ENVIRONMENTAL RISK ASSESSMENT FOR WHEELER RIVER

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Revision Number	Date	Comments
R0	09-September-2022	Initial Issue of report to support EIS submission.
R1	27-October-2024	Revised to address Information Requests from the EIS review process
R2	09-June-2025	Title changed to reflect new version for the project licence application. Updated to address CNSC comments on the following CSA N288.6 topics: • Inclusion of discussion on physical stressors (Section 1.3, 4.1.3.1, 5.1.3.1) • Inclusion of existing conditions surface water quality data in an appendix to the ERA (Appendix D) • Inclusion of discussion on uncertainty of the surface water quality model (Section 3.1.2.4) • Clarification on the assumptions and uncertainties associated with the Traditional Foods Diet (Section 4.2.6, Table 4-13)

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. Physical stressors were evaluated qualitatively, with more detail available in the Wheeler River Project Final Environmental Impact Statement.

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. All estimated total HQs for all COPCs (arsenic, cadmium, chromium, cobalt, copper, molybdenum, selenium, uranium, vanadium, zinc, chloride and sulphate) for all ecological receptors are predicted to remain below the HQ benchmark of 1.

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.

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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.

Physical stressors were considered in detail in the EIS (Denison, 2024), and were not evaluated independently in the ERA. A summary of the main conclusions of the EIS as they relate to physical stressors is presented in Section 4.1.3 for human health and Section 5.1.4 for ecological health.

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.

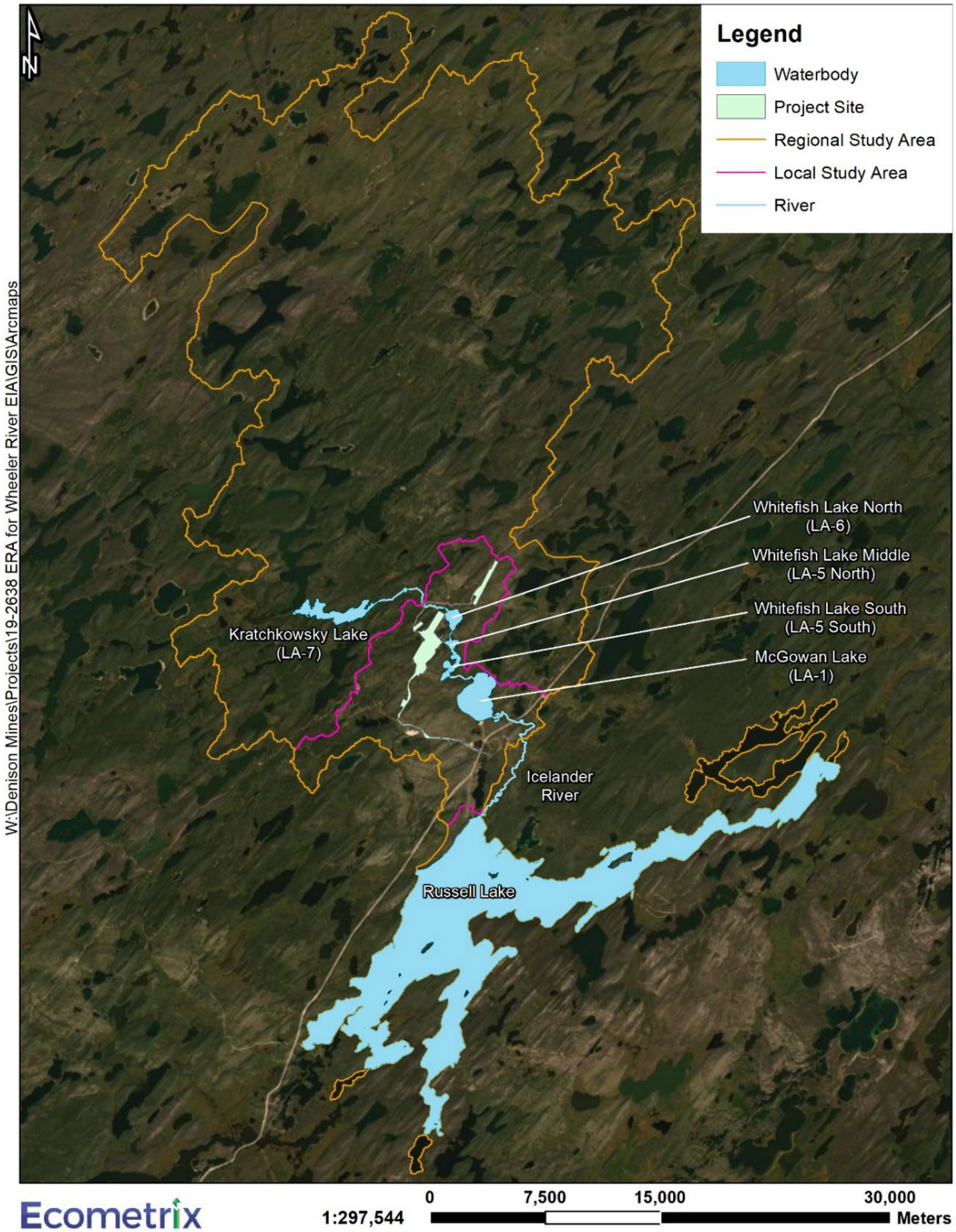


Figure 1-1: Spatial Boundaries of the ERA

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.

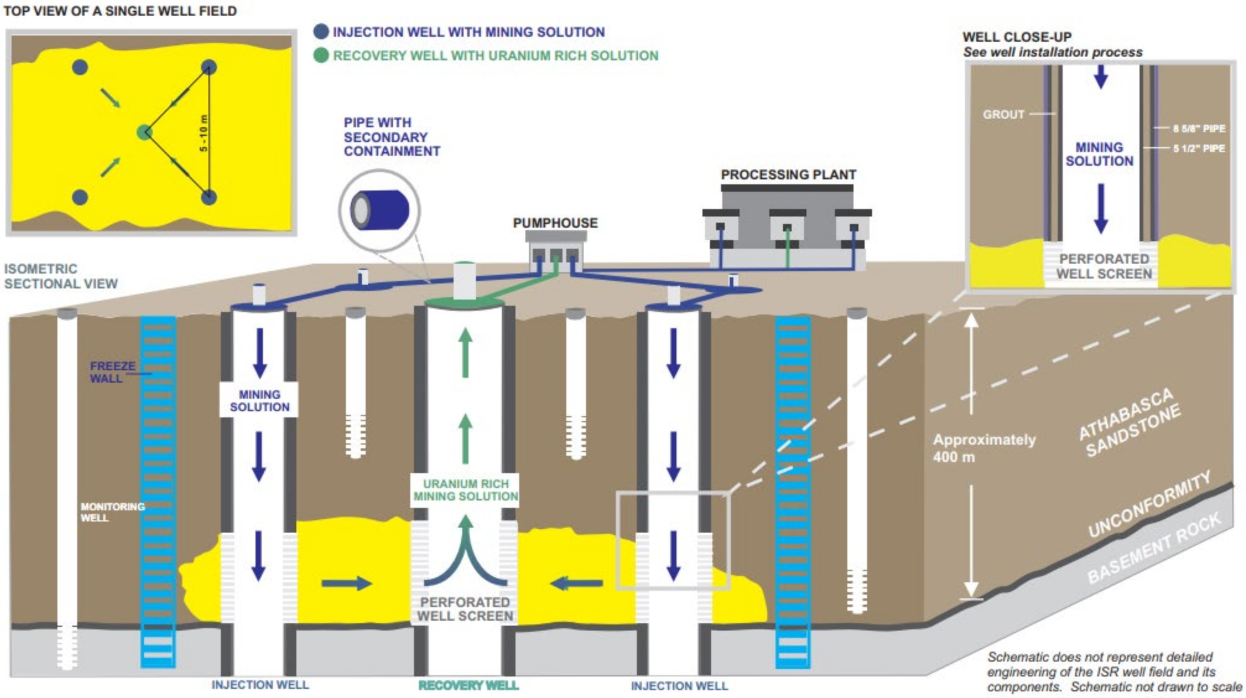


Figure 2-1: Overview of the ISR Process

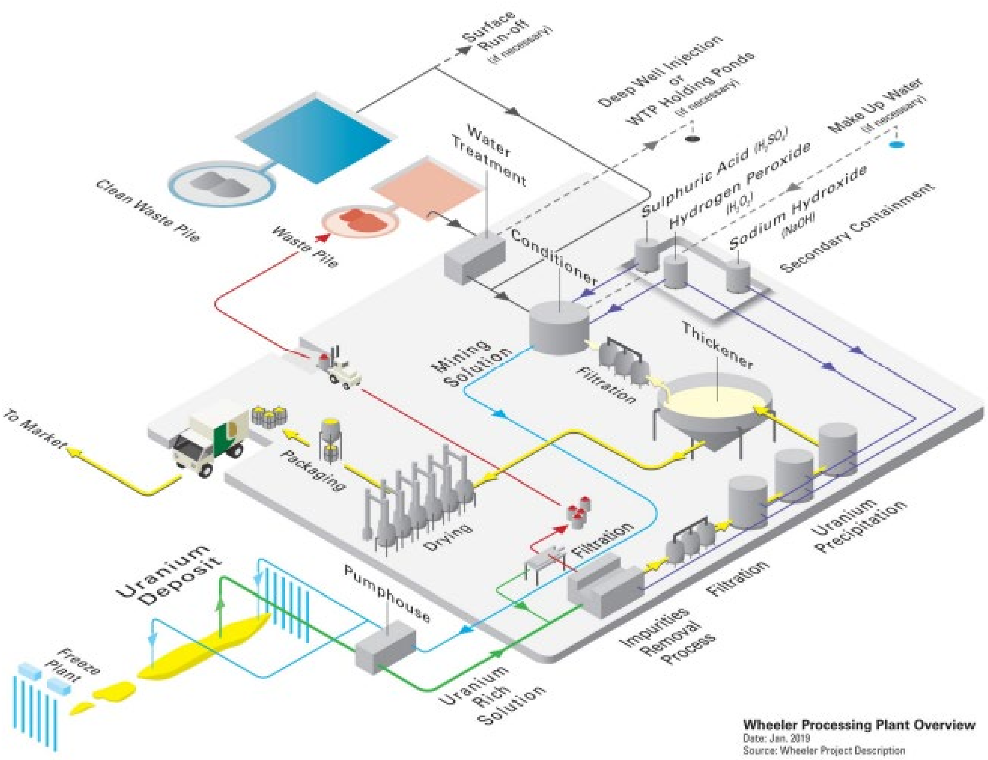


Figure 2-2: Overview of the Processing Plant Process

2.2 Description of the Natural and Physical Environment

The natural and physical environment is presented in the EIS (Denison, 2024) 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. Table 2-1 summarizes the EIS sections and appendices where baseline monitoring information for air, noise, geology and hydrogeology, surface water quantity and quality, and aquatic environment can be found.

Table 2-1: Overview of EIS Sections and Appendices Presenting Baseline Monitoring Information for Air, Noise, and Other Abiotic Aquatic VCs

Topic	EIS Section	Baseline Information Included
Air Quality	Section 6.1.3: Air Quality – Existing Environment	Provides: • The climate (temperature, precipitation, wind) of the Project Area. • Summary statistics for baseline air quality data from on-site monitors, SK MOE monitoring stations, and monitoring stations at nearby operations. • Methods for using available background air quality data to develop conservative background concentrations for TSP, PM10, PM2.5, dustfall, CO, NO_2, SO_2, uranium, and metals using the SK Air Quality Modelling Guideline.
Air Quality	Appendix 6-C: Climate Baseline and Greenhouse Gas Emissions Report	Provides background meteorological data and data summaries. This report also provides estimations of future climate out to the year 2100.
Air Quality	Appendix 6-D: Baseline Air Quality Monitoring Report	Provides detailed field protocols, results of the air quality baseline monitoring program, method detection limits, and quality assurance and quality control (QA/QC) procedures.
Noise	Section 6.2.3: Noise – Existing Environment	Provides: • Baseline noise monitoring methods • Ambient noise measurement data • A comparison of baseline conditions to federal and provincial guidelines
Noise	Appendix 6-E: Acoustic Assessment Technical Supporting Document	This report provides additional technical background details on the noise assessment methodology, assessment scenarios, source identification and characterization, predictive modelling, and modelling outputs. Sound level data are provided in the report's Appendix A.
Geology and Groundwater	Section 7.3: Geology and Groundwater – Existing Conditions	Provides an overview of the methods used to characterize existing geology and groundwater conditions. Also summarizes the existing physical geography and the geological and hydrological setting of the Wheeler River Project.
Geology and Hydrogeology	Appendix 7-A: Baseline Geology and Hydrogeology Report	Provides baseline geological, hydrological, mineralogical, geochemical, and hydrochemistry information. Also provides detailed field sampling methodologies, analytical reports and QA/QC results, summary values, method detection limits, and groundwater quality data.
Surface Water Quantity	Section 8.1.3: Surface Water Quantity – Existing Environment	Outlines baseline hydrological monitoring methods, baseline stream flow and low flow results, and climate change information. Summary statistics are provided for: - Baseline stream flow (Table 8.1-3) - Low flow return period estimated discharges (Table 8.1-4)
Surface Water Quantity	Appendix 8-B: 2011 – 2019 Baseline	Provides:

Topic	EIS Section	Baseline Information Included
	Hydrology Summary Report	- Details regarding hydrological surveys conducted between 2011 and 2019, including detailed hydrological monitoring methods. - Key hydrological characteristics of the study area, including lake and pond surface water elevation and streamflow data. - Raw and summary data are provided in appendices.
Hydrology; Surface Water Quality; Sediment Quality and Limnology; Aquatic Habitat and Bathymetry; Plankton Community; Benthic Invertebrate Community and Chemistry; Fish Community, Spawning, and Fish Tissue Chemistry	Appendix 8-D: Baseline Aquatic Environment Study	Provides: - Detailed methods and results of baseline aquatic monitoring studies - Quality management procedures and results for field and laboratory studies - Baseline aquatic environment data - Summary statistics for baseline aquatic environment data, including method detection limits where appropriate - Descriptions of how discharge measurement outliers were handled

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, 2025). 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).

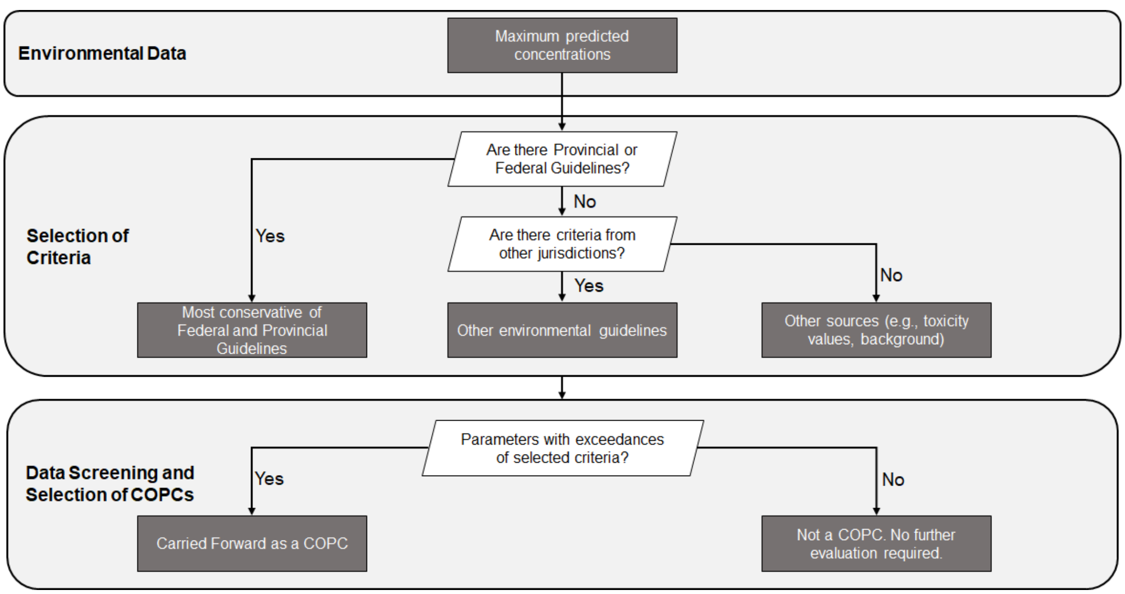


Figure 3-1: Selection of Surface Water Screening Values for the ERA

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, 2025). 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. Baseline sediment quality data were collected in 2016. A summary of the baseline surface water and sediment quality data is provided in Appendix D.

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		
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

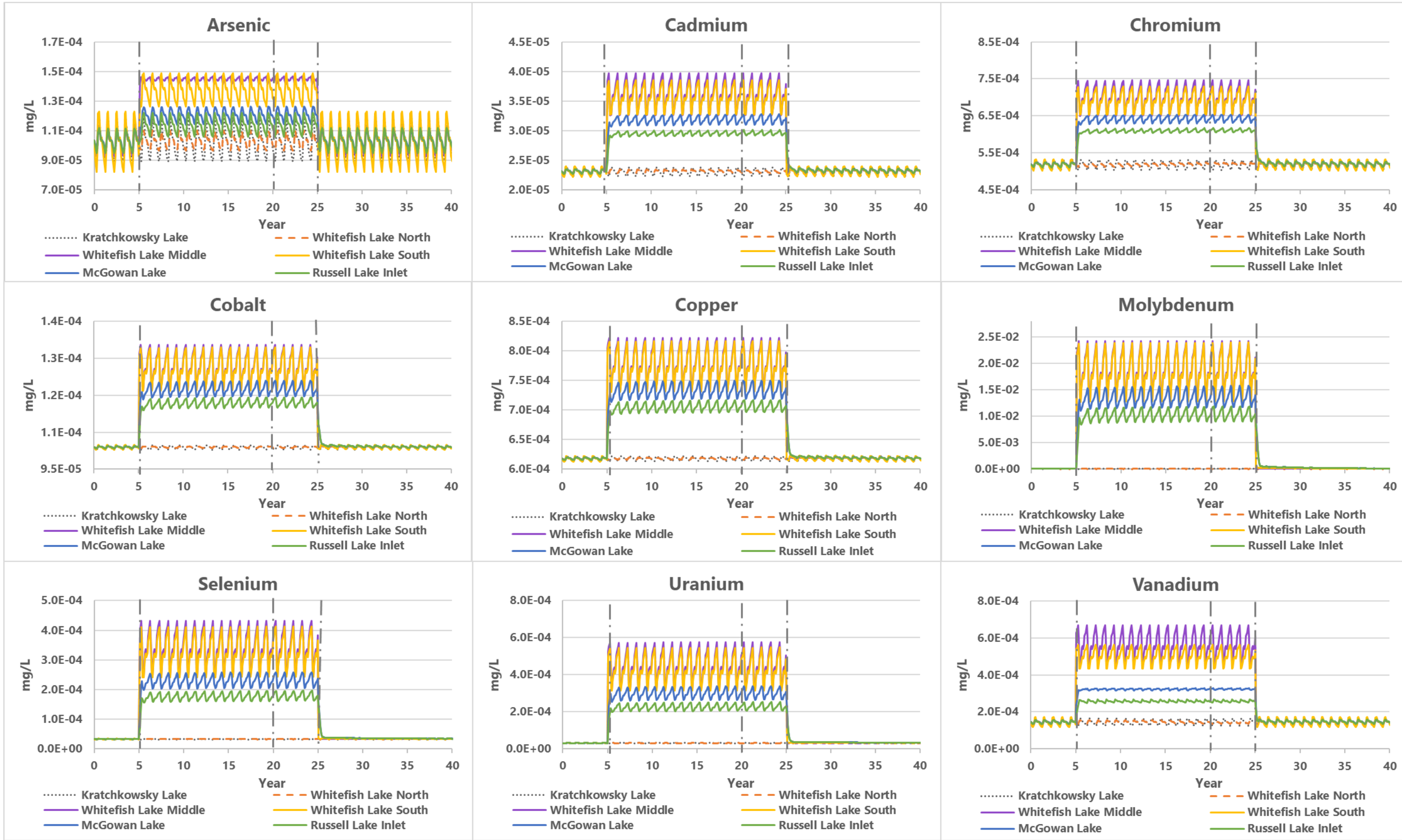
Note:
(a) Estimated from uranium using the specific activity of 12,356 Bq/g and assuming secular equilibrium between uranium-238 and uranium-234 (**https://www.wise-uranium.org/rup.html**).

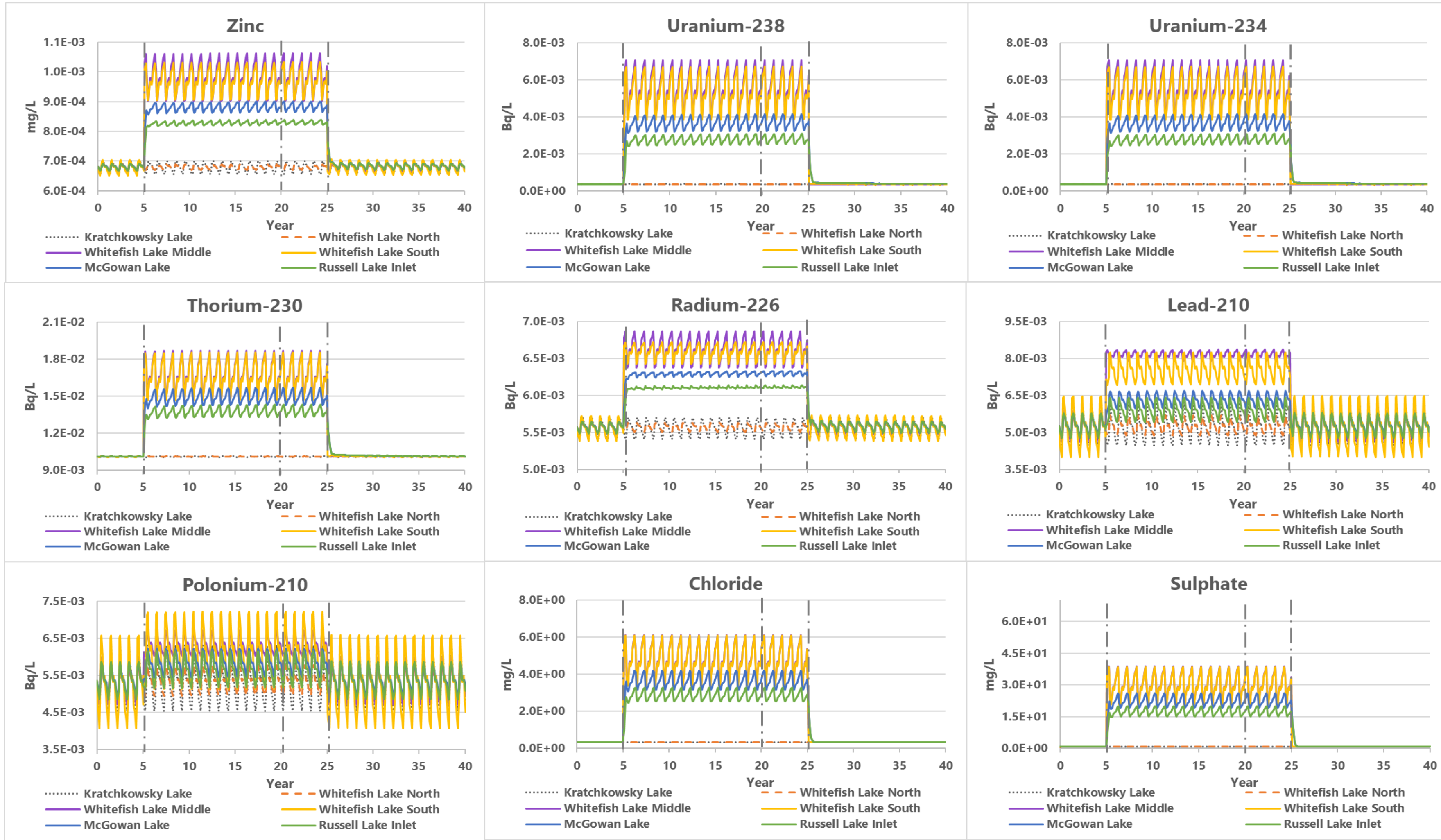
Table 3-3: Maximum Concentration of COPCs in Water and Sediment during Project Phases

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

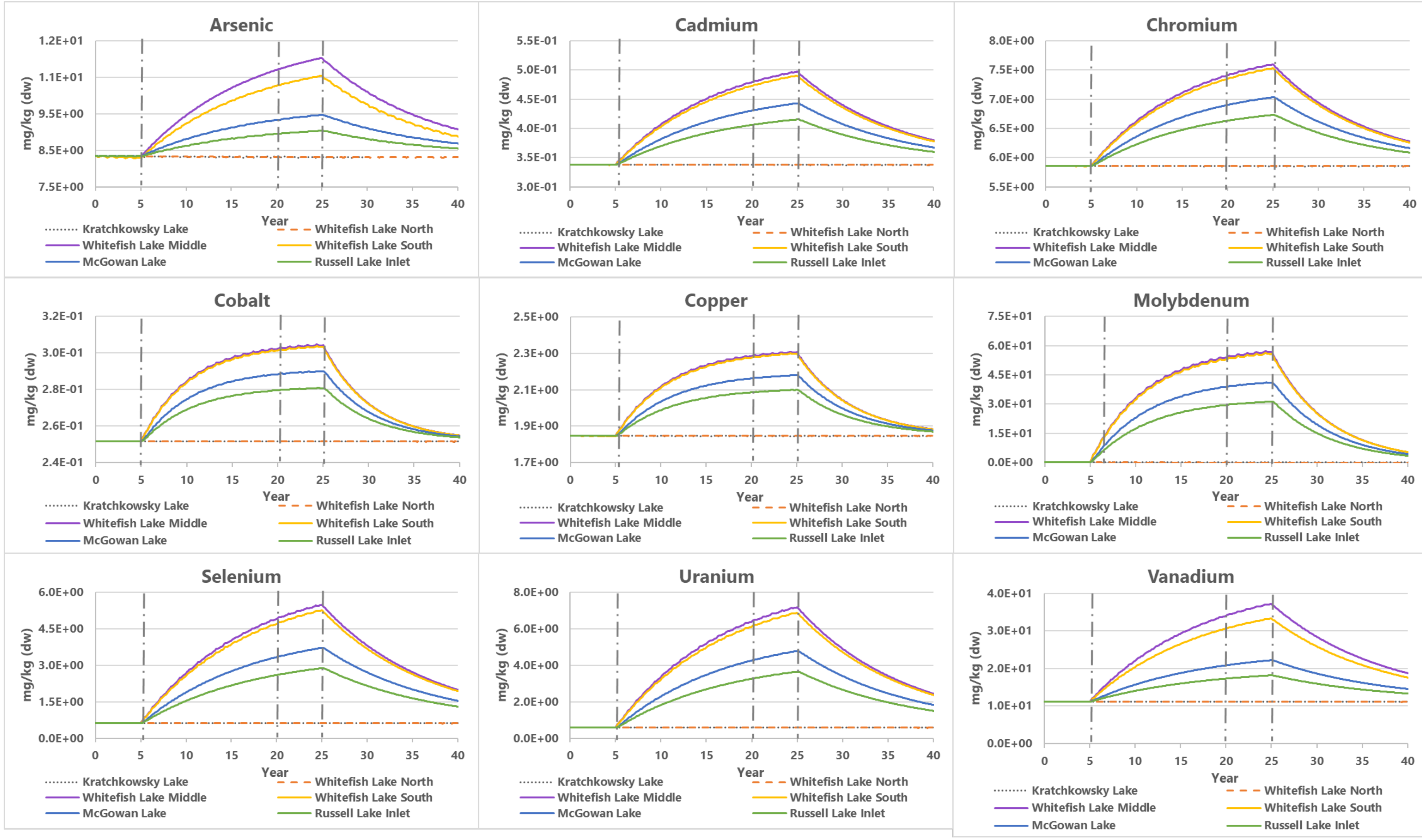
n/a = not applicable
Water quality guidelines are as shown in Table 3-1 and sediment quality guidelines are as shown in Table 3-6.

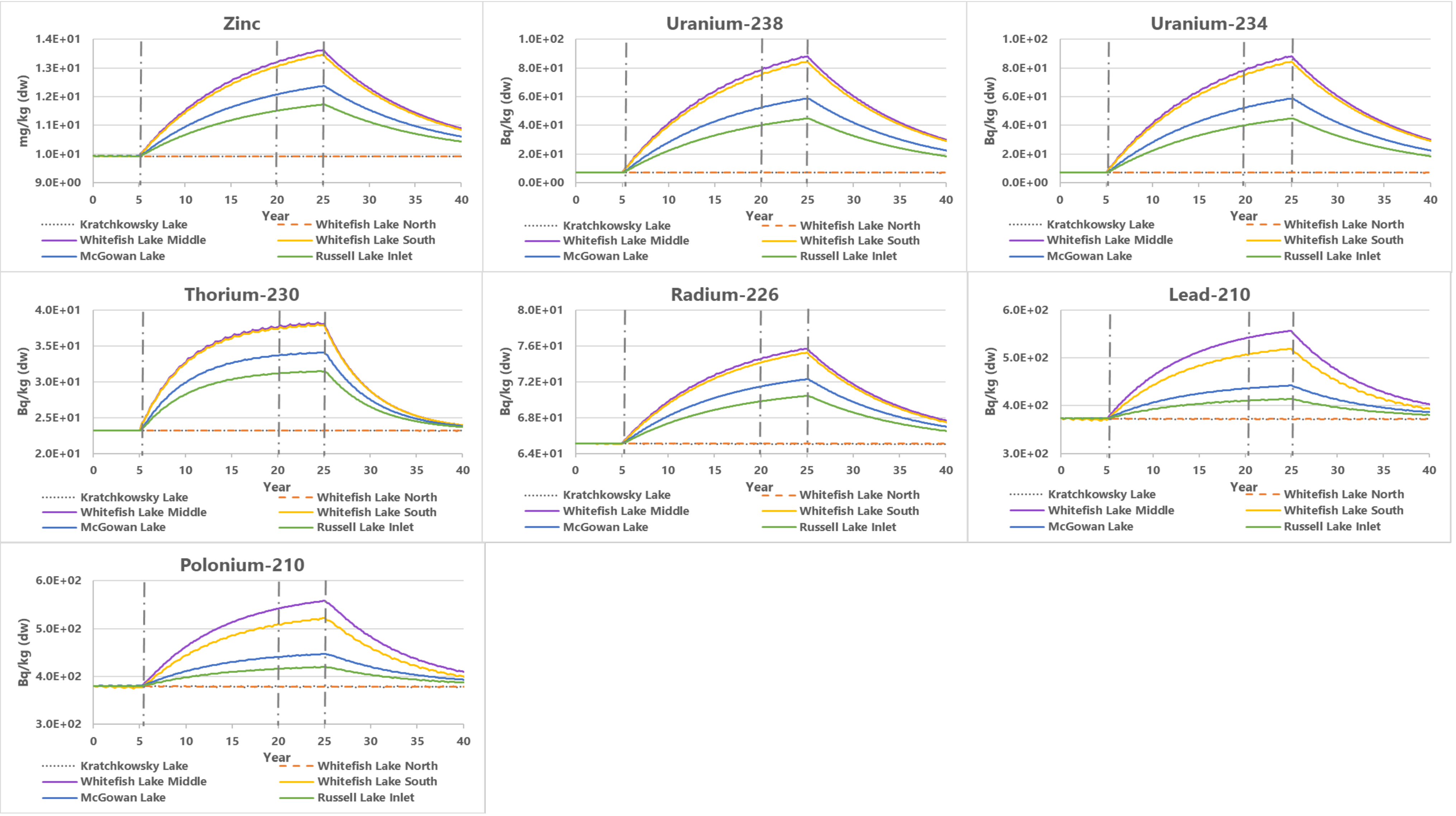

Arsenic
1.7E-04
1.5E-04
1.3E-04
1.1E-04
9.0E-05
7.0E-05
mg/L
0 5 10 15 20 25 30 35 40
Year
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
Cadmium
4.5E-05
4.0E-05
3.5E-05
3.0E-05
2.5E-05
2.0E-05
mg/L
0 5 10 15 20 25 30 35 40
Year
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
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
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
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
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
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
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
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
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
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
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
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
Kratchkowsky Lake
Whitefish Lake North
Whitefish Lake Middle
Whitefish Lake South
McGowan Lake
Russell Lake Inlet
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:

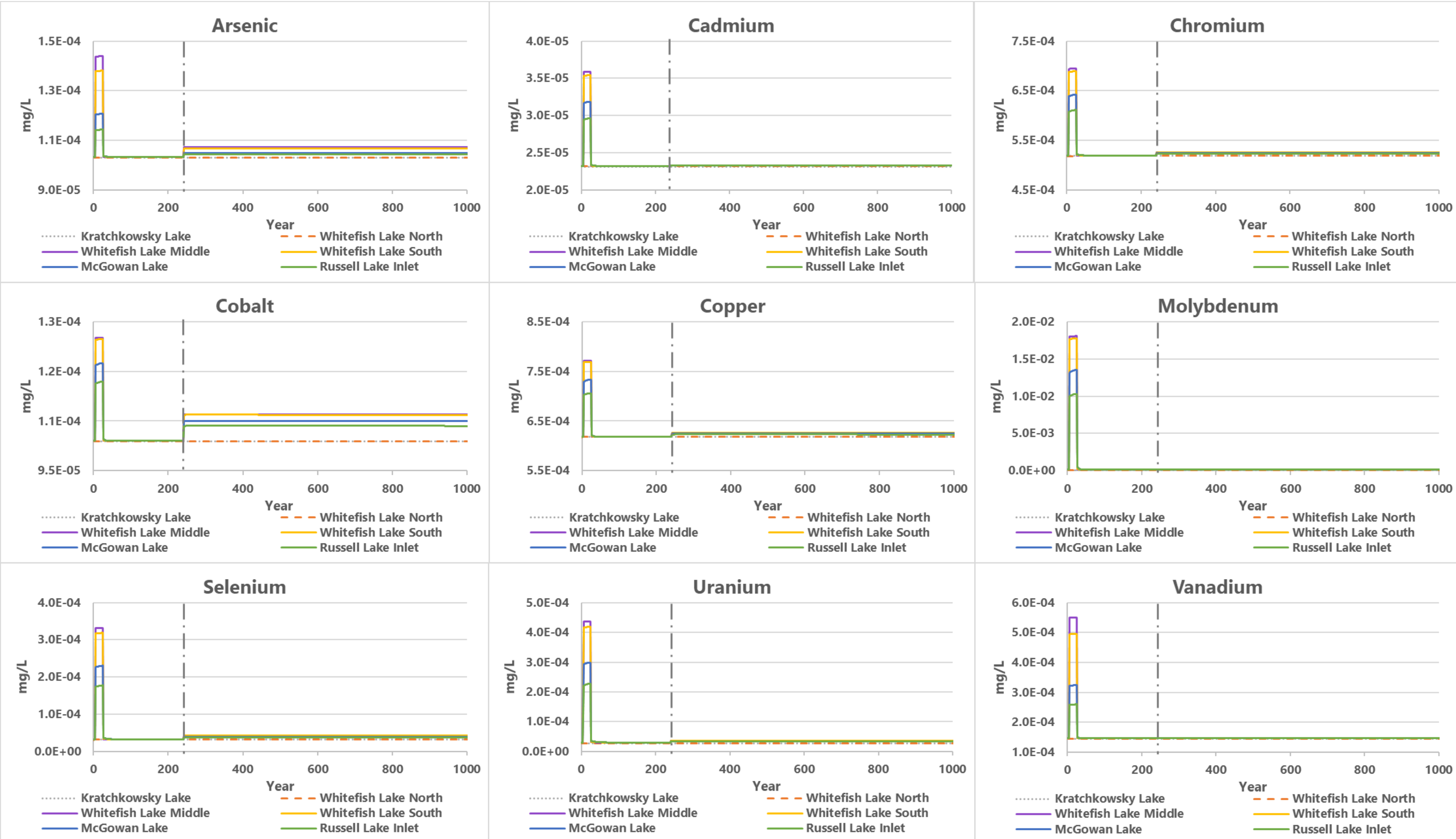
a) Estimated from uranium using the specific activity of 12356 Bq/g and assuming secular equilibrium between uranium-238 and uranium-234.
b) Unit conversion from mg/s to Bq/s using the specific activity of 7.47E+08 Bq/g which was calculated from its half-life of 77000 y.
c) Unit conversion from mg/s 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.

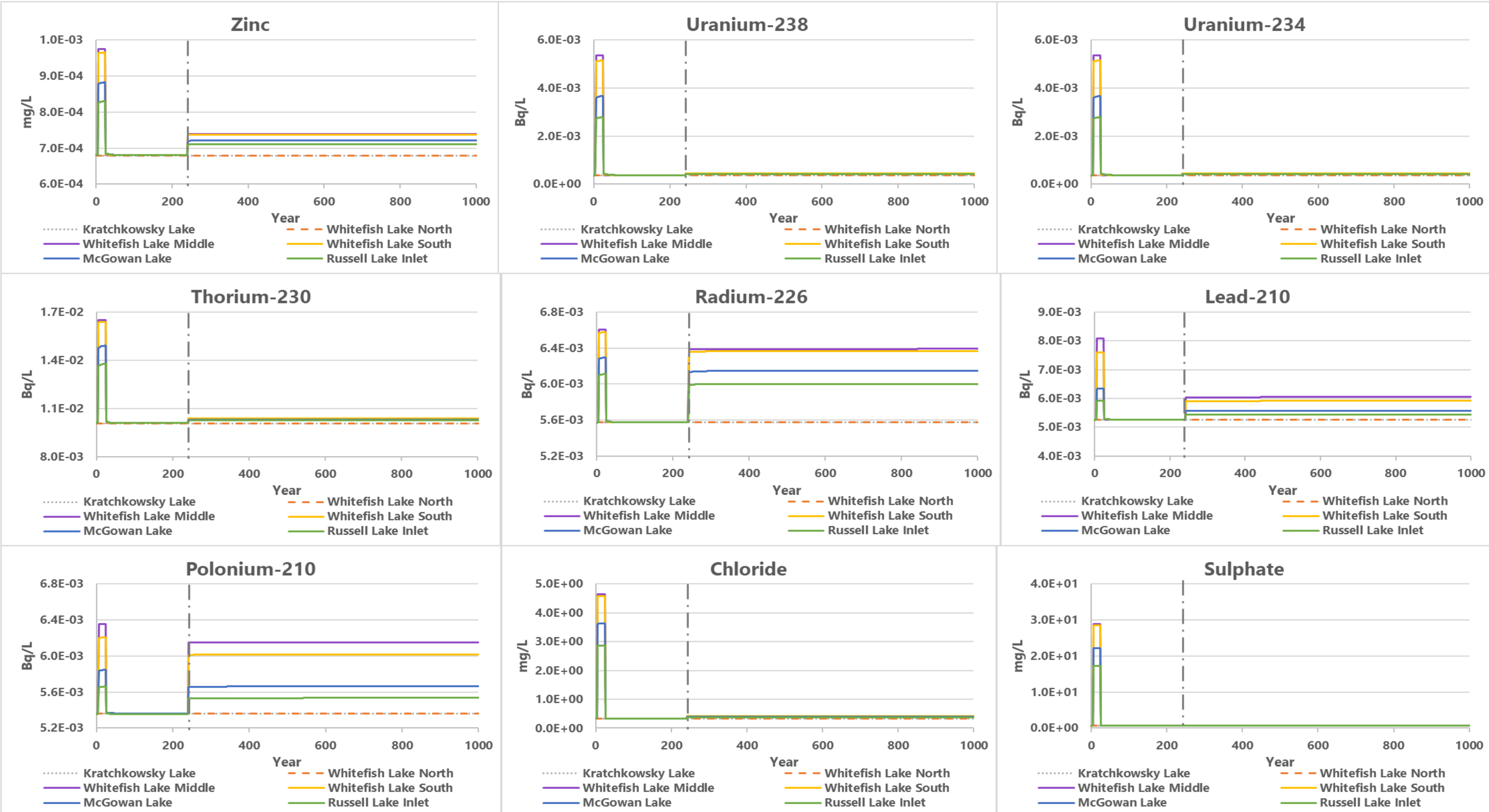
Table 3-5: Maximum Concentration of COPCs in Water and Sediment during Future Centuries

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

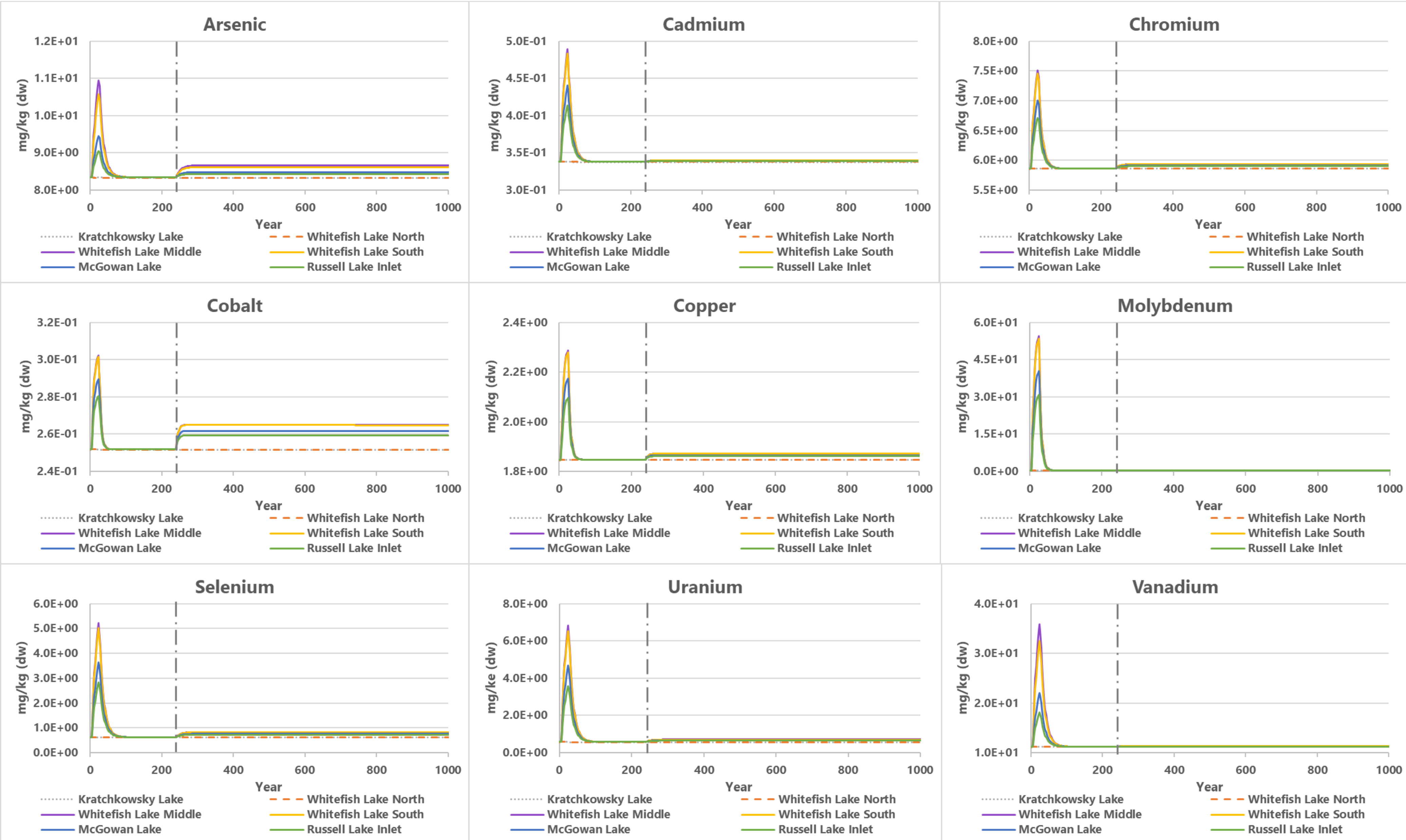
n/a = not applicable
Water quality guidelines are as shown in Table 3-1 and sediment quality guidelines are as shown in Table 3-6.

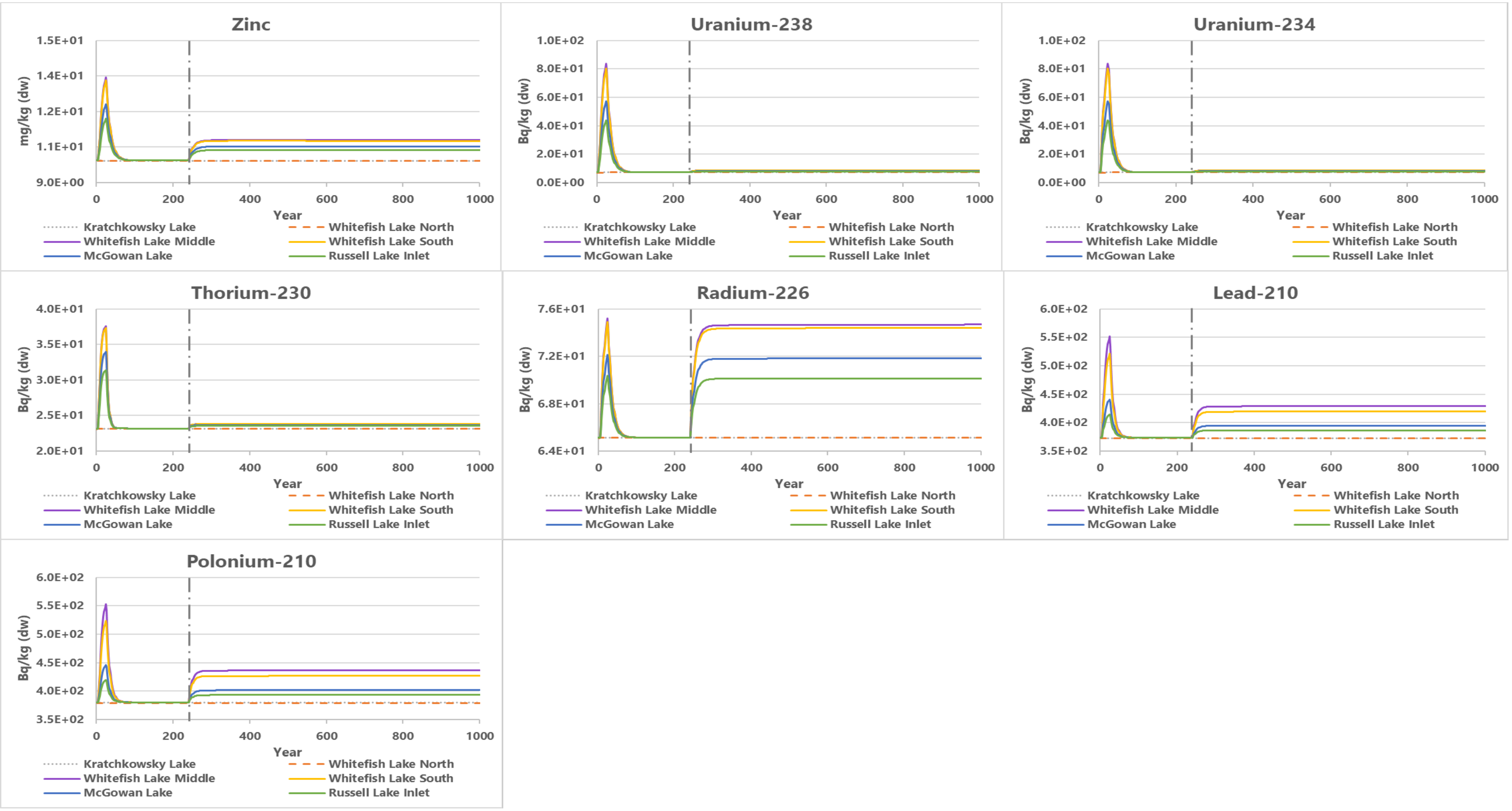

Arsenic
1.5E-04
1.3E-04
1.1E-04
9.0E-05
mg/L
0
200
400
600
800
1000
Year
Cadmium
4.0E-05
3.5E-05
3.0E-05
2.5E-05
2.0E-05
Chromium
7.5E-04
6.5E-04
5.5E-04
4.5E-04
Cobalt
1.3E-04
1.2E-04
1.1E-04
9.5E-05
Copper
8.5E-04
7.5E-04
6.5E-04
5.5E-04
Molybdenum
2.0E-02
1.5E-02
1.0E-02
5.0E-03
0.0E+00
Selenium
4.0E-04
3.0E-04
2.0E-04
1.0E-04
0.0E+00
Uranium
5.0E-04
4.0E-04
3.0E-04
2.0E-04
1.0E-04
0.0E+00
Vanadium
6.0E-04
5.0E-04
4.0E-04
3.0E-04
2.0E-04
1.0E-04
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 3-4: 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)
0
200
400
600
800
1000
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
200
400
600
800
1000
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
200
400
600
800
1000
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)
0
200
400
600
800
1000
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)
0
200
400
600
800
1000
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)
0
200
400
600
800
1000
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)
0
200
400
600
800
1000
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)
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/**).

3.1.2.4 Uncertainty in the Surface Water Quality Model

The surface water quality modelling reflects a conservative, science-based approach consistent with regulatory guidance. The uncertainty in the surface water model used relates to the following items:

- Availability of baseline data;
- Uncertainty in the inputs used to set up the model; and
- Uncertainty around the source terms.

Baseline water and sediment data from 2011-2019 were used to validate water-to-sediment partitioning coefficients (Kds) applied to the surface water quality model. Kd values were selected using regional published data calibrated for similar sites in northern Saskatchewan and in some cases derived from site-specific data (see Appendix A, Section 3.2 and 3.3). These Kd values were assumed to be stable over time. Additional uncertainty in baseline surface water and sediment quality data arise from data being below detection limits. Since concentrations at the detection limit were assumed to be equal to the detection limit, baseline concentrations may be overestimated.

The surface water quality model used inputs obtained from other models such as the regional hydrological model, consistent with Appendix 8-C of the EIS (Denison, 2024), and the groundwater models including PHREEQC for reactions and FEFLOW for transport. Any conservatisms or uncertainties in other models are carried forward into the surface water quality model. With respect to the groundwater model, COPC mass flux estimates from groundwater to the receiving waterbody (Whitefish Lake) evaluated in the ERA were for the "base case" scenario, that was an appropriately conservative conceptualization of subsurface conditions with respect to groundwater flow and contaminant transport. Uncertainty analysis was performed (Appendix 7-C to the EIS (Denison, 2024)), and the consistency in predicted concentrations in groundwater at Whitefish Lake, affirmed the base case as representative and provides confidence that risks are not underestimated in the ERA. In the groundwater flow model, model parameters for the base case were affirmed to be representative and conservative through a robust uncertainty assessment in which 50 sets of calibrated model parameters were generated.

With respect to hydrological data, streamflow monitoring data for the Project was available from 2011 to 2019 and was supplemented with data from Environment and Climate Change Canada hydrometric gauging station on the Wheeler River below Russell Lake. Average monthly flows in the waterbodies were used in the surface water model for the ERA to capture seasonal variability. Since the hydrological data is based on many years of measured site-specific data, the data used is a valid representation of existing flow conditions in the watershed, with minimal uncertainty.

The surface water quality model had inherent uncertainties associated with the source-term for treated effluent quality and the mass flux from groundwater (discussed in previous paragraph) into Whitefish Lake. To overcome these limitations and uncertainties, the source-terms applied conservative assumptions to ensure that potential environmental effects were not underestimated. Specific assumptions were made with respect to the treated effluent that will be released into Whitefish Lake during the operation and decommissioning phases of the Project. Treated effluent was assumed to be continuously released during the operation and decommissioning phases – whereas effluent is likely to be released intermittently. As well, effluent quality for constituents of interest were represented using reasonable upper bound concentrations. Reasonable upper bound concentrations were developed using a conservative approach intended to overestimate effluent concentrations that may be released to Whitefish Lake. For most constituents, these values were calculated by applying a safety factor (typically three) to expected concentrations obtained from laboratory-scale effluent treatment tests conducted by Denison. For a small number of constituents (including cadmium, chromium, and selenium) concentrations were instead derived based on ensuring that predicted surface water and sediment concentrations in the middle part of Whitefish Lake would not exceed applicable environmental quality guidelines. This method introduces a precautionary bias into the model inputs, supporting a conservative assessment of potential changes in surface water quality.

Overall, the precautionary approach was used to address uncertainty so that the predictions in the surface water quality model would not be underestimated. Ongoing water and sediment quality monitoring will be conducted as part of Denison's environmental monitoring program. The data will be used to continue to validate the surface water quality model and modify assumptions as needed to ensure the model is providing reasonable predictions.

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/m^3)								
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 $\mu g/m^3$ [1 ppm = 1880 $\mu g/m^3$) 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 $\mu g/m^3$) is supported. The maximum predicted concentration of 1-hour NO_2 was 355 $\mu g/m^3$, 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 $\mu g/m^3$), 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}.

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 3-12).

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 3-13), 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 3-12, 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 3-13.

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 3-13 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 3-14.

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 and confirmed with EFRN during an engagement meeting on March 26, 2025. 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 similar 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.

4.1.3.1 Physical Stressors

The EIS (Denison, 2024) considered noise as a physical stressor to humans in its assessment of Project-related effects (EIS Section 6.2). The assessment included an analysis of potential Project-related interactions between noise and sensitive receptor locations within the LSA and RSA (i.e., locations/areas where human health could be adversely affected by Potential Project-related changes in noise levels). For interactions resulting in a potential effect after mitigation, residual and cumulative effects analyses were conducted.

The Project is expected to introduce new sound sources to the environment through site clearing activities, construction of facilities, power generators, diesel-powered mobile equipment, drilling in the wellfield, on-site traffic and air traffic, chilling equipment associated with the freeze plant, and various equipment associated with the ISR process (e.g., pumps). Noise from these activities is expected to change the nature of the existing environment and to result in localized increases in sound levels. The assessment focused on potential effects at sensitive receptor locations, such as traditional land use areas, residences, and camps. These receptors formed the basis for modelled predictions and were used to evaluate compliance with applicable noise criteria.

Overall, potential changes in noise due to the Project are expected to pose little risk to human health. Noise levels were thoroughly assessed using industry-standard methods and models, and no exceedances of provincial or federal noise standards were predicted at sensitive locations during any Project phase. Increases in sound levels were predicted to result in a moderate effect at one receptor location (a seasonal leased cabin) during Construction in the daytime hours, which may be perceptible and potentially objectionable. As a conservative measure, this was carried forward in the EIS as a residual effect. However, the assessment in the EIS found that the residual effect would be infrequent, short-term, and limited in geographic extent. Mitigation and monitoring plans will be in place to further ensure that noise remains within safe and acceptable limits. Given the results of the EIS, noise is not assessed further as part of the ERA.

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

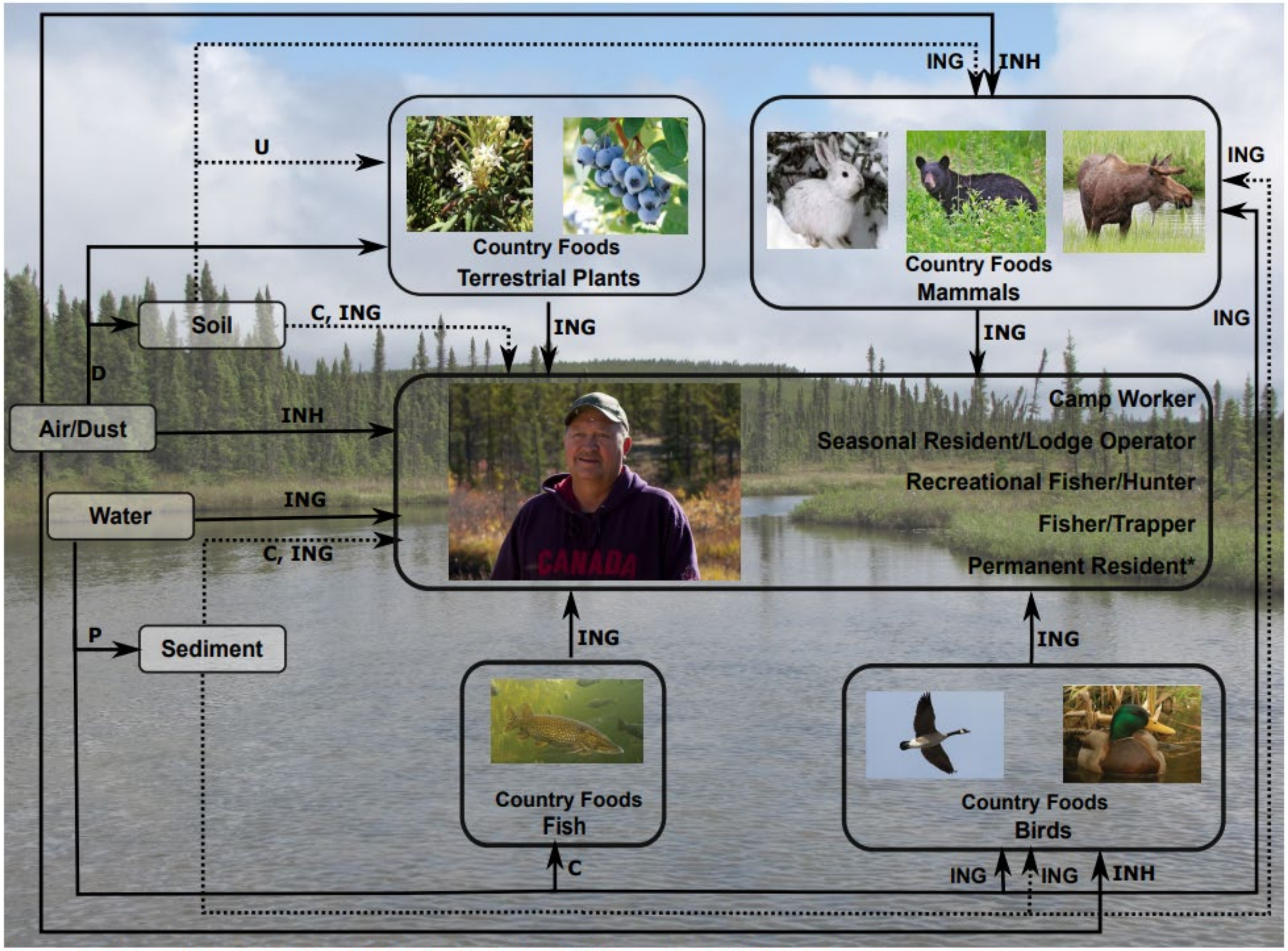
Radiological and non-radiological exposure pathways were assessed in the HHRA. The primary exposure routes for human health included:

- 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

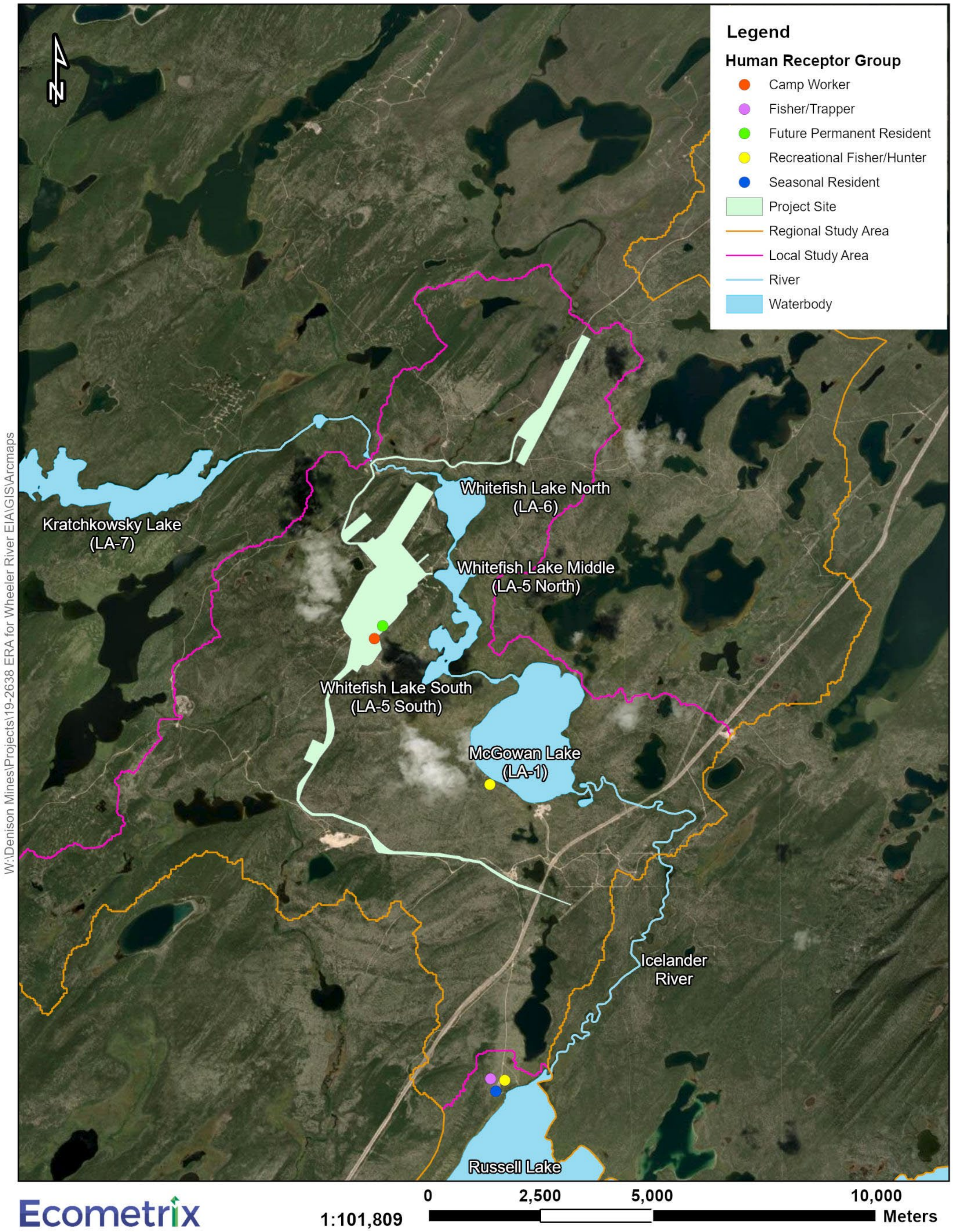


Figure 4-2: Human Receptor Locations for the Wheeler River HHRA

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**

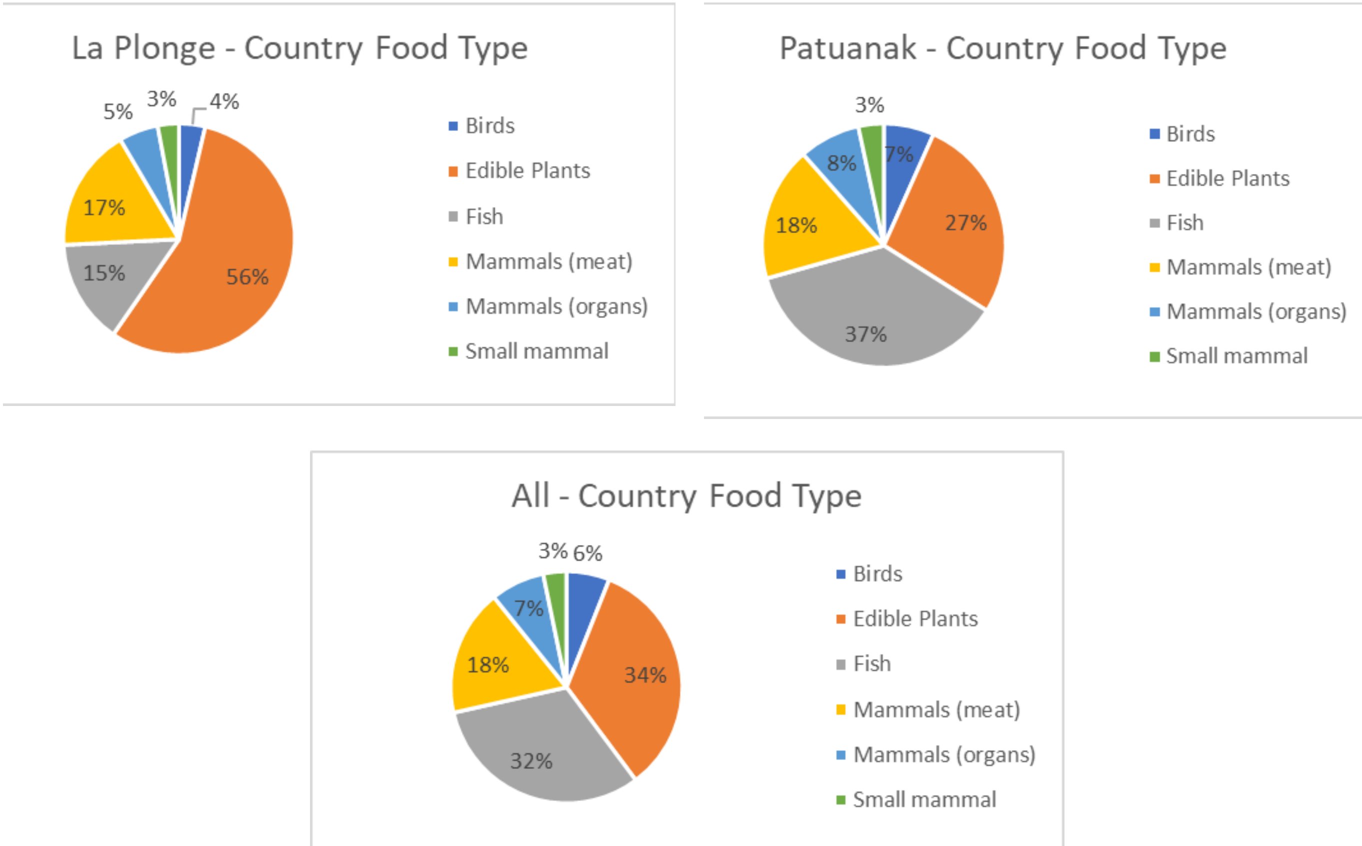


Figure 4-3: Proportion of Food Types in ERFN Traditional Food Diet

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). Additionally, in an engagement meeting with the ERFN on March 26, 2025, the ERFN confirmed that consumption rates for the high consumer of Traditional Foods receptor are representative of the maximum consumption rate for an ERFN fisher/trapper utilizing the land at the Wheeler River Project.

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 3-13. 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
Rec F/H One-year-old (Russell Lake)	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**
	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	Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
		Non-radiological Dose by Pathway during Project Phases (mg/kg/d)									
	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**
Seasonal Resident Adult (Russell Lake)	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									
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**
		Baseline Dose									
Rec F/H (Russell Lake)	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	Is the Traditional Foods diet representative of local consumers? • 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	• The uncertainty is addressed by selecting appropriately conservative but representative diets. • Receptors included an average consumer (ERFN country foods study) and a high consumer (Bobby John diet) of Traditional Foods to provide a range of exposure levels for different types of consumers. • For average consumers of Traditional Foods, the Patuanak diet from the ERFN country foods study was conservatively applied since those residents are higher consumers of traditional foods than La Plonge. • High consumer of Traditional Foods is conservative for fish and caribou consumption in diet compared to ERFN and compared to high consumer for the Boreal Shield in the First Nations Food, Nutrition and Environment Study for Saskatchewan (see Section 4.4.1.1) • Based the total food intake for male and female receptors on an adult male diet (N288.1-20 central tendency), which is

Area of Uncertainty	Description of Uncertainty	How Uncertainty has been Addressed
		conservative since males ingest greater quantities of food than females. • Used available information from Indigenous and Local Knowledge in developing the diet to provide a representative assessment.
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	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
Rec F/H One-year-old (Russell Lake)		**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
	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									
Seasonal Resident (Russell Lake)	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	<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
Rec F/H Adult (Russell Lake)		**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
		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	Water (internal)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic Plants	Aquatic Animals	Terrestrial Plants	Terrestrial Animals	Total by COPC
		HQ during Future Centuries									
	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 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 <u>Alaskan clubmoss</u> (ranked S2) and <u>three-seeded sedge (ranked S3)</u>.	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						
<u>Woodland caribou</u> (*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 <u>river otter</u>.	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*****						
<u>Olive-sided flycatcher</u> (*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 <u>barn swallow</u> and <u>common nighthawk</u>.	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: 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	Selection Rationale and Applicable Criteria[1,2,3]
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 Major Plant/Animal Group	2 Facility or Stakeholder Importance*	3 Ecological Significance**	4 Socio-Economic Significance***	5 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.
<u>Species names that are highlighted and underlined</u> 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.

5.1.4.1 Physical Stressors

The physical stressors to environmental health that are assessed in the EIS (Denison, 2024) include noise (EIS Section 6.2), sensory disturbance effects (including noise, vibration, dust deposition, and artificial light; EIS Sections 9.3 and 9.4), heat (EIS Sections 8.2 and 8.3), wildlife-vehicle collisions (EIS Sections 9.3 and 9.4), bird-structure collisions (EIS Section 9.4), and entrapment in Project facilities (EIS Sections 9.3 and 9.4). Assessments included an analysis of potential Project-related interactions between physical stressors and aquatic and/or terrestrial VCs within the LSA and RSA. For interactions resulting in a potential effect after mitigation, residual and cumulative effects analyses were conducted.

The Project is expected to introduce new sound sources to the environment through site clearing activities, construction of facilities, power generators, diesel-powered mobile equipment, drilling in the wellfield, on-site traffic and air traffic, chilling equipment associated with the freeze plant, and various equipment associated with the ISR process (e.g., pumps). Noise from these activities is expected to change the nature of the existing environment and to result in localized increases in sound levels. The EIS (Section 6.2) focused on potential effects at sensitive receptor locations (i.e., locations/areas where the health of humans or wildlife could be adversely affected by potential Project-related changes in noise levels), such as traditional land use areas, residences and camps, and ecological receptor locations. These receptors formed the basis for modelled predictions and were used to evaluate compliance with applicable noise criteria. Overall, potential changes in noise due to the Project are expected to pose little risk to environmental health. Noise levels were thoroughly assessed using industry-standard methods and models, and no exceedances of provincial or federal noise standards were predicted at sensitive locations during any Project phase. No residual or cumulative effects were predicted for wildlife. Mitigation and monitoring plans will be in place to further ensure that noise remains within safe and acceptable limits.

Surface water intake and effluent discharge may result in localized physical stress to aquatic systems through changes in surface water quantity and quality and through changes in aquatic habitat structure. As discussed in EIS Section 8, potential effects include minor reductions in flow, localized changes in water quality parameters, and disturbance to benthic habitat due to infrastructure installation. In particular, installation of the effluent discharge diffuser, a multiport structure proposed for placement in Whitefish Lake, would overprint a small portion of lakebed habitat and potentially alter local water movement. These changes were assessed in relation to potential effects on surface water quantity (EIS Section 8.1), surface water quality (EIS Section 8.2), fish and fish habitat (EIS Section 8.3), sediment quality and benthic invertebrates (EIS Section 8.4), and fish health (EIS Section 8.5). Hydrological modelling was used to characterize changes in water levels and flow. Mitigation measures to avoid or reduce physical stress include implementation of a Surface Water Management Program, minimizing freshwater withdrawals through water recycling, and following federal guidelines for intake and in-water works. The diffuser was also designed to have a limited footprint and to promote rapid mixing within a defined mixing zone, which will minimize habitat overprinting and disturbance to benthic habitats. With these mitigation measures in place, residual effects are predicted to be low in magnitude, localized, fully reversible, and unlikely to result in adverse population-level impacts to aquatic biota.

Heat was assessed through potential changes in water temperature. As discussed in EIS Section 8.2 and 8.3, during winter, discharge pond temperatures are expected to be maintained at approximately 5°C to prevent freezing, while ambient lake water beneath the ice is expected to be around 3–4°C. This results in a localized temperature differential of only 1–2°C. Beyond the mixing zone, modeled temperature increases are negligible (~0.2°C) and not expected to exceed CCME guidelines for thermal exposure (i.e. maximum weekly average temperature criteria and short-term maximum temperature criteria; (CCME, 2003)). The assessment concludes that thermal effects are minor in magnitude, spatially limited, and temporally constrained, with no significant adverse effects anticipated for aquatic biota.

The EIS assessed potential Project-related sensory disturbance effects on wildlife VCs, which include ungulates, furbearers, Woodland Caribou, raptors, migratory breeding birds, and bird species at risk (EIS Sections 9.3 and 9.4). Sensory disturbances may displace wildlife, alter habitat selection patterns, lower feeding opportunities and/or reduce vegetation palatability (due to dust), and interfere with reproductive and foraging behaviours. To reduce sensory disturbances to wildlife, especially during sensitive periods, such as breeding and calving periods, Denison will implement several mitigation strategies, which include using low sound emission equipment, installing silencers or mufflers, avoiding excessive noise-generating activities (especially during sensitive time periods, like nesting), directing lighting only at active work areas, and employing dust suppression techniques, such as road wetting. With these mitigation measures in place, residual effects are predicted to be of low magnitude, local in extent, and fully reversible. Therefore, residual effects are assessed as not significant, with no anticipated impact on the ability of regional wildlife populations to sustain themselves.

The EIS also assessed wildlife-vehicle collisions effects on wildlife VCs (EIS Sections 9.3 and 9.4). Vehicle collisions were identified as a potential source of direct mortality for wildlife. These collisions could occur due to increased traffic volumes related Construction, Operation, and Decommissioning activities. The EIS includes a suite of mitigation measures focused on reducing collision risks. These include implementing speed limits and appropriate road signage, maintaining clear sightlines and snowbank gaps along roads, designing ditches and culverts to reduce wildlife attractants, managing vegetation to discourage roadside foraging, and requiring vehicles to yield to wildlife. Traffic volume will also be managed through convoy scheduling and limiting non-essential access. Employees will be trained to report wildlife sightings and roadkill, and wildlife deterrence strategies will be applied where needed. The residual effect of wildlife-vehicle collisions is expected to be of low magnitude and infrequent, with effects predicted to decline post-decommissioning as project activities cease and infrastructure is removed. Cumulative effects are also assessed as low and not significant, as similar mitigation practices are expected to be applied across projects. Both residual and cumulative effects are considered fully reversible and are not anticipated to alter the viability of regional wildlife populations.

Bird-structure collisions are also discussed in the EIS (Section 9.4). The Project has the potential to increase bird mortality from collisions with buildings, windows, and other project components, as well as from electrocution or collisions associated with power transmission lines and energized infrastructure. To mitigate these effects, the Project will use deflectors on power transmission lines leading to Project components, where appropriate, and will implement measures to discourage birds from nesting on utility poles. Additionally, employees will be trained to avoid disturbing birds. The residual effects of bird mortality are predicted to be of low magnitude and regional in extent, occurring intermittently throughout the Project's lifecycle. With mitigation in place, effects are not anticipated to result in population-level changes for bird species, including species at risk. The EIS concludes that both residual and cumulative effects are not significant and fully reversible over the long term, particularly as project components are decommissioned and habitats are reclaimed post-closure.

Entrapment in Project facilities is discussed in EIS Sections 9.3 and 9.4. Entrapment in facilities, such as buildings, snow berms, waste ponds, or treatment ponds, may result in direct mortality of wildlife. Mitigation measures to reduce the risk of direct mortality to mammals include exclusion fencing around pads and ponds and the implementation of breaks in snowbanks. Buildings and other Project components will also be designed and maintained to exclude mammals from using buildings for refuge or shelter, and to deter wildlife from potentially becoming entrapped. Buildings and other Project infrastructure will also be designed and maintained to exclude bats and birds as much as possible. This may include installing solid barriers (e.g., corner slope panels or 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 avian use of buildings and other Project infrastructure for refuge, shelter, or nesting, and to deter birds from potentially becoming entrapped. Physical, visual, and/or auditory deterrents and exclusion measures will be employed around hazardous materials to discourage avian use as required. Wildlife mortality from entrapment is expected to have low magnitude, regional impacts that may occur intermittently throughout the Project's lifecycle. With mitigation measures in place, effects are not expected to lead to population-level impacts. The EIS concludes that any residual and cumulative effects on wildlife will not be significant and will be fully reversible, particularly following decommissioning and habitat restoration.

Given that the EIS did not identify physical stressors as having significant impacts on ecological receptors, physical stressors are not assessed further as part of the ERA.

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 Sediment Browse Lichen Macrophytes
	Snowshoe hare	Direct contact	On soil
		Inhalation	Air
		Ingestion	Water Soil

Category	Ecological Receptor	Exposure Pathways	Environmental Media
			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
		Inhalation	Air
		Ingestion	Water Sediment Benthic invertebrates Macrophytes
	American mink	Direct contact	In water On soil On sediment
		Inhalation	Air

Category	Ecological Receptor	Exposure Pathways	Environmental Media
		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
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

Category	Ecological Receptor	Exposure Pathways	Environmental Media
		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.

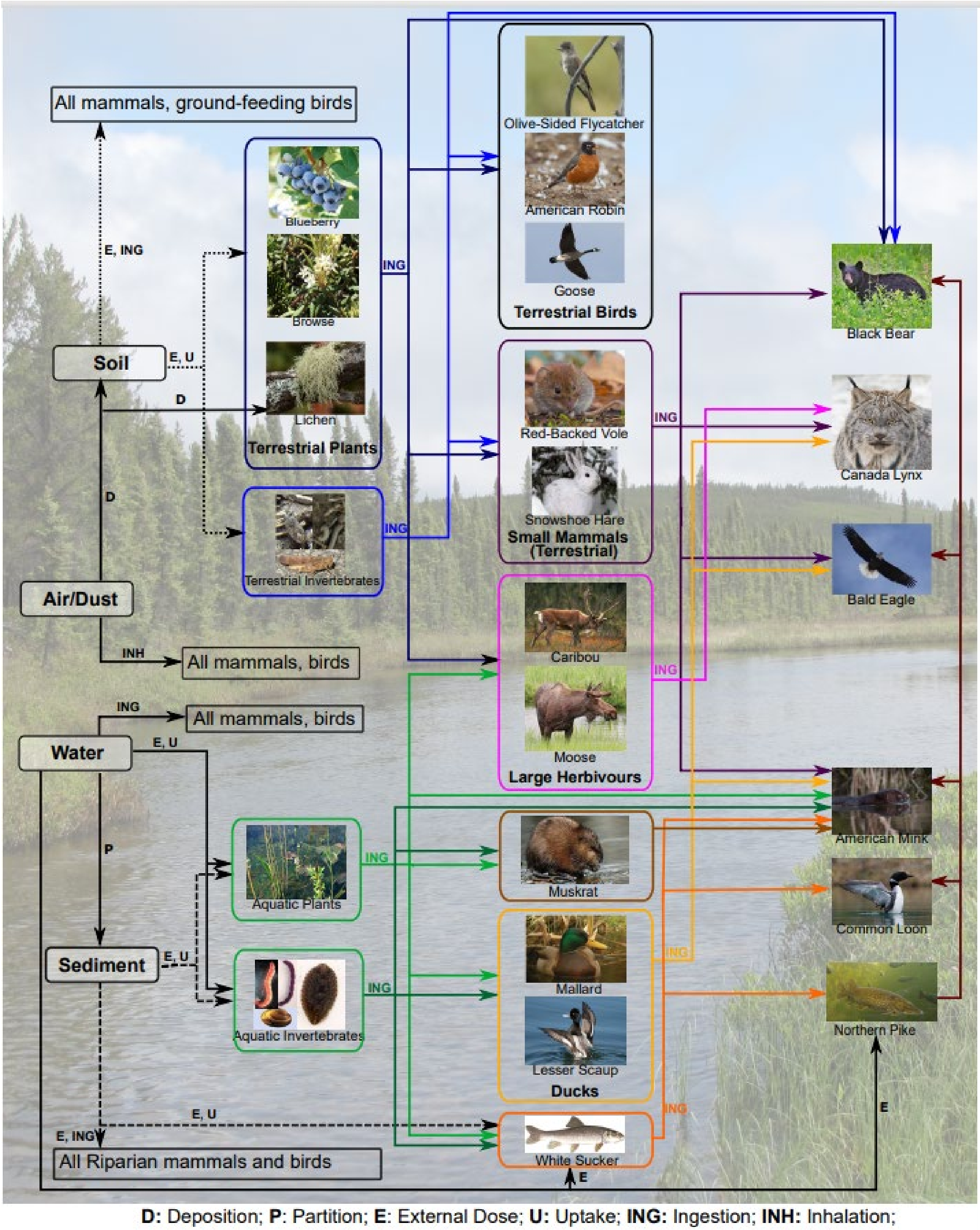


Figure 5-1: Ecological CSM for the Wheeler River Project

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.

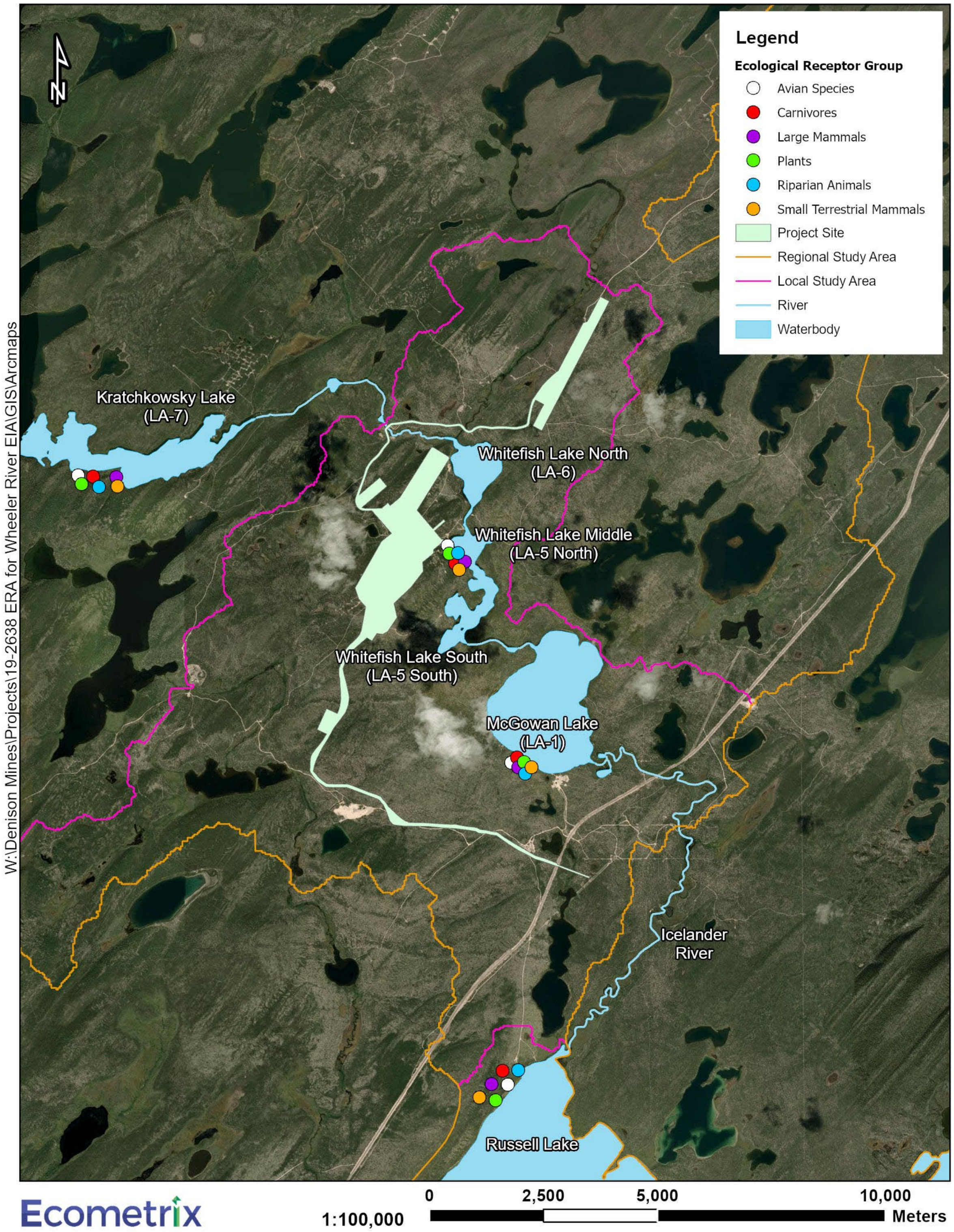


Figure 5-2: Locations of Ecological Receptors Assessed in the Ecological Risk Assessment

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, 2008, 2011a). 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]	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	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.
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.

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.

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.

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 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).

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	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	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	**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	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

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 Sensitivity Analysis

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.

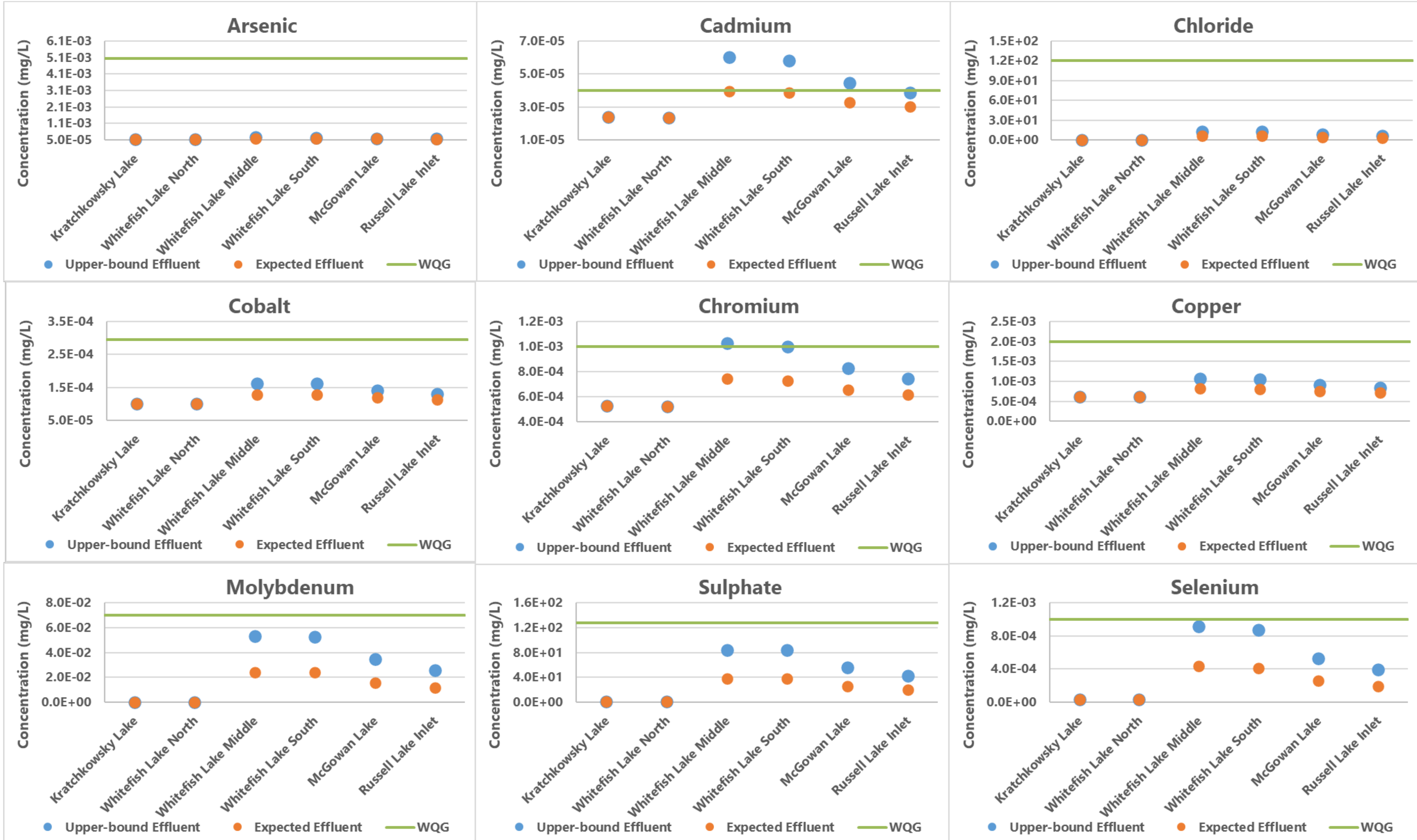
The predicted maximum molybdenum concentration in sediment is predicted to be 57.2 mg/kg dw in Whitefish Lake Middle at the expected discharge rate and 125 mg/kg dw in Whitefish Lake Middle at the upper bound discharge rate. Both values are above its reference (REF) value of 23 mg/kg dw, but below its no-effect (NE2) sediment quality benchmark of 245 mg/kg dw.

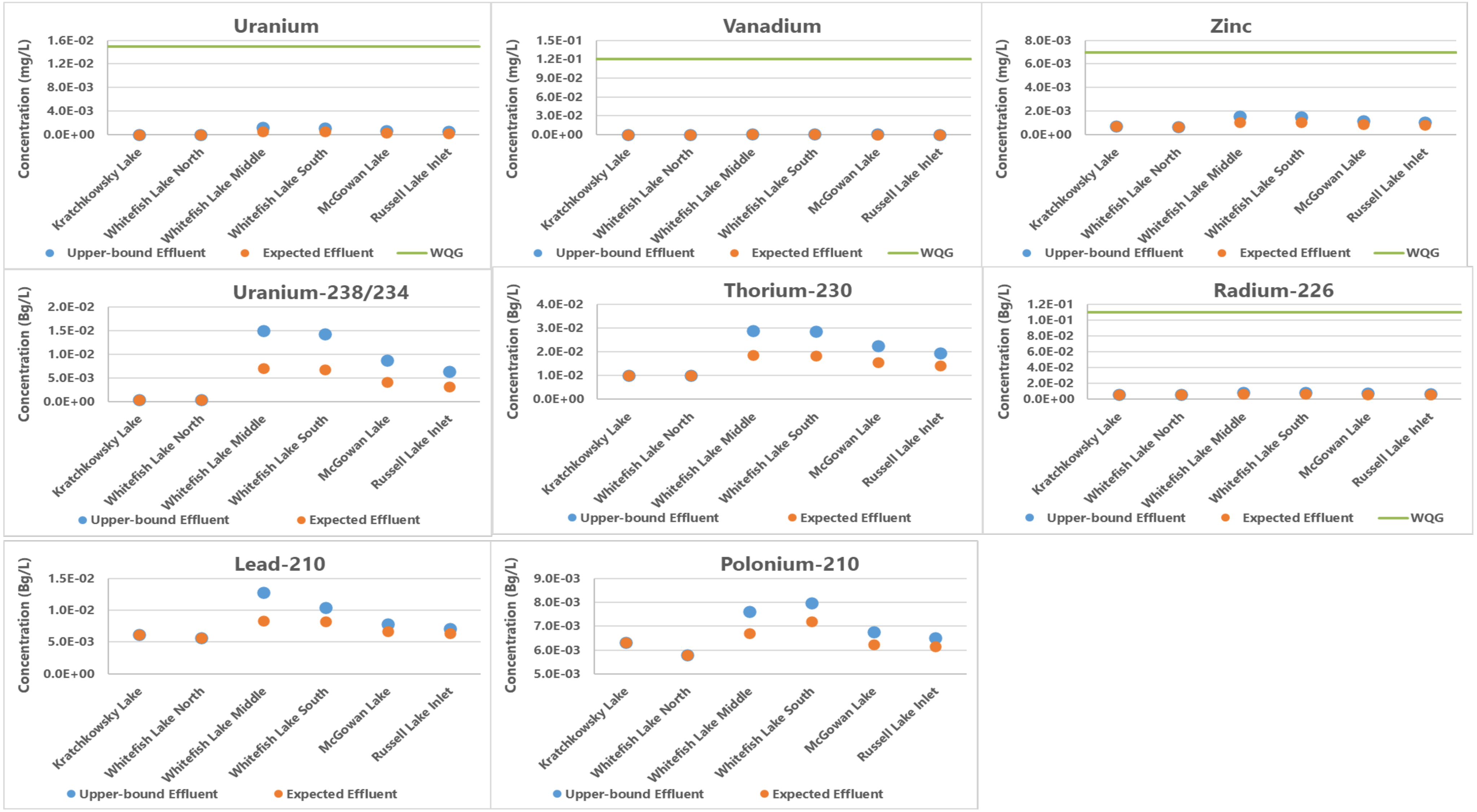
The maximum selenium concentration in sediment is 5.48 mg/kg dw in Whitefish Lake Middle at the expected discharge rate and 11.3 mg/kg dw in Whitefish Lake Middle at the upper bound discharge rate. Both values are above its REF value of 3.6 mg/kg dw, but below its NE2 value of 30 mg/kg dw.

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

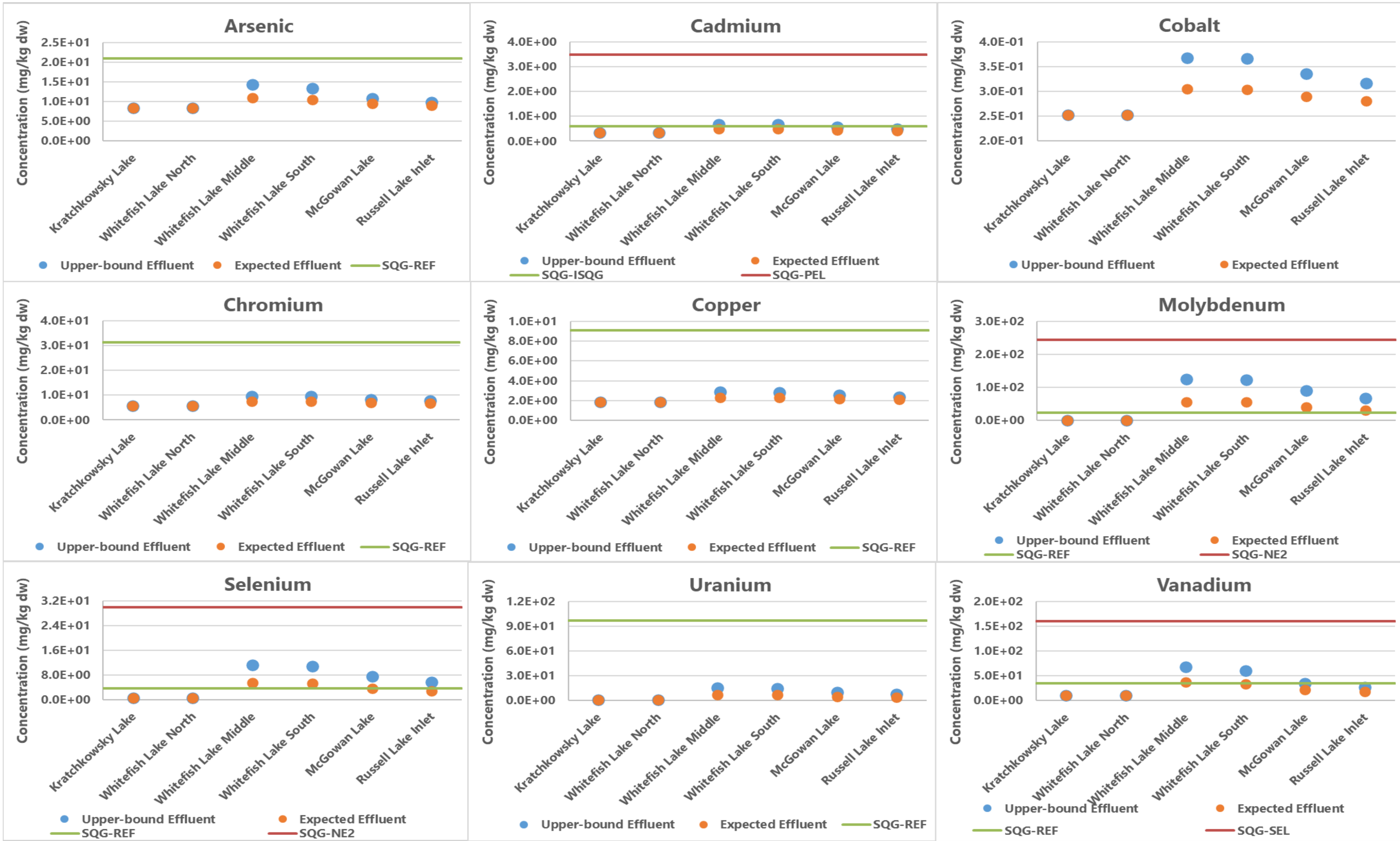
Liber, 2013). The predicted sediment concentration for exceedances of a REF or LEL value are not indicative of adverse effects to benthic communities but do suggest that further investigation may be warranted. The LEL represents a concentration in sediment that the majority of benthic organisms can tolerate, 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.

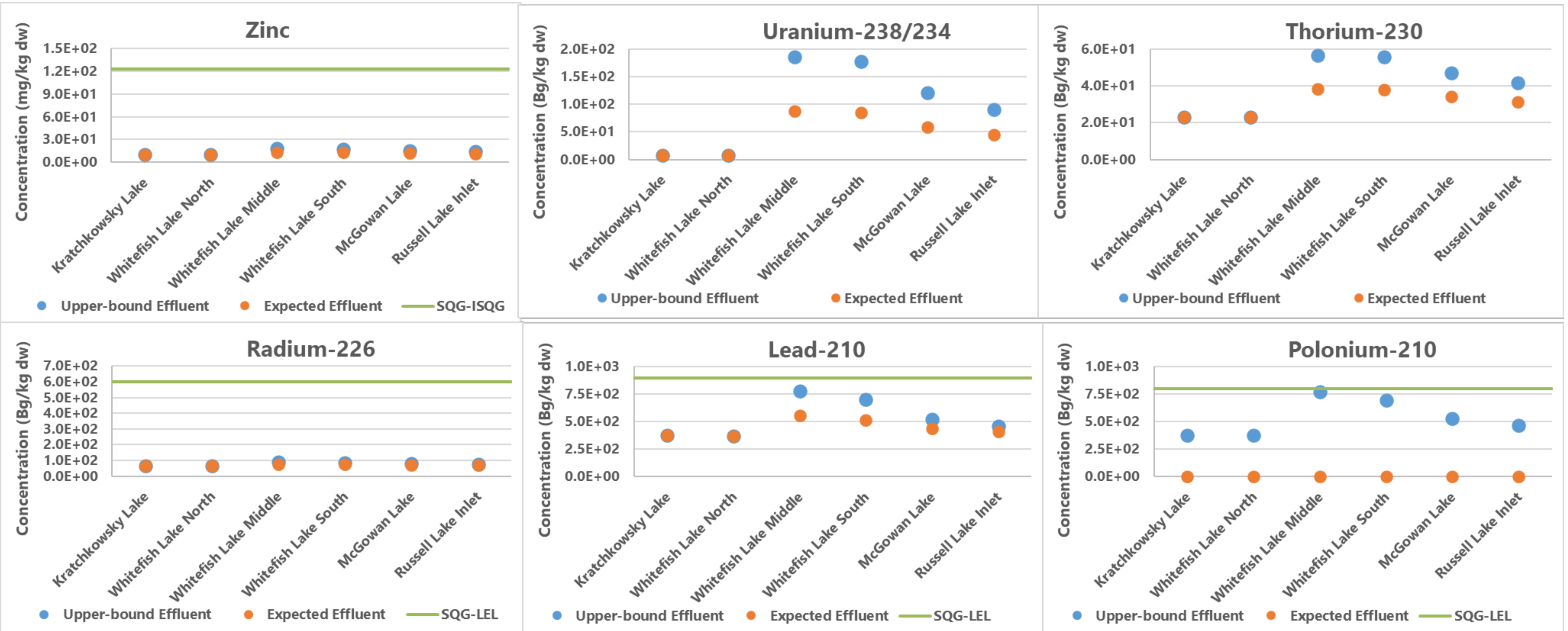

Arsenic
Concentration (mg/L)
6.1E-03
5.1E-03
4.1E-03
3.1E-03
2.1E-03
1.1E-03
5.0E-05
Cadmium
7.0E-05
5.0E-05
3.0E-05
1.0E-05
Chloride
1.5E+02
1.2E+02
9.0E+01
6.0E+01
3.0E+01
0.0E+00
Cobalt
3.5E-04
2.5E-04
1.5E-04
5.0E-05
Chromium
1.2E-03
1.0E-03
8.0E-04
6.0E-04
4.0E-04
Copper
2.5E-03
2.0E-03
1.5E-03
1.0E-03
5.0E-04
0.0E+00
Molybdenum
8.0E-02
6.0E-02
4.0E-02
2.0E-02
0.0E+00
Sulphate
1.6E+02
1.2E+02
8.0E+01
4.0E+01
0.0E+00
Selenium
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

6.2.3 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

6.2.3.1 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.

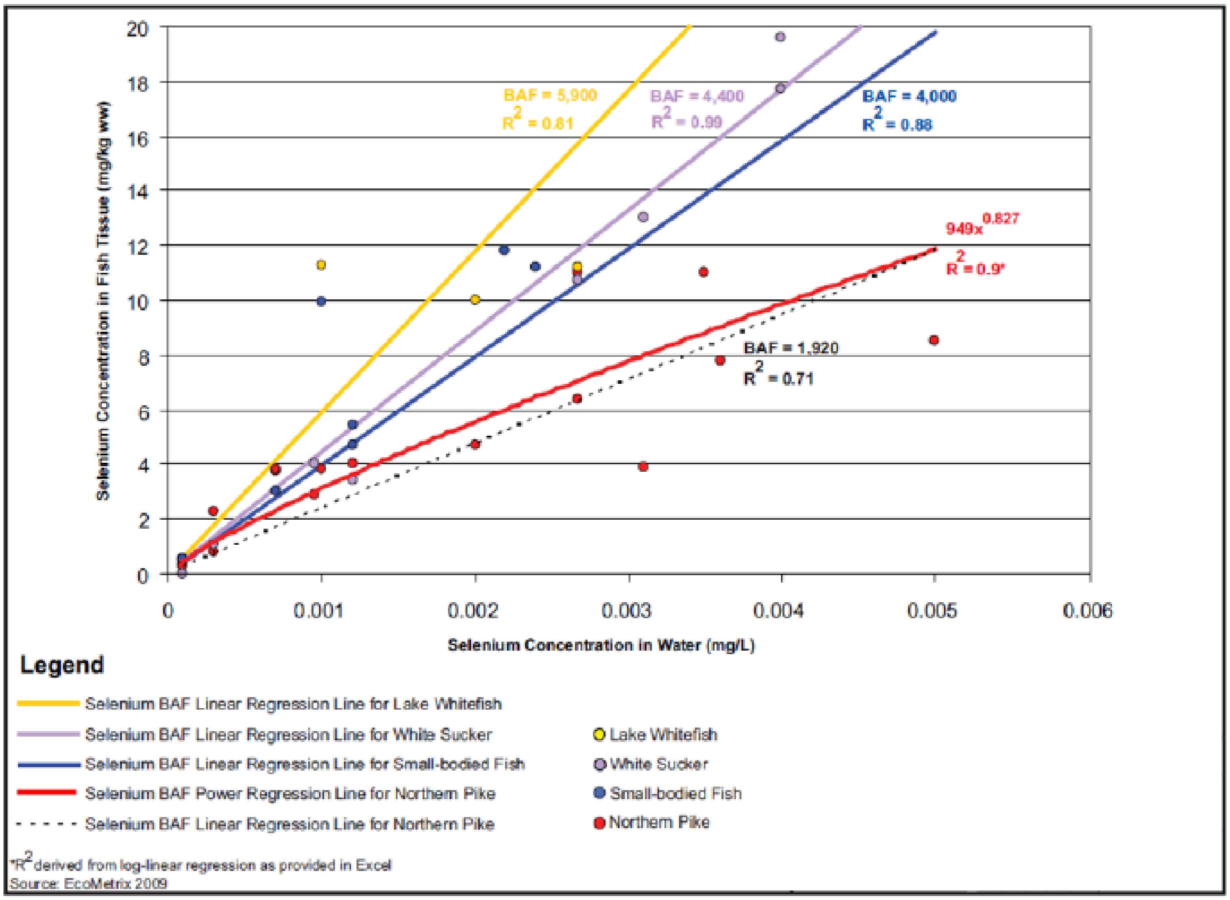


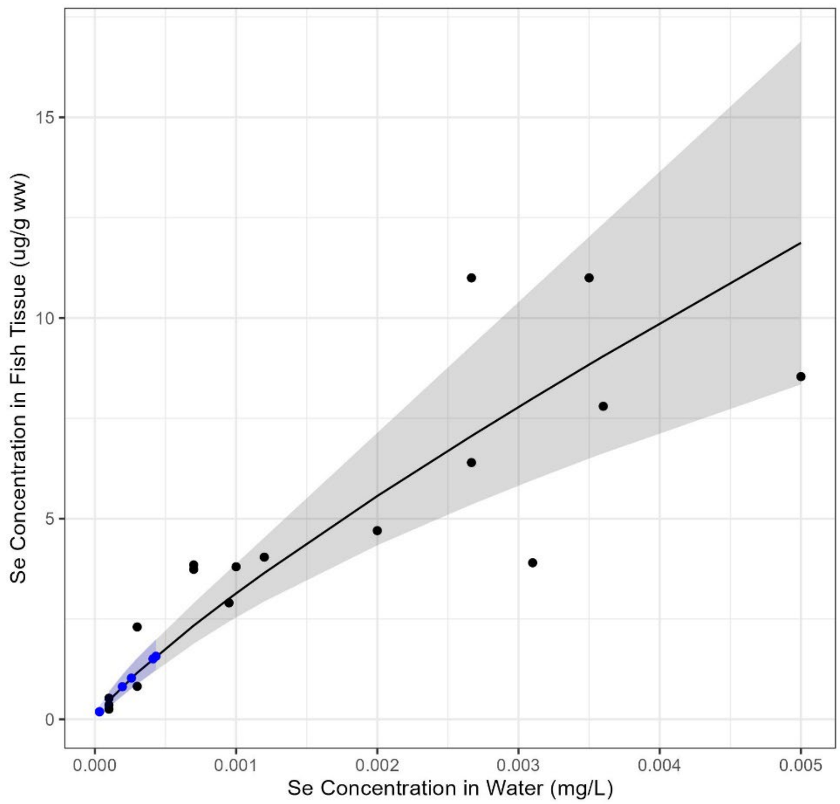
Figure 6-3: Development of Regional Fish BAFs for Selenium in Saskatchewan

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.

6.2.4 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 it is expected that hardness will increase to approximately 250 mg/L and pH will increase to approximately 7, the BLM was re-run under updated site 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	0.0052	mg/L	Fathead minnow, growth (IC_{10} = 0.0026 mg/L)	FEQG BLM
	Predator fish	0.0008	mg/L	White sturgeon, growth (EC_{10} = 0.0004 mg/L)	FEQG BLM
	Zooplankton	0.0009	mg/L	Daphnia magna, reproduction (EC_{10} = 0.0004 mg/L)	FEQG BLM
	Benthic invertebrates	0.0004	mg/L	Pond snail, growth (EC_{10} = 0.0002 mg/L)	FEQG BLM
	Phytoplankton	0.0091	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	0.025	mg/L	Fathead minnow, growth (IC_{10} = 0.012 mg/L)	FEQG BLM
	Predator fish	0.005	mg/L	White sturgeon, growth (EC_{10} = 0.002 mg/L)	FEQG BLM
	Zooplankton	0.005	mg/L	Daphnia magna, reproduction (EC_{10} = 0.003 mg/L)	FEQG BLM
	Benthic invertebrates	0.003	mg/L	Pond snail, growth (EC_{10} = 0.001 mg/L)	FEQG BLM
	Phytoplankton	0.040	mg/L	Rotifer, intrinsic (EC_{10} = 0.02 mg/L)	FEQG BLM
	Aquatic plants	0.014	mg/L	Duckweed, root length (EC_{10} = 0.007 mg/L)	FEQG BLM

Notes:
BLM based on hardness of 250 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 more realistic site conditions for hardness and pH, HQs for all aquatic organisms are less than 1 at all locations, indicating no adverse effects to aquatic organisms from facility related copper. It is relevant to consider all aspects of the receiving environment, and this includes induced hardness 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	0.03	0.14	0.12	0.25	0.02	0.05
Whitefish Lake Middle	8.22E-04	0.16	**1.06**	0.93	**1.97**	0.09	0.04	0.03	0.18	0.16	0.33	0.02	0.06
Whitefish Lake South	8.17E-04	0.16	**1.05**	0.92	**1.96**	0.09	0.04	0.03	0.18	0.16	0.32	0.02	0.06
McGowan Lake	7.50E-04	0.14	0.97	0.85	**1.80**	0.08	0.04	0.03	0.16	0.14	0.30	0.02	0.05
Icelander River	7.49E-04	0.14	0.97	0.84	**1.80**	0.08	0.04	0.03	0.16	0.14	0.30	0.02	0.05
Russell Lake Inlet	7.17E-04	0.14	0.92	0.81	**1.72**	0.08	0.03	0.03	0.16	0.14	0.28	0.02	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 for all ecological receptors are predicted to remain below the HQ benchmark of 1. 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.

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Appendix A Wheeler River Project IMPACT Model

Appendix B Model Results in Support of the ERA

Appendix C Ecological Receptor Profiles

Appendix D Existing Surface Water and Sediment Quality Data