further assessment
14.3	Transformer, turbine, generator fire / explosion	Co / Op / De	Occupational fatalities	Personnel training and orientation Occupational health and safety program Personal protection equipment Inspection and maintenance Emergency response plan Fire safety plan and firefighting systems	1	5	ALARP, moderate	Best practice in worker health and safety program resulting in ALARP, no further assessment

Notes: "Co" is construction
"Op" is operations
"De" is Decommissioning
"L" is likelihood
"S" is severity
"RR" is risk ranking

Fire Protection System - Summary – Two potential scenarios have been identified. Risks have been characterized as low as it concerns environmental risks. No scenarios are carried forward for quantitative assessment.

Table 3-15: Hazard Identification Evaluation – Fire Protection System

ID#	Accident / Malfunction	Phase	Consequence	Existing Safeguards / Design Features	L	S	RR / Significance	Screening Decision / Rationale
15.1	Failure of fire pump	Co / Op / De	Loss of firefighting capacity	Personnel training and orientation Occupational health and safety program Personal protection equipment Inspection and maintenance Redundancy Fire safety plan and firefighting systems (including and elevated fire water tank, and a gas-powered pump for at a groundwater well) Emergency response plan	1	3	Low	Overall low risk, highly unlikely event, no further assessment
15.2	Loss or lack of fire water	Co / Op / De	Loss of firefighting capacity	Personnel training and orientation Occupational health and safety program Personal protection equipment Inspection and maintenance Fire safety plan and firefighting systems Emergency response plan	1	3	Low	Overall low risk, highly unlikely event, no further assessment

Notes: “Co” is construction
“Op” is operations
“De” is Decommissioning
“L” is likelihood
“S” is severity
“RR” is risk ranking

Hazardous Waste Management System - Summary – One potential scenario has been identified. Risks have been characterized as low as it concerns environmental risks. No scenarios are carried forward for quantitative assessment.

Table 3-16: Hazard Identification Evaluation – Hazardous Waste Management System

ID#	Accident / Malfunction	Phase	Consequence	Existing Safeguards / Design Features	L	S	RR / Significance	Screening Decision / Rationale
16.1	Hazardous waste spill	Co / Op / De	Potential for surface water and soil contamination	Personnel training and orientation Occupational health and safety program Personal protection equipment Inspection and maintenance Waste management plan Emergency response plan Onsite monitoring	2	2	Low	Overall low risk, minor consequence event, no further assessment

Notes: "Co" is construction
"Op" is operations
"De" is Decommissioning
"L" is likelihood
"S" is severity
"RR" is risk ranking

4.0 SCENARIOS ADVANCED FOR FURTHER ASSESSMENT

Based on the HI process presented in the previous section, seven hazard scenarios have been selected for more detailed risk analysis (**Table 4-1**). This further assessment will include the calculation of the probability, and consequences of each of these selected scenarios. This will result in more in-depth and representative characterization of the risk of these scenarios, as the estimation of the risk in this current report was preliminary and at the screening level.

Table 4-1: Accident and Malfunction Scenarios Advanced for Further Quantitative Assessment

Potential Accident or Malfunction	Project Phase	Potential Effect Pathway	Environmental Interactions	Initial Risk Characterization
Vehicle accident, including rollover, collision, run off road	O	Aquatic release of radioactivity	Potential effects on surface water quality, aquatic environment VCs, wildlife VCs and human health	High Risk
Vehicle accident, including rollover, collision, run off road	C/O/D	Aquatic release of fuel, hazardous chemicals, and reagents	Potential effects on surface water quality, aquatic environment VCs, wildlife VCs and human health	High Risk
Loss of freeze capacity	O	Loss of freeze wall and secondary underground containment	Potential effects on the groundwater VCs	Moderate Risk
Failure of freeze wall	O	Loss of secondary underground containment and groundwater contamination	Potential effects on the groundwater VCs	Moderate Risk
Process vessel and piping system failure	O	Release of radon from storage tank	Potential effects on groundwater, soils, vegetation, wildlife VCs and human health	Moderate Risk
Facility fire/explosion	O	Release of radioactivity and uranium concentrate powder to atmosphere	Potential effects on air quality and human health	High Risk
Vehicle accident, including rollover, collision, run off road	C/ O/D	Terrestrial release of radioactivity and chemicals	Potential effects on groundwater, soils, vegetation, wildlife VCs and human health	Moderate Risk

Red are high risks scenarios; yellow are moderate risk scenarios

5.0 REFERENCES

CNSC (Canadian Nuclear regulatory Commission). 2014. REGDOC-2.4.2, Safety Analysis Probabilistic Safety Assessment (PSA) for Reactor Facilities, Version 2. Available at **https://www.nuclearsafety.gc.ca/eng/pdfs/regulatory-documents/regdoc2-4-2/REGDOC-2.4.2_Probabilistic_Safety_Assessment_(PSA)_for_Reactor_Facilities_Version_2.pdf**

IAEA (International Atomic Energy Agency). 2002. Procedures for conducting probabilistic safety assessment for non-reactor nuclear facilities, IAEA-TECDOC-1267, January 2002, ISSN 1011–4289. Available at **https://www.pub.iaea.org/MTCD/Publications/PDF/te_1267_prn.pdf**

APPENDIX B – WATER CROSSINGS ON TRANSPORT ROUTE

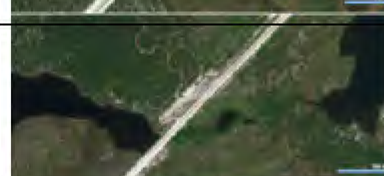
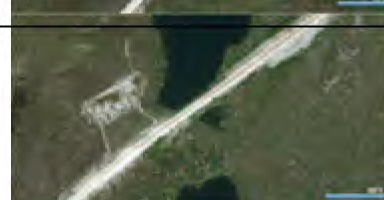
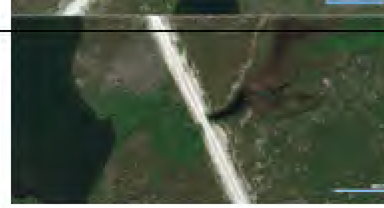
Ecometrix | Environmental INTELLIGENCE

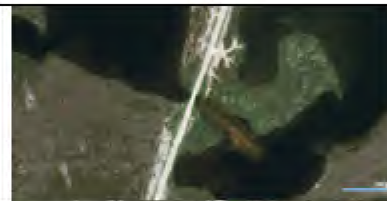
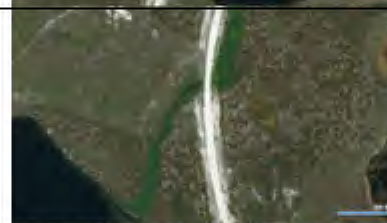
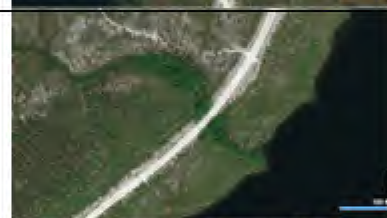
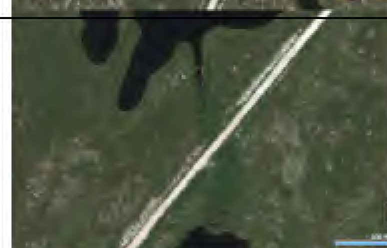
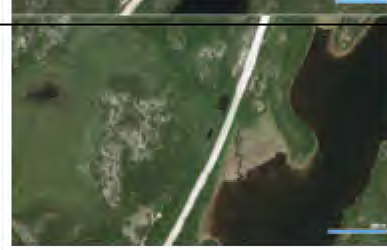
TO:	FROM:
Denison Mines	Ecometrix
REF:	**DATE:**
Appendix B to the Wheeler River Project EIS - Accidents and Malfunctions Assessment, Appendix 14-B – Water Crossings on the Transport Route	27 September 2023

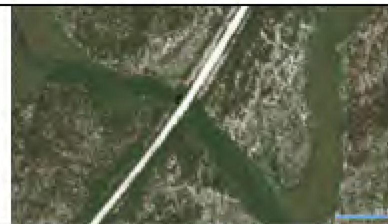
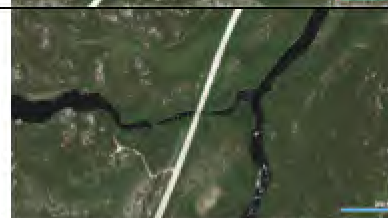
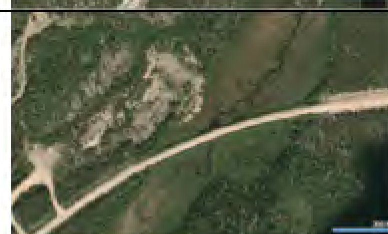
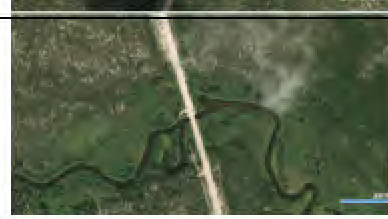
Per Federal Indigenous Review Team (FIRT) comments (FIRT-217) on the Wheeler River Project Draft Environmental Impacts Statement (EIS) submission, a review of water crossings associated with the Project-related transportation route have been completed and is provided as Appendix B of the Accidents and Malfunctions Assessment Technical Supporting Document (TSD) (EIS Appendix 14-A). For reference, the analysis considers Hwy 914 south from the project site to its junction with Hwy 165. Hwy 165 was further considered east to Hwy 2 and west to Hwy 155. A total of 66 water crossings were identified as shown in the table, below. Coordinates (lat., long.; are provided for each of the crossings along with a basic description of each and a corresponding satellite image. For reference, in the table the designation "Highway 165W" means the location of the crossing is on Hwy 165 west of Hwy 914, beginning at the Hwy 165/155 and travelling east and the designation "Highway 165E" means the crossing is east of Hwy 914, travelling east toward Hwy 2. It is noted that most crossings are not identifiable by a specific name and are thus identified as "Unnamed creek".

As noted by the FIRT review, the potential aquatic environment release scenarios focused on the Wheeler River crossing location. This location was chosen as it represents an important location to resource users in the study area. The scenarios provide examples of the consequences of such releases to local receptors. That is, the results of the assessment of the releases at this location would be expected to be representative of crossings along the transport route since the key endpoint in the assessment is overall risk, as defined for the assessment process as probability multiplied by consequence. For reference, the crossing analysis reference above and presented in the technical memorandum has identified in excess of 100 water crossings along the transportation route as described. It is not practical to assess each of these crossings. While the specific conditions at these crossings may differ in size or nature, the results of the analysis presented can generally be applied more broadly as indicated above. The approach used is consistent with past practice for comparable assessments for uranium projects in the province.

Crossing #	Hwy	Coordinates	Name	Feature	Feature Width (m)	Image
1	914	57.439217, -105.399002	Unnamed creek	Water crossing	10	
2	914	57.378448, -105.464859	Unnamed creek	Water crossing	<2	
3	914	57.354164, -105.485123	Russell Lake	Lake crossing	900	
4	914	57.285332, -105.570038	Unnamed creek	Water crossing	<2	

5	914	57.273514, -105.591202	Unnamed creek	Wetland complex	100	
6	914	57.220776, -105.685287	Unnamed creek	Water crossing	13	
7	914	57.053490, -105.983330	Unnamed creek	Wetland complex	35	
8	914	56.898136, -106.130302	Unnamed creek	Water crossing	50	
9	914	56.882645, -106.152107	Unnamed creek	Water crossing	60	
10	914	56.850391, -106.159187	Unnamed creek	Water crossing	10	

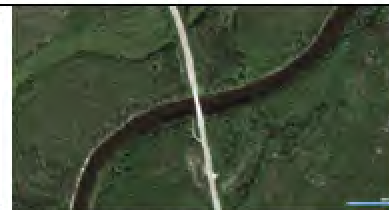
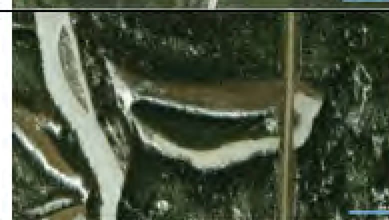
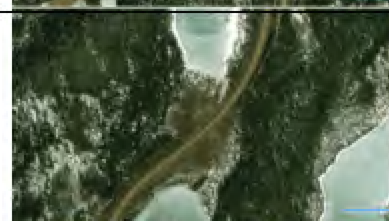
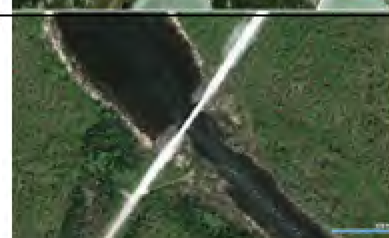
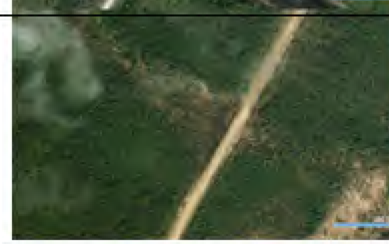
11	914	56.793152, -106.146248	Unnamed creek	Water crossing	15	
12	914	56.787197, -106.149460	Unnamed creek	Water crossing	<2	
13	914	56.722340, -106.165710	Unnamed creek	Water crossing	<2	
14	914	56.669765, -106.201149	Unnamed creek	Water crossing	10	
15	914	56.600300, -106.252251	Unnamed creek	Water crossing	<2	
16	914	56.572754, -106.281494	Unnamed creek	Water crossing	<2	

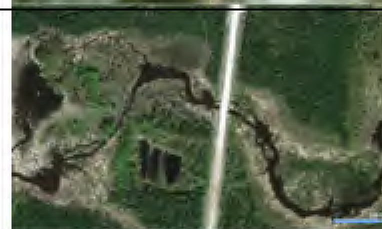
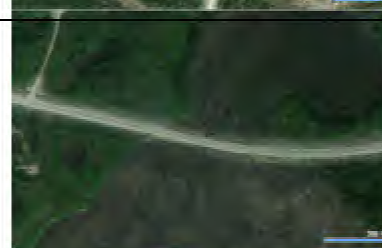
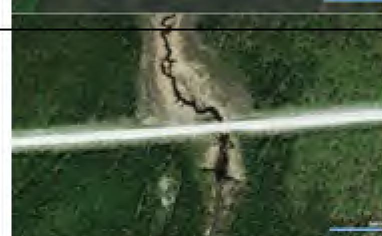
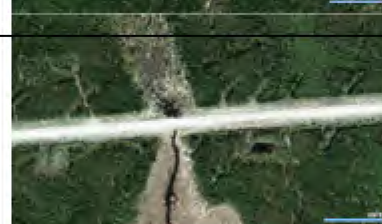
17	914	56.554306, -106.306236	Unnamed creek	Water crossing	<2	
18	914	56.539055, -106.330338	Unnamed creek	Water crossing	5	
19	914	56.444473, -106.401733	Unnamed creek	Water crossing	10	
20	914	56.388561, -106.512726	Unnamed creek	Water crossing	20	
21	914	56.353569, -106.565643	Unnamed creek	Water crossing	<2	
22	914	56.329689, -106.562004	Unnamed creek	Water crossing	10	

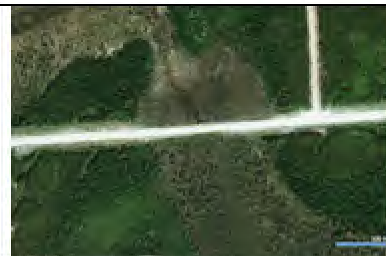
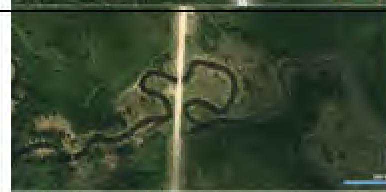
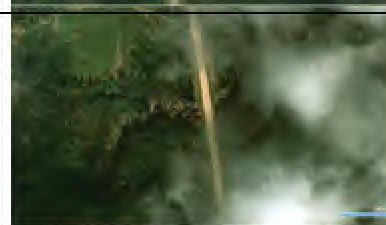
DATE: 27 September 2023

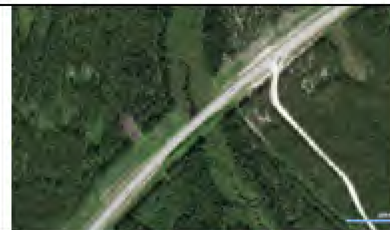
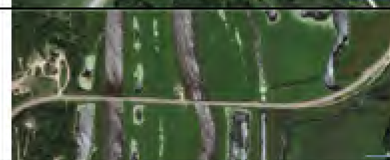
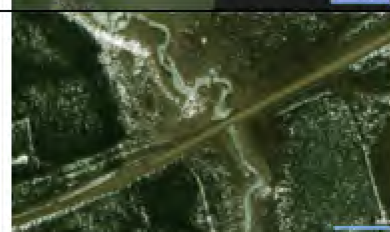
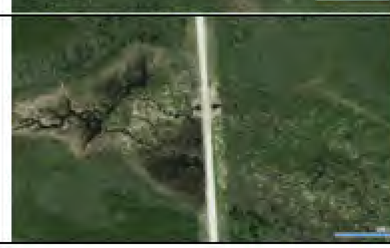
TO: Denison Mines

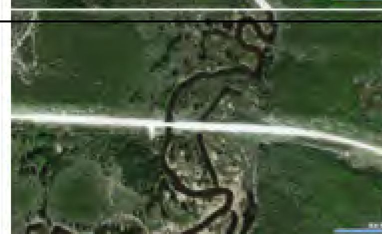
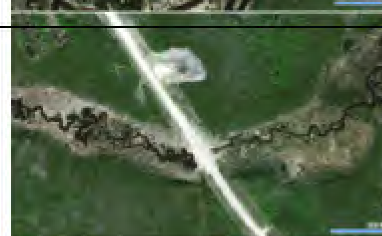
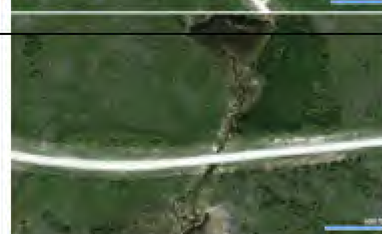
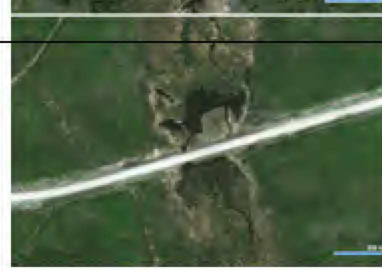
REF: Appendix B to the Wheeler River Project EIS - Accidents and Malfunctions Assessment, Appendix 14-B – Water Crossings on the Transport Route

23	914	56.147633, -106.613579	Unnamed creek	Water crossing	35	
24	914	55.994797, -106.521835	Unnamed creek	Water crossing	10	
25	914	55.967976, -106.532318	Unnamed creek	Water crossing	30	
26	914	55.867905, -106.503120	Unnamed creek	Water crossing	<2	
27	914	55.733261, -106.565331	Churchill River	Water crossing	40	
28	914	55.660831, -106.585144	Unnamed creek	Water crossing	<2	

29	914	55.656418, -106.588326	Unnamed creek	Water crossing	<2	
30	914	55.568588, -106.603722	Unnamed creek	Water crossing	10	
31	914	55.494350, -106.646774	Unnamed creek	Water crossing	<2	
32	914	55.504215, -106.714218	Unnamed creek	Water crossing	7	
33	914	55.500674, -106.768551	Unnamed creek	Water crossing	5	
34	914	55.474350, -106.836800	Unnamed creek	Water crossing	20	

35	914	55.465046, -106.865280	Unnamed creek	Water crossing	<2	
36	914	55.434074, -106.842552	Unnamed creek	Water crossing	<2	
37	914	55.378868, -106.833595	Unnamed creek	Water crossing	10	
38	914	55.358044, -106.839149	Unnamed creek	Water crossing	<2	
39	914	55.282467, -106.815933	Unnamed creek	Water crossing (2x)	40	

40	165W	55.124847, -107.681786	Unnamed creek	Water crossing	15	
41	165W	55.153086, -107.597933	Beaver River	Crossing complex	750	
42	165W	55.219022, -107.403364	Unnamed creek	Water crossing (minor)	3	
43	165W	55.222092, -107.214650	Unnamed creek	Water crossing	18	
44	165W	55.240179, -106.869717	Unnamed creek	Water crossing (minor)	3	
45	165E	55.229849, -106.789293	Unnamed creek	Wetland complex	100	

46	165E	55.210766, -106.789518	Unnamed creek	Water crossing	6	
47	165E	55.190045, -106.755394	Unnamed creek	Water crossing (one side ponded)	60	
48	165E	55.178462, -106.686886	Unnamed creek	Crossing complex	13	
49	165E	55.164998, -106.635760	Unnamed creek	Water crossing (one side ponded)	25	
50	165E	55.147328, -106.569588	Unnamed creek	Water crossing (minor)	5	
51	165E	55.145846, -106.480813	Unnamed creek	Water crossing	10	

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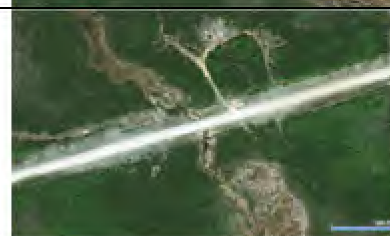
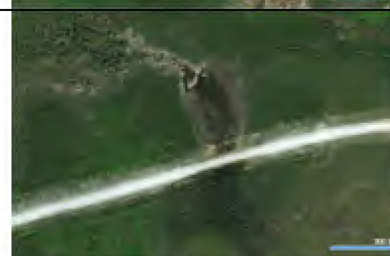
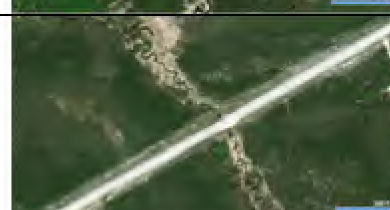
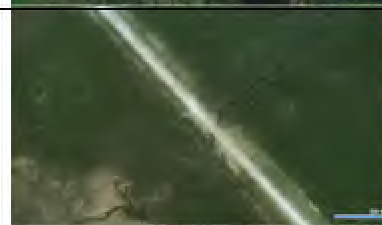
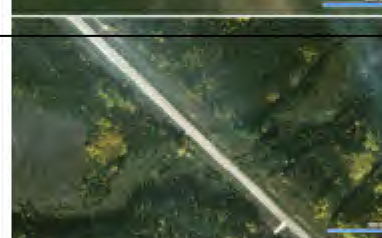
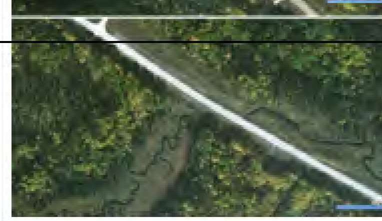
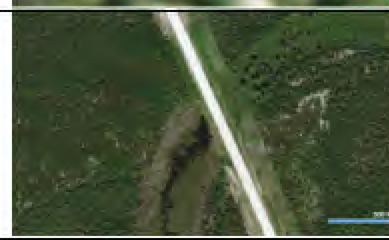
52	165E	55.148323, -106.465283	Unnamed creek	Water crossing (minor)	3	
53	165E	55.155644, -106.419692	Unnamed creek	Water crossing (minor)	3	
54	165E	55.160151, -106.391546	Unnamed creek	Wetland complex	25	
55	165E	55.156452, -106.340823	Unnamed creek	Water crossing	10	
56	165E	55.159666, -106.317084	Unnamed creek	Water crossing	5	
57	165E	55.166328, -106.259241	Unnamed creek	Water crossing (minor)	2	

58	165E	55.163412, -106.206745	Smoothstone River	Water crossing (major)	50	
59	165E	55.122788, -106.016421	Unnamed creek	Water crossing (minor)	5	
60	165E	55.103940, -105.963149	Unnamed creek	Water crossing (minor)	3	
61	165E	55.104002, -105.949567	Unnamed creek	Water crossing (ponded)	70	
62	165E	55.076830, -105.859303	Unnamed creek	Water crossing (minor)	3	
63	165E	55.059849, -105.821333	Unnamed creek	Water crossing (minor)	5	

64	165E	55.056275, -105.810201	Unnamed creek	Water crossing (minor)	3	
65	165E	54.884914, -105.748054	Montreal River	Water crossing (major)	20	
66	165E	54.811663, -105.671518	Unnamed creek	Water crossing (ponded)	38	

Denison Mines

Wheeler River Project

Final Environmental Impact Statement

November 2024

Powering PEOPLE, PARTNERSHIPS AND PASSION.

Section 14: Engagement Database Summary Table – Accidents and Malfunctions

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments (From Interested Party)	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
18-EN-VILX-3.33, 18-EN-VILX-3.35	3	Workshop	2018-01-17	As part of the engagement program for the Wheeler River Project, Denison organized a workshop in Ile a la Crosse for community and A La Baie Métis members to attend. The workshop gathered community and student input in relation to road alignment options, treated effluent discharge locations, and mining methods.	Village of Ile a la Crosse	Need a stormwater management plan and a spill response plan.	Denison considered this in section: Influence of Indigenous Knowledge, Local Knowledge, and Engagement on the Assessment	The context in which this comment was used within the Accidents and Malfunctions section of the EIS serves as a local perspective, documented as coming from an individual who attended a workshop in Ile a la Crosse in the year 2018. Denison will have in place procedures to effectively respond to spills. The waste management program accounts for retention and treatment of potentially contaminated storm water. See the Project Description section of the EIS for more information.
19-EN-ML82-62.21	62	Meeting	2019-11-05	Denison, MN-S representatives, and the Métis Local Presidents meet to discuss process for engagement. Denison requested MN-S provide direction related to rescheduling the community workshops for January 2020.	A La Baie Métis Local #21, Kineepik Métis Local #9, Métis Local #67 (Dore/Sled Lake), Métis Nation - Saskatchewan, Métis Nation - Saskatchewan, Métis Nation - Saskatchewan - Region 3, Patuanak Métis Local 82, Sipishik Métis Local #61	If one of the pipes breaks, what would happen?	Denison considered this in section: Influence of Indigenous Knowledge, Local Knowledge, and Engagement on the Assessment	The context in which this comment was used within the Accidents and Malfunctions section of the EIS serves as a local perspective, documented as coming from a Métis Nation Saskatchewan representative/a Métis Local President who attended meeting in the year 2019. Mitigation and monitoring will be implemented, thereby decreasing the likelihood of accidents and malfunctions, such as leaks. In the event of an accident or malfunction, a detailed process outline within the Emergency Preparedness and Response Program will be followed. The Emergency Preparedness and Response Program is being developed as a condition of licensing and is consistent with guidance provided by the CNSC in REGDOC-2.10.1, Nuclear Emergency Preparedness and Response (CNSC 2016).
21-EN-VPL-444.14	444	Virtual Meeting	2021-02-11	Denison hosted a virtual meeting for the municipality of Pinehouse Lake. The public meetings were focused on the Project generally, and did not seek input or comments on the distinct interests of the Métis in respect of the Project or Métis land use. This was expressly stated at the outset of each of the public meetings. Included in the discussion was an overview on the Valued Components for the Wheeler River Project, with a request to provide feedback to Denison via an online survey with specific questions pertaining to Valued Components.	Village of Pinehouse Lake	Would Denison partner with Pinehouse to create an emergency response team?	Denison considered this in section: Influence of Indigenous Knowledge, Local Knowledge, and Engagement on the Assessment	The context in which this comment was used within the Accidents and Malfunctions section of the EIS serves as a local perspective, documented as coming from an individual from Pinehouse who attended a virtual meeting in the year 2018.
21-EN-VPL-444.25	444	Virtual Meeting	2021-02-11	Same as above	Village of Pinehouse Lake	If the chemicals are dangerous will Denison have an emergency response team to respond? Are there preventative measures in place to prevent the chemicals from entering the environment?	Denison considered this in section: Influence of Indigenous Knowledge, Local Knowledge, and Engagement on the Assessment	The context in which this comment was used within the Accidents and Malfunctions section of the EIS serves as a local perspective, documented as coming from an individual from Pinehouse who attended a virtual meeting in the year 2021. Mitigation and monitoring will be implemented, thereby decreasing the likelihood of accidents and malfunctions, such as leaks. In the event of an accident or malfunction, a detailed process outline within the Emergency Preparedness and Response Program will be followed. The Emergency Preparedness and Response Program is being developed as a condition of

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments (From Interested Party)	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
								licensing and is consistent with guidance provided by the CNSC in REGDOC-2.10.1, Nuclear Emergency Preparedness and Response (CNSC 2016).
21-EN-SUR-446.65	446	Survey	2021-02-16	As part of engagement activities for the municipalities of Beauval, Ile a la Crosse and Pinehouse Lake, Denison prepared and shared an online survey which included information about Denison, the Wheeler River Project, and posed validation questions about the Valued Components being assessed as part of the environmental assessment process. A total of 68 responses were received and 62 of the responses were considered complete, for a 91% completion rate. The information related to the Valued Components was incorporated into the assessment and questions asked on the surveys was incorporated into the overall engagement database.	Village of Beauval, Village of Ile a la Crosse, Village of Pinehouse Lake	Denison Question: Based on what you know so far about the Wheeler Project, what aspects of the project could be challenging or cause concern for your community? Response: Non transparency in regards to spills.	Denison considered this in section: Influence of Indigenous Knowledge, Local Knowledge, and Engagement on the Assessment	The context in which this comment was used within the Accidents and Malfunctions section of the EIS serves as a local perspective, documented as coming from a member of Beauval, Ile a La Crosse, or Pinehouse, who completed a survey in the year 2021. Public Information and Disclosure (CNSC 2018) sets out requirements and guidance for public information and disclosure for licensees and applicants of Class I and Class II nuclear facilities, and uranium mines and mills, for all lifecycle phases. The primary goal of the public information program, as it relates to the licensed activities, is to ensure that information related to the health, safety and security of persons and the environment, and other issues associated with the lifecycle of nuclear facilities are effectively communicated to the public. Denison would meet all requirements set out in this REGDOC, including the development of an appropriate public information program and disclosure protocol.
21-EN-SUR-446.66	446	Survey	2021-02-16	Same as above	Village of Beauval, Village of Ile a la Crosse, Village of Pinehouse Lake	Denison Question: Based on what you know so far about the Wheeler Project, what aspects of the project could be challenging or cause concern for your community? Response: Just pollutions	Denison considered this in section: Influence of Indigenous Knowledge, Local Knowledge, and Engagement on the Assessment	The context in which this comment was used within the Accidents and Malfunctions section of the EIS serves as a local perspective, documented as coming from a member of Beauval, Ile a La Crosse, or Pinehouse, who completed a survey in the year 2021. The record reference serves to highlight pertinent information within the engagement database. Denison has completed an environment assessment to understand Project impacts on the environment. Denison has determined that there will be no significant impacts as a result of Project activities.
21-EN-SUR-446.91	446	Survey	2021-02-16	Same as above	Village of Beauval, Village of Ile a la Crosse, Village of Pinehouse Lake	Denison Question: Based on what you know so far about the Wheeler Project, what aspects of the project could be challenging or cause concern for your community? Response: Water contamination.	Denison considered this in section: Influence of Indigenous Knowledge, Local Knowledge, and Engagement on the Assessment	The context in which this comment was used within the Accidents and Malfunctions section of the EIS serves as a local perspective, documented as coming from a member of Beauval, Ile a La Crosse, or Pinehouse, who completed a survey in the year 2021. Denison has completed an environment assessment to understand Project impacts on the environment. The assessment considers potential impact to groundwater and lakes. Denison determined that there will be no significant impacts as a result of Project activities.
21-EN-SUR-446.92	446	Survey	2021-02-16	Same as above	Village of Beauval, Village of Ile a la Crosse, Village of Pinehouse Lake	Denison Question: Based on what you know so far about the Wheeler Project, what aspects of the project could be challenging or cause concern for your community? Response: The quality of the water if something were to leak. Ile a la crosse is a basin where all of the rivers meet, so if something were to spill into the water system it would be concerning for our community.	Denison considered this in section: Influence of Indigenous Knowledge, Local Knowledge, and Engagement on the Assessment	The context in which this comment was used within the Accidents and Malfunctions section of the EIS serves as a local perspective, documented as coming from a member of Beauval, Ile a La Crosse, or Pinehouse, who completed a survey in the year 2021. Denison has completed an environment assessment to understand Project impacts on the environment. The assessment considers accident and malfunction scenarios as well as potential impact to water. Denison has determined that there will be no significant impacts as a result of Project activities.

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments (From Interested Party)	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
21-EN-ERFN-447.37	447	Virtual Meeting	2021-03-31	Denison hosted a virtual meeting for English River First Nation (Patuanak, La Plonge and Urban Members). Included in the discussion was an overview on the Valued Components for the Wheeler River Project, with a request to provide feedback to Denison via an online survey with specific questions pertaining to Valued Components.	English River First Nation	Ice lander river is close to the project if a spill would happen would it reach or contaminate the river?	Denison considered this in section: Influence of Indigenous Knowledge, Local Knowledge, and Engagement on the Assessment	The context in which this comment was used within the Accidents and Malfunctions section of the EIS serves as a local perspective, documented as coming from a member of English River First Nation who attended a virtual meeting in the year 2021. Denison has completed an environment assessment to understand Project impacts on the environment. The assessment considers accident and malfunction scenarios as well as potential impact to water. Denison determined that there will be no significant impacts as a result of Project activities. In the event of an accident or malfunction, a detailed process outlined within the Emergency Preparedness and Response Program will be followed. The Emergency Preparedness and Response Program is being developed as a condition of licensing and is consistent with guidance provided by the CNSC in REGDOC-2.10.1, Nuclear Emergency Preparedness and Response (CNSC 2016).
21-EN-YOUTH-448.2	448	Virtual Meeting	2021-03-31	Denison provided a virtual presentation to the high school in English River on the Patuanak Reserve about the Wheeler River Project. Included in the discussion was an overview on the Valued Components for the Wheeler River Project, with a request to provide feedback to Denison via an online survey with specific questions pertaining to Valued Components.	English River First Nation	Any chance of the wells blowing and contaminating the ground around it?	Denison considered this in section: Influence of Indigenous Knowledge, Local Knowledge, and Engagement on the Assessment	The context in which this comment was used within the Accidents and Malfunctions section of the EIS serves as a local perspective, documented as coming from a youth member of English River First Nation who attended a virtual meeting in the year 2021. Denison has completed an environment assessment to understand Project impacts on the environment. The assessment considers accident and malfunction scenarios as well as potential impact to terrain/soil/peat. Denison determined that there will be no significant impacts as a result of Project activities. Mitigation and monitoring will be implemented, thereby decreasing the likelihood of accidents and malfunctions, such as leaks. In the event of an accident or malfunction, a detailed process outline within the Emergency Preparedness and Response Program will be followed. The Emergency Preparedness and Response Program is being developed as a condition of licensing and is consistent with guidance provided by the CNSC in REGDOC-2.10.1, Nuclear Emergency Preparedness and Response (CNSC 2016).
21-EN-ERFN-474.1	474	Meeting	2021-06-30	Denison, its third party consultants for socioeconomic and health and wellness assessment (Intergroup) and the English River First Nation Lands & Resources Officer and the third party consultant for English River First Nation (Shared Value Solutions) held a meeting in which Denison provided an overview of the Wheeler River Project scope, and Intergroup provided an overview of the approach taken for the socioeconomic and wellness assessment for the Environmental Assessment.	English River First Nation	Any difference in spill management for ISR operation relative to from other standard mining operations?	Denison considered this in section: Influence of Indigenous Knowledge, Local Knowledge, and Engagement on the Assessment	he context in which this comment was used within the Accidents and Malfunction section of the EIS serves as a local perspective, documented as coming from a member of English River First Nation who attended a meeting in the year 2021. The Environmental Assessment was conducted based on anticipated Project components, one of which includes the ISR mining method. A Spill Management Plan will be developed as part of the Environmental Management Program as condition of licensing and regulatory requirements.

Denison Mines

Wheeler River Project

Final Environmental Impact Statement

November 2024

Powering PEOPLE, PARTNERSHIPS AND PASSION.

Section 15: Engagement Database Summary Table – Effects of the Environment on the Project

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments (From Interested Party)	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
16-EN-ERFN-100.17	100	Community Meeting	2016-07-27	Denison hosted a community meeting in Patuanak for English River First Nation members, the purpose of which was to provide an overview of the Wheeler River Project.	English River First Nation	Today because of climate change, things are starting to happen that normally didn't happen. Even the permafrost is now further down. In the Wheeler River area, where there's some permafrost, have your environment guys seen a change? Will there be a change? These are some of the questions that need to be answered in order to come out with a positive spin.	Denison considered this in section: Climate Change	The context in which this comment was used within the Effects of the Environment on the Project section of the EIS serves as a local perspective, documented as coming from a member of English River First Nation who attended a community meeting in the year 2016. The record reference serves to highlight dialogue related to climate change. The Project is in a mapped area designated as Sporadic Discontinuous Permafrost. Large and/or expansive areas of continous cryosolic soil and permafrost terrain do not occur within the RSA. For this reason, the potential effects are not expected to affect terrain stability within the Project Area within the life of the Project. Denison has completed an environment assessment to understand Project impacts on the environment. The assessment provides a description of the existing environment for valued components, including geological & groundwater, and terrestrial environments. Existing conditions are based on available information and are accompanied by supporting information that includes natural and human caused trends that are presently affecting baseline conditions. Denison determined that there will be no significant impacts as a result of Project activities.
18-EN-VB-4.39	4	Workshop	2018-01-18	As part of the engagement program for the Wheeler River Project, Denison organized a workshop in Beauval for community members to attend. The workshop gathered community input in relation to road alignment options, treated effluent discharge locations, and mining methods.	Village of Beauval	Our waterbodies up north change drastically; in the last two years we've even flooded over here, while a few years ago we were in drought mode.	Denison considered this in section: Extreme Weather (Short-term Events), Existing Environmental Conditions	The context in which this comment was used within the Effects of the Environment on the Project section of the EIS serves as a local perspective, documented as coming from an individual who attended a workshop in Beauval in the year 2018. The record reference serves to highlight existing environmental conditions.
19-LK-ERFNTrap-134.232	134	Site Visit	2019-10-29	Denison met with local land user and English River First Nation member Trapper at the Wheeler River Project site location for a full-day to interview him regarding his knowledge of the area, including providing information and feedback on specifics pertaining to wildlife and wildlife movement patterns, fish and spawning areas, local lakes and lake names, recreational and commercial use, traditional food	ERFN Trapper	I believe in climate change.	Denison considered this in section: Climate Change	The context in which this comment was used within the Effects of the Environment on the Project section of the EIS serves as a local perspective, documented as coming from ERFN Trapper who attended a site visit in the year 2019. The record reference serves to highlight dialogue related to climate change.

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments (From Interested Party)	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
				consumption, and specific aspects of the Wheeler River Project. ERFN Trapper provided his consent to Denison to use the information he provided in the environmental assessment. He reviewed the notes taken from the meeting, and provided his revisions / modifications to Denison on January 2, 2020.				
21-EN-VPL-444.4	444	Virtual Meeting	2021-02-11	Denison hosted a virtual meeting for the municipality of Pinehouse Lake. The public meetings were focused on the Project generally, and did not seek input or comments on the distinct interests of the Métis in respect of the Project or Métis land use. This was expressly stated at the outset of each of the public meetings. Included in the discussion was an overview on the Valued Components for the Wheeler River Project, with a request to provide feedback to Denison via an online survey with specific questions pertaining to Valued Components.	Village of Pinehouse Lake	Does Denison anticipate that climate change will potentially impact the EA baseline information?	Denison considered this in section: Climate Change	The context in which this comment was used within the Effects of the Environment on the Project section of the EIS serves as a local perspective, documented as coming from an individual who attended a virtual meeting for the Village of Pinehouse in the year 2021. The record reference serves to highlight dialogue related to climate change. Existing conditions are based on available information and are accompanied by supporting information that includes natural and human caused trends that are presently affecting baseline conditions.
21-EN-VPL-444.18	444	Virtual Meeting	2021-02-11	Same as above	Village of Pinehouse Lake	Are there current studies on the freeze wall method and climate change?	Denison considered this in section: Climate Change	The context in which this comment was used within the Effects of the Environment on the Project section of the EIS serves as a local perspective, documented as coming from an individual who attended a virtual meeting for the Village of Pinehouse in the year 2021. The record reference serves to highlight dialogue related to climate change. Studies considered in the environmental assessment for the Project are listed as references within each section of the EIS in which they are referred. Climate change has been considered in relation to the Project components, including the freeze wall.
22-EN-ERFN-621.5	621	Meeting	2022-05-30	Denison hosted a meeting with the Chief and Council of English River First Nation, hosted in ERFN Patuanak, to share information about the Wheeler River Project, preliminary effects assessment of the Project, and	English River First Nation	What about small quakes?	Denison considered this in section: Seismic Events, Existing Environmental Conditions	The context in which this comment was used within the Effects of the Environment on the Project section of the EIS serves as a local perspective, documented as coming from member of English River First Nation who attended a meeting in the year 2022. The record reference serves to highlight dialogue related to seismic events.

UNIQUE ID	ROC	Event Type	Date	Event Summary	Interested Parties	Comments (From Interested Party)	Response (From Denison)	Denison's Response to Question/Concern (where applicable)
				proposed mitigation and monitoring. A representative from the Canadian Nuclear Safety Commission and from the Province of Saskatchewan were also in attendance.				Because the Project is in a low seismic hazard zone, it is unlikely that a seismic event will occur. Denison will appropriately design buildings to meet the standards of the National Building Code of Canada (National Research Council of Canada 2015). This code uses earthquake probabilities and the nature of the ground motion most likely to occur at a site to determine structural design criteria. These infrastructure design features, combined with the low probability of seismic activity in northern Saskatchewan, are expected to mitigate the potential of any risk from seismic events.
22-EN-ERFN-621.15	621	Meeting	2022-05-30	Same as above	English River First Nation	Is climate change considered?	Denison considered this in section: Climate Change	The context in which this comment was used within the Effects of the Environment on the Project section of the EIS serves as a local perspective, documented as coming from member of English River First Nation who attended a meeting in the year 2022. The record reference serves to highlight dialogue related to climate change. Denison has completed an environment assessment to understand Project impacts on the environment. The assessment considers climate change within each valued component section. Climate change has been included in the cumulative effects section because it is an external force that can influence the potential effects of the Project.
22-EN-SUR-652.57	652	Survey	2022-06-03	As part of engagement activities for English River First Nation, Beauval, and Pinehouse, Denison prepared and shared, both online and as a hardcopy during Spring Engagement meetings, a survey that asked a series of questions relating to the results of the environmental assessment. A total of 39 surveys were entirely or partially completed.	Unknown	Denison Question: Are there any topics of particular concern that Denison needs to pay special attention to? Response: Climate change- exploitation of the north, no returns.	Denison considered this in section: Climate Change	The context in which this comment was used within the Effects of the Environment on the Project section of the EIS serves as a local perspective, documented as coming from an individual who completed a survey available to residents of English River First Nation, Pinehouse, and Beauval, in the year 2022. The record reference serves to highlight dialogue related to climate change. Denison has completed an environment assessment to understand Project impacts on the environment. The assessment considers climate change and cumulative effects. Denison has determined that there will be no significant impact as a result of Project activities.

Denison Mines

Wheeler River Project

Final Environmental Impact Statement

November 2024

Powering PEOPLE, PARTNERSHIPS AND PASSION.

1 Summary of Residual Effects

This Appendix summarizes all predicted residual effects of the Wheeler River Project (the Project) and their significance by each Valued Component (VC) considered to inform the assessment. This is intended to provide the context of the residual effects in a transparent, concise approach to show the fulsome, rigorous analysis undertaken for the environmental assessment (EA) of the Project.

Using accepted approaches and best practices, the EA of the Project focuses on the VCs that were determined in consultation with Indigenous communities. The previous VC-specific sections in Parts II and III of this Environmental Impact Statement (EIS) identified current baseline conditions, potential effects, and appropriate mitigation measures, characterized the residual effects on each of the Key Indicators (KIs), and then rolled up the ratings of the characteristics to determine the significance of the effect on receptor VC as a result of the Project. Significance determination is not completed on intermediate VCs, but integrated into the residual effect evaluation, residual effect characterization, and significance determination for related receptor VCs. A summary of the assessment outcomes, predicted residual effect, and significance determination (where applicable) for each VC are summarized in the following tables.

Atmospheric and Acoustic Environment – Summary of the Environmental Assessment Considerations and Significance Determination for Predicted Residual Effects

Component	Valued Components (Key Indicators)	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Mitigation Measures	Residual Effect	Significance
Atmospheric and Acoustic	Air Quality (levels of dust, combustion products, uranium, metals, and/or radionuclides)	Change in concentrations and deposition rates of total suspended particulate (TSP) compared to the most appropriate air quality criterion.	• On-site and off-site operation of vehicles and transport of materials. • Site preparation and earthworks; clearing, levelling, and grading of the Project Area.	Construction	• Watering of unpaved roads and surfaces. • Limiting equipment and vehicle speeds to <40 km/h.	Exceedances of 24-hour TSP criterion.	Intermediate VC (residual effects carried forward to Aquatic, Terrestrial and Human Health)
	Air Quality (levels of dust, combustion products, uranium, metals, and/or radionuclides)	Change in concentrations and deposition rates of TSP compared to the most appropriate air quality criteria.	• Operation of the in situ recovery (ISR) wellfield. • Operation of the processing plant and production of uranium concentrate. • On-site and off-site operation of vehicles and transport of materials.	Operation	• Watering of unpaved roads and surfaces. • Limiting equipment and vehicle speeds to <40 km/h. • Equip the dryer, calciner, and hygiene exhausts with scrubber systems. • Dryer, calciner, and hygiene exhaust stacks are appropriate height from the building height to eliminate building downwash effects.	Exceedances of 24-hour TSP criterion.	Intermediate VC (residual effects carried forward to Aquatic, Terrestrial and Human Health)
	Air Quality (levels of dust, combustion products, uranium, metals, and/or radionuclides)	Change in concentrations and deposition rates of TSP compared to the most appropriate air quality criterion.	• Remediation of contaminated areas (wellfield, pads, ponds, domestic wastewater treatment location, and process plant area). • On-site and off-site operation of vehicles and transport of materials.	Decommissioning	• Watering of unpaved roads and surfaces. • Limiting equipment and vehicle speeds to <40 km/h.	Exceedances of 24-hour TSP criterion.	Intermediate VC (residual effects carried forward to Aquatic, Terrestrial and Human Health)
	Air Quality (levels of dust, combustion products, uranium, metals, and/or radionuclides)	Change in concentrations and deposition rates of inhalable particulate matter (PM10) compared to the most appropriate air quality criterion.	• On-site and off-site operation of vehicles and transport of materials. • Site preparation and earthworks; clearing, levelling, and grading of the Project Area.	Construction	• Watering of unpaved roads and surfaces. • Limiting equipment and vehicle speeds to <40 km/h.	Exceedances of 24-hour PM10 criterion.	Intermediate VC (residual effects carried forward to Aquatic, Terrestrial and Human Health)
	Air Quality (levels of dust, combustion products, uranium, metals, and/or radionuclides)	Change in concentrations and deposition rates of PM10 compared to the most appropriate air quality criterion.	• Operation of the ISR wellfield. • Operation of the processing plant and production of uranium concentrate. • On-site and off-site operation of vehicles and transport of materials.	Operation	• Watering of unpaved roads and surfaces. • Limiting equipment and vehicle speeds to <40 km/h. • Equip the dryer, calciner, and hygiene exhausts with scrubber systems. • Dryer, calciner, and hygiene exhaust stacks are appropriate height from the building height to eliminate building downwash effects.	Exceedances of 24-hour PM10 criterion.	Intermediate VC (residual effects carried forward to Aquatic, Terrestrial and Human Health)

Component	Valued Components (Key Indicators)	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Mitigation Measures	Residual Effect	Significance
	Air Quality (levels of dust, combustion products, uranium, metals, and/or radionuclides)	Change in concentrations of nitrogen dioxide (NO_2) compared to the most appropriate air quality criterion.	• On-site and off-site operation of vehicles and transport of materials. • Power generation – generators. • Site preparation and earthworks; clearing, levelling, and grading of the Project Area.	Construction	• Planning vehicle and equipment routes to minimize travel distances, where possible. • Employ standard operating procedures and complete regular inspections of equipment machinery to make sure it is in good working order.	Exceedances of 1-hour NO_2 criterion.	Intermediate VC (residual effects carried forward to Aquatic, Terrestrial and Human Health)
	Air Quality (levels of dust, combustion products, uranium, metals, and/or radionuclides)	Change in concentrations of NO_2 compared to the most appropriate air quality criterion.	• Operation of the ISR wellfield. • Operation of the processing plant and production of uranium concentrate. • On-site and off-site operation of vehicles and transport of materials. • Power generation – generators (emergency).	Operation	• Planning vehicle and equipment routes to minimize travel distances, where possible. • Employ standard operating procedures and complete regular inspections of equipment machinery to make sure it is in good working order.	Exceedances of 1-hour NO_2 criterion.	Intermediate VC (residual effects carried forward to Aquatic, Terrestrial and Human Health)
	Air Quality (levels of dust, combustion products, uranium, metals, and/or radionuclides)	Change in concentrations of NO_2 compared to the most appropriate air quality criterion.	• Remediation of contaminated areas (wellfield, pads, ponds, domestic wastewater treatment location, and process plant area). • Power generation – generators. • On-site and off-site operation of vehicles and transport of materials.	Decommissioning	• Planning vehicle and equipment routes to minimize travel distances, where possible. • Employ standard operating procedures and complete regular inspections of equipment machinery to make sure it is in good working order.	Exceedances of 1-hour NO_2 criterion.	Intermediate VC (residual effects carried forward to Aquatic, Terrestrial and Human Health)
	Air Quality (levels of dust, combustion products, uranium, metals, and/or radionuclides)	Change in concentrations and deposition rates of uranium compared to the most appropriate air quality criterion.	• Operation of the ISR wellfield. • Operation of the processing plant and production of uranium concentrate.	Operation	• Equip the dryer, calciner, and hygiene exhausts with scrubber systems. • Dryer, calciner, and hygiene exhaust stacks are appropriate height from the building height to eliminate building downwash effects.	Exceedances of 24-hour uranium criterion.	Intermediate VC (residual effects carried forward to Aquatic, Terrestrial and Human Health)
	Noise	Change in daytime sound level (Ld).	• Power generation – generators. • Wellfield and freeze hole drilling; ground freezing. • Batch plant operation (concrete); crusher at borrow area.	Construction	• Locate the concrete batching operation as far away from sensitive locations as possible. • Direct the generator discharge openings away from sensitive locations. • Make use of available on-site obstructions to control sound exposure at sensitive areas (i.e., locate sources behind buildings).	Moderate increase in Ld.	Intermediate VC (residual effects carried forward to Terrestrial, Land and Resource Use)

Geology and Groundwater – Summary of the Environmental Assessment Considerations and Significance Determination for Predicted Residual Effects

Component	Valued Components (Key Indicators)	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Mitigation Measures	Residual Effect	Significance
Geology and Groundwater	Geology (terrain morphology and stability)	Vertical displacement (i.e., subsidence at the ground surface).	• ISR operations affecting subsidence at the ground surface associated with consolidation of rock mass (ore) at significant depth (approximately 400 m) below ground.	Operation	• Incorporation of specific Project design components and practices, including: 1. Site Monitoring: pre- and post-elevation measurements will be taken at the well collars to account for any vertical movement between Construction and Decommissioning. 2. Development of contingency plans, including cementing wells in place, which will act to stabilize the geological environment.	Maximum subsidence at the ground surface is predicted to be between 5.0 to 7.5 cm.	Intermediate VC (Residual effects carried forward to aquatic environment)
	Groundwater Quantity (groundwater flow patterns and discharge rates to local surface water; groundwater elevation changes)	Change in shallow and deep ground levels measured in monitoring wells (m) and baseflow to surface water bodies (L/sec).	• Site preparation; site clearing and grading. • Development of surface infrastructure. • Ground freezing. • Water supply and surface water releases.	Construction	• Incorporation of specific Project design components and practices, including: 1. Limit construction footprint (i.e., PSA) to the extent possible to reduce the potential for reductions in groundwater recharge and limit the number of watersheds overprinted by the PSA. 2. Project design to limit water use and water recycling. 3. Water management best practices to reduce site runoff and recharge to aquifers. • Commitment to follow-up ongoing hydrogeological evaluations, as well as monitoring and adaptive management, including: 1. Groundwater elevations in the groundwater well network. 2. Water elevations in local surface waters.	No residual effect predicted with mitigation measures.	Intermediate VC (Residual effects carried forward to aquatic environment)
	Groundwater Quality (focus on changes to groundwater discharge to local surface water bodies [i.e., Whitefish Lake])	Changes in concentrations of physical and chemical parameters in groundwater (mg/L or µg/L) compared to appropriate risk-based surface water environmental quality criteria.	• Water management. • Fuel management; refuelling of equipment; general site construction activities.	Construction	• Incorporate best management practices to avoid effects on groundwater. • Develop environmental management plans, programs, and procedures to provide consistent and responsible practices. • Make sure employee training programs and procedures are in place.	No residual effect predicted with mitigation measures.	Intermediate VC (Residual effects carried forward to aquatic environment)
	Groundwater Quality (focus on changes to groundwater discharge to local surface water bodies [i.e., Whitefish Lake])	Changes in concentrations of physical and chemical parameters in groundwater (mg/L or µg/L) compared to appropriate risk-based surface water	ISR operations effecting groundwater, in particular constituent concentrations.	Operation	• Incorporation of specific Project design components, including: 1. Establish freeze wall before mining operations to create the mining chamber, effectively isolating the area with mining solution (area inside the mining chamber) from the surrounding groundwater environment. 2. Create hydraulic controls that will limit vertical migration to the area 50 m above the ore zone.	No residual effect predicted with mitigation measures.	Intermediate VC (Residual effects carried forward to aquatic environment)

Component	Valued Components (Key Indicators)	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Mitigation Measures	Residual Effect	Significance
		environmental quality criteria.			3. Design injection and recovery wells to have secondary containment, or adequate containment. 4. Recognize option to drill additional wells to recover mining solution excursions. 5. Design pipelines to have secondary containment or catchment. 6. Establish a leak detection system for wells and pipelines. 7. Implement site monitoring within and exterior to freeze wall chambers. 8. Develop contingency plans, including drilling additional wells into any potentially contaminated areas for recovery of the mining solution back to surface. 9. Develop emergency response plans to respond to unplanned incidents and implement timely response (e.g., timely response for clean-up surface spills).		
	Groundwater Quality (focus on changes to groundwater discharge to local surface water bodies [i.e., Whitefish Lake])	Changes in concentrations of physical and chemical parameters in groundwater (mg/L or µg/L) compared to appropriate risk-based surface water environmental quality criteria.	Site infrastructure such as landfills and pads effecting groundwater, in particular constituent concentrations.	Operation	• Incorporation of Project design components, including: 1. Landfill and pads designed with geomembrane liner protective systems; double lining system with leak detection; and leachate collection systems depending on infrastructure and design. 2. Hazardous substances stored in approved storage areas with secondary containment as required. 3. Implementation of appropriate monitoring and management plans: • Groundwater monitoring plan with wells established near the processing plant terrace, landfill, and fuel and hazardous waste storage area to allow for detection of any changes in groundwater quality. • Environment, health, and safety management plans, programs, and procedures. • Waste management plans, programs, and procedures. • Employee training programs and procedures.	No residual effect predicted with mitigation measures.	Intermediate VC (Residual effects carried forward to aquatic environment)
	Groundwater Quality (focus on changes to groundwater discharge to local surface water bodies [i.e., Whitefish Lake])	Changes in concentrations of physical and chemical parameters in groundwater (mg/L or µg/L) compared to appropriate risk-based surface water	Concentrations of constituents greater than expected may be present during the horizontal groundwater remediation, flushing, and thawing of the freeze wall.	Decommissioning – ISR wellfield and operations.	• Incorporation of Project design components, including: 1. Mining horizon remediation – water will be injected into the mining horizon via injection wells and then recovered through the recovery wells to flush residual mass post mining. 2. Groundwater remediation with flushing of residual constituents of concern will be completed until the concentrations meet predetermined end points that are protective of the environment over the long term (i.e., future centuries period[1]).	No residual effect predicted with mitigation measures.	Intermediate VC (Residual effects carried forward to aquatic environment)

Component	Valued Components (Key Indicators)	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Mitigation Measures	Residual Effect	Significance
		environmental quality criteria.			3. Site monitoring (levels and quality) within and exterior to the former freeze wall chambers will be completed to evaluate site conditions. 4. Contingency plans will be developed, including drilling additional wells into any potentially contaminated areas for recovery of the mining solution back to surface. 5. Emergency response plans will be developed to respond to unplanned incidents and implement timely response (e.g., timely response for clean-up surface spills).		

1 **Future Centuries Period:** The temporal scope of the assessment for Groundwater included consideration of the period during which the highest constituent concentrations in groundwater are predicted to interact with surface water based on groundwater modeling. Due to the relatively low groundwater velocities between the proposed Project site and the surface water environment where groundwater/surface water interactions are expected, as well as the potential for chemical reactions along the groundwater flow pathway, such a “Future Centuries Period” scenario was deemed appropriate to fully assess potential future effects beyond the Project timeline (i.e., 0 to 38 years).

In this context, the Future Centuries Period scenario is considered with respect to the interaction of groundwater migration from the Project site and its potential influence on surface water in local water bodies. The Future Centuries Period projection encompasses the long-term period during which slow migration of groundwater from the Phoenix Ore Zone area to the surface water environment is anticipated and constitutes a bounding scenario of maximum concentrations of constituents of potential concern. For this assessment, groundwater flow and reactive transport modelling tools were constructed to help understand the migration and attenuation of constituents from the Phoenix Ore Zone area toward Whitefish Lake, the primary surface water receptor.

Based on the base case modelling results, the simulated concentrations of dissolved constituents emanating from the Phoenix Ore Zone were below the thresholds for protection of freshwater aquatic life in Whitefish Lake. A sensitivity analysis was performed to evaluate key uncertainties. All scenarios indicated that concentrations would not exceed Fresh Water Aquatic, maximum acceptable concentrations (FAL MAC) thresholds, except for modest (5%) exceedances of aluminum, which is attributed to existing elevated background conditions. All other constituents are simulated to remain below FAL MAC thresholds when they reach Whitefish Lake. The simulated conditions indicate that the natural setting has a large assimilative capacity, and reflects transport processes that include dispersion, sorption, and other geochemical reactions. The sorption and geochemical reactions evaluated are constituent-specific and were derived from well-established literature and findings at other in situ recovery (ISR) projects.

The residual effects assessment was evaluated for this time period. In addition to being a VC, Groundwater is also an intermediate component as changes to Groundwater must be understood to assess other Project interactions, such as changes to surface water quality. Residual effects characterizations for the Groundwater VC link to other VCs and do not have significance determination on their own. No residual effects were assessed based on the modelling that will cause a change in the Surface Water VC, including altering its status or integrity beyond an acceptable level.

As part of Post-Decommissioning, remediation Groundwater evaluations, and site SOPS, the following activities will be completed into the future to assess trends and compliance with model predictions:

- site monitoring of water levels to evaluate groundwater flow and comparison to model results; and
- groundwater quality sampling and analysis.

Post-Decommissioning and remediation monitoring will be completed to verify modelling results and predictions.

Aquatic Environment – Summary of the Environmental Assessment Considerations and Significance Determination for Predicted Residual Effects

Component	Valued Components (Key Indicators)	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Mitigation Measures	Residual Effect	Significance
Aquatic Environment	Surface Water Quantity	• Average monthly discharge (flow; m^3/s). Percentage change to average monthly discharge (%). • 5th percentile monthly discharge (flow; m^3/s). Percentage change to 5th percentile monthly discharge (%). • Change in surface water body water level (water level in metres).	• Project overprinting of drainage areas and implementation of site water management. • Surface water taking. • Discharge to surface water.	Construction, Operation, Decommissioning	• Limit and stage construction of the Project footprint. • Maximize recycling of contact and process water for re-use to minimize water taking. • Attenuate peak discharges and augment baseflows to the environment using Project water management/storage features (i.e., runoff, process water, contact water, monitoring/effluent ponds). • Maintain existing drainage patterns with the use of culverts were applicable. • Maintain access roads by periodically regrading and ditching to improve water flow, reduce erosion, and manage vegetation growth.	Changes in flows and/or water levels are well below criteria identifying a residual effect for all phases of the mine life.	Intermediate VC (Residual effects carried forward to Fish and Fish Habitat and Benthic Invertebrates)
	Surface Water Quality	• Change in the concentration of constituents that are directly related to Project activities, measured as a mass of a chemical per unit volume in water (e.g., mg/L).	• Land disturbance and clearing resulting in the mobilization of suspended material into natural surface water features. • Direct discharge of treated effluent to the natural environment.	Construction, Operation, Decommissioning	• Develop and implement a site-wide water management plan that includes an integrated framework to manage water quality. • Maximize recycling and re-use of contact and process water to reduce freshwater intake and release to Whitefish Lake. • Design the discharge diffuser/outfall to provide effective and rapid mixing of treated effluent to minimize the mixing zone. • Develop a site-specific effluent treatment system to treat effluent to appropriate release limits in accordance with provincial standards and licence/permit conditions.	Change in water quality (constituent concentrations) from baseline conditions.	Intermediate VC (Residual effects carried forward to Sediment Quality, Benthic Invertebrates, Fish and Fish Habitat, and Fish Health.
	Sediment Quality	• Change in the concentration of constituents that are directly related to Project activities, measured as a mass of a chemical per unit mass in sediment (e.g., µg/g).	• Land disturbance and clearing resulting in the mobilization of suspended material into natural surface water features. • Direct discharge of treated effluent to the natural environment.	Construction, Operation, Decommissioning	• Develop and implement a site-wide water management plan that includes an integrated framework to manage water quality. • Maximize recycling and re-use of contact and process water to reduce freshwater intake and release to Whitefish Lake. • Design the discharge diffuser/outfall to occupy the smallest footprint possible while providing effective and rapid mixing of treated effluent, thereby minimizing the mixing	Change in sediment quality (constituent concentrations and/or physical quality) from baseline conditions.	Not Significant

Component	Valued Components (Key Indicators)	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Mitigation Measures	Residual Effect	Significance
		• Change in the physical quality (grain size) of sediments.			zone and preventing the mobilization of sediments around the discharge zone via scouring from discharge flows. • Develop a site-specific effluent treatment system to treat effluent to appropriate release limits in accordance with provincial standards and licence/permit conditions.		
	Benthic Invertebrates	• Change in sediment quantity and physical quality (particle size). • Change in sediment quality (chemical). • Alteration and/or loss of aquatic habitat (area). • Change in water level or flow.	• Land disturbance and clearing resulting in the mobilization of suspended material into natural surface water features. • Direct discharge of treated effluent to the natural environment. • Pipeline and diffuser construction overprinting benthic substrates. • Construction of access road crossings.	Construction, Operation, Decommissioning	• Develop and implement a site-wide water management plan that includes an integrated framework to manage water quality • Maximize recycling and re-use of contact and process water to reduce freshwater intake and release to Whitefish Lake. • Design the discharge diffuser/outfall to occupy the smallest footprint possible while providing effective and rapid mixing of treated effluent, thereby minimizing the mixing zone and preventing the mobilization of sediments around the discharge zone via scouring from discharge flows. • Design access road crossings as clear-span structures to avoid instream works and disturbance of aquatic habitat.	The assessment predicted residual effects on benthic invertebrates due to change in sediment quantity and physical quality (particle size), change in sediment quality (chemical), change in aquatic habitat (area), and change in water level or flow.	Not Significant
	Fish and Fish Habitat	• Change in water quality (i.e., chemical, thermal). • Change in sediment quality (i.e., chemical, physical). • Alteration and/or loss of aquatic habitat (area) • Change in water level or flow.	• Land disturbance and clearing resulting in the mobilization of suspended material into natural surface water features. • Direct discharge of treated effluent to the natural environment. • Pipeline and diffuser construction overprinting substrates. • Construction of access road crossings.	Construction, Operation, Decommissioning	• Develop and implement a site-wide water management plan that includes an integrated framework to manage water quality. • Maximize recycling and re-use of contact and process water to reduce freshwater intake and release to Whitefish Lake. • Design the discharge diffuser/outfall to occupy the smallest footprint possible while providing effective and rapid mixing of treated effluent, thereby minimizing the mixing zone and preventing the mobilization of sediments around the discharge zone via scouring from discharge flows so as not to detrimentally affect fish habitat. • Design access road crossings as clear-span structures to avoid instream work and disturbance of aquatic habitat.	The assessment predicted residual effects on fish habitat due to change in water quality, change in sediment quality, alteration of aquatic habitat, and change in water level or flow.	Not Significant

Component	Valued Components (Key Indicators)	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Mitigation Measures	Residual Effect	Significance
	Fish Health	• Change in water quality (i.e., chemical, thermal). • Change in sediment quality (i.e., chemical, physical). • Change in fish tissue concentrations.	• Land disturbance and clearing resulting in the mobilization of suspended material into natural surface water features. • Direct discharge of treated effluent to the natural environment.	Construction, Operation, Decommissioning	• Develop and implement a site-wide water management plan that includes the collection and monitoring of contact water to determine whether treatment is required prior to release to the environment and inform optimal levels of treatment. • Monitor and manage effluent, including contingency for effluent treatment as may be required, so that water discharge objectives are achieved as defined in applicable provincial and federal regulatory instruments.	The assessment predicted residual effects on fish health due to change in water quality, change in sediment quality, and change in fish tissue concentrations.	Not Significant

Terrestrial Environment – Summary of the Environmental Assessment Considerations and Significance Determinations for Predicted Residual Effects

Component	Valued Components (Key Indicators)	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Mitigation Measures	Residual Effect	Significance
Terrestrial Environment	Terrain (terrain morphology, terrain stability)	• Change in slope grade, aspect; change in topographical contours and drainage patterns. • Change in the stability of landform attributes; increase in erosion potential; acceleration of erosional processes.	• Development of access roads and air strip. • Site preparation and earthworks. • Development of surface infrastructure.	Construction	• Project design, Project siting and sequencing. • Environmental management planning and follow-up. • Commitment to progressive and final reclamation.	Effects are predicted to result in a change in terrain morphology and terrain stability from baseline condition(s). Change in terrain morphology is anticipated to be within the range of natural variation; no anticipated change in terrain stability.	Not significant
			• Expansion of ponds and pads. • Progressive decommissioning and reclamation.	Operation			
			• Reclamation of disturbed areas.	Decommissioning			
	Soil (soil quantity, soil quality)	• Change (i.e., net loss) of soil volume. • Degradation in soil physical properties (particle size/texture, structure, and aggregation). • Increase in concentration of constituents of potential concern (COPCs) in soil.	• Development of access roads and air strip. • Site preparation and earthworks. • Development of surface infrastructure.	Construction	• Project design, Project siting and sequencing. • Environmental management planning and follow-up. • Commitment to progressive and final reclamation.	Potential effects are predicted to result in a change in soil quantity and soil quality from baseline condition(s). Potential change in soil quality and soil quantity is anticipated to be within or at the limits of the range of natural variation; no anticipated change in land use capability.	Not significant
			• Expansion of ponds and pads. • Progressive decommissioning and reclamation.	Operation			
			• Reclamation of disturbed areas.	Decommissioning			
	Organic Matter/Peat (organic matter/ peat quantity)	• Change (i.e., net loss) in percentage of area extent of organic matter.	• Development of access roads and air strip. • Site preparation and earthworks. • Development of surface infrastructure.	Construction	• Project design, Project siting and sequencing. • Environmental management planning and follow-up. • Commitment to progressive and final reclamation.	Potential effects are predicted to result in a change in organic matter/peat from baseline condition(s). Potential change in organic matter/peat quantity is anticipated to	Not significant
			• Expansion of ponds and pads. • Progressive decommissioning and reclamation.	Operation			

Component	Valued Components (Key Indicators)	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Mitigation Measures	Residual Effect	Significance
			• Development of access roads and air strip. • Site preparation and earthworks. • Development of surface infrastructure.	Construction		be within or at the limits of the range of natural variation; no anticipated change in land use capability.	
Terrestrial Environment	Vegetation and Ecosystems (vegetation abundance)	• Change in areal extent of habitat types.	• Development of access roads and air strip. • Site preparation and earthworks; clearing, levelling, and grading of the Project Area. • Water management (including treatment and site runoff). • Surface water withdrawal.	Construction	• Potential adverse effects on the Vegetation and Ecosystems, Listed Plant Species, and Wetlands VCs will be avoided or minimized to the extent possible through Project design measures. • Additional mitigation measures specific to the Vegetation and Ecosystems, Listed Plant Species, and Wetlands VCs are tailored to Project features and will be incorporated into the various Project management plans. • Disturbance to vegetation and soils will be avoided by clearly delineating Project Area boundaries (e.g., with the use of fencing, staking, or flagging), adhering to construction plans and schedules, and restricting off-site machine use. • Wetland boundaries in the proximity of planned disturbances will be clearly delineated (e.g., with the use of fencing, staking, or flagging) to facilitate avoidance to the extent practicable. • In areas requiring clearing only, grubbing will be avoided, and roots and groundcover will be retained to the extent feasible. • Pre-construction listed plant surveys will be completed within the Project Area. • Listed plants located adjacent to planned disturbances will be clearly delineated (e.g., with the use of fencing, staking, or flagging) to avoid and reduce the potential for accidental encroachment outside of the Project footprint.	Change in areal extent of habitat types.	Not significant
			• Water withdrawal from groundwater or surface water body. • Management of surface water (including seepage and site runoff). • Water release to surface water body.	Operation			
			• Site water management, treatment, and release. • Process water treatment and release. • Reclamation of disturbed areas.	Decommissioning			
	Vegetation and Ecosystems (constituent concentrations in vegetation)	• Change in level of COPCs in plant tissue.	• On-site and off-site operation of vehicles and transportation of materials.	Construction		Change in level of constituents of concern in plant tissue.	Not significant
			• Hazardous waste management (temporary storage, handling, and off-site transportation). • Storage and disposal of drill waste rock, process precipitates, and industrial wastewater treatment plant precipitates.	Operation			

Component	Valued Components (Key Indicators)	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Mitigation Measures	Residual Effect	Significance
			• On-site and off-site operation of vehicles and transport of materials.		• Herbicide use will be avoided within 100 m of any known listed plant occurrences. Where herbicide use is unavoidable, use will be restricted to direct application instead of broadcast spraying and will be completed by qualified personnel. • Progressive reclamation and ecosystem-based revegetation will be conducted on disturbed areas as soon as practicable with the use of suitable native species. • Sediment and erosion control measures will be implemented. • Surface water management features (e.g., culverts and ditches) will be constructed and maintained (as per Project design specification) along access roads and facility sites to facilitate surface drainage continuity and hydrologic connectivity, especially in proximity to wetlands, water crossings, and waterbodies. • Equipment and vehicles will arrive at the Project Area clean, will be inspected for soil, plant material, and seeds, and will be cleaned as appropriate to limit the potential for the introduction of invasive plants and noxious weeds. • Areas with a high risk for the potential spread of invasive plants and noxious weeds (i.e., within or adjacent to existing infestations) will be avoided to the extent practicable. If work must occur in these areas, invasive plant management will be implemented before starting work.		
			• Remediation of contaminated areas (wellfield, pads, ponds, domestic wastewater treatment location, and process plant area). • Decommissioning of landfills; hazardous materials management (temporary storage and off-site disposal). • On-site and off-site operation of vehicles and transportation of materials.	Decommissioning			
	Listed Plant Species (listed plant species)	• Change in number of listed plants.	• Development of access roads and air strip. • Site preparation and earthworks; clearing, levelling, and grading of the Project Area. • Water management (including treatment and site runoff). • Surface water withdrawal.	Construction		Change in number of listed plants.	Not significant
			• Water withdrawal from groundwater or surface water body. • Management of surface water (including seepage and site runoff). • Water release to surface water body.	Operation			
			• Site water management, treatment, and release. • Process water treatment and release. • Reclamation of disturbed areas.	Decommissioning			

Component	Valued Components (Key Indicators)	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Mitigation Measures	Residual Effect	Significance
	Wetlands (wetlands)	• Change in areal extent of wetlands.	• Development of access roads and air strip. • Site preparation and earthworks; clearing, levelling, and grading of the Project Area. • Water management (including treatment and site runoff). • Surface water withdrawal.	Construction	• Gravel, fill, straw matting, or similar materials to be used for erosion control will be inspected to minimize the potential for seeds or propagules of invasive plants being brought to site. • Seed used during re-vegetation will be certified weed free, with a valid "Certificate of Seed Analysis". • Dust deposition on soil, vegetation, and waterbodies (including wetlands) will be reduced by controlling access and travel during peak construction and (if/where necessary) applying dust suppression measures. • Hazardous materials will be handled, stored, and disposed of appropriately and in accordance with a Waste Management Plan to avoid attracting avian scavengers (e.g., in wildlife-proof containers). • A minimum 100 m distance from any waterbody will be maintained for fuel storage, refueling activities, or equipment servicing. • Vehicles and equipment will be maintained in good working condition (e.g., no leaks) and furnished with industry-standard spill response kits. • Mitigation measures to reduce the potential for dispersion of radiological contaminants of potential concern to vegetation will be implemented in accordance with the Radiation Protection Plan. • A vegetation and soil sampling program—comprising scheduled collection of soil and plant tissues from permanent sampling locations for analysis of constituents of concern—will be conducted to identify if plants	Change in areal extent of wetlands.	Not significant
			• Water withdrawal from groundwater or surface water body. • Management of surface water (including seepage and site runoff). • Water release to surface water body.	Operation			
			• Site water management, treatment, and release. • Process water treatment and release. • Reclamation of disturbed areas.	Decommissioning			

Component	Valued Components (Key Indicators)	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Mitigation Measures	Residual Effect	Significance
					within the Vegetation LSA are accumulating constituents of concern within their tissues.		
Terrestrial Environment	Ungulates (moose)	• Amount of habitat that may be altered or lost relative to its availability in the Terrestrial RSA.	• Development of access roads and air strip. • Site preparation and earthworks; clearing, levelling, and grading of the Project Area. • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Construction		Alteration and/or loss of habitat	Not significant
			• On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Operation			
			• Demolition and disposal of non-salvageable surface infrastructure and materials. • Reclamation of disturbed areas. • On-site and off-site operation of vehicles and transport of materials.	Decommissioning			
		• Moose mortalities directly or indirectly attributable to the Project.	• Development of access roads and air strip. • Site preparation and earthworks; clearing, levelling, and grading of the Project Area. • On-site and off-site operation of vehicles and transport of materials.	Construction		Change in mortality.	Not significant
			• On-site and off-site operation of vehicles and transport of materials.	Operation			
			• On-site and off-site operation of vehicles and transport of materials.	Decommissioning			

Component	Valued Components (Key Indicators)	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Mitigation Measures	Residual Effect	Significance
	Furbearers (wolverine, pine marten, mink, muskrat)	• Amount of habitat that may be altered or lost relative to its availability in the Terrestrial RSA.	• Development of access roads and air strip. • Site preparation and earthworks; clearing, levelling, and grading of the Project Area. • Waste management (composting, domestic and industrial landfill operation, recycling). • Water management (including treatment and site runoff). • Surface water withdrawal. • On-site and off-site operation of vehicles and transport of materials.	Construction	• Potential adverse effects on the Ungulates, Furbearers, and Woodland Caribou VCs will be avoided or minimized to the extent possible through Project design measures. • Additional mitigation measures specific to the Ungulates, Furbearers, and Woodland Caribou VCs, and tailored to Project features, will be incorporated into the various Project management plans. • Employees and contractors will be provided with wildlife education and awareness training, including education about potential wildlife issues on site and training on the mitigation measures. Plan to avoid or minimize potential Project effects on wildlife and wildlife habitat. • Wildlife and habitat protection measures will be implemented to avoid or minimize wildlife harassment. • Project activities will be assessed for their potential to disturb wildlife and/or affect wildlife habitat during sensitive time periods (to minimize sensory disturbance of wildlife. • To deter wildlife from potentially becoming entrapped, secure fencing will be installed around all radiological areas, and buildings and other Project components will be designed and maintained to exclude wildlife from entering. • Road and traffic management measures will be implemented to avoid or reduce sensory disturbance of wildlife and wildlife-vehicle collisions. • Waste and hazardous materials management measures will be implements to avoid or reduce the potential of wildlife exposure and wildlife conflicts.	Alteration and/or loss of habitat.	Not significant
			• Water withdrawal from groundwater or surface water body. • Management of surface water (including seepage and site runoff). • Water treatment, both domestic and industrial. • Water release to groundwater and/or surface water body. • Waste management (composting, domestic and industrial landfill operation, recycling). • On-site and off-site operation of vehicles and transport of materials.	Operation			
			• Site water management, treatment and release. • Process water treatment and release. • Demolition and disposal of non-salvageable surface infrastructure and materials. • Reclamation of disturbed areas.	Decommissioning			

Component	Valued Components (Key Indicators)	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Mitigation Measures	Residual Effect	Significance
			• On-site and off-site operation of vehicles and transport of materials. • Waste management (composting, domestic and industrial landfill operation, recycling).				
		• Furbearer mortalities directly or indirectly attributable to the Project.	• Development of access roads and air strip. • Site preparation and earthworks; clearing, levelling, and grading of the Project Area. • Waste management (composting, domestic and industrial landfill operation, recycling). • On-site and off-site operation of vehicles and transport of materials.	Construction		Change in mortality.	Not significant
			• Waste management (composting and landfill operation). • On-site and off-site operation of vehicles and transport of materials.	Operation			
			• On-site and off-site operation of vehicles and transport of materials. • Waste management (composting and landfill operation).	Decommissioning			
	Woodland Caribou (woodland caribou)	• Amount of habitat that may be altered or lost relative to its availability in the Terrestrial RSA.	• Development of access roads and air strip. • Site preparation and earthworks; clearing, levelling, and grading of the Project Area. • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Construction		Alteration and/or loss of habitat.	Not significant

Component	Valued Components (Key Indicators)	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Mitigation Measures	Residual Effect	Significance
			• On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Operation			
			• Demolition and disposal of non-salvageable surface infrastructure and materials. • Reclamation of disturbed areas. • On-site and off-site operation of vehicles and transport of materials.	Decommissioning			
		• Woodland caribou mortalities directly or indirectly attributable to the Project.	• Development of access roads and air strip. • Site preparation and earthworks; clearing, levelling, and grading of the Project Area. • On-site and off-site operation of vehicles and transport of materials.	Construction		Change in mortality.	Not significant
			• On-site and off-site operation of vehicles and transport of materials.	Operation			
			• On-site and off-site operation of vehicles and transport of materials.	Decommissioning			
Terrestrial Environment	Raptors (Bald Eagle, Osprey)	• Amount of habitat that may be altered or lost relative to its availability in the Terrestrial RSA.	• Development of access roads and air strip. • Site preparation and earthworks; clearing, levelling, and grading of the Project Area. • Waste management (composting, domestic and industrial landfill operation, recycling). • Water management (including treatment and site runoff). • Surface water withdrawal.	Construction	• Potential adverse effects on the Raptors, Migratory Breeding Birds, and Bird Species at Risk VCs will be avoided or minimized to the extent possible through Project design measures. • Additional mitigation measures specific to the Raptors, Migratory Breeding Birds, and Bird Species at Risk VCs, in accordance with the *Migratory Birds Convention Act* and tailored to Project features, will be incorporated into the various Project management plans.	Alteration and/or loss of habitat.	Not significant

Component	Valued Components (Key Indicators)	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Mitigation Measures	Residual Effect	Significance
			• On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.		• Employees and contractors will be provided with wildlife education and awareness training, including education about potential wildlife issues on site and training on the mitigation measures to avoid or minimize potential Project effects on avian species and their habitat. • Site clearing and other works that involve disturbance of vegetation and/or soil will be conducted outside of the nesting season, whenever practicable. • Active nests and suspected nest locations will be protected with a no-disturbance setback buffer consistent with regulatory guidelines. • Avian species and habitat protection measures will be implemented to avoid or minimize adverse effects. • Buildings and other Project infrastructure will be designed and maintained to exclude birds as much as possible. Physical, visual, and/or auditory deterrents will be used to discourage avian use of buildings and other Project infrastructure for refuge, shelter, or nesting, and to deter birds from potentially becoming entrapped. • Deflectors will be used on Project power transmission lines leading to the Project components, if appropriate. • Measures will be taken to discourage birds, particularly raptors, from nesting on utility poles. • Road and traffic management measures will be implemented to avoid or reduce sensory disturbance of avian species and vehicle collisions.		
			• Management of surface water (including seepage and site runoff). • Waste management (composting, domestic and industrial landfill operation, recycling). • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Operation			
			• Process water treatment and release. • Demolition and disposal of non-salvageable surface infrastructure and materials. • Reclamation of disturbed areas. • Site water management, treatment, and release. • Waste management (composting, domestic and industrial landfill operation, recycling). • On-site and off-site operation of vehicles and transport of materials.	Decommissioning			
		• Raptor mortalities directly or indirectly attributable to the Project.	• Site preparation and earthworks; clearing, levelling, and grading of the Project Area. • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Construction		Change in mortality.	Not significant
			• On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Operation			

Component	Valued Components (Key Indicators)	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Mitigation Measures	Residual Effect	Significance
			• On-site and off-site operation of vehicles and transport of materials.	Decommissioning	• Waste and hazardous materials management measures will be implements to avoid or reduce the potential of avian exposure and associated conflicts.		
	Migratory Breeding Birds (waterbirds and waterfowl, upland game birds, migratory songbirds)	• Amount of habitat that may be altered or lost relative to its availability in the Terrestrial RSA.	• Development of access roads and air strip. • Clearing, levelling, and grading of the Project site and laydown area. • Waste management (composting, domestic and industrial landfill operation, recycling). • Water management (including treatment and site runoff). • Surface water withdrawal. • On-site and off-site operation of vehicles and transportation of materials. • Air transportation for workers.	Construction		Alteration and/or loss of habitat.	Not significant
			• Water withdrawal from groundwater or surface water body. • Management of surface water (including seepage and site runoff). • Water treatment, both domestic and industrial. • Water release to surface water body. • Waste management (composting, domestic and industrial landfill operation, recycling). • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Operation			

Component	Valued Components (Key Indicators)	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Mitigation Measures	Residual Effect	Significance
			• Process water treatment and release. • Demolition and disposal of non-salvageable surface infrastructure and materials. • Reclamation of disturbed areas. • Site water management, treatment, and release. • On-site and off-site operation of vehicles and transport of materials. • Waste management (composting, domestic and industrial landfill operation, recycling).	Decommissioning			
		• Migratory Breeding Bird mortalities directly or indirectly attributable to the Project.	• Development of access roads and air strip. • Site preparation and earthworks; clearing, levelling, and grading of the Project site and laydown area. • Waste management (composting, domestic and industrial landfill operation, recycling). • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Construction		Change in mortality.	Not significant
			• Water withdrawal from groundwater or surface water body. • Management of surface water (including seepage and site runoff). • Water treatment, both domestic and industrial. • Water release to surface water body. • Waste management (composting, domestic and industrial landfill operation).	Operation			

Component	Valued Components (Key Indicators)	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Mitigation Measures	Residual Effect	Significance
			• On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.				
			• Site water management, treatment, and release. • Process water treatment and release. • Demolition and disposal of non-salvageable surface infrastructure and materials. • Reclamation of disturbed areas. • Waste management (composting, domestic and industrial landfill operation, recycling). • On-site and off-site operation of vehicles and transport of materials.	Decommissioning			
	Bird Species at Risk (Common Nighthawk, Short-eared Owl, Yellow Rail, Rusty Blackbird, Olive-sided Flycatcher)	• Amount of habitat that may be altered or lost relative to its availability in the Terrestrial RSA.	• Development of access roads and air strip. • Site preparation and earthworks; clearing, levelling, and grading of the Project Area. • Water management (including treatment and site runoff). • Surface water withdrawal. • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Construction		Alteration and/or loss of habitat.	Not significant
			• Management of surface water (including seepage and site runoff). • Water release to surface water body. • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Operation			

Component	Valued Components (Key Indicators)	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Mitigation Measures	Residual Effect	Significance
			• Process water treatment and release. • Demolition and disposal of non-salvageable surface infrastructure and materials. • Reclamation of disturbed areas (site, roads, camp, and airstrip). • Site water management, treatment, and release. • On-site and off-site operation of vehicles and transport of materials.	Decommissioning			
		• Bird Species at Risk mortalities directly or indirectly attributable to the Project.	• Development of access roads and air strip. • Site preparation and earthworks; clearing, levelling, and grading of the Project Area. • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Construction		Change in mortality.	Not significant
			• On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers.	Operation			
			• Demolition and disposal of non-salvageable surface infrastructure and materials. • Reclamation of disturbed areas. • On-site and off-site operation of vehicles and transport of materials.	Decommissioning			

Human Health – Summary of the Environmental Assessment Considerations and Significance Determination for Predicted Residual Effects

Component	Valued Components (Key Indicators)	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Residual Effect	Mitigation Measures	Significance
Human Health	Human Health and Safety (public health)	• Evaluation of the risk of exposure to constituents of potential concern using hazard quotient, incremental lifetime cancer risk, and radiation dose.	Construction • Development of access roads and air strip. • Site preparation and earthworks; clearing, levelling, and grading of the Project Area. • Power generation – generators. • Wellfield and freeze hole drilling; ground freezing. • Batch plant operation (concrete); crusher at borrow area. • Development of surface infrastructure (camp, operations centre, plants, ponds, pads, and support facilities). • On-site and off-site operation of vehicles and transport of materials. Operation • Operation of the ISR wellfield. • Wellfield and freeze wall drilling. • Batch plant operation (grout and cement); crusher in borrow area. • Operation of the processing plant and production of uranium concentrate. • Water release to surface water body. • Waste management (composting, domestic and industrial landfill operation, recycling). • Storage and disposal of drill waste rock, process precipitates, and industrial wastewater treatment plant precipitates. • On-site and off-site operation of vehicles and transport of materials.	Construction Operation Decommissioning	• The Human Health Risk Assessment (HHRA) indicated residual effects on the fisher/trapper (one of the human receptors evaluated) from eating fish due to selenium concentrations in the inlet to Russell Lake. • No other residual effects were identified in the HHRA.	• Develop site-wide water management plan. • Develop site-specific effluent treatment to treat constituents of potential concern to appropriate release limits. • Monitor and manage effluent. • Create and implement a dust management plan.	Not significant

Component	Valued Components (Key Indicators)	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Residual Effect	Mitigation Measures	Significance
			• Power supply – primarily power from the grid; also generators and back-up generators. Decommissioning • Site water management, treatment, and release. • Remediation of contaminated areas (wellfield, pads, ponds, domestic wastewater treatment location, and process plant area). • Power generation – generators. • On-site and off-site operation of vehicles and transport of materials. • Reclamation of disturbed areas.				
	Worker Health and Safety (employee health)	• Change in the risk of exposure to constituents of concern. • Radiological exposure values.	Operation • Operation of the ISR wellfield. • Wellfield and freeze wall drilling. • Operation of the processing plant and production of uranium concentrate. • Storage and disposal of drill waste rock, process precipitates, and industrial wastewater treatment plant precipitates. • Package and transport of nuclear substances. Decommissioning • Site water management, treatment, and release. • Mining horizon remediation and thawing of freeze wall. • Remediation of contaminated areas (wellfield, pads, ponds, domestic wastewater treatment location, and process plant area).	Operation Decommissioning	• No residual effect predicted with implementation of mitigation measures and the Radiation Protection Plan.	• Maximize distance from radiation sources; minimize time near radiation sources. • Berm around Special Waste Pad for shielding. • Use powered air purifying respirators for the drying and packaging/loading areas of the ISR Plant. • Monitor dust levels, radon, and worker dose. • Implement the Radiation Protection Plan. • Implement a conventional Health and Safety Plan.	N/A

Land and Resource Use – Summary of the Environmental Assessment Considerations and Significance Determination for Predicted Residual Effects

Component	Valued Components (Key Indicators)	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Mitigation Measures	Residual Effect	Significance
Land and Resource Use	Indigenous Land and Resource Use (ILRU)[1] (perceived suitability of land and resources therein)	Perceived suitability of land and resources for safe use.	• Waste management. • Water management. • Groundwater supply. • Surface water withdrawal. • Water release to surface water body. • Hazardous waste management. • Storage and disposal of drill waste rock, process precipitates, and industrial wastewater treatment plant precipitates. • Package and transport of nuclear substances. • Remediation of contaminated areas. • Decommissioning of landfills; hazardous materials management.	Construction Operation Decommissioning	• Mitigation measures for the perceived suitability of lands and resources are required to reduce the potential effects of traffic, noise, dust dispersion, and air emissions, and the potential for constituents of potential concern from entering the environment. The ISR mining method is new to Canada, and despite the exercise of due diligence, trust will need to be built with those who have little experience with this mining method. • Traffic mitigations include air transportation to site and pick-up/drop-off points, driver training, emergency response plans, maintenance of site roads and access roads, and a requirement for Denison truck traffic to slow to 40 km/hr for a minimum of 2.5 kms on either side of the culture camp(s) in which are understood to occur in September and October (dates may be adjusted at the community's direction). • Noise mitigations include use of high-quality, low-sound emission equipment, situating noise-generating equipment behind on-site obstructions, using industry best practices, and monitoring noise. • Air quality mitigations include dust suppressants for roads and speed limitations to reduce road dust. • Waste management mitigations include features to prevent release of any harmful substances into the environment. • An environmental monitoring program will be developed. • Agreements will be negotiated between Denison and the Indigenous Communities of Interest.	Change in the perception of suitability of lands and resources resulting in avoidance of areas and selection of alternate areas to carry out land use activities. While it is difficult to predict individual perceptions on the suitability of land proximal to the Project for ILRU, resource users may experience disturbances from traffic, noise, and air quality changes, changes related to the relationship to the land, and increased competition for resources. Resource users may also be concerned about personal exposure to contamination of surface water and groundwater, soils, and sources of waste. Some perceptions may be strong enough to cause some individuals to avoid practicing ILRU in areas proximal to the Project.	Not significant
Land and Resource Use	Other Land and Resource Use (OLRU)[2]	Perceived suitability of resources for safe use.	• Waste management. • Water management. • Groundwater supply.	Construction Operation Decommissioning	• Mitigation measures for the perceived suitability of lands and resources therein KI are required to reduce the potential effects of traffic, noise, dust dispersion, air emissions, and the potential for constituents of	Change in the perception of suitability of lands and resources resulting in avoidance of areas and	Not significant

Component	Valued Components (Key Indicators)	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Mitigation Measures	Residual Effect	Significance
	(perceived suitability of land and resources therein)		• Surface water withdrawal. • Water release to surface water body. • Hazardous waste management. • Storage and disposal of drill waste rock, process precipitates, and industrial wastewater treatment plant precipitates. • Package and transport of nuclear substances. • Remediation of contaminated areas. • Decommissioning of landfills; hazardous materials management.		potential concern to enter the environment. The ISR mining method is new to Canada and, despite the exercise of due diligence, trust will also need to be built with those who have little experience with this mining method. • Traffic mitigations include air transportation to site and pick-up/drop-off points, driver training, emergency response plans, maintenance of site roads and access road, and a requirement for Denison truck traffic to slow to 40 km/hr for a minimum of 2.5 kms on either side of the culture camp(s) in which are understood to occur in September and October (dates may be adjusted at the community's direction). • Noise mitigations include use of high-quality, low sound emission equipment, locate noise-generating equipment behind on-site obstructions, use of industry best practices, and monitoring noise. • Air quality mitigations include dust suppressants for roads and speed limitations to reduce road dust. • Waste management mitigations include features to prevent release of any harmful substances into the environment. • An environmental monitoring program will be developed. • Agreements will be negotiated between Denison and any future trapper, if appropriate.	selection of alternate areas to carry out land use activities. While it is difficult to predict individual perceptions on the suitability of land proximal to the Project for OLRU, resource users may experience disturbances from traffic, noise, air quality changes, a loss of a 'wilderness experience', and increased competition for resources. Some perceptions may be strong enough to cause them to avoid practicing commercial and recreational use in areas proximal to the Project.	
Land and Resource Use	Heritage Resources (archaeological sites)	Change in the number of known archaeological resources directly or indirectly altered/lost as a result of Project activities.	• Development of access roads and air strip. • Site preparation and earthworks; clearing, leveling and grading of the project area. • Wellfield and freeze hole drilling; ground freezing. • Development of surface infrastructure (camp, operations centre, plants, ponds, pads, and support facilities).	Construction Operation Post-Decommissioning	• Mitigation includes avoidance, testing, excavation, and monitoring of any new heritage sites	Decrease in number of archaeological sites	Not significant

Component	Valued Components (Key Indicators)	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Mitigation Measures	Residual Effect	Significance
			• On-site and off-site operation of vehicles and transport of materials. • Expansion of pond and pads • Asset removal (including site power transmission lines and electrical infrastructure). • Remediation of contaminated areas (wellfield, pads, ponds, domestic wastewater treatment location, and process plant area). • Reclamation of disturbed areas.				

Notes:

1 Indigenous Land and Resource Use key indicators, changes to resource availability (including terrestrial and aquatic resource availability and the health of the resources), lands/waters available for traditional practices (including availability/accessibility of land and waterways), and changes to the perceived suitability of land and resources therein (including aesthetic experience and quality of resources for consumption) were not carried forward for a residual effects assessment. The only key indicator for Indigenous Land and Resource Use carried forward for a residual effects assessment include perceived suitability of land and resource use and measurable parameter perceived suitability for safe use.

2 Other Land and Resource Use key indicators, changes to resource availability (including terrestrial and aquatic resource availability and the health of the resources), lands available to conduct recreational and commercial harvests (including availability/accessibility of land and waterways), and changes to the perceived suitability of land and resources therein (including aesthetic of resource use) were not carried forward for a residual effects assessment. The only key indicator for Other Land and Resource Use carried forward for a residual effects assessment include perceived suitability of land and resource use and measurable parameter perceived suitability of resources for safe use.

Quality of Life – Summary of the Environmental Assessment Considerations and Significance Determination for Predicted Residual Effects

Component	Valued Component (Key Indicators)	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Mitigation Measures	Residual Effect	Significance
Quality of Life	Cultural expression[1] (traditional diet)	Changes in availability of country foods included in a traditional diet.	• Development of access roads and air strip. • Site preparation and earthworks. • Waste management. • Surface water withdrawal. • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers. • Water treatment • Water release to surface water body. • Hazardous waste management. • Storage and disposal of drill waste rock, process precipitates and industrial wastewater treatment plant precipitates. • Package and transport of nuclear substances. • Remediation of contaminated areas.	Construction Operation Decommissioning	• To minimize land disturbed by the Project, the Project Area has been reduced to the extent practicable and much of the proposed Project footprint has been developed within previously disturbed areas. • Denison will implement an Environmental Monitoring Program consistent with Canadian Standards Association for nuclear facilities and mines. • Denison is currently working with communities to make sure Project outcomes include the development of mutually beneficial relationships and minimized Project effects.	The Project's effects on the availability and abundance of species that are important to a traditional diet are expected to be low. The area where Project effects are anticipated for traditional diet species are not areas with intensive use . Those effects are anticipated in the Local Study Area (LSA) for Indigenous Land and Resource Use (ILRU), north of the Key Lake gate.	Not significant
		Changes in the perceived suitability of country foods in a traditional diet.	• Development of access roads and air strip. • Ste preparation and earthworks. • Waste management. • Surface water withdrawal. • On-site and off-site operation of vehicles and transport of materials. • Air transportation for workers. • Water treatment. • Water release to surface water body. • Hazardous waste management.	Construction Operation Decommissioning	• Mitigation measures will be applied to reduce the effects of traffic, noise, dust dispersion, air emissions, and the potential for COPCs to enter the environment. • Denison will implement an Environmental Monitoring Program consistent with Canadian Standards Association for nuclear facilities and mines. • Denison is currently working with communities to make sure Project outcomes include the development of mutually beneficial relationships and minimized Project effects.	The perceived suitability of country foods may be adversely affected by the Project. The predicted exceedance of the benchmark for selenium from eating a large quantity of fish in Russell Lake, although based on conservative assumptions and monitored throughout the life of the Project, may cause some residents of the LSA to avoid country foods harvested close to the Project footprint. As noted, these areas are not intensively used now. Therefore, a change in perceived suitability and safety of country foods may change some behaviour but is not expected to cause a large reduction in the	Not significant

Component	Valued Component (Key Indicators)	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Mitigation Measures	Residual Effect	Significance
			• Storage and disposal of drill waste rock, process precipitates and industrial wastewater treatment plant precipitates. • Package and transport of nuclear substances. • Remediation of contaminated areas.			amount of country foods included in a traditional diet.	
Quality of Life	Community Well-being[2] (income of local workers)	Change in income of local workers	• Employment and expenditures[3]	Construction Operations Decommissioning Post-Decommissioning	Mitigation measures relating to this potential residual effect include: • health and wellness programming; • health promotion and on-site health care; • life skills programming; • employee and family assistance programs (EFAPs) to assist workers and their families; • culturally sensitive employment policies; • policy for no drugs and alcohol on site; • workforce transition plan prior to Decommissioning; • continued liaison with LSA communities and relevant authorities; and • supports for communities as identified in any agreements entered into with communities.	Increased income because of the Project can be beneficial to households in communities in the LSA and Regional Study Area (RSA). Adverse effects may also result (e.g., work rotations can limit the amount of time families have together). Increased cash income, while also having positive effects, may result in misspending. Employment may reduce participation in traditional economy. Loss of employment following decommissioning may contribute to individual stress.	Not significant
	Community Well-being[2] (community cohesion)	Change in community cohesions as understood by community members through Key Person Interviews.	Employment and expenditures[3]	Construction Operation Decommissioning Post-Decommissioning	Mitigation measures relating to this potential residual effect include: • health and wellness programming; • health promotion and onsite health care; • life skills programming • EFAPs to assist workers and their families; • policy for no drug and alcohol on site; • pick up and drop off points; • culturally sensitive employment policies;	Participation in worker rotation may result in family tensions, use of alcohol/substances, increased violence and crime	Not significant

Component	Valued Component (Key Indicators)	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Mitigation Measures	Residual Effect	Significance
					• continued liaison with LSA communities and relevant authorities; and • supports for communities as identified in any agreements entered into with communities.		
Quality of Life	Infrastructure and services (traffic)	Change in traffic volumes and types and risk of accident.	On-site and off-site operation of vehicles and transport of materials.	Construction Operation	Mitigation measures relating to this potential residual effect include: • air transportation for workers between drop off locations and communities; • compliance with highway weight restrictions/permits; • spring road restrictions; • appropriate driver training; • vehicles transporting dangerous goods or hazardous products will display required placards; • development of an Emergency Response Plan in case there is a spill; • maintenance by Denison of roads within the Project site and the main access road to the Project site; and • require Denison truck traffic to slow to 40 km/hr for a minimum of 2.5 kms on either side of the culture camp(s) in which are understood to occur in September and October (dates may be adjusted at the community's direction)	The movement of equipment, materials, supplies, and personnel to and from the site has the potential to result in increased traffic volumes and associated concerns regarding wear and tear of highway infrastructure, along with risks and collisions.	Not significant
	Infrastructure and services (community infrastructure and services)	Change in access to and capacity of community infrastructure and services.	Employment and expenditures[3]	Construction Operation Decommissioning	Mitigation measures relating to this potential residual effect include: • services and programs provided on site and accessible to workers, including health and wellness programming, health promotion, immunization programs, and life skills development programming;	The Project has the potential to cause increased stress on community infrastructure and services because of increased income and lifestyle changes that can result from large projects (e.g., additional support services for community members).	Not significant

Component	Valued Component (Key Indicators)	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Mitigation Measures	Residual Effect	Significance
					• workforce education to encourage healthy lifestyles; • EFAPs; and • ongoing communication between Denison and LSA communities and relevant authorities.	Participation in employment and the commuter rotation system may cause increased stress for individuals and families. This may result in an increased demand on social services at the community level and for those services associated with the potential change, such as childcare and mental health services.	
		Change in emergency services capacity.	• Employment and expenditures[3] • On-site and off-site operation of vehicles and transport of materials.	Construction Operation Decommissioning	Mitigation measures relating to this potential residual effect include: • first aid facilities and the appropriate amount of first aid training; • primary care paramedic on site through all Project phases; • mandatory safety orientations for employees; • health and safety management plans; • training of workers in fuel handling, equipment maintenance, and fire prevention and response; • enforcement of Denison's Environment, Health, Safety, and Sustainability policy; • emergency response and spill prevention plans, and support and/or training to local emergency services; • ongoing communication between Denison and LSA communities and relevant authorities; and • support and/or training provided by Denison to local emergency staff to make sure staff are adequately prepared in the event of an accident/malfunction or spill on Highway 914 or 165.	The Project has the potential to cause increased stress on health and emergency services. Increased pressure on emergency services is most likely to stem from an accident or malfunction on Highways 914 or 165. The extent to which these changes could affect any given community would depend on the nature of the accident or malfunction. If such an event were to occur, local resources may be called upon to provide support.	Not significant

Notes:

1 Cultural expression key indicator knowledge transmission (including measurable parameters changes to cultural practices that support knowledge transmission and changes in the location of cultural practices that support knowledge transmission) were not carried forward to the discussion of residual effects.

2 Community well-being key indicator population and demographics was not material enough to measure and was not carried through to discussion of residual effects.

3 Project employment and expenditures are generated by most Project activities and components throughout the phases of the Project. Hence, Project employment and expenditures have been added into the table as a separate column for each Project phase instead of acknowledging these individually by component or activity.

Economics – Summary of the Environmental Assessment Considerations and Significance Determination for Predicted Residual Effects

Component	Valued Component (Key Indicators)	Measurable Parameters	Project Activities Resulting in Primary Interactions	Project Phase	Mitigation Measures	Residual Effect	Significance
Economics	Economy (traditional economy)	Change in participation in the traditional economy due to the Project and its activities.	• Changes to the biophysical environment stemming from the Project and its activities. • Employment and Expenditures[2]	Construction Operation Decommissioning Post-Decommissioning	Mitigation measures relating to this potential residual effect include: • culturally sensitive employment policies; • agreements with appropriate Indigenous communities that will reflect each community's interests and objectives relative to Project opportunities; and • a trapper's compensation agreement may be entered into by Denison if a future trapper becomes active in proximity to the site.	The physical presence of the Project and its activities, including participation in the commuter rotation may limit some traditional land and resource activity. Regarding the physical presence of the Project and its activities, it is anticipated that most effects will occur close to the Project site, although the Project may displace some individual activities relating to land and resource use within the LSA. Regarding participation in the wage economy limiting the ability of individuals to participate in the traditional economy, effects may be more widespread to communities in the LSA.	Not significant

Notes:

1 Economic valued components employment and training, income, business opportunities, and government revenues are expected to have mostly positive residual effects, as a result they were not carried through to the residual effects assessment.

2 Project employment and expenditures are generated by most Project activities and components throughout the phases of the Project. Hence, Project employment and expenditures have been added into the table as a separate column for each Project phase instead of acknowledging these individually by component or activity.

Denison Mines

Wheeler River Project

Final Environmental Impact Statement

November 2024

Powering PEOPLE, PARTNERSHIPS AND PASSION.

1 Summary of Cumulative Effects

This Appendix summarizes all predicted cumulative effects of the Wheeler River Project (the Project) and their significance. The Cumulative Effects Assessment (CEA) for the Project considers whether residual adverse effects of the Project on a given Valued Component (VC) of the biophysical or human environment will overlap spatially and temporally with residual adverse effects on the same VC that result from other past, present and reasonably foreseeable projects or activities. For residual effects to be considered in the CEA, the following criteria need to be met:

- there is potential for a residual adverse effect of the Project on a VC;
- the residual adverse effect can be demonstrated to act cumulatively with the residual adverse effects from other projects or activities on the same VC;
- other projects or activities must have been or are expected to be carried out in the reasonably foreseeable future; and
- the cumulative effect is likely to occur.

The approach for assessing cumulative effects considers both the current conditions (which include changes caused by past development, projects, and activities, and are therefore considered in the baseline condition of the VC) and the identified reasonably foreseeable future projects and/or activities. Additional information is available in Section 5.9 of the Wheeler River Draft Environmental Impact Statement (EIS) regarding the methods used in the CEA process including:

- identification of present or reasonably foreseeable projects and activities;
- lands taken from an Indigenous perspective;
- additional mitigation measures for cumulative effects;
- cumulative effects characterization and determination of significance;
- environmental monitoring and follow-up; and
- climate change considerations.

When potential residual effects are identified, each VC-specific section in Parts II and III of the EIS goes through the CEA process and identifies potential cumulative effects, which are summarized in the following tables, including the significance of the potential cumulative from the Project.

As outlined within the various tables presented in this Appendix, using accepted CEA methods, the cumulative effects associated with the Project are not expected to alter the integrity of the VC to the point where it is not sustainable or is unavailable to contribute to ecological functions at the Regional Study Area level.

Atmospheric and Acoustic Environment – Summary of Significance of Cumulative Effects

Component	Valued Component	Key Indicator	Cumulative Effects	Summary of Significance of the Cumulative Effect
Atmospheric and Acoustic Environment	Air Quality	Levels of dust, combustion products, uranium, metals, and/or radionuclides.	Increase in concentrations of air contaminants.	**Not Significant**: It is not expected that the air emissions from other reasonably foreseeable projects in the area will combine with those from the Project to result in an increase in concentrations of air contaminants.
	Noise	Noise levels.	Increase in local noise levels.	**Not Significant**: It is not expected that noise from other reasonably foreseeable projects in the area will overlap with those from the Project to result in an increase in local noise levels.

Geology and Groundwater – Summary of Significance of Cumulative Effects

Component	Valued Component	Key Indicator	Cumulative Effects	Summary of Significance of the Cumulative Effect
Geology and Groundwater	Geology	Terrain Morphology and Stability	Change in terrain morphology and stability.	**Not Significant**: Changes to terrain morphology and stability from subsidence at ground surface due to extraction of uranium ore will be limited spatially to a discrete and localized area (the wellfield), and to a very minor change in elevation. As stated below (Terrain VC), the effect(s) is not expected to cause a change in terrain morphology in the Terrain RSA to the point where it is not sustainable or is unavailable to contribute to ecological functions.
	Groundwater	Quantity	Change in groundwater quantity.	**Not Significant:** Changes to groundwater quantity (as groundwater discharge) will occur only within the immediate vicinity of the Project, to Whitefish Lake. Changes in groundwater quantity are expected to revert to baseline conditions by year 9 of Post-Decommissioning. There are no expected changes to overall flows and water levels in Whitefish Lake because groundwater discharge is a small component of water flow through the lake. Changes in groundwater quantity are not anticipated to overlap with spatially or temporally with changes in groundwater quantity from existing or reasonably foreseeable projects; therefore, no cumulative effects are expected.
		Quality	Change in groundwater quality.	**Not Significant:** Changes to the Groundwater Quality VC are expected following remediation of the mining area and thawing of the freeze wall. Changes are predicted to remaining below values that would result in an environmental risk and to be localized to Whitefish Lake. Groundwater quality is linked to Surface Water Quality VC. As stated below and demonstrated through groundwater modelling, potential residual effects to surface water quality from groundwater quality are expected to be spatially limited in proximity to the mine site and are not expected to extend to the Wheeler River. No interactions with existing and reasonably foreseeable activities are envisioned over the Project timeline; therefore, no cumulative effects are expected.

Note: As outlined in this table, using accepted cumulative effect assessment methods, the cumulative effects on each of the VCs is not expected to alter the integrity of the VC to the point where it is not sustainable or is unavailable to contribute to ecological functions at the Regional Study Area level.

Aquatic Environment – Summary of Significance of Cumulative Effects

Component	Valued Component	Key Indicator	Cumulative Effects	Summary of Significance of the Cumulative Effect
Aquatic Environment	Water Quantity	Average monthly discharge (flow) (m^3/s). Percentage change to average monthly discharge (%). 5th percentile monthly discharge (flow) (m^3/s). Percentage change to 5th monthly discharge (%). Change in surface water body water level (water level in metres).	Change in surface water flows and / or levels.	**Not significant:** Changes to surface water levels and flows will be well below criteria identifying a residual effect for all phases of the mine life. Spatially, the interactions of the Project with the surface water quantity VC are highly localized to Whitefish Lake (LA-5) and is not further propagated downstream of this immediate area. Existing or reasonably foreseeable activities envisioned over the Project timeline will not spatially interact with the Project; therefore, no cumulative effects are expected to surface water quantity.
	Water Quality	Changes in the concentrations of constituents that are directly related to Project activities as measured as a mass of a chemical per unit volume in water (e.g., mg/L).	Change in surface water quality resulting from discharge of treated effluent to the aquatic environment during Operation and Decommissioning. Increased contaminant transport via groundwater to surface water during the long-term, “Future Centuries” phase.	**Not significant:** Potential residual effects from releases of treated mine water or from potential releases related to solids mobilization from the Project are expected to be spatially limited in proximity to the mine site and are not expected to extend to the Wheeler River. Existing or reasonably foreseeable activities envisioned over the Project timeline will not spatially interact with the Project; therefore, no cumulative effects are expected to surface water quality. Dissolved constituent concentrations emanating over hundreds to thousands of years in the future (“Future Centuries”) from the mining area to Whitefish Lake will be localized to that waterbody and remain below fresh water environmental quality criteria. As such, impacts to downstream portions of the drainage including Russell Lake are not expected. Existing or reasonably foreseeable activities envisioned over the “future centuries” period will not spatially interact with the Project; therefore, no cumulative effects are expected to surface water quality.
	Sediment Quality	Changes in the concentrations of constituents that are directly related to Project activities as measured as a mass of a chemical per unit mass in sediment (e.g., µg/g). Changes in the physical quality (grain size) of sediments.	Change in sediment quality via surface water pathway resulting from discharge of treated effluent to the aquatic environment during Operation and Decommissioning. Increased contaminant transport via	**Not significant:** Potential residual effects from releases of treated mine water or from potential releases related to solids mobilization from the Project are expected to be spatially limited in proximity to the mine site and are not expected to extend to the Wheeler River. Existing or reasonably foreseeable activities envisioned over the Project timeline will not spatially interact with the Project; therefore, no cumulative effects are expected to sediment quality. Dissolved constituent concentrations emanating over hundreds to thousands of years in the future (“Future Centuries”) from the mining area to Whitefish Lake will be localized to that waterbody and remain

Component	Valued Component	Key Indicator	Cumulative Effects	Summary of Significance of the Cumulative Effect
			groundwater during the long-term, "Future Centuries" phase.	below fresh water environmental quality criteria. As such, impacts to downstream portions of the drainage including Russell Lake are not expected. Existing or reasonably foreseeable activities envisioned over the "future centuries" period will not spatially interact with the Project; therefore, no cumulative effects are expected to sediment quality.
	Benthic Invertebrates	Sediment quantity and physical quality (particle size). Change in sediment quality (chemical). Alteration and/or loss of aquatic habitat (area). Change in water level or flow.	Change in surface water and sediment quality resulting from discharge of treated effluent to the aquatic environment during Operation and Decommissioning. Increased contaminant transport via groundwater during the long-term, "Future Centuries" phase.	**Not significant:** Potential residual effects from releases of treated mine water or from potential releases related to solids mobilization from the Project are expected to be spatially limited in proximity to the mine site and are not expected to extend to the Wheeler River. Alteration or loss of aquatic habitat (direct or indirect) is anticipated to be minor. Existing or reasonably foreseeable activities envisioned over the Project timeline will not spatially interact with the Project; therefore, no cumulative effects are expected to benthic invertebrates from water, sediment and related aquatic pathways. Dissolved constituent concentrations emanating over hundreds to thousands of years in the future ("Future Centuries") from the mining area to Whitefish Lake will be localized to that waterbody and remain below fresh water environmental quality criteria. As such, impacts to downstream portions of the drainage including Russell Lake are not expected. Existing or reasonably foreseeable activities envisioned over the "future centuries" period will not spatially interact with the Project; therefore, no cumulative effects are expected to benthic invertebrates from water, sediment and related aquatic pathways.
	Fish and Fish Habitat	Change in water quality (i.e., chemical, thermal). Change in sediment quality. Alteration and/or loss of aquatic habitat (area). Change in water level or flow.	Change in surface water and sediment quality resulting from discharge of treated effluent to the aquatic environment during Operation and Decommissioning. Increased contaminant transport via groundwater during the long-term, "Future Centuries" phase.	**Not significant:** Potential residual effects from releases of treated mine water or from potential releases related to solids mobilization from the Project are expected to be spatially limited in proximity to the mine site and are not expected to extend to the Wheeler River. Alteration or loss of aquatic habitat (direct or indirect) is anticipated to be minor. Existing or reasonably foreseeable activities envisioned over the Project timeline will not spatially interact with the Project; therefore, no cumulative effects are expected to fish and fish habitat. Dissolved constituent concentrations emanating over hundreds to thousands of years in the future ("Future Centuries") from the mining area to Whitefish Lake will be localized to that waterbody and remain below fresh water environmental quality criteria. As such, impacts to downstream portions of the drainage including Russell Lake are not expected. Existing or reasonably foreseeable activities envisioned over

Component	Valued Component	Key Indicator	Cumulative Effects	Summary of Significance of the Cumulative Effect
				the "future centuries" period will not spatially interact with the Project; therefore, no cumulative effects are expected to fish and fish habitat.
	Fish Health	Change in water quality (i.e., chemical, thermal). Change in sediment quality. Change in fish tissue concentrations.	Change in surface water and sediment quality resulting from discharge of treated effluent to the aquatic environment during Operation and Decommissioning. Increased contaminant transport via groundwater during the long-term, "Future Centuries" phase.	**Not significant:** Potential residual effects from releases of treated mine water are expected to be spatially limited in proximity to the mine site and are not expected to extend to the Wheeler River. Existing or reasonably foreseeable activities envisioned over the Project timeline will not spatially interact with the Project; therefore, no cumulative effects are expected to fish health. Dissolved constituent concentrations emanating over hundreds to thousands of years in the future ("Future Centuries") from the mining area to Whitefish Lake will be localized to that waterbody and remain below fresh water environmental quality criteria. As such, impacts to downstream portions of the drainage including Russell Lake are not expected. Existing or reasonably foreseeable activities envisioned over the "future centuries" period will not spatially interact with the Project; therefore, no cumulative effects are expected to fish health.

Note: As outlined in this table, using accepted cumulative effect assessment methods, the cumulative effects on each of the VCs is not expected to alter the integrity of the VC to the point where it is not sustainable or is unavailable to contribute to ecological functions at the Regional Study Area level.

Terrestrial Environment – Summary of Significance of Cumulative Effects

Component	Valued Component	Key Indicator	Cumulative Effect	Summary of Significance of the Cumulative Effect
Terrestrial Environment	Terrain	Terrain morphology	Change in terrain morphology is expected to be within the natural range of variability.	**Not significant**: the effect(s) is not expected to cause a change in terrain morphology in the Terrain RSA to the point where it is not sustainable or is unavailable to contribute to ecological functions.
		Terrain stability	Change in terrain stability is expected to be within the natural range of variability.	**Not significant**: the effect(s) is not expected to cause a change in terrain stability in the Terrain RSA to the point where it is not sustainable or is unavailable to contribute to ecological functions.
	Soil	Soil quantity	Change in soil quantity is expected to be within the natural range of variability.	**Not significant**: the effect(s) is not expected to cause a change in soil quantity in the Soil RSA to the point where it is not sustainable or is unavailable to contribute to ecological functions.
		Soil quality	Change in soil quality is expected to be within the natural range of variability.	**Not significant**: the effect(s) is not expected to cause a change in soil quality in the Soil RSA to the point where it is not sustainable or is unavailable to contribute to ecological functions.
	Organic Matter/ Peat	Organic matter/peat quantity	Change in organic matter/peat quantity is expected to be within the natural range of variability.	**Not significant**: the effect(s) is not expected to cause a change in organic matter/peat quantity in the Organic matter/Peat RSA to the point where it is not sustainable or is unavailable to contribute to ecological functions.
Terrestrial Environment	Vegetation and Ecosystems	Vegetation abundance	Change in areal extent of habitat types.	**Not Significant**: The cumulative change in areal extent of habitat types is not expected to result in a change in the vegetation abundance KI that will alter its integrity within the Vegetation RSA to the point where it is not sustainable or is unavailable to contribute to ecological functions.
		Constituent concentrations in vegetation	Change in level of constituents of concern in plant tissue.	**Not Significant**: The cumulative change in level of constituents of concern in plant tissue is not expected to result in a change in the constituent concentrations in vegetation KI that will alter its integrity within the Vegetation RSA to the point where it is not sustainable or is unavailable to contribute to ecological functions.
	Listed Plant Species	Listed plant species	Change in number of listed plants.	**Not Significant**: The cumulative change in number of listed plants is not expected to result in a change in the listed plant species KI that will alter its integrity within the Vegetation RSA to the point where it is not sustainable or are unavailable to contribute to ecological functions.
	Wetlands	Wetlands	Change in areal extent of wetlands.	**Not Significant**: The cumulative change in areal extent of wetlands is not expected to result in a change in the wetlands KI that will alter its integrity

Component	Valued Component	Key Indicator	Cumulative Effect	Summary of Significance of the Cumulative Effect
				within the Vegetation RSA to the point where it is not sustainable or str unavailable to contribute to ecological functions.
Terrestrial Environment	Ungulates	Moose	Alteration and/or loss of habitat.	**Not significant**: It is not expected that the cumulative effect of alteration and/or loss of habitat will alter the integrity of moose habitat within the Terrestrial RSA to the point where it is not sustainable or available to contribute to ecological functions.
			Change in mortality.	**Not significant**: It is not expected that the cumulative effect of change in mortality will alter the integrity of the regional moose population to the point where it is not sustainable or available to contribute to ecological functions.
	Furbearers	Wolverine, pine marten, mink, muskrat	Alteration and/or loss of habitat.	**Not significant**: It is not expected that the cumulative effect of alteration and/or loss of habitat will alter the integrity of furbearer habitat within the Terrestrial RSA to the point where it is not sustainable or available to contribute to ecological functions.
			Change in mortality.	**Not significant**: It is not expected that the cumulative effect of change in mortality will alter the integrity of the regional furbearer population to the point where it is not sustainable or available to contribute to ecological functions.
	Woodland Caribou	Woodland caribou	Alteration and/or loss of habitat.	**Not significant**: It is not expected that the cumulative effect of alteration and/or loss of habitat will alter the integrity of woodland caribou habitat within the Terrestrial RSA to the point where it is not sustainable or available to contribute to ecological functions.
			Change in mortality.	**Not significant**: It is not expected that the cumulative effect of change in mortality will alter the integrity of the regional woodland caribou population to the point where it is not sustainable or available to contribute to ecological functions.
Terrestrial Environment	Raptors	Bald Eagle, Osprey	Alteration and/or loss of habitat.	**Not significant**: The cumulative effect of alteration and/or loss of habitat is not expected to alter the integrity of raptor habitat within the Terrestrial RSA to the point where it is not sustainable or available to contribute to ecological functions.
			Change in mortality.	**Not significant**: The cumulative effect of change in mortality is not expected to alter the integrity of the regional Bald Eagle or Osprey populations to the point where they are not sustainable or available to contribute to ecological functions.

Component	Valued Component	Key Indicator	Cumulative Effect	Summary of Significance of the Cumulative Effect
	Migratory Breeding Birds	Waterbirds and waterfowl, upland game birds, migratory songbirds	Alteration and/or loss of habitat.	**Not significant**: The cumulative effect of alteration and/or loss of habitat is not expected to alter the integrity of migratory breeding bird habitat within the Terrestrial RSA to the point where it is not sustainable or available to contribute to ecological functions.
			Change in mortality.	**Not significant**: The cumulative effect of change in mortality is not expected to alter the integrity of the regional migratory breeding bird population to the point where it is not sustainable or available to contribute to ecological functions.
	Bird Species at Risk	Common Nighthawk, Short-eared Owl, Yellow Rail, Rusty Blackbird, Olive-sided Flycatcher	Alteration and/or loss of habitat.	**Not significant**: The cumulative effect of alteration and/or loss of habitat is not expected to alter the integrity of bird species at risk habitat within the Terrestrial RSA to the point where it is not sustainable or available to contribute to ecological functions.
			Change in mortality.	**Not significant**: The cumulative effect of change in mortality is not expected to alter the integrity of the regional Common Nighthawk, Short-eared Owl, Yellow Rail, Rusty Blackbird, or Olive-sided Flycatcher populations to the point where they are not sustainable or available to contribute to ecological functions.

Human Health – Summary of Significance of Cumulative Effects

Component	Valued Component	Key Indicator	Cumulative Effects	Summary of Significance of the Cumulative Effect
Human Health	Human Health	Human Health	Not applicable	**Not significant:** Air emissions from the Project are expected to be localized and unlikely to overlap with the existing or predicted emissions from existing and reasonably foreseeable projects; therefore, no cumulative effects on human health from air and related terrestrial pathways are expected. Potential residual effects from releases of treated mine water from existing and reasonably foreseeable projects are expected to be spatially limited in proximity to the mine site and are not anticipated to extend to the Wheeler River; therefore, no cumulative effects on human health from water and related aquatic pathways are expected.

Note: As outlined in this table using accepted cumulative effect assessment methods, the cumulative effects on each of the VCs is not expected to alter the integrity of the VC to the point where it is not sustainable or is unavailable to contribute to ecological functions at the Regional Study Area level.

Land and Resource Use – Summary of Significance of Cumulative Effects

Component	Valued Component	Key Indicator	Cumulative Effects	Summary of Significance of the Cumulative Effect
Land and Resource Use	Indigenous Land and Resource Use (ILRU)	Perceived suitability of land and resources therein	Perceived suitability of resources for safe use.	**Not significant:** The only project carried through to the cumulative effects assessment is the Highway 914 extension project. Improved access to ILRU Regional Study Area (RSA) via the Highway 914 extension and a bypass of the Key Lake gate is expected to affect the suitability of lands and resources therein due to increased traffic, noise, dust and increases in competition for resources. The magnitude of these effects is relative to individual resource user perspectives, ranging from no effect to a perception that the area has become completely unsuitable for land use. Similarly, the absence of the Key Lake gate will provide recreational users, along with local Indigenous communities, greater access to the ILRU Local Study Area (LSA), which is not currently used intensively as the process of gaining access at the gate (requiring ID) will be removed. Cumulative effects are expected to be confined to the ILRU RSA around the Project Area and adjacent to roadways.
	Other Land and Resource Use (OLRU)	Perceived suitability of land and resources therein	Perceived suitability of resources for safe use.	**Not significant:** The only project carried through to the cumulative effects assessment is the Highway 914 extension project. Improved access to OLRU RSA via the Highway 914 extension and a bypass of the Key Lake gate is expected to affect the suitability of lands and resources therein due to increased traffic, noise, dust, and increases in competition for resources. Competition for resources is of particular concern as the highway extension could introduce resource users from other communities who would otherwise have to travel substantial distances to access the area. the magnitude of these effects is relative to individual resource user perspectives ranging from no effect to a perception that the area has become completely unsuitable for land use. Recreational land use also may increase due to resource users arriving from the south and may affect perceptions of competition for resources. Lodge owners and outfitters operating in the OLRU LSA are remote fly-in operations and are not affected by increased traffic and though cabin owners may experience increased traffic, dust, and noise on their commute, it is not expected to affect the enjoyment of their cabins.
	Heritage Resources	Archaeological Sites	Decrease in number of archaeological sites.	**Not significant:** It is highly unlikely that future projects will have the same footprint as the Project. Therefore, little to no potential for overlap exists between the Project and future projects and low potential for there to be cumulative effects on heritage resources.

Note: As outlined in this table using accepted cumulative effect assessment methods, the cumulative effects and determination of significance on each of the VCs does not change with consideration of the Highway 914 extension project.

Quality of Life – Summary of Significance of Cumulative Effects

Component	Valued Component	Key Indicator	Cumulative Effects	Summary of Significance of the Cumulative Effect
Quality of Life	Cultural Expression	Availability of country foods included in a traditional diet	Changes in availability of country foods included in a traditional diet. Changes in the perceived suitability of country foods in a traditional diet.	**Not significant:** The only project carried through to the cumulative effects assessment was the Highway 914 extension project. The Highway 914 extension project is expected to affect wildlife and fish through increased mortality risk either from increased harvesting pressures, vehicle strikes, or predation as the area along Highway 914 becomes more easily accessible. No change to wildlife or fish health through dust deposition or emissions is anticipated. Because the residual effect for Cultural Expression is a reduction to the inclusion of country foods that make up a traditional diet due to changes in the perceived suitability of those foods, no cumulative effect for Cultural Expression is anticipated.
		Suitability of country foods in a traditional diet		
	Community Well-being	Income of local workers	Change in income of local workers. Change in community cohesions as understood by community members through Key Person Interviews.	**Not significant:** The assessment of cumulative effects and determination of significance for Community Well-being does not change with consideration of the Highway 914 extension project. Given the understanding of the Highway 914 extension project, the overlap in effects stemming from employment, such as those associated with income and community cohesion, is unlikely to result in any discernable changes, particularly as the opportunities associated with the Highway 914 extension project may involve a broader labour pool.
	Community Well-being	Community cohesion		
	Infrastructure and services	Traffic	Change in traffic volumes and types and risk of accident.	**Not significant:** Both the Project and the Highway 914 extension project have the potential to increase traffic volumes along the existing Highway 914. Although the cumulative changes to traffic may be discernable to users of the highway, it is anticipated that the overall increases in traffic can be effectively managed with the mitigation practices. The overall conclusions of the residual effects analysis with the Project do not change with consideration of the Highway 914 extension project.
	Infrastructure and services	Community infrastructure and services	Change in access to and capacity of community infrastructure and services.	**Not significant:** Changes to community infrastructure and services were considered both relative to the Project's demand for infrastructure (deemed negligible as the Project will supply its own infrastructure) or stem from employment and participation in the commuter rotation system, which may result in an increased demand in services at the community level. Although the Highway 914 extension project could draw upon the same labour pool as the Project, the opportunities associated with the Highway 914 extension project would be of shorter duration, with construction occurring over a three to five year period depending on the final design, and it is anticipated that some of the employment would be seasonal. As such, it is unlikely to result in any discernable changes relative to the demand for services in local communities.

Component	Valued Component	Key Indicator	Cumulative Effects	Summary of Significance of the Cumulative Effect
				The assessment of cumulative effects and determination of significance for community infrastructure and services does not change with consideration of the Highway 914 extension project.
		Change in emergency services capacity	Change in emergency services capacity.	**Not significant:** During the Operation phase of the Project, the Highway 914 extension project would be publicly accessible, meaning that accidents or malfunctions along the highway would become the most likely pathway to emergency response services. However, the extension to Highway 914 allows for connections to communities and services further north, which may or may not result in any potential demand on community emergency services to extend to communities outside of the LSA and into the RSA. It is not anticipated that conditions with the Project would be exacerbated by the Highway 914 extension project. Exactly how community emergency responses are deployed in the future would need to be determined in collaboration with the Province and the communities in the future. With the application of mitigation measures, the assessment of cumulative effects and determination of significance for community infrastructure and services does not change with consideration of the Highway 914 extension project.

Note: As outlined in this table using accepted cumulative effect assessment methods, the cumulative effects and determination of significance on each of the VCs does not change with consideration of the Highway 914 All Weather Road Extension Project.

Economics – Summary of Significance of Cumulative Effects

Component	Valued Component	Key Indicator	Cumulative Effects	Summary of Significance of the Cumulative Effect
Economics	Economy (measurable parameter – traditional economy)	Change in participation in the traditional economy due to the Project	Changes associated with biophysical effects, including ease of access and competition from new resource users associated with the Highway 914 extension project.	**Not significant:** Consideration of the Highway 914 extension project's cumulative effect to the traditional economy does not alter the determination of significance, although Denison and the Province of Saskatchewan should continue to engage with potentially-affected Indigenous communities regarding their concerns of the two combined projects. It is expected that areas of other more intensive community use will remain central to participation in the traditional economy, and that the non-monetary contribution of these activities to communities will be sustained.

Note: As outlined in this table using accepted cumulative effect assessment methods, the cumulative effects and determination of significance for the traditional economy does not change with consideration of the Highway 914 extension project.

Denison Mines

Wheeler River Project

Final Environmental Impact Statement

November 2024

Powering
PEOPLE, PARTNERSHIPS
AND PASSION.

1 Summary of Monitoring and Follow-up Programs

1.1 Background

Monitoring and follow-up programs are implemented to assess the environmental performance of the Wheeler River Project (the Project) relative to the predictive assessment that has been completed in support of the environment assessment process. Such monitoring is needed since there is always some level of uncertainty associated with environmental assessment (EA) predictions. Monitoring and follow-up programs provide the information that is required to verify predicted effects (or their absence), evaluate the effectiveness of mitigation measures and for the purpose of confirming compliance with statutory requirements. These programs also serve as a conduit for communications with Indigenous Communities and interested parties in that they provide real-time information regarding Project performance.

A pictorial representation of the relationship between the design/EA and implementation stages of the Project is provided in Figure 1.1-1. As can be seen, the monitoring and follow-up program is the link between the predictive (i.e., design/EA) and performance (i.e., implementation phases of the assessment) stages of the Project.

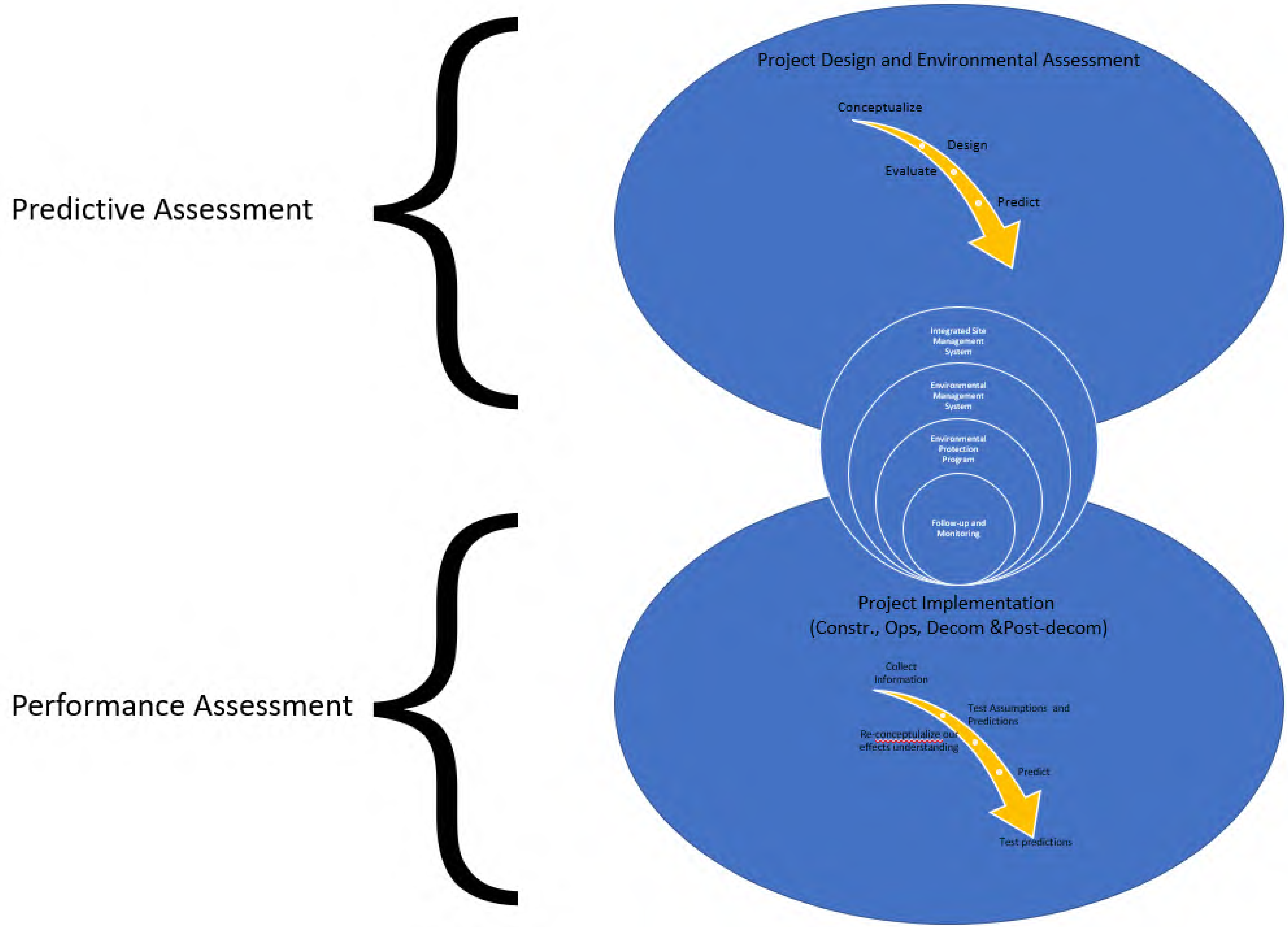


Figure 1.1-1: Relationship Between Project Design/Environmental Assessment Process and Project Implementation

Conceptual monitoring and follow-up programs to be undertaken by Denison Mines Corp. (Denison) in relation to each of the discipline-specific assessments have been presented in Section 6 Atmospheric and Acoustic Environment through Section 13 Economics of the Environmental Impact Statement (EIS) for the proposed Project, as applicable. These programs will serve to address the uncertainties associated with the effects predictions and the performance of mitigation, verify the effects predictions, and identify any unanticipated effects and provide for the implementation of adaptive management to limit these effects.

As indicated above, the monitoring and follow-up programs information presented herein is conceptual in nature and provides a preliminary description of the activities proposed for the Project. Further detailed programs will be developed as Project designs are finalized that may influence the nature, frequency, and locations of monitoring. In addition, input from regulatory agencies, the public and Indigenous Peoples will be considered. These monitoring and follow-up programs will be finalized as the Project advances into and through the licensing process. At that time, program design documentation will include sufficient detail on the type, quantity and quality of information required to reliably verify predicted effects (or absence of them) and confirm the effectiveness of mitigation. These programs will be prepared consistent with the following Canadian Standards Association's Standards, as applicable: N288.4-10 (Environmental Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills [CSA Group 2010]); N288.5-11 (Effluent Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills [CSA Group 2011]); and, N288.7-15 (Groundwater Protection Programs At Class I Nuclear Facilities and Uranium Mines and Mills [CSA Group 2015]).

Monitoring and follow-up programs will be integrated with Denison's overall Environmental Management System (EMS) framework and implemented through the various programs, plans and procedures that would be developed therein. Denison understands that the accountability for monitoring and follow-up programs lies with corporation, and as such is committed to ensuring adequate resources, both personnel and financial, are made available. Within that context Denison would delegate responsibility to implement monitoring and follow-up programs to qualified persons within the organization.

Monitoring and follow-up programs will be carried out throughout all phases of the Project. For reference, the following phases were identified for the Project (Table 1.1-1), as described in Section 2 Project Description of the EIS.

Table 1.1-1: Project Phases and Timelines Associated with the Wheeler River Project

Phase	Duration	Description
Construction	2 years	Development of access roads and air strip; clearing, level and grading of the project site, laydown area; wellfield and freeze hole drilling; ground freezing; batch plant operation (concrete); development of surface infrastructure (camp, administration buildings, plants, ponds, pads and support infrastructure); waste management (incineration and landfill operation); water management (including treatment); power generation – generators; groundwater supply and release; surface water withdrawal; fuel management (e.g., propane for comfort heating; vehicle and aircraft fuel); on-site and off-site operation of vehicles and transportation of materials; air transportation for workers.
Operation	15 years	Operation of the in situ recovery (ISR) wellfield; wellfield and freeze wall drilling; operation of freeze wall; expansion of pond and pads; operation of the ISR processing plant and production of uranium concentrate; water withdrawal from groundwater or surface water body; management of surface water (including seepage and site run-off); water treatment of human waste (black, grey and kitchen water treated and discharged to an effluent pond) and process water; water release to groundwater and/or surface water body; waste management (composting and landfill operation); hazardous waste management (temporary storage, handling, and off-site transportation); contaminated waste management (temporary storage, handling, and off-site transportation); storage and disposal of process waste rock and radioactive plant precipitates; on-site and off-site operation of vehicles and transportation of materials; power supply – generators and back-up generators; package and transport of nuclear substances; fuel management (e.g., propane for comfort heating; vehicle and aircraft fuel); air transportation for workers.
Decommissioning	5 years	Mining horizon remediation and thawing of freeze wall; process water treatment and release; closure of ISR and freeze wells and infrastructure; salvageable asset removal (including site power transmission lines and electrical infrastructure); demolition and disposal of non-salvageable surface infrastructure and materials; remediation of contaminated areas (wellfield, waste pads, ponds, water treatment location, and process plant area); reclamation disturbed areas (site, roads, camp, and airstrip); site water management, treatment and release; power generation – generators; waste management (incineration and landfill operation); management of hazardous materials; on-site and off-site operation of vehicles and transportation of materials.
Post-Decommissioning	15 years	Environmental monitoring. Regulatory site inspections. Engagement – site visit from interested parties.

1.2 Information Management

Information management is a key management system priority and processes that define the information management system, including information management needs, standards, and responsibilities, would be developed as part of the overall EMS.

Information and data collected through monitoring and follow-up programs will be stored and tracked to make sure they can be used to fulfill their specific objective(s). Information and data quality objectives will be defined a priori, and information and data collected will be assessed relative to these objectives to make sure quality assurance and control requirements are met.

Denison will store information and data generated from the EA monitoring and follow-up program in a robust database for future analysis and reporting. Analysis of results from the monitoring and follow-up program will be reported and submitted to the relevant regulatory agencies as required. In addition, a process for sharing information derived from monitoring and follow-up programs would be developed to provide timely and transparent sharing of information with government departments, Indigenous Groups and interested parties.

1.3 Adaptive Management

Denison is committed to achieving continual improvement in environmental performance through its EMS. As part of this overall commitment to continual improvement, monitoring and follow up programs will be implemented via an adaptive management approach. Adaptive management is a systematic process for continuously improving environmental management practices by learning from their outcomes. It provides the flexibility to address/accommodate new circumstances, to adjust monitoring, to identify and implement new mitigation measures, or to modify existing measures throughout all Project phases. Further, it provides a means to confirm that the monitoring elements remain valid, meet regulatory requirements, and be responsive to evolving objectives.

The adaptive management process is shown pictorially in Figure 1.3-1. The process includes:

- conceptualizing issues to identify solutions, sources of uncertainty and risks;
- designing specific implementation strategies with measurable indicators with predefined thresholds of acceptable and unacceptable levels of change;
- implementing the strategy;
- tracking and reporting on monitoring activities and results;
- investigating incidents and unexpected results, including results that exceed any thresholds and/or action levels (i.e., environmental performance criteria) that will be established as early warning signs to potentially changing site conditions, and/or non-conformance and non-compliance events. Such thresholds and/or actions levels would be developed based on predictions that have been made as part of effects assessment as detailed herein;
- developing and implementing corrective and preventative measures; and
- establishing a feedback loop through continued monitoring and updated monitoring and follow up programs, as necessary.

As seen in Figure 1.3-1, communication is central to and permeates all aspects of the adaptive management process. Communication with Indigenous Communities and interested parties provides the opportunity for two-way communication, feedback, and support.

Further to the above, if an environmental monitoring and follow-up program identifies predicted effects are greater than anticipated, Denison will evaluate whether these effects could result in changes to the conclusions in this EIS. If changes are confirmed, then Denison will evaluate the need for revised mitigation actions and management practices to manage effects. As highlighted above, Denison's interpretation of monitoring data would include reference to environmental performance criteria. An exceedance of environmental performance criteria would trigger Denison to respond to further investigate the potential issue. Based on this investigation, where need for revised mitigations is identified these measures would be developed and implemented. It is expected that the adaptive management process would be informed by input sought from Indigenous people, stakeholders, and regulatory agencies.

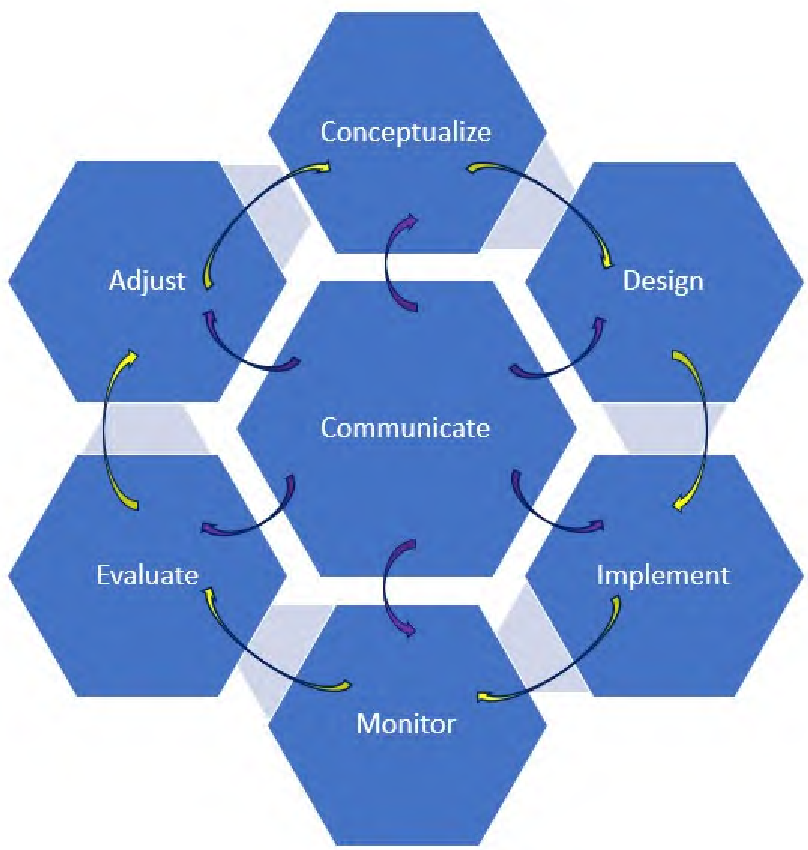


Figure 1.3-1: Adaptive Management Framework

1.4 Commitment to Proactive Consultation and Engagement

Denison is committed to proactively seek, engage, and support meaningful discussion with the interested parties and Indigenous Peoples on issues and opportunities related to the Project, including the EA monitoring and follow-up programs.

Accordingly, Denison would establish a specific protocol regarding consultation and engagement related to monitoring and follow-up programs. The protocol would establish a process by which information would be sought/shared during all phases of monitoring and follow-up program implementation (design, execution, assessment, interpretation) and it would be expected that information collected through such activities would feed directly into the adaptive management process described above.

Its is envisioned that identification of opportunities for the participation of the public and Indigenous groups would be facilitate through its engagement processes. Provisions for follow up activities and monitoring are expected to be included in agreements developed between Denison and its key Indigenous partners, and such follow up activities and monitoring could include independent research. The sharing of information related to this type of independent research can and would only be shared with the expressed consent of the agreement signatories in such cases. As recently as October 2023, Denison has engaged with Indigenous Communities of Interest about how the outcomes of the environmental assessment process become key areas of focus by the licensing and approvals regime – including in relation to environmental monitoring (see Section 4). Further to this, Denison has planned a comprehensive and technical workshop with ERFN in March 2024, and expects to undertake the same for KML soon thereafter, focused very specifically on the aspects of items licensed or approved post-environmental assessment. This will include environmental monitoring and among other things the relationship to country foods, including potential country foods to be monitored as part of monitoring programs. The CNSC and the Saskatchewan Ministry of Environment are lifecycle regulators for the Project and Denison is required to provide information related to the outcome of these discussions into forthcoming updates in the IER and annual reports. Input provided in these meetings, and others as they occur, would be integrated into monitoring program development/execution as appropriate.

Denison would continually evaluate its consultation and engagement related to monitoring and follow-up programs, internally and with its external Project partners to provide a culture of continual improvement.

1.5 Summary of Monitoring and Follow-up Programs

As indicated, conceptual monitoring and follow-up programs (or program elements) to be undertaken by Denison in relation to each of the discipline-specific assessments have been presented in Section 6 through Section 13 of the EIS, as appropriate. This information is consolidated in this EIS section (Section 16 Assessment Summary and Conclusions) for ease of reference.

Conceptual monitoring and follow-up programs are summarized by Valued Component (VC) in Table 1.5-1, highlighting the following:

- the applicable section of the EIS;
- the residual effect that has been identified that is associated with the program element and the project phase in which the effect is predicted;
- the objective of the program element;

- the monitoring program and framework; and
- the expected duration of the program element.

Additional program information regarding the program element's relationship to the Project's EMS programs and plans is also provided.

A more detailed presentation of the monitoring and follow-up programs is provided in Table 1.5-2, which provides the following:

- Monitoring station locations and station descriptions;
- Rationale for monitoring;
- Duration of the program;
- Frequency of monitoring;
- Sampling / Measuring Method; and
- Constituents / Parameters Measured.

The monitoring details shown in Table 1.5-2 are consistent with the current status of the development of the overall Environmental Monitoring Plan.

Additional information with respect to the development and implementation of follow-up monitoring is provided below:

- With respect to the definition of roles and responsibilities for Denison, regulatory agencies, Indigenous people, local and regional organizations and others in the design, implementation and evaluation of the program results - At this time and commensurate with the level of detail (i.e., concept) at which the follow up activities have been defined the proponent (Denison) assumes responsibility for execution of all proposed activities. This may change as the program details are developed, and Denison presumes this is likely as it continues to work with the key Indigenous groups. As noted above, Denison is committed to proactively seek, engage, and support meaningful discussion with the interested parties and Indigenous Peoples on issues and opportunities related to the Project, including the EA monitoring and follow-up programs, and specific roles in such will be defined as part the processes, as highlighted in Section 1.4. Regulatory agencies at the provincial and federal levels are expected to largely play a review/approval role consistent with their responsibilities under various laws/acts/licenses/permits under which the Project, and follow up activities, will be executed. At this time there are no specific plans with local and regional organizations as it pertains to the design, implementation and evaluation of the program results; but this may change in the future.
- With respect to the possible involvement of independent researchers in follow up activities - Involvement of independent researchers in follow up activities has not been identified at this time. This does not preclude possible involvement of independent researchers in the future; however,

need for such has not been specifically flagged. Provisions for follow up activities and monitoring are expected to be included in agreements developed between Denison and its key Indigenous partners, and such follow up activities and monitoring could include independent research. The sharing of information related to this type of independent research can and would only be shared with the expressed consent of the agreement signatories in such cases.

- With respect to program funding sources - As noted above, the proponent (Denison) assumes responsibility for execution of all proposed follow up activities that have ben identified and therefore the funding of such. Also as noted above, provisions for follow up activities and monitoring that may be included in agreements developed between Denison and its key Indigenous partners will be subject to non-disclosure covenants in those agreements. This would include information concerning any funding that may be associated with these programs. It would inappropriate (and may remain so) that specific details regarding any funding that may be provided for follow up activities be shared without the expressed consent of the agreement signatories.

Table 1.5-1: Wheeler River Monitoring and Follow-up Program Summary

Valued Component	EIS Reference	Project Phase and Residual Effect	Monitoring Project Objective(s)	Conceptual Monitoring Program Framework and Components	Duration of Program	Additional Information
Air Quality	Section 6 Atmospheric and Acoustic Environment, Section 6.1.8 Monitoring and Follow-up	Construction, Operation, and Decommissioning phases: Exceedances of 24-hour total suspended particulate (TSP) criterion. Construction and Operation phases: Exceedances of 24-hour PM10 criterion. Construction, Operation, and Decommissioning phases: Exceedances of 1-hour NO2 criterion. Operation phase: Exceedances off 24-hour uranium criterion.	To confirm the residual effects of the Project on Air Quality and demonstrate compliance with provincial ambient air quality standards.	An air quality monitoring will be an extension of the ongoing baseline monitoring program for the Project and will include TSP, dustfall, uranium, select metals and radionuclides in TSP and/or dustfall, passive NO2 and radon.	All Project phases	An adaptive Environmental Management System will be developed to include air quality management plan. The air quality management plan will contain monitoring requirements which will be finalized during permitting and licensing. The air quality management plan will incorporate monitoring requirements directed by provincial and federal regulators and by Indigenous groups and other Interested Parties as requested. Air quality monitoring will detail the air quality monitoring objectives, sampling design and methods. A dust management will be developed to outline operational procedures and controls used to control fugitive emissions of particulate matter from unpaved roads, open areas, and material stockpiles. Dust monitoring will be designed to evaluate the effectiveness of these measures and will also include a community complaints and response procedure.
Noise	Section 6 Atmospheric and Acoustic Environment, Section 6.2. Monitoring and Follow-up	Construction phase: Daytime increase in noise over baseline.	To confirm that the Project is compliant with the federal and provincial guidelines that have been adopted for this assessment.	Noise monitoring will be similar in nature to baseline monitoring that was completed in support of this assessment and will be finalized during permitting and licensing. Sound levels will be monitored on a continuous basis using a calibrated Class 1 sound level meter and data logger.	All Project phases	The Environmental Management System will incorporate plans and monitoring for noise and will be directed by provincial and federal regulators and any received input from Indigenous groups and other Interested Parties as requested.
Geology	Section 7 Geology and Groundwater, Section 7.8 Monitoring and Follow-up	Operation phase: Maximum subsidence at ground surface predicted to be between 5 to 7.5 cm and corrected with mitigative measures	As part of the mining operations, detailed monitoring activities will be completed to assess the performance of various components of the Project associated with engineering mining designs, subsidence and performance, and infrastructure designs to protect the Geology VC.	Pre- and post-elevation measurements will be taken at the well collars to account for any vertical movement between construction and decommissioning; however, it is anticipated that changes may not be measurable as they are within the bounds of other surface activities.	All Project phases	Contingency plans, including measures for adaptive management, and emergency preparedness plans will be designed to safeguard the local environment.
Groundwater	Section 7 Geology and Groundwater, Section 7.8 Monitoring and Follow-up	No residual effects (with the implementation of mitigation measures) have been identified.	The Project has the potential to either directly, through the ISR process, or indirectly influence groundwater quality and/or quantity near the Project Area. Groundwater conditions will be monitored extensively prior to, during, and post Operation. A Groundwater Protection and Groundwater Monitoring Plan (GWMP) will provide a detailed groundwater monitoring plan for the Project. The GWMP is informed by the understanding of existing groundwater conditions at the Project Area, the reactive transport modelling of groundwater constituents of potential concern (COPC) associated with the restored mining zone, and the	The groundwater well monitoring network and sampling plan will be flexible and adapted at each stage to identify any changes in groundwater quality and quantity associated with mining activities in a timely fashion. The spatial pattern of monitoring wells (i.e., well locations and density) and the sampling schedule will reflect the spatial and temporal distribution of COPC, guided by anticipated operational conditions and by the range of constituent behaviours identified in the site-specific COPC fate and transport modelling. The monitoring system will be designed at each phase of the Project to provide adequate coverage of all hydrostratigraphic units. The chemical and physical constituents to be monitored in groundwater were established in the Hydrogeological Baseline Report, and from review of the Project Description for surface facilities. They include: • pH; • oxidation-reduction potential (ORP); • electrical conductivity (EC); • sulfate; • other major ions (total alkalinity, bicarbonate, carbonate, chloride, sodium, magnesium, potassium, calcium);	All Project phases	A Groundwater Protection and Groundwater Monitoring Program will be developed as part of the Environmental Management System and is a mandatory components of the CSA N288.7-15 standard *Groundwater protection programs at Class I nuclear facilities and uranium mines and mills*. The GWMP is a 'living document' that will be adapted and updated as required to achieve the level of environmental protection committed to in the EIS, over the life of the Project.

Valued Component	EIS Reference	Project Phase and Residual Effect	Monitoring Project Objective(s)	Conceptual Monitoring Program Framework and Components	Duration of Program	Additional Information
			commitments made within the Geology and Groundwater section of this report. The requirements of the GWMP are to be able to demonstrate, at each phase of the Project, that: • excursions are not occurring and, if excursions do occur, to provide early warning/a timely signal of when and where there are occurring, such that appropriate further evaluation and actions can be undertaken; • commitments made in the EA have been achieved; and • protection of groundwater end use/receiving environment.	• uranium, iron, aluminum, and heavy metals/trace elements; • nitrogen species (ammonium, nitrate, nitrite); • radionuclides (226Ra, 230Th, 210Pb and 210Po); and • temperature. There are additional constituents of potential concern, including volatile organic compounds, that will be monitored in association with a small number of surface facilities. Not all the above parameters will be measured in groundwater at all sampling locations, or during each sampling event. Higher priority has been given to some parameters that are key indicators of site activity-related changes in water quality. The list of parameters being analyzed at any given location and time will be rationalized in the GWMP for each Project phase, and for each Project area (i.e., surface facilities versus ISR mining horizon versus freeze wall perimeter, etc.).		
Surface Water Quantity	Section 8 Aquatic Environment, Section 8.1 Surface Water Quantity, Section 8.1.8 Monitoring and Follow-up	Following mitigation and through water management of the site, no residual adverse effects on Surface Water Quantity are predicted to occur.	As no significant residual effects were identified and uncertainty was low with respect to the assessment of Project effects on Surface Water Quantity, a follow-up program is not required. However, it is suggested that continued hydrologic monitoring is important to provide Project phase information to monitor predictions and support effluent discharge permitting and approvals (i.e., meet approvals for continued surface water quality levels).	The long-term hydrological monitoring study at the Project site has been in place since 2011. The program should remain consistent to allow for the continued establishment of long-term streamflow trends at the site through relationships to long-term operating hydrometric gauging stations in the same watershed. Monitoring should continue to include the following: • streamflow monitoring; • lake level monitoring; and • installation of stage dataloggers. Hydrological monitoring stations should continue to be surveyed at locations throughout key catchment areas.	All Project phases	An Environmental Management System will be developed to include surface water monitoring and effluent monitoring plans.
Surface Water Quality	Section 8 Aquatic Environment, Section 8.2 Surface Water Quality, Section 8.2.8 Monitoring and Follow-up	Following mitigation, and through water management of the Project site, no residual adverse effects on Surface Water Quality are predicted to occur.	Monitoring and follow-up are proposed for the Surface Water Quality VC to verify the accuracy of the predicted effects and the effectiveness of the proposed mitigation measures. The surface water quality monitoring program should be considered in conjunction with the surface water quantity (hydrology) monitoring program.	The surface water quality monitoring and follow-up program will have the following objectives: • collecting and recording surface water quality to confirm that source and receiving water quality predictions are consistent with those presented in the EIS; and • monitoring to confirm the effluent and receiving water quality meet applicable regulation criteria. The monitoring and follow-up program will include measurement of water quality parameters to meet regulatory criteria (i.e., provincial discharge permits, Metal and Diamond Mining Effluent Regulation [MDMER, Government of Canada 2022] and CSA N288.4). At a minimum, this will include collection of non-radiological parameters (e.g., metals [including total mercury and methyl mercury], nutrients, hardness, temperature, pH, total dissolved solids (TDS), total suspended solids [TSS], and sulphate) and radiological parameters. Monitoring will occur within the collection ponds, specifically the Effluent Monitoring and Release Ponds and the receiving water (Whitefish Lake). Water quality monitoring in the natural environment will occur at the point of discharge (near-field) at LA-5 (Whitefish Lake South), at an upstream reference location (Whitefish Lake North [LA-6]) and at downstream locations (far-field locations). The far-field monitoring locations will be located in Whitefish Lake South (LA-5) prior to its discharge to McGowan Lake (LA-1). Constituent concentrations will be compared to the values used in the EIS and to applicable regulatory criteria or objectives.	All Project phases	An Environmental Management System will be developed to include surface water monitoring and effluent monitoring plans.

Valued Component	EIS Reference	Project Phase and Residual Effect	Monitoring Project Objective(s)	Conceptual Monitoring Program Framework and Components	Duration of Program	Additional Information
Fish and Fish Habitat	Section 8 Aquatic Environment, Section 8.3 Fish and Fish Habitat, Section 8.3.8 Monitoring and Follow-up	Construction, Operation, and Decommissioning phases: Decrease in surface water quality. Construction, Operation, and Decommissioning phases: Reduction of fish habitat. Construction, Operation, and Decommissioning phases: Reduction in surface water quantity (flow and level).	Monitoring and follow-up are proposed for the Fish and Fish Habitat VC to verify the accuracy of the predicted effects and the effectiveness of the proposed mitigation measures. The fish and fish habitat monitoring program should be considered in conjunction with the surface water quantity (hydrology), surface water quality, sediment quality and benthic invertebrates and fish health monitoring programs as it is specifically tied to these monitoring programs from the perspective of pathways of effects. Specifically, monitoring of water quality in the effluent monitoring ponds and other catchment ponds prior to discharge to the environment will be important to provide context to further evaluate Project-related effects on Fish and Fish Habitat in the receiving water environment (i.e., Whitefish Lake).	The fish and fish habitat monitoring and follow-up program will include the following: • collecting and recording surface water quality data to confirm that source and receiving water quality predictions for mobilization of solids are consistent with those presented in the EIS; • monitoring to confirm that effluent and receiving water quality meet applicable regulation criteria; • monitoring changes in fish communities/populations within the Project Local Study Area (LSA); and • monitoring changes in physical fish habitat within the receiving environment of LA-5. Fish and fish habitat monitoring will include collection of metrics associated with species presence, abundance, and life history parameters (e.g., survival, condition, growth) to meet applicable agency guidance (i.e., MDMER and CSA N288.4).	Changes in fish communities/ populations will be assessed through comparison of Construction, Operation, and Decommissioning results to pre-development.	The Environmental Management System will include fish and fish habitat monitoring requirements that will occur in tandem with water quality, sediment quality, benthic invertebrate, and fish health sampling. Sampling locations will be co-located to facilitate comparison to water quantity, water quality, and sediment quality characteristics. Specific monitoring and follow-up plans for the Fish and Fish Habitat VC will be prepared to refine and finalize the approach and specific metrics following consultation with Indigenous groups, other stakeholders, and relevant federal and provincial agencies with interest in the development and implementation of this VC-specific program. Follow and monitoring would be implemented through surface water monitoring and effluent monitoring plans.
Sediment Quality and Benthic Invertebrates	Section 8 Aquatic Environment, Section 8.4 Sediment Quality and Benthic Invertebrates, Section 8.4.8 Monitoring and Follow-up	Construction, Operation, and Decommissioning phases: change in sediment quantity and physical quality (particle size). Construction, Operation, and Decommissioning phases: change in sediment quality (chemical). Construction, Operation, and Decommissioning phases: change in aquatic habitat (area). Construction, Operation, and Decommissioning phases: change in water level or flow.	Monitoring and follow-up are proposed for the Sediment Quality and Benthic Invertebrates VCs to verify the accuracy of the predicted effects and effectiveness of proposed mitigation measures.	The sediment quality and benthic invertebrate monitoring program should be considered in conjunction with the surface water quantity (hydrology) (Section 8.1) and surface water quality (Section 8.2) monitoring programs as sediment quality and benthic invertebrate are specifically tied to surface water quantity and quality from the perspective of pathways of effects. Specifically, monitoring of TSS in the effluent monitoring ponds and other catchment ponds prior to discharge to the environment will be important to provide context to further evaluate Project-related effects on sediment and benthic invertebrate communities in the receiving water environment (i.e., Whitefish Lake). The sediment quality and benthic invertebrate monitoring and follow-up program will have the following objectives: • collecting and recording surface water quality to confirm that source and receiving water quality predictions for mobilization of solids are consistent with those presented in the EIS; • monitoring to confirm that effluent and receiver sediment quality meet applicable regulation criteria; and • monitoring benthic invertebrate community structure and abundance in the near-field discharge area to assess any changes that may be attributable to the Project. The monitoring and follow-up program will include measurement of sediment quality parameters to meet regulatory criteria (i.e., provincial discharge permits, MDMER [Government of Canada 2022] and CSA N288.4). At a minimum, this will include collection of non-radiological parameters (e.g., metals, nutrients, pH, and sulphate), radiological parameters, and physical characteristics (grain size). Benthic invertebrate community monitoring will include the collection of samples following regulatory guidance (Government of Canada 2022) on proper collection and analysis to detect change in biota assemblages. This will include reasonable replication over a geographic area. Metrics assessed will be associated with benthic invertebrate community diversity, evenness, density, taxa richness, and similarity indices. Sediment and benthic invertebrate monitoring will occur in tandem and sampling locations will be co-located to facilitate comparison of benthic invertebrate community metrics with sediment quality characteristics.	All Project phases	An Environmental Management System will include programs to be implemented to monitor the aquatic environment through liquid effluent monitoring and surface water monitoring plans.

Valued Component	EIS Reference	Project Phase and Residual Effect	Monitoring Project Objective(s)	Conceptual Monitoring Program Framework and Components	Duration of Program	Additional Information
				Sediment and benthic invertebrate monitoring in the natural environment will occur at the point of discharge in Whitefish Lake South (near-field), at an upstream reference location (Whitefish Lake North), and at downstream locations (far-field). The far-field monitoring locations will be located in Whitefish Lake South prior to its discharge to McGowan Lake. Constituent concentrations will be compared to the values used in the EIS and to applicable regulatory criteria or objectives.		
Fish Health	Section 8 Aquatic Environment, Section 8.5 Fish Health, Section 8.5.8 Monitoring and Follow-up	Construction, Operation, and Decommissioning phases: change in water quality. Construction, Operation, and Decommissioning phases: change in sediment quality. Construction, Operation, and Decommissioning phases: change in fish tissue concentration.	Monitoring and follow-up are proposed for the Fish Health VC to verify the accuracy of the predicted effects and the effectiveness of the proposed mitigation measures.	The fish health monitoring program should be considered in conjunction with the surface water quality monitoring (Section 8.2), fish and fish habitat monitoring (Section 8.3), and sediment and benthic invertebrate monitoring (Section 8.4) programs as it is specifically tied to these monitoring programs from the perspective of pathways of effects. Specifically, monitoring of water quality in the effluent monitoring ponds and other catchment ponds prior to discharge to the environment will be important to provide context to further evaluate Project-related effects on Fish Health in the receiving water environment (i.e., LA-5 – Whitefish Lake South). The fish health monitoring and follow-up program will have the following objectives: • collecting and recording surface water quality to confirm that source and receiving water quality predictions for mobilization of solids are consistent with those presented in the EIS; • monitoring to confirm that effluent and receiving water quality meet applicable regulation criteria; and • monitoring changes in fish tissue concentrations of COPC that may be attributable to the Project. The monitoring and follow-up program will include measurements of fish health to meet regulatory criteria (i.e., provincial tissue residue guidelines for the protection of piscivorous wildlife, MDMER [Government of Canada 2022] and CSA N288.4). At a minimum, this will include collection of representative fish species from multiple trophic levels and size classes to investigate the bioaccumulation potential of non-radiological (e.g., molybdenum, selenium, mercury/methyl mercury, and other metals) and radiological parameters. Fish will also be assessed for their general health condition through assessment of condition and growth metrics consistent with those described in current or updated Metal and Diamond Mining Effluent Regulations (MDMER) Environmental Effects Monitoring (EEM) technical guidance (e.g., Environment Canada 2012). Fish health monitoring will occur in tandem with surface water quantity (hydrology), surface water quality, sediment quality and benthic invertebrates and fish health monitoring programs. Sampling locations will be co-located to facilitate comparison to water quality and sediment quality characteristics. Sediment and benthic invertebrate monitoring in the natural environment will occur at an upstream reference location (i.e., LA-6 – Whitefish Lake North), at a downstream near-field location close to the point of discharge (i.e., LA-5 – Whitefish Lake South), and at downstream far-field locations (i.e., in LA-5 – Whitefish Lake South prior to its discharge to LA-1 – McGowan Lake). Fish tissue concentrations will be compared to the values used in the EIS and to applicable regulatory criteria or objectives (i.e., provincial tissue residue guidelines for the protection of piscivorous wildlife, MDMER [Government of Canada 2022]). The assessment will also include comparison of fish tissue COPC concentrations between a pre-mining period (i.e., before) and the Construction, Operation, and Decommissioning period (i.e., after). It is recognized that additional collection of pre-mining fish tissue concentrations in Whitefish Lake and a reference area are needed.	All Project phases	An Environmental Management System will include programs to be implemented to monitor the aquatic environment through liquid effluent monitoring and surface water monitoring plans.
Terrain	Section 9 Terrestrial Environment, Section 9.1 Terrain, Soil, and Organic Matter/Peat, Section 9.1.8	Construction phase: Effects are predicted to result in a change in terrain morphology and terrain stability from baseline conditions. Operation and Decommissioning phases: Change in terrain morphology anticipated to be	Verify that the Project is constructed to design specifications (i.e., in a manner that meets geotechnical requirements) and that mitigation measures are both appropriate and effective in relation to the level of geotechnical risk.	Construction and geotechnical monitoring will be implemented in accordance with other mitigation and monitoring plans under the Environmental Management System such as, surface erosion and sediment controls, soil and vegetation monitoring, and decommissioning plans. Construction monitoring procedures will clearly define and delineate indicators and descriptors to identify potential deficiencies (e.g., types of slope failures and leading causes), triggers and corrective actions.	The timing/frequency of monitoring and reporting requirements will be determined in consultation with qualified personnel responsible for	Adaptive management processes will be applied to update and refine the Environmental Management System components (e.g., incorporating additional maintenance, monitoring, and/or best management practices [BMPs]) to reduce effects during the lifetime of the Project.

Valued Component	EIS Reference	Project Phase and Residual Effect	Monitoring Project Objective(s)	Conceptual Monitoring Program Framework and Components	Duration of Program	Additional Information
	Monitoring and Follow-up	within the natural range of variability. No anticipated change in terrain stability.			construction and geotechnical oversight (e.g., Professional Engineer).	
Soil	Section 9 Terrestrial Environment, Section 9.1 Terrain, Soil, and Organic Matter/Peat, Section 9.1.8 Monitoring and Follow-up	Change in soil quantity (volume) and soil quality (textural properties) within or at the limits of the natural range of variability.	Verify that mitigation measures are both appropriate and effective and provide a procedure to adapt mitigation measures if/where necessary.	Period monitoring of soil stockpiles will be conducted to evaluate the stability of salvaged soil, e.g., in relation to potential erosion and/or degradation. Soil inventory data, including volume and location, will be recorded by construction supervisors at the time of soil stockpiling. Soil quality monitoring—comprising scheduled collection of soil from permanent sampling locations for analysis of COPC—will be conducted. This will provide a mechanism to evaluate potential effects of dust on soil quality, and other interrelated VC. Soil quality monitoring procedures will clearly define and delineate indicators and descriptors to identify potential deficiencies (e.g., COPC exceedances), triggers and corrective actions. These procedures will identify the key personnel (e.g., managers, superintendents, and technical leads) responsible for document review, approval, and implementation). If/where mitigation measures are not deemed to be successful, adaptive management processes will be employed to revise the environmental management plans (e.g., incorporating additional maintenance, monitoring, and/or BMPs) to reduce effects during the lifetime of the Project.	Periodic monitoring of soil stockpiles will be conducted (as/when necessary) during Operation. Soil quality monitoring will be conducted during Operation. Soil quality monitoring data will be compiled and reported annually/periodically.	Monitoring of soil salvage activities will be implemented in accordance with other mitigation and monitoring plans, under the Environmental Management System including the erosion and sediment controls, soil and vegetation monitoring, and decommissioning plans.
Organic Matter/Peat	Section 9 Terrestrial Environment, Section 9.1 Terrain, Soil, and Organic Matter/Peat, Section 9.1.8 Monitoring and Follow-up	Change in the quantity of organic matter/peat within or at the limits of the natural range of variability.	Verify that mitigation measures are both appropriate and effective and provide a procedure to adapt mitigation measures if/where necessary.	Period monitoring of soil stockpiles will be conducted to evaluate the stability of salvaged soil (e.g., in relation to potential erosion and/or degradation). Soil inventory data, including volume and location, will be recorded by construction supervisors at the time of soil stockpiling. If/where mitigation measures are not deemed to be successful, adaptive management processes will be employed to revise the environmental management plans (e.g., incorporating additional maintenance, monitoring, and/or BMPs) to reduce effects during the lifetime of the Project.	Periodic monitoring of soil stockpiles will be conducted (as/when necessary) during Operation.	Monitoring of soil salvage activities will be implemented in accordance with other mitigation and monitoring plans, under the Environmental Management System including the surface erosion and sediment controls, soil and vegetation monitoring, and decommissioning plans.
Vegetation and Ecosystems	Section 9 Terrestrial Environment, Section 9.2 Vegetation and Ecosystems, Section 9.2.8 Monitoring and Follow-up	All Project phases: Change in areal extent of habitat types. All Project phases: Change in concentration of constituents of concern in plant tissue.	Verify that mitigation measures are both appropriate and effective and provide a procedure to adapt mitigation measures if/where necessary.	Targeted monitoring and inspection will be undertaken to verify that mitigation measures to reduce effects on Vegetation and Ecosystems have been appropriately applied, maintained, and removed, where necessary. Construction monitoring procedures will clearly define and delineate indicators and descriptors to identify potential deficiencies, triggers, and corrective actions. The procedures will identify the key personnel (e.g., Managers, Superintendents and Technical Leads) responsible for document review, approval, and implementation. Vegetation monitoring will be conducted periodically throughout all Project Phases to reduce the potential for effects on vegetation associated with routine vegetation clearing and maintenance within the Project Area and to avoid the introduction and spread of invasive plant species. Vegetation monitoring will verify compliance and evaluate the success of mitigation measures and management plans specific to Vegetation, including surface erosion and sediment controls, soil and vegetation monitoring, and decommissioning plans, and applicable approval conditions. These procedures will identify the key personnel (e.g., Managers, Superintendents and Technical Leads) responsible for document review, approval, and implementation. Vegetation and soil sampling and laboratory analyses for constituents of concern commenced in 2017 and will be conducted periodically throughout all Project Phases to identify if plants within the Vegetation LSA are accumulating constituents of concern within their tissues. Monitoring for constituents of concern in vegetation will be completed in accordance with the methodologies outlined within the Environmental Management System	Targeted monitoring and inspection will be undertaken during Construction.	Where mitigation measures are not deemed to be successful, adaptive management techniques will be employed. Findings during monitoring, as well as revised BMPs, improved scientific methods, and regulatory changes will be incorporated into the environmental management plans to reduce effects during the lifetime of the Project.
Listed Plant Species	Section 9 Terrestrial Environment, Section 9.2 Vegetation and	All Project phases: Change in the number of known listed plant occurrences.	To verify EA predictions and identify mitigation measures to protect Listed Plant Species occurrences, as appropriate.	Pre-construction listed plant surveys will be undertaken within the Project Area within ecosites that were not encountered during the 2017 surveys, as well as within selected areas of the Project Area with the potential to support listed plants (e.g., transitional habitats favoured by Alaskan clubmoss). Should occurrences of listed plant species be identified within the Project Area, site- and species-specific mitigation measures will be developed by a qualified vegetation ecologist in	Listed plant surveys will be undertaken in the pre-construction phase.	Findings during monitoring will be incorporated into the programs within the Environmental Management System to reduce effects during the lifetime of the Project.

Valued Component	EIS Reference	Project Phase and Residual Effect	Monitoring Project Objective(s)	Conceptual Monitoring Program Framework and Components	Duration of Program	Additional Information
	Ecosystems, Section 9.2.8 Monitoring and Follow-up			accordance with the programs developed under the Environmental Management System to avoid and/or minimize potential Project Effects.		
Wetlands	Section 9 Terrestrial Environment, Section 9.2 Vegetation, Section 9.2.8 Monitoring and Follow-up	All Project phases: Change in the areal extent of wetlands.	Verify that mitigation measures are both appropriate and effective and provide a procedure to adapt mitigation measures if/where necessary.	Targeted monitoring and inspection will be undertaken to verify that mitigation measures to reduce effects on Wetlands VCs have been appropriately applied, maintained, and removed, where necessary. Construction monitoring procedures will clearly define and delineate indicators and descriptors to identify potential deficiencies, triggers, and corrective actions. The procedures will identify the key personnel (e.g., Managers, Superintendents and Technical Leads) responsible for document review, approval, and implementation.	Targeted monitoring and inspection will be undertaken during Construction.	Where mitigation measures are not deemed to be successful, adaptive management techniques will be employed. Findings during monitoring, as well as revised BMPs, improved scientific methods, and regulatory changes will be incorporated into the programs within the Environmental Management System to reduce effects during the lifetime of the Project.
Ungulates Furbearers Woodland Caribou	Section 9 Terrestrial Environment, Section 9.3 Ungulates, Furbearers, and Woodland Caribou, Section 9.2.8 Monitoring and Follow-up	All Project phases: Alteration and/or loss of habitat. All Project phases: Change in mortality.	Verify that Project design and mitigation measures have been appropriately applied and maintained. Following verification, the success of Project design and mitigation measures will be evaluated to assist in the determination of additional mitigation measure requirements.	Pre-construction wildlife surveys conducted in accordance with the environmental programs and plans developed under the Environmental Management System prior to the commencement of any vegetation clearing or soil disturbance. Wildlife species routinely monitored (e.g., through the Project-wide implementation of the current wildlife card system) throughout the life of the Project in accordance with the wildlife monitoring plans (including implemented setback distances during sensitive time periods, if applicable). Progressive reclamation and revegetation of disturbed areas (i.e., transitioning into wildlife habitat) monitored in accordance with the Decomissioning Plan.	Management plans, will be considered living documents, and updated when warranted to include input from consultations, monitoring results, regulatory or legislative changes, and any updated, improved, or revised BMPs and scientific methods.	An adaptive management process will be employed, after applicable consultations and approvals, where implemented mitigation measures are found to be unsuccessful.
Raptors Migratory Breeding Birds Bird Species at Risk	Section 9 Terrestrial Environment, Section 9.4 Raptors, Migratory Breeding Birds, and Bird Species at Risk, Section 9.4.8 Monitoring and Follow-up	All Project phases: Alteration and/or loss of habitat. All Project phases: Change in mortality.	Verify that Project design and mitigation measures have been appropriately applied and maintained. Following verification, the success of Project design and mitigation measures will be evaluated to assist in the determination of additional mitigation measure requirements.	Pre-construction nest surveys conducted in accordance with the programs developed under the Environmental Management System prior to the commencement of any vegetation clearing or soil disturbance. Avian species routinely monitored throughout the life of the Project in accordance with the Wildlife Management Plan (including implemented setback distances during sensitive time periods, if applicable). Progressive reclamation and revegetation of disturbed areas (i.e., transitioning into avian habitat) monitored in accordance with the Reclamation Plan.	Management plans, will be considered living documents, and updated when warranted to include input from consultations, monitoring results, regulatory or legislative changes, and any updated, improved, or revised BMPs and scientific methods.	An adaptive management process will be employed, after applicable consultations and approvals, where implemented mitigation measures are found to be unsuccessful.
Human Health	Section 10 Human Health, Section 10.1 Human Health, Section 10.1.8 Monitoring and Follow-up	Potential residual effect identified due to exposure of the Fisher/Trapper to selenium during Operation.	Monitoring with the objective to collect environmental data to verify Environmental Risk Assessment (ERA) model predictions, and to provide data to improve model predictions as the Project begins.	The environmental monitoring program to support the ERA should be designed in conjunction with monitoring to support the water quality, sediment quality, fish health VCs. The Environmental Monitoring Program (EMP) would follow the requirements and guidance in CSA N288.4-19, *Environmental monitoring programs at nuclear facilities and uranium mines and mills* and include collection of surface water, sediment, and soil samples as well as fish tissue samples, benthic invertebrate tissue samples, and country foods such as blueberries. Monitoring locations should be focused on potential exposure locations including Whitefish Lake, McGowan Lake, and Russell Lake, as well as suitable reference locations. Constituents of potential concern for analysis would include those identified as COPC in the ERA, including metals and uranium-238 series radionuclides, and chloride and sulphate in lake waters. Monitoring could extend to include other COPC for other purposes, such as meeting regulatory requirements for monitoring, or addressing COPC of public interest based on experience at other uranium mines and process plants.	All Project phases; however, the program design will evolve as more data are collected.	The EMP supports the Environmental Management System and feeds into ERA updates

Valued Component	EIS Reference	Project Phase and Residual Effect	Monitoring Project Objective(s)	Conceptual Monitoring Program Framework and Components	Duration of Program	Additional Information
Worker Health and Safety	Section 10 Human Health, Section 10.2 Worker Health and Safety, Section 10.2.7 Monitoring and Follow-up	There were no residual effects identified.	Monitoring of radiation exposure to workers throughout all phases of the Project is a key component of the Radiation Protection Plan (RPP).	Licensees are required to use a dosimetry service that is licensed by the Canadian Nuclear Safety Commission (to measure and monitor the doses of radiation received by and committed to Nuclear Energy Workers (NEWs) who have a reasonable probability of receiving one or both of: • an effective dose greater than 5 mSv in a one-year dosimetry period; and • an equivalent dose to the skin, or to the skin of the hands and feet, that is greater than 50 mSv in a one-year dosimetry period. All NEWs are required to wear personal dosimeters, measured at regular intervals (three months). Dosimetry monitoring will document worker exposures to radiation and will demonstrate compliance with dose limits. Personal dosimeters are measuring external gamma exposure; however, personal alpha dosimetry may be implemented in areas where exposure to uranium and decay products is increased (ISR plant). A bioassay program may be implemented to monitor internal exposure of workers that will have a higher exposure to uranium and its progeny. In addition to personal dose monitoring, area monitoring for gamma radiation, radon and/or radioactive dust in air will be performed in work areas where higher exposures are expected. This will provide information for estimating doses in these areas to facilitate safe work planning. Action levels and administrative levels for exposure will be defined, and monitoring data will be compared to these levels, to make sure that corrective action can be taken as needed to maintain worker doses ALARA.	All Project phases	Monitoring will be implemented as part of the Radiation Protection Plan.
Indigenous Land and Resource Use	Section 11 Land and Resource Use, Section 11.1 Indigenous Land and Resource Use, Section 11.1.8 Monitoring and Follow-up			Monitoring and follow-up in relation to the key indicators associated with Indigenous Land and Resource Use, such as aquatics, terrain, and wildlife, are addressed in those portions of the report, respectively (see Sections 8 and 9). Denison is committed to ensuring that the monitoring and follow-up activities from these other respective disciplines informs a part of programs designed to share information in a transparent manner with the Indigenous Communities of Interest with whom Denison is regularly engaging about the Project. Such an information-sharing program would consider the involvement of the Regulators to make sure the information available addresses the issues identified as concerns. As part of agreement negotiating processes, specific monitoring measures and approaches may be negotiated between Denison and the parties pertaining to the parameters of Indigenous Land and Resource Use.		
Other Land and Resource Use	Section 11 Land and Resource Use, Section 11.2 Other Land and Resource Use, Section 11.2.8 Monitoring and Follow-up			Monitoring and follow-up in relation to the key indicators associated with Other Land and Resource Use, such as aquatics, terrain, and wildlife, are addressed in those portions of the report, respectively (see Sections 8 and 9). Denison is committed to ensuring that the monitoring and follow-up activities from these other respective disciplines informs a part of programs designed to share information in a transparent manner with the General Public, and specifically those Communities of Interest and Nearby Land Users with whom Denison is regularly engaging about the Project. Such an information-sharing program would consider the involvement of the Regulators to make sure the information available addresses the issues identified as concerns.		
Heritage Resources	Section 11 Land and Resource Use, Section 11.3 Heritage Resources, Section 11.3.8 Monitoring and Follow-up			During Project activities, all personnel working on site will be made of the Heritage Resources Management Plan (HRMP) and the possibility of affecting unknown Heritage Resources. Should new Heritage Resources be identified, the HRMP will be followed and additional archaeological assessment and/or monitoring of ground disturbance activities may be required. Any changes to the Project (i.e., expansion of the Project Area or the addition of additional infrastructure) that might affect Heritage Resources must be submitted to the Heritage Conservation Branch for their review, and additional Heritage Resource Impact Assessments may be required.		

Valued Component	EIS Reference	Project Phase and Residual Effect	Monitoring Project Objective(s)	Conceptual Monitoring Program Framework and Components	Duration of Program	Additional Information
Cultural Expression	Section 12 Quality of Life, Section 12.1 Cultural Expression, Section 12.1.8 Monitoring and Follow-up			Monitoring and follow-up in relation to the key indicators associated with Cultural Expression, such as aquatics, terrain, and wildlife, are addressed in those portions of the report, respectively (see Sections 8 and 9). Additionally monitoring will occur in relation to the elements of the Traditional Diet through Denison's EMP, such as that which is designed to address and consider Human Health (see Section 10).		
Community Well-being	Section 12 Quality of Life, Section 12.2 Community Well-being, Section 12.2.8 Monitoring and Follow-up			No specific monitoring is anticipated for Community Well-Being. Government departments and private-sector companies that provide community services will continue to monitor the ongoing demand. Through regular liaising with Indigenous and non-Indigenous Communities of Interest, Denison will generally understand any arising circumstances in relation to the Project, and will work with appropriate entities on the matter, where appropriate.		
Infrastructure and Services	Section 12 Quality of Life, Section 12.3 Infrastructure and Services, Section 12.3.8 Monitoring and Follow-up			No monitoring is anticipated for Community Infrastructure and Services. In terms of traffic, the Saskatchewan Ministry of Highways and Transportation is responsible for highway maintenance. Government departments and private-sector companies that provide community infrastructure and services will continue to monitor the ongoing demand for community health and emergency services. Through regular liaising with Indigenous and non-Indigenous Communities of Interest, Denison will generally understand any arising circumstances in relation to the Project, and will work with appropriate entities on the matter, where appropriate.		
Economy	Section 13 Economics, Section 13.7 Monitoring and Follow-up	All Project phases: Adverse effects related to the traditional economy.	Monitoring and follow-up are required to confirm the residual and cumulative effects and any uncertainties	Denison will work with the Province of Saskatchewan to develop the Project's Surface Lease Agreement, which typically includes commitments related to an overall and Human Resource Development Agreement, along with annual human resources development plans. Annual reporting may include metrics such as total employment and employment of residents in the LSA and Regional Study Area (RSA), disaggregated employment by sex and Indigenous identity (self-identified), total wages in dollars, northern procurement volumes in dollars and percentage of total procurement, any details on training partnerships and employee development, and community involvement such as scholarships, outreach, and information sharing with northern residents (Government of Saskatchewan 2018).	All Project phases	NA

Table 1.5-2: Wheeler River Monitoring and Follow-up Program Details

Media	Station ID	Station Description	Rationale for Monitoring	Duration of Program	Frequency	Sampling/Measuring Method	Constituents / Parameters
Noise	NO-01	Near baseline location	• To demonstrate compliance with federal and provincial guidelines	All Project phases	One week campaign once per phase	Integrating sound level meters	Energy equivalent sound level for the daytime period ($L_{eq,day}$); energy equivalent sound level for the nighttime period ($L_{eq,night}$); combined day-night sound level (L_{dn})
	Risk 2	Nearest sensitive receptor where access is granted (Cabin at McGowan Lake)		All Project phases			
Atmosphere	Radon1, Radon2, Radon3, Radon4, Radon5, Radon6,	Near baseline Location - final points will be defined with detailed design	• To demonstrate compliance with provincial ambient air quality standards	All Project phases	Quarterly collection of monitors	Alpha-track etch monitors	Radon
	DF-01, DF-02, DF-03	Near baseline Location- final points will be defined with detailed design		All Project phases	Monthly collection of samplers	Dustfall sampler	Dustfall (mg/cm²/30-day) Metals in dustfall (% of fixed dustfall)
	PC-01	Near baseline Location- final points will be defined with detailed design		All Project phases	Monthly collection of samplers	Passive sampler	Nitrogen Dioxide Sulphur Dioxide
	G-01	Near baseline Location- final points will be defined with detailed design		All Project phases	Quarterly collection of OSLDs	Landauer InLight optically stimulated luminescence dosimeters	External Gamma
	TBD	Near baseline Location- final points will be defined with detailed design		Site Preparation and Construction. Operation Monitoring TBD.	Quarterly composite of 4 weekly 24-hr Hi Vol samples	Passive samplers for CO High Volume Air Samplers	Total suspended particulates (TSP), Particulate Matter (PM10, PM2.5), carbon monoxide, arsenic, cadmium, cobalt, chromium, copper, molybdenum, nickel, lead, selenium, uranium, vanadium, zinc
Surface Water Quantity	SA-1	Icelander River flowing from McGowan Lake	• To confirm predictions and support effluent discharge permitting and approvals	All Project phases	Continuous	Stage dataloggers, hydrometric monitoring	Streamflow, lake level, stream discharge, water levels
Surface Water Quantity	SA-2	Inflow to McGowan Lake from Whitefish Lake		All Project phases	Continuous		
	SA-3	Inflow to McGowan Lake from Whitefish Lake		All Project phases	Continuous		
	SA-4	Inflow to LA-6 (Unnamed Lake) from Kratchkowsky Lake		All Project phases	Continuous		
	SA-5	Inflow to LA-6		All Project phases	Continuous		
	SA-6/LA-6	Flow from LA-6 to Whitefish Lake		All Project phases	Continuous		
	SB-3	Southern Project drainage basin flowing to Russell Lake		All Project phases	Continuous		
	LA-1	McGowan Lake		All Project phases	Continuous		
	LA-5	Whitefish Lake		All Project phases	Continuous		
	TBD	Kratchkowsky Lake		All Project phases	Continuous		

Media	Station ID	Station Description	Rationale for Monitoring	Duration of Program	Frequency	Sampling/Measuring Method	Constituents / Parameters
Surface Water Quality (See Note 1)	SA-1	Stream colloquially known as the Icelander River, which is located downstream of LA-1 (McGowan Lake)	• To verify the accuracy of the predicted effects and the effectiveness of the proposed mitigation measures	All Project phases	Annual grab samples during construction Quarterly grab samples during operations	In situ during field surveys, depth profiles Laboratory analysis of samples collected from the field	Conductivity, pH, temperature, dissolved oxygen, water clarity. pH, conductivity, total suspended solids, total dissolved solids, alkalinity, acidity, hardness, nutrients (total and dissolved phosphorus, ammonia and total kjeldahl nitrogen), chloride, sulphate, total and dissolved metals, low level mercury, methylmercury (at select locations), and radionuclides (Pb-210, Po-210, Ra-226, Th-230).
	SA-2	Downstream of the outflow from LA-5 (Whitefish Lake South) and upstream of the inflow to LA-1 (McGowan Lake)		All Project phases	Annual grab samples during construction Quarterly grab samples during operations		
	SA-3	Situated in a small channel upstream of LA-1 (McGowan Lake) and downstream of LA-2		All Project phases	Annual grab samples during construction Quarterly grab samples during operations		
	SA-4	Upstream of the inflow to LA-6 (Whitefish Lake North)		All Project phases	Annual grab samples during construction Quarterly grab samples during operations		
	SA-5	Situated upstream of the inflow to LA-6 (Whitefish Lake North)		All Project phases	Annual grab samples during construction Quarterly grab samples during operations		
	SA-6	Situated downstream of the outflow from LA-6 (Whitefish Lake North) and upstream of the inflow to LA-5 (Whitefish Lake South)		All Project phases	Annual grab samples during construction Quarterly grab samples during operations		
	LAB	Russell Lake		All Project phases	Annual grab samples during construction Quarterly grab samples during operations		
Sediment (See Note 1)	McGowan Lake (LA-1)	Representative sample locations in depositional areas of lakes within the Local Study Area	• To verify the accuracy of the predicted effects and the effectiveness	All Project Phases	Every 3 years	Field collection of sediment samples in depositional areas (by	Moisture, grain size, total organic carbon, metals, radionuclides (Pb-210, Po-210,
	Whitefish Lake South (LA-5)			All Project Phases	Every 3 years		

Media	Station ID	Station Description	Rationale for Monitoring	Duration of Program	Frequency	Sampling/Measuring Method	Constituents / Parameters
	Whitefish Lake North (LA-6)		of the proposed mitigation measures	All Project Phases	Every 3 years	coring or petit Ponar grab) and laboratory analysis	Ra-226, Th-230), nutrients, total mercury, methylmercury (at select locations)
	Russell Lake (LAB-1)			All Project Phases	Every 3 years		
	Russell Lake (LAB-2)			All Project Phases	Every 3 years		
Fish and Fish Habitat (	TBD	Within Project Local Study Area, at representative near-field, mid-field and far-field locations and inclusive of sensitive habitats. .	• To verify the accuracy of the predicted effects and the effectiveness of the proposed mitigation measures	All Project Phases	Every 3 years	Field collection of fish by netting or electroshocking. Observation/measuring of physical parameters relevant to fish habitat	Fish species presence, abundance and life history parameters (e.g., sex, length, weight, condition, age). Physical parameters of water body (e.g., depth width, flow, substrate).
Fish Health (See Note 1)	TBD	An upstream reference location (i.e., LA-6 – Whitefish Lake North), at a downstream near-field location close to the point of discharge (i.e., LA-5 – Whitefish Lake South), and at downstream mid-field locations (i.e., in LA-5 – Whitefish Lake South prior to its discharge to LA-1 – McGowan Lake), downstream far-field location (i.e., Russell Lake).	• To confirm predictions and monitor changes in fish tissue concentrations of COPC that may be attributable to the Project • Monitoring to meet regulatory criteria (i.e., federal tissue residue guidelines)	All Project Phases	Every 3 years	Field collection of fish by netting or electroshocking.	Fish tissue concentrations of non-radiological (selenium, mercury, methylmercury, other metals), radiological parameters, and moisture. Life history parameters collected via fish and fish habitat sampling will be used for interpretation of fish health.
Benthic invertebrates (See Note 1)	McGowan Lake (LA-1)	Representative sample locations within the Local Study Area	• To verify the accuracy of the predicted effects and effectiveness of proposed mitigation measures	All Project Phases	Every 3 years	Field collection of benthic invertebrate samples in depositional areas (by petit Ponar with sieving) and laboratory analysis (taxonomic and chemical)	Benthic invertebrate community measures (e.g., mean Simpson's diversity, dominant taxa) Benthic invertebrate chemistry (metals and radionuclides)
	Whitefish Lake South (LA-5)			All Project Phases	Every 3 years		
	Whitefish Lake North (LA-6)			All Project Phases	Every 3 years		
	Russell Lake (LAB-1)			All Project Phases	Every 3 years		
	Russell Lake (LAB-2)			All Project Phases	Every 3 years		
Soil	RSV1-10	Permanent sample plots distributed throughout the Local Study Area and Regional Study Area	• To verify that mitigation measures are both appropriate and effective and provide a procedure to adapt mitigation measures if necessary	All Project Phases	Periodically throughout all Project phases (approximately every 3 years).	Field collection of soil samples and laboratory analysis	Essential and non-essential metals and radionuclides
Vegetation (lichen, blueberry)	RSV1-10	Permanent sample plots distributed throughout the Local Study Area and Regional Study Area	• To verify that mitigation measures are both appropriate and effective and provide a procedure to adapt mitigation measures if necessary	All Project Phases	Coincident with soil sampling.	Field collection of vegetation samples and laboratory analysis	Essential and non-essential metals and radionuclides
Environmental Effects Monitoring	TBD	Within the area of influence, reference waterbodies and far-field waterbodies	• To satisfy regulatory requirements (MDMER)	All Project Phases	Every three years initially, then as required according	Biological and receiving water quality monitoring studies	TBD, but may include fish population, fish tissue and benthic invertebrate

Media	Station ID	Station Description	Rationale for Monitoring	Duration of Program	Frequency	Sampling/Measuring Method	Constituents / Parameters
(See Note 1)					to the monitoring results and MDMER.		community studies. Analysis of water quality samples.

Notes:

Station IDs where provided refer to locations established as part of baseline environmental surveys.

TBD is “to be determined”.

Note 1 - Water quality, fish habitat, fish health, sediment quality and benthic invertebrate community studies identified would be harmonized with the Environmental Effects Monitoring, such that the data collected as part of those activities could be used to support the MDMER requirements.