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Annual Program Report

Regulatory Oversight Report for Uranium Mines and Mills in Canada: 2018

Rapport annuel sur les programmes

Rapport de surveillance réglementaire pour les mines et usines de concentration d'uranium au Canada : 2018

Public Meeting

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Canada

Summary

This Commission Member Document (CMD) is on the *Regulatory Oversight Report for Uranium Mines and Mills in Canada: 2018*.

There are no actions requested of the Commission. This CMD is for information only.

Résumé

Le présent document à l'intention des commissaires (CMD) porte sur le *Rapport de surveillance réglementaire des mines et usines de concentration d'uranium au Canada : 2018*.

Aucune mesure n'est requise de la Commission. Ce CMD est fourni à titre d'information seulement.

Signed/signé le

11 October 2019

Haidy Tadros

Director General

Directorate of Nuclear Cycle and Facilities Regulation

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PREFACE / EXECUTIVE SUMMARY

The *Regulatory Oversight Report for Uranium Mines and Mills in Canada: 2018* presents Canadian Nuclear Safety Commission (CNSC) staff's assessment of licensee performance for uranium mines and mills in Canada during the 2018 calendar year. This report also provides an update on CNSC staff regulatory activities related to public information, community engagement, and aspects of the CNSC's Independent Environmental Monitoring Program that relate to uranium mines and mills. Where possible, trends are shown and information is compared to previous years.

CNSC staff use 14 safety and control areas (SCAs) to evaluate the performance of each licensee. This report provides performance ratings for all 14 SCAs for uranium mines and mills. This report specifies details on three SCAs that contain the majority of the key performance indicators for these facilities: radiation protection, environmental protection, and conventional health and safety.

The SCA ratings in this report were derived from results of compliance activities conducted by CNSC staff. These activities included onsite inspections, technical assessments, reviews of reports submitted by licensees, event and incident review, and ongoing exchanges of information with licensees. For the 2018 reporting year, CNSC staff rated all SCAs as "satisfactory" for all uranium mines and mills with the exception of the McClean Lake radiation protection SCA which continued to be rated "fully satisfactory".

CNSC staff confirmed that all uranium mine and mill facilities in Canada operated safely during 2018.

CNSC staff concluded that the licensees for the regulated facilities covered in this report have made adequate provision for the health and safety of workers, the protection of the public and the environment, and Canada's international obligations. Documents referenced in this report are available to the public upon request.

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CLEAR LANGUAGE SUMMARY

The *Regulatory Oversight Report for Uranium Mines and Mills in Canada: 2018* provides information about the CNSC's work to ensure the safety and protection of people and the environment around operating uranium mines and mills in Canada, all of which are located in Northern Saskatchewan. The uranium mines and mills continued to operate safely in 2018. Monitoring continues to show that the country foods and water surrounding the mines and mills remain safe to eat and drink. There were no releases that could have harmed human health or the environment.

This report provides information on the following uranium mines and mills in Saskatchewan:

- Cigar Lake – operating uranium mine
- McArthur River – uranium mine in care and maintenance
- Rabbit Lake – uranium mine and mill in care and maintenance
- Key Lake – uranium mill in care and maintenance
- McClean Lake – operating uranium mill

When in a state of care and maintenance, a mine and/or mill is not mining, milling or processing uranium ore, and is not producing uranium concentrate (yellowcake). These facilities still have sufficient staff to complete ongoing maintenance, water treatment and protection of employees, the public and the environment.

Each year, CNSC inspectors conduct inspections at uranium mines and mills. The number of inspections and the focus of the inspections depend on performance and operating status of the mine or mill. The CNSC uses a risk-informed approach when planning inspections. In 2018, CNSC staff performed a total of 26 inspections across the five mines and mills. As a result of these inspections, 31 non-compliances or action notices were issued. All concerns raised during the inspections have been addressed by the operators.

Although the CNSC evaluates operating nuclear facilities across 14 functional areas, this report focuses on the following three areas:

- **Radiation protection:** In 2018, the maximum individual radiation dose to a worker at any of the five uranium mine and mill facilities was only 14 percent of the annual regulatory limit. No workers exceeded their regulatory radiation dose limit.
- **Environmental protection:** CNSC licensees are required to report any unauthorized release of hazardous substances or nuclear materials to the environment, to the CNSC and other regulatory authorities. In 2018, there were 20 unauthorized releases reported. This is in the normal range of releases for uranium mines and mills. All releases were corrected by the mine or mill operators. There was no lasting impact to the environment as a result of these spills. Each mine and mill facility uses water as part of the mining and milling process. All water used in the operation must be treated before being discharged back to the environment. All discharged water met the federal or provincial discharge requirements, ensuring that the persons near the facility are safe.

- **Conventional health and safety:** All mining and milling operations must report any lost time, workplace-related injuries to the CNSC and provincial agencies. In 2018, only one injury required reporting. This is consistent with previous years.

Indigenous and Community Engagement:

As an agent of the Government of Canada, the CNSC recognizes and understands the importance of building relationships with Indigenous peoples in Canada. The CNSC's goal is to build partnerships and trust with Indigenous communities through collaborative ongoing engagement activities related to CNSC-regulated facilities and activities of interest within their traditional and/or treaty territories. The uranium mines and mills discussed in this report lie within Treaty 8 and Treaty 10 and Métis Nation-Saskatchewan Northern Region 1, as well as the traditional territories of many Indigenous communities.

In 2018, CNSC staff efforts supported their ongoing commitment to meeting consultation and engagement obligations and continuing to build relationships with Indigenous peoples with interests in Canada's uranium mines and mills.

In 2019, as a result of recommendations from the Commission, CNSC staff took an initiative to meet with Indigenous groups and communities before the public consultation period to provide information and seek opportunity for improvement on the regulatory oversight report.

In summary:

- Workers at each facility were safe and properly protected.
- There were no releases that could have harmed the environment or health and safety of people nearby.
- Airborne radiation was not increased as a result of these facilities.
- All water released from the facility was safe.
- Fish and plants were safe to eat.

1 INTRODUCTION

1.1 Background

The Canadian Nuclear Safety Commission (CNSC) regulates Canada's uranium mines and mills to protect health, safety, security and the environment; to implement Canada's international commitments on the peaceful use of nuclear energy; and to disseminate objective scientific, technical and regulatory information to the public. This mandate is derived from the *Nuclear Safety and Control Act* (NSCA) [1], which along with the regulations made under it, contains requirements with which CNSC licensees must comply.

Each year the CNSC produces a regulatory oversight report on the operating performance of Canada's uranium mines and mills licensees and licensed facilities. This report includes data for the 2018 calendar year for uranium mines and mills. Every third year, the CNSC report also includes updates on historic and decommissioned uranium mine and mill sites. Data for historic and decommissioned sites was presented in the *Regulatory Oversight Report for Uranium Mines, Mills, Historic and Decommissioned Sites in Canada: 2017*, and will be presented again in 2020.

This report:

- describes the CNSC's regulatory efforts, public information and community engagement activities, and Independent Environmental Monitoring Program (IEMP);
- includes information on licensee operation, licence changes, major developments at licensed facilities, as well as any significant events;
- presents the performance rating for each safety and control area (SCA) for uranium mine and mill facilities regulated by the CNSC; and
- presents performance data on the SCAs of radiation protection, environmental protection, and conventional health and safety for each licensed facility.

This report summarizes CNSC staff's assessment of the following regulated uranium mine and mill facilities:

- Cigar Lake Operation
- McArthur River Operation
- Rabbit Lake Operation
- Key Lake Operation
- McClean Lake Operation

Throughout the review period, CNSC staff continued to perform compliance activities, including onsite inspections, technical assessments, review of reports submitted by licensees, event and incident reviews, and ongoing exchanges of information with licensees for all uranium mine and mill facilities.

1.2 CNSC Regulatory Efforts

1.2.1 Licensing

The CNSC regulates each uranium mine and mill under a separate licence. An approved licence under the NSCA [1] defines licence terms, licensed activities and licence conditions. Tables summarizing the uranium mine and mill licences can be found in appendix A. In July 2018, a Commission panel approved the change of the licensee name from AREVA Resources Canada Inc. (AREVA) to Orano Canada Inc. and issued the amended licence UMOL-MINEMILL-McCLEAN.01/2027. Each CNSC licence is accompanied by a licence conditions handbook (LCH) which contains compliance verification criteria used by CNSC staff to ensure compliance with the conditions comprising the licence. Any changes made to the LCHs during this review period are also provided in appendix A.

1.2.2 Regulatory Developments

CNSC staff continue to modernize the regulatory framework with the REGDOC series of regulatory and guidance documents. The licensees continue to be in compliance with the regulatory documents, or applicable standards, identified in their licence conditions handbooks during the transition process. The licensees are on track for meeting all deadlines established. CNSC staff continue to monitor progress through regular licensing meetings.

Table 1.1 lists the updates made to the CNSC regulatory documents since 2016 that apply to the uranium mine and mill licensees and includes the implementation status.

Table 1.1: Regulatory documents applicable to uranium mine and mill facilities

Regulatory document	Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClean Lake
REGDOC-2.2.2, *Personnel Training*, Version 2 December 2016	To be implemented as part of 2021 licence renewal	To be implemented in 2019	Implementation to be completed June 2022	Implementation to be completed June 2022	Implemented
REGDOC-2.10.1, *Nuclear Emergency Preparedness and Response*, Version 2 February 2017	To be implemented as part of 2021 licence renewal	Implementation plan to be submitted in 2020	Implementation plan to be submitted in 2020	Implementation plan to be submitted in 2020	Implemented
REGDOC-2.9.1, *Environmental Protection: Environmental Principles, Assessments and Protection Measures*, Version 1.1, April 2017	To be implemented as part of 2021 licence renewal	Implementation plan expected in 2020	Implementation to be completed June 2022	Implementation to be completed June 2022	Implementation to be completed June 2020

Regulatory document	Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClean Lake
REGDOC-1.6.1, *Licence Application Guide: Nuclear Substances and Radiation Devices*, Version 2, May 2017	To be implemented as part of 2021 licence renewal	Implemented	Implementation to be completed June 2022	Implementation to be completed June 2022	Implemented
REGDOC-3.1.2, *Reporting Requirements, Volume I: Non-Power Reactor Class I Nuclear Facilities and Uranium Mines and Mills* January 2018	To be implemented as part of 2021 licence renewal	Implemented	Implementation to be completed June 2022	Implementation to be completed June 2022	Implementation to be completed June 2022
REGDOC-2.13.1, *Safeguards and Nuclear Material Accountancy* February 2018	To be implemented as part of 2021 licence renewal	Implementation plan to be submitted by January 2020	Implementation plan to be submitted by January 2020	Implementation plan to be submitted by January 2020	Implementation to be completed June 2022
REGDOC-2.5.4, *Design of Uranium Mines and Mills: Ventilation Systems* March 2018	To be implemented as part of 2021 licence renewal	Implemented	Implementation plan to be submitted by January 2020	Implementation plan to be submitted by January 2020	Implementation plan to be submitted by January 2020
REGDOC-2.1.2, *Safety Culture* April 2018	Implementation to be completed June 2022	Implementation to be completed June 2022	Implementation to be completed June 2022	Implementation to be completed June 2022	Implementation to be completed June 2022
REGDOC-3.2.1, *Public Information and Disclosures* May 2018	To be implemented as part of 2021 licence renewal	Implementation plan to be submitted in 2020	Implementation plan to be submitted in 2020	Implementation plan to be submitted in 2020	Implementation plan to be submitted in 2020
REGDOC-2.11.1, *Waste Management, Volume III: Assessing the Long-Term Safety of Radioactive Waste Management* May 2018	Not applicable	Not applicable	Implementation plan to be submitted in January 2020	Implementation plan to be submitted in January 2020	Implementation plan to be submitted in January 2020
REGDOC-2.11.1, *Waste Management, Volume II: Management of Uranium Mine Waste Rock and Mill Tailings* November 2018	To be implemented as part of 2021 licence renewal	Implemented	Implementation plan to be submitted in January 2020	Implementation plan to be submitted in January 2020	Implementation plan to be submitted in January 2020

1.2.3 Compliance

The CNSC ensures licensee compliance through verification, enforcement and reporting activities. CNSC staff develop compliance plans for each facility commensurate with the associated risk, and implement these plans by conducting regulatory activities including onsite inspections and technical assessments of licensee programs, processes and reports. Changes to compliance plans are made on an ongoing basis in response to events, facility modifications and changes in licensee performance.

Figure 1.1 shows a CNSC inspector presenting a preliminary facts and findings report to a licensee following an inspection at the Cigar Lake Operation.

Figure 1.1: CNSC staff presenting a preliminary facts and findings report

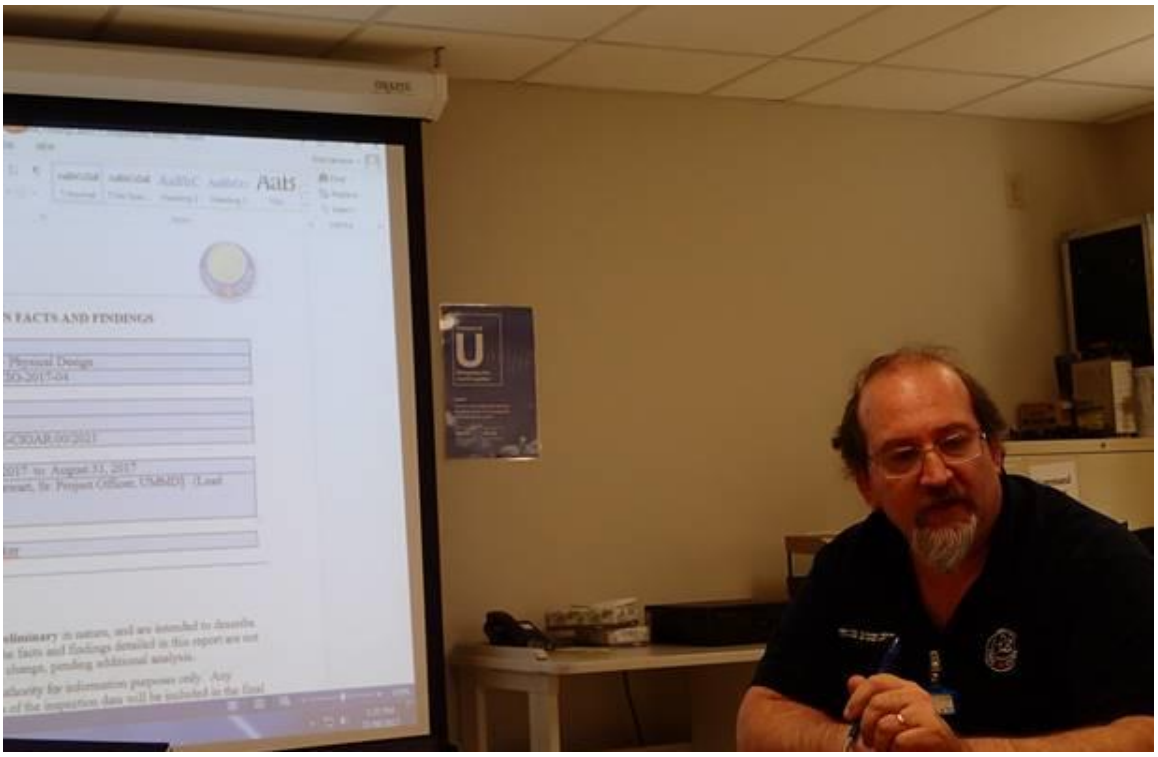


Table 1.2 presents data on CNSC staff inspections conducted at uranium mines and mills. Non-compliances arising from these inspections were provided to the licensees in detailed inspection reports and recorded in the CNSC Regulatory Information Bank in order to ensure these actions were tracked to completion. Examples of non-compliances include: failure to wear radiation monitoring equipment; non-compliance with National Fire Code, failure to follow procedures; additional training needs identified and incorrect or incomplete labelling or signage.

Table 1.2: Compliance inspections at uranium mines and mills

Year	Inspections	Non-compliances
2018	26	31
2017	30	23
2016	30	41
2015	30	37
2014	24	31

All instances of non-compliances identified were of low safety significance. Safety significance is determined based on comparison to criteria developed and used in the CNSC Regulatory Information Bank. Examples of the criteria are included in the appendices to this report in tables H-2, I-2, J-2 and K-2. Additional details on the inspections covered in this reporting period can be found in appendix B. CNSC staff assessed licensee's corrective actions taken in response to identified instances of non-compliance and verified that these actions were appropriate and acceptable. All non-compliances were addressed appropriately by licensees, met all regulatory requirements and have been closed by CNSC staff.

Other regulatory bodies that conduct inspections at the facilities include the Saskatchewan Ministry of Environment, the Saskatchewan Ministry of Labour Relations and Workplace Safety, and Environment and Climate Change Canada. These regulatory bodies primarily focus on areas of conventional health and safety and environmental protection. CNSC staff take into account the findings from these regulatory bodies when assessing licensees' performance. When logistically reasonable, joint inspections are conducted with other federal, provincial or territorial regulatory agencies.

1.2.4 Safety and Control Area Framework

SCAs are the technical topics that CNSC staff use across all regulated facilities and activities to assess, evaluate, review, verify and report on regulatory requirements and performance. The CNSC's SCA framework which staff use to evaluate licensee safety performance includes 14 SCAs. Each SCA is subdivided into specific areas that define its key components. Appendix C provides definitions of these SCAs and their specific areas.

CNSC staff use the following four ratings, defined in appendix D, to grade the licensee performance in each applicable SCA:

- fully satisfactory (FS);
- satisfactory (SA);
- below expectations (BE); and
- unacceptable (UA).

This report provides CNSC staff's performance ratings for all applicable SCAs, with a focus on the three SCAs that cover many of the key performance indicators for mining and milling operations: radiation protection, environmental protection, and conventional health and safety.

For 2018, all SCA performance ratings for uranium mines and mills were rated "satisfactory", with the exception of radiation protection at the McClean Lake Operation which continues to be rated "fully satisfactory".

CNSC staff concluded, based on the results from regulatory oversight activities that uranium mine and mill facilities met the following requirements:

- radiation protection measures were effective and radiation doses received by workers remained consistent with the as low as reasonably achievable (ALARA) principle and as a result:
  - no worker doses were in excess of regulatory effective dose limits; and
  - where action level exceedances took place, they were reported, investigated to establish the causes, and corrective actions were identified by the licensee. At the time of writing, CNSC staff were in progress of assessing the corrective actions denoted by the licensee as complete. Additional corrective actions are scheduled to be completed by the licensee in early 2020 and will be assessed through ongoing CNSC compliance activities.
- environmental protection programs were effective and resulted in emissions and effluents remaining within the ALARA principle:
  - no discharges were in excess of regulatory limits; and
  - where action level exceedances took place, they were reported, investigated, corrective measures implemented by the licensee, and verified by CNSC staff.
- conventional health and safety programs continued to protect workers:
  - where a lost-time injury (LTI) was reported, corrective measures were implemented by the licensee, and verified by CNSC staff.

Appendix E contains the SCA performance ratings for the 2014 to 2018 reporting period for uranium mines and mills.

1.2.5 Independent Environmental Monitoring Program

Under the NSCA [1], the CNSC requires each nuclear facility licensee to develop, implement and maintain an environmental monitoring program to demonstrate that the public and the environment are protected from any releases to the environment related to the facility's nuclear activities. CNSC staff evaluate and assess the results of these monitoring programs to ensure compliance with applicable requirements and limits, as set out in regulations that govern Canada's nuclear industry.

The CNSC implement an IEMP to verify that all persons and the environment around licensed nuclear facilities are protected. The IEMP is a regulatory tool that complements and informs the CNSC's ongoing compliance verification program. The IEMP does not rely on licensees to provide samples. CNSC staff or independent contractors obtain samples from publicly accessible areas around nuclear facilities, then measure and report to the Commission and/or public the amount of radiological and hazardous substances in these samples.

There were no IEMP sampling campaigns at the uranium mines and mills in 2018. Results from previous IEMP sampling campaigns are available on the CNSC's IEMP Web page.

1.3 Public Information and Indigenous Engagement

The availability and clarity of information pertaining to nuclear activities is essential to establishing an atmosphere of openness, transparency and trust between the licensee and the public. Since 2012, the CNSC requires major licensees to maintain a Public Information and Disclosure Program (PIDP) supported by a robust disclosure protocol that addresses local communities and stakeholders' needs.

CNSC document REGDOC-3.2.1, *Public Information and Disclosure*, [2] (formerly known as RD/GD-99.3) sets out the requirements for public information and disclosure. The primary goal of the program, as it relates to the licensed activities, is to ensure that information related to the health, safety and security of persons and the environment, and other issues associated with the lifecycle of nuclear facilities are effectively communicated to the public. This information promotes transparency and improves the public's understanding of the licensed activities and operations. The program includes a commitment and protocol for ongoing, timely dissemination of information related to the licensed facility during the course of the licence period.

In 2018, licensees continued regular communication with interested communities. As part of the public information program, licensees regularly participate in Northern Saskatchewan Environmental Quality Committee (EQC) meetings and facility tours. The EQC represents more than 30 communities throughout the greater northern Saskatchewan region. The EQC, established in 1995, enables northerners to learn more about uranium mining activities and the environmental protection measures in place. Further information on the EQC can be found on the EQC Web page.

Some key activities and best practices noted among licensees in 2018 include:

- Cameco upheld commitments to be open and transparent with their stakeholders. Cameco promptly provided material on their website related to onsite events of interest to their audiences, their operations and regular licensed activities. Cameco hosted a variety of community information sessions and remain in compliance with regulatory requirements.
- Orano continued to meet the commitments made in their public information program by providing the public with updated information related to their regular operations and in advance of the Cluff Lake Project licence renewal. Numerous company representatives engage in project-specific related dialogue, which is captured in a database to track requested information, and, over time, gain improved understanding of public interest areas and concerns.
- Cameco and Orano collaborated and hosted a special engagement workshop with the Athabasca collaboration agreement communities. The purpose was to have open dialogue regarding upcoming decommissioning activities, financial guarantees and to determine effective ways to maintain strong communications between the licensees and the local communities.

CNSC staff evaluated Cameco and Orano's public information and disclosure programs throughout 2018 and determined the uranium mine and mill facilities complied with requirements in CNSC REGDOC-3.2.1, *Public Information and Disclosure* [2].

CNSC staff assessed licensee activities and conducted regular reviews of the public information and disclosure programs through compliance verification activities, such as desktop reviews, inspections, and observation of community meetings. CNSC staff determined that Cameco and Orano provided information on the status of their facilities through a variety of communication activities and products. Some activities implemented by the licensees included facility updates to community committees, northern tour public information sessions, disclosure of onsite events, facility tours, organization of and participation in community events, newsletters and promotion of activities and public engagement using social media. CNSC staff have d that Cameco and Orano tailor communication efforts to be primarily in-person given the local communities communication preference. Each organization has made efforts to be present in the community, host local meetings and regularly participate in local committees to ensure clear, effective and two-way information is shared.

In 2018, CNSC staff continued to keep the public and Indigenous communities informed of our regulatory activities through regular website updates, local magazine updates, publicly webcast Commission proceedings, social media and regular face-to-face discussion with key audiences in Northern Saskatchewan including the EQC (further described below).

Figure 1.2: CNSC staff presentation to the EQC

Indigenous consultation and engagement

As an agent of the Government of Canada, the CNSC recognizes and understands the importance of consulting and building relationships with Indigenous Peoples in Canada. The CNSC's goal is to build partnerships and trust with Indigenous communities through collaborative ongoing engagement activities related to CNSC-regulated facilities and activities of interest within their traditional and/or treaty territories. Cameco's and Orano's facilities lie within Treaty 8 and Treaty 10 and Métis Nation-Saskatchewan Northern Region 1, as well as the traditional territories of many Indigenous communities.

The CNSC's Indigenous engagement practices, which include information sharing and funding support through the CNSC's Participant Funding Program (PFP), are meant to help Indigenous Peoples meaningfully participate in Commission proceedings and ongoing regulatory activities. These practices are consistent with the principles of upholding the honour of the Crown and reconciliation.

CNSC staff efforts in 2018 supported the CNSC's ongoing commitment to meeting its consultation and engagement obligations and building relationships with Indigenous Peoples with interests in Canada's uranium mines and mills.

In 2018, participant funding was awarded to six Indigenous groups to assist in their review and comment of the *Regulatory Oversight Report for Uranium Mines, Mills, Historic and Decommissioned Sites in Canada: 2017.* These groups were English River First Nation, the Ya'thi Néné Land and Resource Office, Algonquins of Ontario, Sagamok Anishnawbek First Nation, Athabasca Chipewyan First Nation, and the Prince Albert Grand Council.

In 2018, CNSC staff continued to work with Indigenous communities and organizations to identify opportunities for formalized and regular engagement throughout the lifecycle of these operations, including meetings and facilitated workshops. CNSC staff met with Indigenous communities to discuss areas of interest such as Orano's proposed uranium mine decommissioning licence renewal for the Cluff Lake Project and Cameco's proposed waste facility operating licence amendment for the Beaverlodge Project. In addition, CNSC staff carried out the following engagement activities including meetings with the public and Indigenous groups in 2018:

- participation in meetings of the Northern Saskatchewan Environmental Quality Committee;
- participation at a meeting with Indigenous communities hosted by Cameco and Orano in Saskatoon on June 6 and 7, 2018, during which CNSC staff presented and answered questions about the CNSC, *Uranium Mines and Mills Regulations* [7], public and Indigenous engagement and the PFP;
- participation in the Saskatchewan Mining Association Annual Conference and environmental forum; and
- meetings with Indigenous groups to provide information on the *Regulatory Oversight Report for Uranium Mines, Mills, Historic and Decommissioned Sites in Canada: 2017*.

To ensure that licensees engage with Indigenous communities, the CNSC published REGDOC-3.2.2, *Aboriginal Engagement* [3], in 2016. REGDOC-3.2.2 sets out requirements and guidance for licensees proposing projects that may raise the Crown's duty to consult. Throughout this reporting period, licensees continued to host meetings and to discuss their operations with Indigenous communities. CNSC staff participated in many of these meetings, verified the engagement work conducted by Cameco and Orano, and ensured that they actively engaged and communicated with Indigenous groups who have interest in their facilities.

CNSC staff confirmed that Cameco and Orano have well established Indigenous engagement and outreach programs and engage with the following Indigenous groups that have interests in their facilities: Athabasca Chipewyan First Nation, Clearwater River Dene Nation, English River First Nation, Buffalo River Dene Nation, Birch Narrows Dene Nation, Lac La Ronge Indian Band, Métis Nation-Saskatchewan, Pinehouse Kineepik Métis, Prince Albert Grand Council, as well as the Athabasca Dene communities of Hatchet Lake First Nation, Black Lake First Nation, and Fond du Lac First Nation who are represented by the Ya'thi Néné Land and Resource Office.

CNSC staff are satisfied with the level and quality of Indigenous engagement conducted by Cameco and Orano in relation to their uranium mine and mill operations in northern Saskatchewan.

In 2019 as a result of recommendations from the Commission, CNSC staff took an initiative to meet with Indigenous groups and communities before the public consultation period to provide information and seek opportunity for improvement on the regulatory oversight report (figures 1.3 and 1.4). In addition, using feedback from the Indigenous engagement, a plain language overview was developed and included in this report. First Nation and Métis communities with interest in Canada's uranium mines and mills were provided a copy of this regulatory oversight report. Through the CNSC's PFP, financial support was made available for participation in the review of this report.

Figure 1.3: CNSC staff presentation to the EQC, September 4, 2019

Figure 1.4: CNSC staff presentation to the Indigenous Community Leaders, September 5, 2019

CNSC staff will continue to engage and update interested Indigenous communities on regulatory activities and are committed to provide key updates on nuclear activities and projects in their territories of interest.

1.4 National Pollutant Release Inventory

Appendix L shows the total annual release of relevant radionuclides to the environment from these facilities from 2014 through 2018.

During the December 2018 Commission meeting, CNSC staff committed to providing an annual update to the Commission on the decision on radionuclide reporting in the National Pollutant Release Inventory (NPRI). The CNSC is making radionuclide release data more readily accessible to the public as part of its commitment to open government and its mandate to disseminate this information to the public. The commitment to provide data on the total annual release of radionuclides in the appendices of the regulatory oversight report continues within this year's report. In addition, the CNSC and the NPRI are working together to establish active links between their websites. A stakeholder sub-group consisting of environmental non-governmental organizations (ENGOs) and industry are completing active beta testing of the links between the NPRI site and existing CNSC data products (regulatory oversight reports, Eastern Athabasca Regional Monitoring Program, etc.). The CNSC has also commenced the creation of downloadable digital databases of radionuclides releases further supplementing the range of CNSC environmental data products linked to the NPRI website. The downloadable databases are expected to become part of the active beta testing activities in the latter part of 2019.

2 OVERVIEW

This section of the report focuses on the performance of the five uranium mines and mills in Canada in 2018. Three of the five facilities are currently in a state of care and maintenance. The facilities listed are located within the Athabasca Basin of northern Saskatchewan and are shown in figure 2.1:

- Cigar Lake Operation (mine)
- McArthur River Operation (mine – care and maintenance)
- Rabbit Lake Operation (mine and mill – care and maintenance)
- Key Lake Operation (mill – care and maintenance)
- McClean Lake Operation (mine and mill)

Figure 2.1: Location of uranium mines and mills in Saskatchewan

In 2016, the Rabbit Lake mine and mill, operated by Cameco, entered into care and maintenance mode and has continued to be in this state since that time.

On November 8, 2017 Cameco notified the CNSC that, effective January 2018, they would be temporarily suspending production at the Key Lake and McArthur River Operations. This included all activities directly related to mining and processing of uranium ore. On July 25, 2018 Cameco notified the CNSC of its decision to suspend production at the Key Lake and McArthur River Operations for an indefinite period until economic conditions improve. During this suspension of production (care and maintenance), there is ongoing work, with sufficient qualified staff, (about 100 persons) remaining at each facility to ensure the protection of people and the environment. Water treatment continues, ensuring that any discharges are meeting the performance criteria and respecting all federal and provincial limits. For mine workings, the licensee conducts regular inspections to assess ground stability, ventilation and dewatering of accessible areas of the mine. In the mill, systems and services require continued maintenance to ensure that they remain operational. Therefore, even though the facilities are in a care and maintenance mode, there is substantial work ongoing at each location.

As the licensee transitions to care and maintenance mode, CNSC staff review the reductions in staff and changes in service levels to ensure that there is no overall decrease in safety of the facilities. A reduction in staff may translate into one person taking on one or more additional roles and CNSC inspectors review the training provided to confirm that the licensee continues to maintain sufficient qualified staff. For example, licensee staff not familiar with conducting measurements or taking samples would have to receive the appropriate training and become qualified to take on those additional tasks. CNSC inspectors include criteria in their inspections to confirm that staffing levels remain appropriate and that workers have the capability and the time needed to perform all expected functions.

Where the licensee reduces services, such as ventilation volumes, CNSC staff evaluate how this will impact workers in the area and that sufficient protective measures, including alarming detectors, are in place to warn against potentially unsafe situations. Licensees continue to train workers to understand the safety implications of the monitors and understand the actions that are needed if an alarm condition is triggered. CNSC specialists are involved in the review of changes which may impact licensed activities to ensure that the licensee maintains an equivalent level of safety.

In 2018, CNSC staff continued routine compliance verification inspections at all facilities to ensure that the licensee continues to meet regulatory expectations and to verify that safety is not compromised by the changes implemented during the transition to care and maintenance. CNSC staff concluded that the operations were safely suspended, and workers, the public and the environment continued to be protected. CNSC staff will continue to use a risk-informed approach for regulatory oversight.

The 2018 uranium production data for uranium mine and mill facilities are shown in table 2.1. CNSC staff confirmed all facilities operated within their authorized annual production limits in 2018. Production data for the McArthur River Operation and the Key Lake Operation was lower than previous years because production was suspended in early 2018.

Table 2.1: Mining and milling production data for uranium mines and mills, 2018

Production data	Cigar Lake	McArthur River	Rabbit Lake[1]	Key Lake[2]	McClean Lake[3]
Mining – ore tonnage (Mkg/year)	43.06	2.79	0	0	0
Mining – average ore grade mined (%U)	16.1	7.57	0	N/A	N/A
Mining – U mined (Mkg U/year)	6.94	0.18	0	0	0
Milling – mill ore feed (Mkg/year)	N/A	N/A	0	0	42.9
Milling – average mill feed grade (%U)	N/A	N/A	0	0	16.26
Milling – mill recovery (%U)	N/A	N/A	0	N/A[2]	98.94
Milling – U concentrate produced (Mkg U/year)	N/A	N/A	0	0.06[2]	6.94
Authorized annual production (Mkg U/year)	9.25	9.6	4.25	9.6	9.23

[1] Rabbit Lake is currently in a safe state of care and maintenance.
[2] Key Lake did not feed ore in 2018, and only processed material already in the mill process.
[3] The McClean Lake mill has been designed to mill high-grade ore from Cigar Lake without any blending or dilution.
N/A = Not applicable.
Mkg = 1,000,000 kg

Licensees are required to develop preliminary decommissioning plans and associated financial guarantees to ensure that work activities are covered financially and work is guaranteed to completion with no liability to the government. Financial guarantee values for the mine and mill facilities range from approximately C$48 million at the McArthur River Operation to C$218 million at the Key Lake Operation. The values of the financial guarantees for each uranium mine and mill are listed in appendix F. Financial guarantees cover all costs necessary to fully decommission and remediate a uranium mine and/or mill to ensure the protection of people and the environment.

2.1 Regulatory Efforts

The CNSC regulates the five uranium mine and mill operations under separate licences. Appendix A provides an outline of these licences and their respective licensing information.

In 2018, CNSC staff performed between four and six inspections at each uranium mine and mill for a total of 26 onsite inspections (these are outlined in appendix B). These inspections resulted in the identification of 31 instances of non-compliances, all of low safety significance. Examples of non-compliances include: failure to wear radiation monitoring equipment; non-compliance with National Fire Code, failure to follow procedures; additional training needs identified and incorrect or incomplete labelling or signage.

CNSC staff assessed all licensee corrective actions taken in response to non-compliances and verified that these actions were appropriate and acceptable. All non-compliances are considered closed. The following figure shows CNSC staff gathering information from a Cameco health and safety representative during a compliance inspection.

Figure 2.2: CNSC staff acquiring information from a licensee representative

2.2 Performance

CNSC staff use expert professional judgment to rate safety and control area (SCA) performance at uranium mine and mill facilities. Ratings are based on the review of key performance indicators [e.g., accident/event occurrences, responses to accidents/events, desktop review of reports, dose information, environmental (radiological and non-radiological) results] and the results of compliance activities such as inspections and technical assessments.

Once established, ratings are compared across all five mines and mills and to the rating definitions in appendix D to ensure that consistent and defendable ratings are assigned. The SCA performance ratings of the mine and mill facilities are presented in table 2.2 and appendix E contains the SCA ratings for each facility from 2014 to 2018.

Table 2.2: SCA performance ratings for uranium mines and mills, 2018

Safety and control area	Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClean Lake
Management system	SA	SA	SA	SA	SA
Human performance management	SA	SA	SA	SA	SA
Operating performance	SA	SA	SA	SA	SA
Safety analysis	SA	SA	SA	SA	SA
Physical design	SA	SA	SA	SA	SA
Fitness for service	SA	SA	SA	SA	SA
Radiation protection	SA	SA	SA	SA	FS
Conventional health and safety	SA	SA	SA	SA	SA
Environmental protection	SA	SA	SA	SA	SA
Emergency management and fire protection	SA	SA	SA	SA	SA
Waste management	SA	SA	SA	SA	SA
Security	SA	SA	SA	SA	SA
Safeguards and non-proliferation	SA	SA	SA	SA	SA
Packaging and transport	SA	SA	SA	SA	SA

FS = fully satisfactory SA = satisfactory

This report details three SCAs that cover many of the key performance indicators for these facilities: radiation protection, environmental protection and conventional health and safety.

Licensees develop and maintain management systems that include integrated links to all 14 SCAs. Management systems are the framework that establish the processes and programs required to ensure an organization achieves its safety objectives, continuously monitors performance, identifies inadequacies, and continually improves and fosters a healthy safety culture. Throughout 2018, CNSC staff reviewed and assessed program performance and key performance indicators through regular compliance verification activities.

For 2018, CNSC staff concluded that performance of the uranium mines and mills was either "satisfactory" or "fully satisfactory".

2.3 Radiation Protection

Uranium mine and mill licensees in Canada are required to implement and maintain radiation protection programs. Each program must ensure that contamination levels and radiation doses received by individuals are monitored, controlled, maintained below regulatory limits and are kept consistent with the as low as reasonably achievable (ALARA) principal.

For 2018, CNSC staff rated the radiation protection SCA at all five facilities as either "satisfactory" or "fully satisfactory" based on regulatory oversight activities. The fully satisfactory rating for McClean Lake is discussed in section 7.2.

Radiation protection ratings

Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClean Lake
SA	SA	SA	SA	FS

FS = fully satisfactory SA = satisfactory

Radiological hazard control

Sources of radiation exposure at uranium mines and mills include:

- gamma radiation;
- long-lived radioactive dust;
- radon progeny; and
- radon gas.

CNSC staff's compliance activities confirmed these hazards were controlled by licensees' radiation protection programs, including practices relating to the effective use of time, distance and shielding, source control, ventilation, contamination control and personal protective equipment.

Radiation protection program performance

During 2018, CNSC staff conducted regulatory oversight activities in the radiation protection SCA at all five facilities. These activities were to verify that licensees were complying with regulatory requirements for implementation of radiation protection programs.

Radiation protection programs include codes of practice that outline licensee administrative levels and action levels for exposures and doses of radiation. Administrative levels include a list of specific actions to be taken by the licensee based on radiological monitoring in the workplace. The radiation protection programs include actions to be taken under specific conditions, for example:

- "continue to work while monitoring or investigating a parameter"; or
- "leave the area and initiate an investigation".

As radiation levels or worker exposure levels increase, the required protective actions become more stringent, which is consistent with a risk-informed approach.

Administrative levels are identified for all radiological hazard types, apply to normal operating conditions, and are used to ensure optimal conditions for workers. Licensees are responsible for identifying the parameters of their programs that represent timely indicators of potential losses of control. For this reason, action and administrative levels are licensee-specific and may change over time depending on operational and radiological conditions. If an action level is reached, it may indicate a loss of control of part of a licensee's radiation protection program. The licensee is then required to establish the cause, notify the CNSC, and, if applicable, restore the effectiveness of the radiation protection program.

The five uranium mines and mills have the same individual nuclear energy worker (NEW) radiation dose action level of 1 millisievert (mSv) per week and 5 mSv per quarter of a given year. As a result of two events at the Cigar Lake Operation, seven radiation related action level exceedances were reported by the licensee in 2018 and are described in appendix H. Figure 2.3 shows a CNSC inspector measuring the gamma dose rate on an ore slurry pipe at the Cigar Lake Operation.

Figure 2.3: CNSC staff measuring gamma dose rate on ore slurry pipe

CNSC staff confirmed that, during the reporting period, the radiation protection programs and practices at uranium mines and mills remained effective in controlling radiological exposure to workers.

Application of ALARA

The radiation protection programs established by uranium mine and mill licensees include responsibilities and processes for ensuring that exposures to workers are consistent with the ALARA principal.

Through onsite inspections, CNSC staff verified that key elements of these ALARA programs (e.g., management control over work practices, personnel qualification and training, control of occupational and public exposure to radiation, planning for unusual situations) were effectively implemented by uranium mine and mill facilities in 2018.

This report includes the reporting of annual collective dose values for nuclear energy workers (NEWs) for each mine and mill (see sections 3.2, 4.2, 5.2, 6.2 and 7.2). The collective dose value is the sum of the effective doses received by all NEWs at a uranium mine and mill in one year. Collective dose is a radiation protection performance indicator that provides the total exposures associated with each operation. It supplements other performance statistics, like average dose, which have been affected by factors including changes in the number of workers or workers who receive radiation exposures over very short periods of time. Collective dose shows the effect of increased or reduced facility activities; for example, the transition of the Rabbit Lake Operation from actively mining and milling of ore to care and maintenance status (figure 5.3) or the ramping-up of production at the McClean Lake Operation (figure 7.3).

Worker dose control

In accordance with the *Radiation Protection Regulations* [4], licensee radiation protection programs include processes and criteria to provide assurance that all individuals identified as NEWs, in accordance with section 2 of the NSCA [1], are appropriately designated and trained. This includes licensee employees and contractors. Radiation exposures are ascertained through approved dosimetry methods and workers are notified of the results.

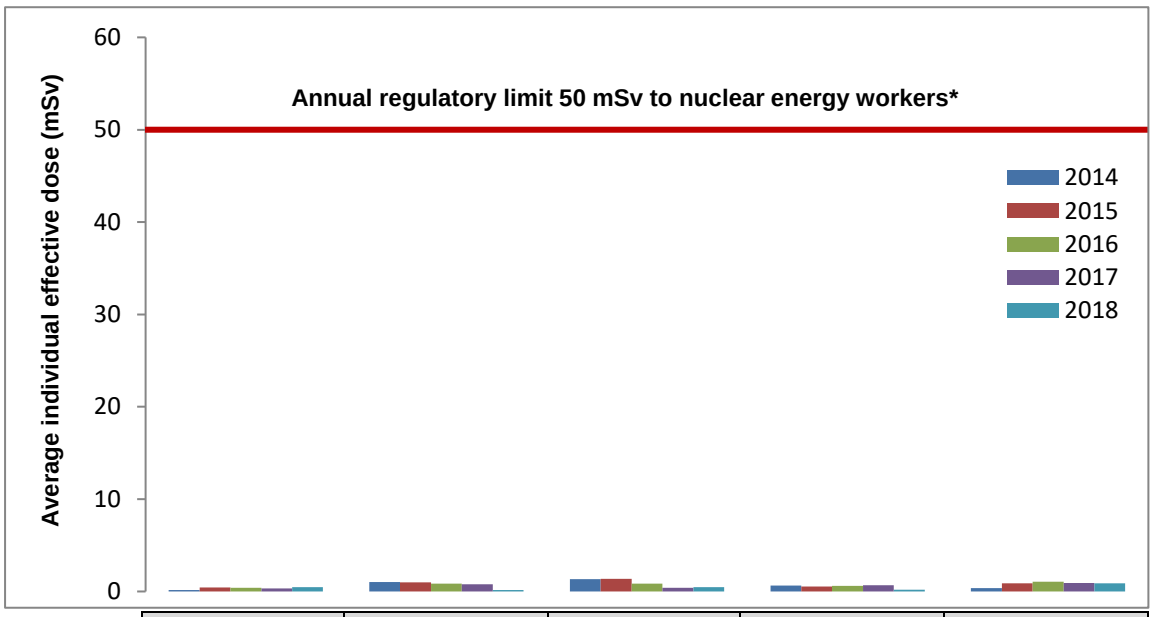
Figure 2.4 shows a continuous air monitor, alphaNUCLEAR PRISM, used in the mine and mill operations to measure radon gas and radon progeny.

Figure 2.4: alphaNUCLEAR PRISM at an underground mine

At all uranium mines and mills, NEWs are issued optically stimulated luminescence dosimeters that measure external gamma radiation exposure. Where required, workers also wear personal alpha dosimeters (PADs) to measure internal alpha radiation exposure from radon progeny and radioactive dust. Optically stimulated luminescence dosimeters and PAD readings are measured by CNSC-licensed dosimetry service providers. Where direct monitoring through dosimeters is not warranted or practical, dose estimation methods authorized by the *Radiation Protection Regulations* [4] (such as area/group monitoring and time cards) are used in accordance with CNSC regulatory guidance. CNSC staff confirmed that all licensees for the facilities discussed in this report met regulatory requirements for the use of licensed dosimetry, during the reporting period.

Figures 2.5 and 2.6 show the average individual effective dose and maximum individual effective dose during the 2014 to 2018 reporting period for the five facilities. In 2018, no worker at any facility exceeded the regulatory individual effective dose limit of 50 mSv in one year and 100 mSv in a five year dosimetry period.

Figure 2.5: Average individual effective dose to nuclear energy workers at uranium mines and mills, 2014–18 (mSv)

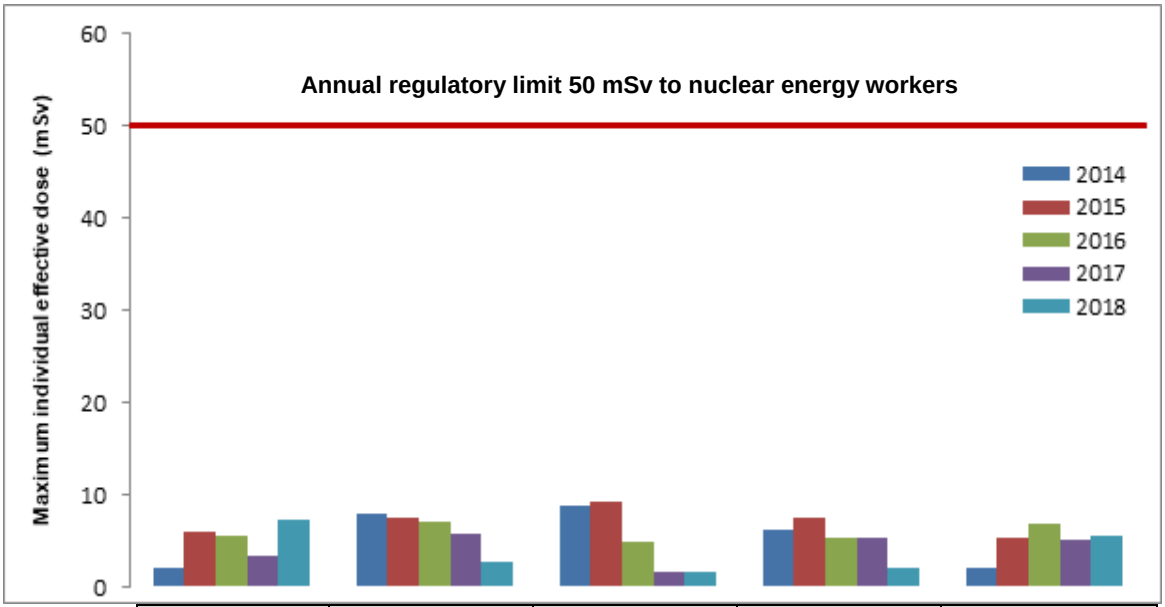


	Cigar Lake (mSv)	McArthur River (mSv)	Rabbit Lake (mSv)	Key Lake (mSv)	McClean Lake (mSv)
2014	0.16	1.03	1.35	0.63	0.37
2015	0.45	1.00	1.36	0.55	0.89
2016	0.39	0.85	0.85	0.62	1.04
2017	0.34	0.79	0.40	0.66	0.91
2018	0.47	0.15	0.46	0.19	0.90

* The annual regulatory limit illustrated applies to individual effective dose and is shown for reference only.

Increases and decreases over time in the effective dose to NEWs are explained in the facility-specific sections of this report under the "worker dose control" subsection.

Figure 2.6: Maximum individual effective dose to nuclear energy workers at uranium mines and mills, 2014–18 (mSv)



	Cigar Lake (mSv)	McArthur River (mSv)	Rabbit Lake (mSv)	Key Lake (mSv)	McClean Lake (mSv)
2014	2.04	7.91	8.84	6.21	2.03
2015	5.99	7.40	9.14	7,56	5.28
2016	5.53	7.02	4.95	5.37	6.94
2017	3.36	5.73	1.56	5.39	5.12
2018	7.28	2.67	1.70	2.02	5.50

The highest maximum individual effective dose to a worker at a uranium mine and mill in 2018 occurred at the Cigar Lake Operation. A dose of 7.28 mSv was assigned to an underground maintenance worker. This exposure is further discussed in the Cigar Lake section of this report. This value is 14.3 percent of the annual dose limit of 50 mSv.

Appendix G displays the number of NEWs at each facility, with corresponding average individual effective dose and maximum individual effective dose for each facility during the 2014 to 2018 period.

Estimated dose to the public

Uranium mine and mill operations are remote from local populations. The *Radiation Protection Regulations* [4] set a public radiation dose limit of 1 mSv per year above natural background radiation to ensure protection of the health and public.

Radiological exposures measured at the boundaries of these remote licensed facilities are close to measured background radiation levels. As published in the CNSC fact sheet on Natural Background Radiation, the background radiation level for Canada is approximately 1.8 mSv.

In 2018, CNSC staff were satisfied that uranium mine and mill licensees controlled radiation doses to persons at levels well below the regulatory limits and that licensees kept doses consistent with the ALARA principle. This conclusion was based on the outcome of inspections, as well as reviews of licensees' radiation protection programs, radiological hazard control, worker dose control and application of the ALARA principle.

2.4 Environmental Protection

The environmental protection SCA covers programs that identify, control and monitor releases of radioactive and hazardous substances and effects on the environment from facilities as a result of licensed activities.

Based on regulatory oversight activities, CNSC staff rated the 2018 performance of all five uranium mine and mill facilities for the environmental protection SCA as "satisfactory". CNSC staff concluded the licensee's environmental protection programs were effectively implemented and met all regulatory requirements.

Environmental protection ratings

Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClean Lake
SA	SA	SA	SA	SA

SA = satisfactory

2.4.1 Environmental management system

The CNSC requires licensees develop and maintain environmental management systems that provide a framework for integrated activities related to environmental protection at the operation. Environmental management systems are described in approved environmental management programs and include activities such as establishing annual environmental objectives, goals and targets. The licensees conduct internal audits of their programs as identified in their CNSC approved management system program. CNSC staff confirmed the licensees' objectives, goals and targets through regular compliance verification activities. Facility-specific details are provided in sections 3.3, 4.3, 5.3, 6.3 and 7.3 of this report.

2.4.2 Effluent and emissions control

Effluent and emissions control programs are associated with an environmental code of practice that sets out administrative levels and action levels for select contaminants of potential concern (COPC) with the potential for adverse environmental effects. An administrative level represents the upper range of design specifications for a specific parameter. Reaching an administrative level triggers an internal review by the licensee. Exceedance of an action level indicates a potential loss of control of the environmental protection program, which is based on the approved facility design envelope, and triggers actions that must be taken by the licensee to correct the problem.

This requires notification to the CNSC, an immediate investigation, subsequent corrective actions and preventive measures in order to restore the effectiveness of the environmental protection program. It is important to recognize that an exceedance of an action level does not imply a potential risk to the environment, but identifies that the operating parameter may be outside the facility design envelope. Facility administrative and action levels are determined through the identification and proper operation of existing treatment technologies, as well as facility-specific environmental risk studies.

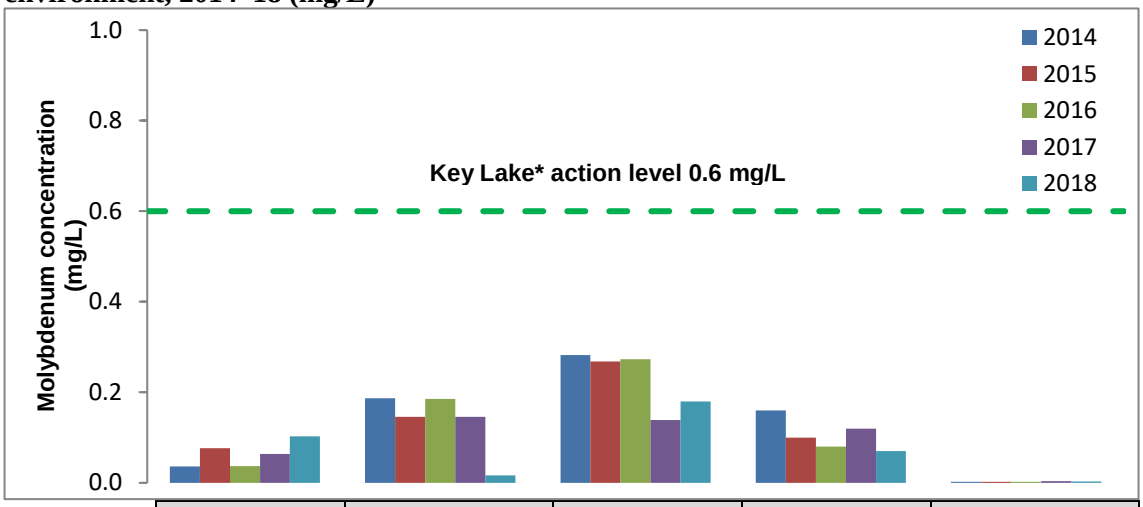
In 2018, there was one action level exceedance for radium-226 at McArthur River and one action level exceedance for total suspended solids (TSS) in treated effluent released to the environment at McClean Lake. More details are provided in the McArthur River and McClean Lake environmental protection sections of this report.

Treated effluent released to the environment

Environmental risk assessments (ERAs) identified releases of molybdenum, selenium and uranium with the potential for adverse environmental effects at uranium mines and mills. As a result, improved engineering controls and treatment technologies to reduce effluent releases of these contaminants were implemented where required. In 2018, the treatment technologies implemented continued to keep these contaminant concentrations stable, below regulatory limits and consistent with the ALARA principle. Figures 2.7 to 2.9 display the 2018 average annual effluent concentrations for molybdenum, selenium and uranium at the five mine and mill facilities.

In the absence of federal or provincial effluent discharge limits for molybdenum, the CNSC required licensees to develop facility-specific effluent controls within their environmental protection program codes of practice. The 2014 to 2018 molybdenum average effluent concentrations for the five facilities were below the Key Lake code of practice action level. The Key Lake action level of 0.6 mg/L for molybdenum is the most stringent of the five operations and is shown in figure 2.7 for reference only.

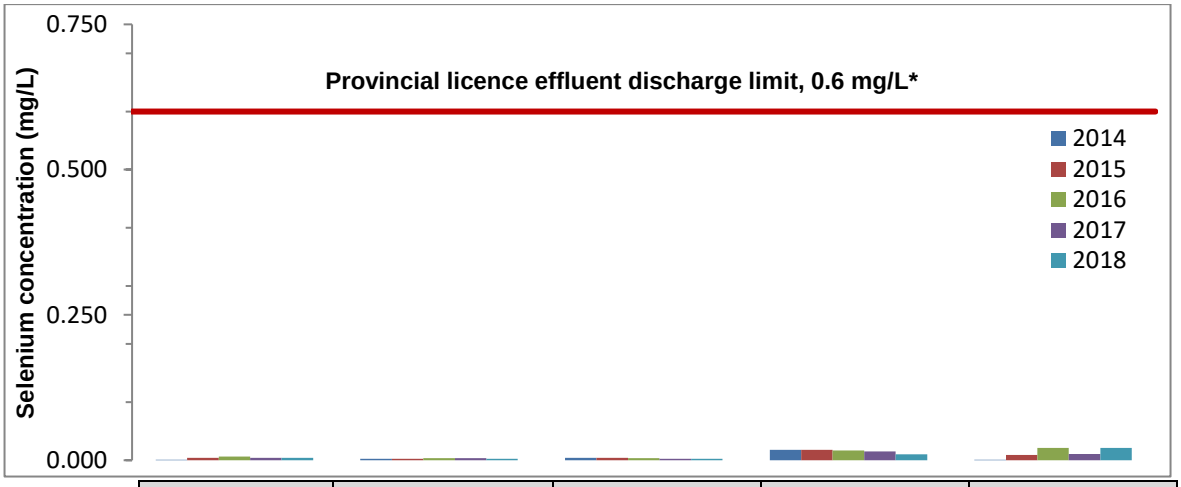
Figure 2.7: Annual average concentration of molybdenum in effluent released to the environment, 2014–18 (mg/L)



	Cigar Lake (mg/L)	McArthur River (mg/L)	Rabbit Lake (mg/L)	Key Lake (mg/L)	McClean Lake (mg/L)
2014	0.0360	0.1865	0.2820	0.1600	0.0024
2015	0.0763	0.1458	0.2680	0.1000	0.0024
2016	0.0369	0.1851	0.2730	0.0800	0.0020
2017	0.0640	0.1460	0.1390	0.1200	0.0040
2018	0.1030	0.0164	0.1800	0.0700	0.0030

Figures 2.8 and 2.9 demonstrate that both selenium and uranium concentrations in treated effluent released to the environment by mine and mill facilities in 2014 to 2018 remained below Saskatchewan's licensed effluent maximum monthly mean discharge limits of 0.6 mg/L and 2.5 mg/L for selenium and uranium, respectively. As indicated on figure 2.9, CNSC identified an interim objective for uranium of 0.1 mg/L. This was derived based on treatment technologies in place at the uranium mines and mills and based on what would be achievable by the uranium metal mining sector. The interim objective was applied to all uranium mine and mill facilities since it was the most stringent and has been consistently met since 2016. The interim objective for uranium in effluent is in place until the CNSC requirements for release limits are published in REGDOC-2.9.2, which is currently undergoing internal CNSC review.

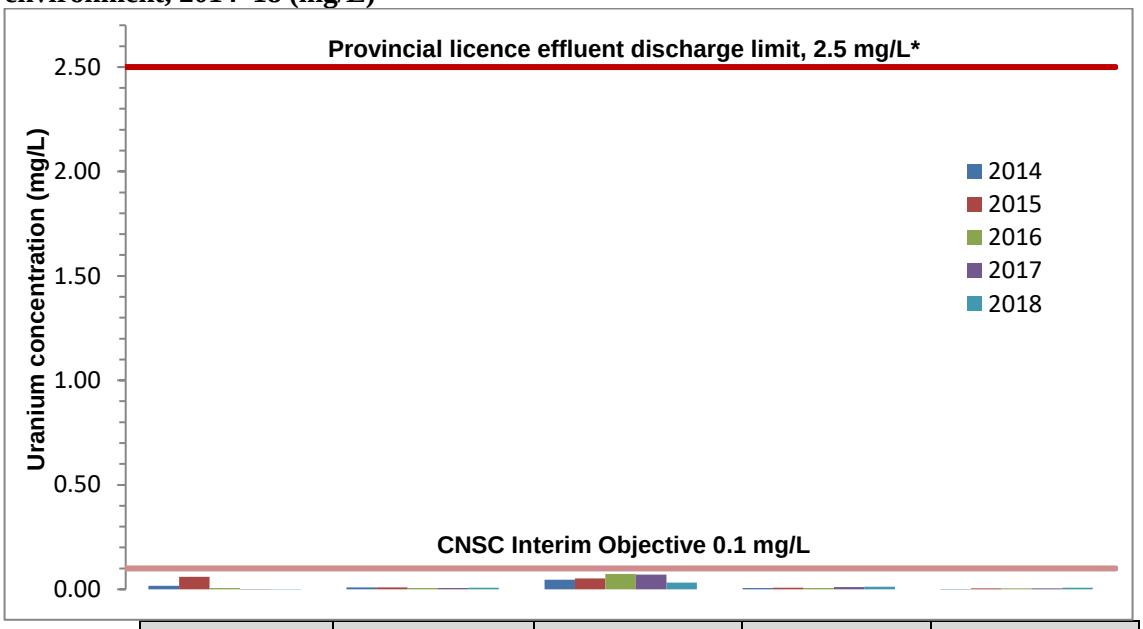
Figure 2.8: Annual average concentration of selenium in effluent released to the environment, 2014-18 (mg/L)



	Cigar Lake (mg/L)	McArthur River (mg/L)	Rabbit Lake (mg/L)	Key Lake (mg/L)	McClean Lake (mg/L)
2014	0.0010	0.0024	0.0042	0.0180	0.0007
2015	0.0041	0.0025	0.0042	0.0180	0.0092
2016	0.0062	0.0037	0.0035	0.0170	0.0210
2017	0.0042	0.0036	0.0024	0.0150	0.0110
2018	0.0044	0.0023	0.0026	0.0100	0.0210

*Action level for Key Lake shown (5 consecutive pond discharges).

Figure 2.9: Annual average concentration of uranium in effluent released to the environment, 2014–18 (mg/L)

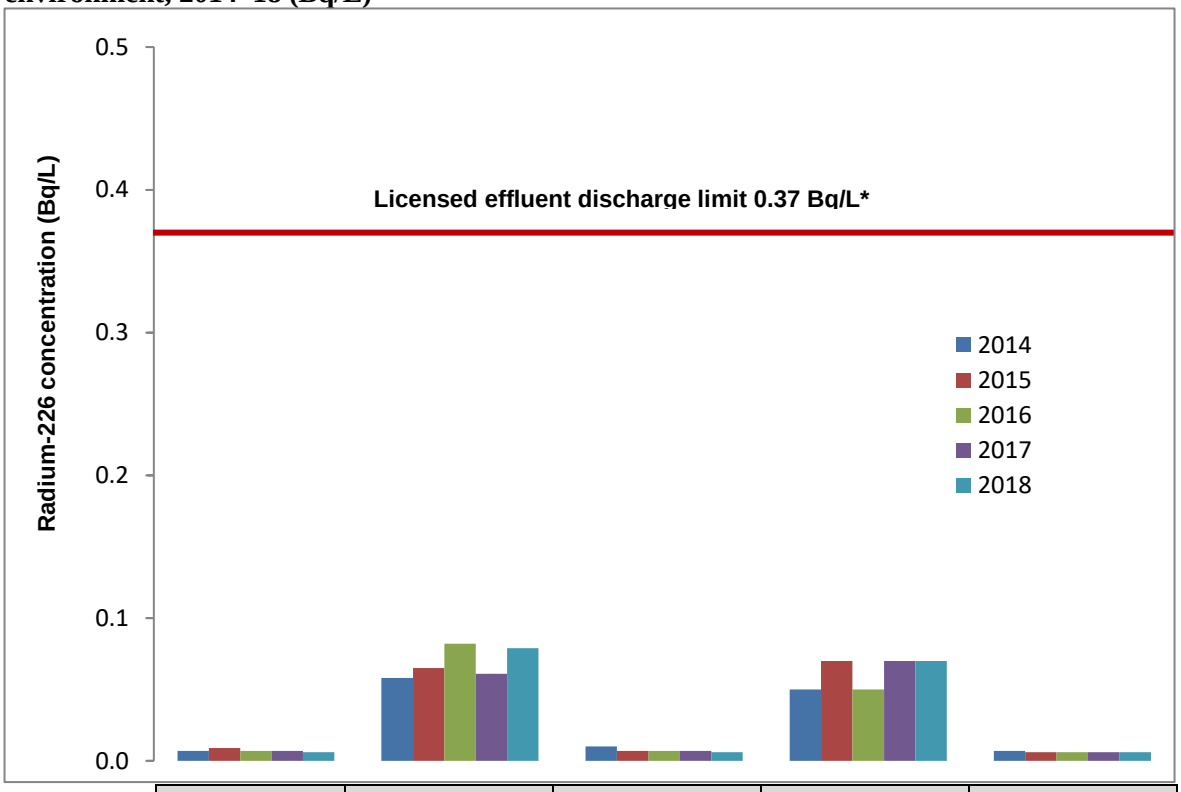


	Cigar Lake (mg/L)	McArthur River (mg/L)	Rabbit Lake (mg/L)	Key Lake (mg/L)	McClean Lake (mg/L)
2014	0.0166	0.0095	0.0460	0.0060	0.0018
2015	0.0594	0.0089	0.0520	0.0080	0.0042
2016	0.0063	0.0055	0.0730	0.0060	0.0040
2017	0.0018	0.0056	0.0700	0.0110	0.0040
2018	0.0005	0.0071	0.0320	0.0130	0.0070

*Action level for Rabbit Lake shown (7 day mean of daily composites).

In addition to the above COPCs with the potential for adverse environmental effects, a graph showing concentrations of radium is provided in figure 2.10. The 2014 to 2018 radium-226 annual average effluent concentrations for the five facilities were well below the CNSC's licence-authorized monthly mean effluent discharge limit of 0.37 Bq/L.

Figure 2.10: Annual average concentration of radium-226 in effluent released to the environment, 2014–18 (Bq/L)



	Cigar Lake (Bq/L)	McArthur River (Bq/L)	Rabbit Lake (Bq/L)	Key Lake (Bq/L)	McClean Lake (Bq/L)
2014	0.007	0.058	0.010	0.050	0.007
2015	0.009	0.065	0.007	0.070	0.006
2016	0.007	0.082	0.007	0.050	0.006
2017	0.007	0.061	0.007	0.070	0.006
2018	0.006	0.079	0.006	0.070	0.006

* Action level for Cigar Lake, Key Lake and McArthur River (for 10 consecutive pond discharges) and McClean Lake (composite sample) shown.

Uranium mine and mill facilities also analyze treated effluent for concentrations of other regulated contaminants and COPC such as arsenic, copper, lead, nickel, zinc, total suspended solids (TSS) and pH. Table 2.3 displays the annual average parameter concentration values in effluent for these substances released in 2018, as well as the discharge limits described in the *Metal and Diamond Mining Effluent Regulations* (MDMER) [5]. All metal mines and mills in Canada are subject to MDMER of the federal *Fisheries Act* [6]. The CNSC incorporates the effluent limit requirements of MDMER in uranium mine and mill licences. In 2018, all treated effluent released to the environment from licensed mining and milling activities for the above substances met the effluent discharge limits.

Table 2.3: Annual average parameter concentration values in effluent released to the environment, 2018

Parameters	MDMER discharge limits	Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClean Lake
Arsenic (mg/L)	**0.5**	0.0603	0.0009	0.0009	0.0080	0.0300
Copper (mg/L)	**0.3**	0.0008	0.0010	0.0003	0.0050	0.0030
Lead (mg/L)	**0.2**	0.0002	0.0009	0.0001	0.0100	0.0028
Nickel (mg/L)	**0.5**	0.0009	0.0031	0.0015	0.2570	0.0130
Zinc (mg/L)	**0.5**	0.0271	0.0014	0.0006	0.0090	0.0030
Molybdenum (mg/L)	**N/A**	0.1030	0.0164	0.1800	0.0700	0.0030
Selenium (mg/L)	**N/A**	0.0044	0.0023	0.0026	0.0100	0.0210
TSS (mg/L)	**15**	1	1	1	2	2
pH annual mean value	**6.0–9.5**	7.3	7.5	7.3	6.7	7.2

CNSC staff will continue to review effluent quality results to ensure effluent treatment performance remains effective.

Treated mining/milling effluent: A comparison of the uranium mining sector to other metal mining sectors across Canada

As noted earlier, metal mines and mills in Canada are subject to MDMER [5] of the federal *Fisheries Act* [6]. Compliance with MDMER limits provides a good effluent treatment comparison of the mining sector to other metal mining sectors across Canada. The effluent treatment quality of the uranium mine and mill facilities compares favourably to other mining sectors of base metal, precious metal and iron mines.

The data used for this comparison are acquired from Environment and Climate Change Canada (ECCC). Figure 2.11 and tables 2.4 and 2.5 provide sector-specific MDMER [5] information available for 2018 for effluent constituents of molybdenum, selenium and uranium. ECCC effluent quality data for 2017 and 2018 for arsenic, copper, nickel, lead, zinc, pH, TSS, and acute lethality testing was not available at the time of writing this report. A comparison of these parameters for the most recent available MDMER data (2016 data) is presented in the 2017 regulatory oversight report. The 2017 regulatory oversight report concluded that uranium sector was similar or better than the other three metal mining sectors with regard to the performance indicators: effluent concentrations, compliance with regulatory limits, and toxicity test results.

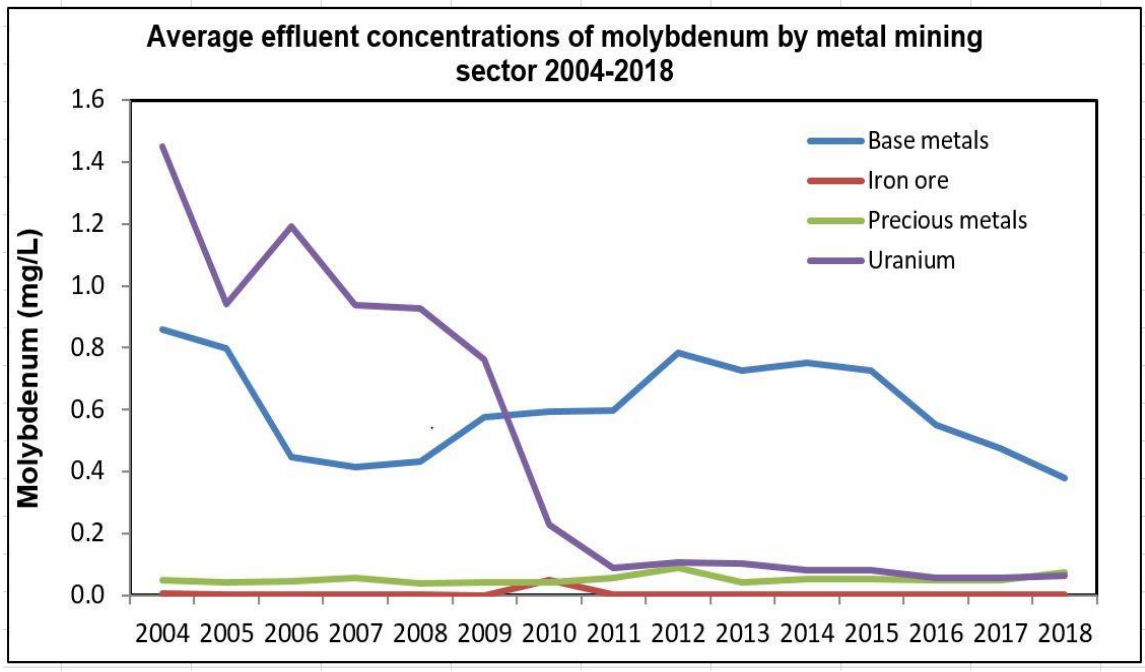
The mines that released treated effluent reporting under MDMER are grouped into four metal mining sectors based on the primary metal produced. The metal mining sectors are:

- uranium – 5 facilities;
- base metals (such as copper, nickel, molybdenum or zinc) – 47 facilities;
- precious metals (such as gold or silver) – 56 facilities; and
- iron – 8 facilities.

Molybdenum is a parameter requiring routine monitoring of treated effluent subject to MDMER [5]. Ecological risk assessments completed in the mid-2000s indicated that releases of molybdenum posed a risk to biota that merited adaptive management. As a result of a request from the Commission, licensees added administrative controls and treatment technology upgrades to their effluent management systems. The success of these actions is evident in figure 2.11, which shows molybdenum releases in the uranium mining sector have decreased substantially.

In 2018, molybdenum concentrations in uranium mining sector effluent were similar to those measured in effluent of precious metal and iron mines, and less than those measured in effluent of base metal mines.

Figure 2.11: Average treated effluent concentration of molybdenum by metal mining sector, 2004–18



In mid-2012, *Metal Mines Effluent Regulations* (MMER) added the requirement for monitoring selenium. Table 2.4 summarizes the average selenium concentration in treated effluent from each mining sector using data collected since 2012. Selenium concentration in uranium sector effluent was similar to that of other metal mining sectors in Canada.

Table 2.4: Average selenium concentration in treated effluent by metal mining sector, last half of 2012 and all of 2013–18

Year	Metal mining sector			
	Uranium (mg/L)	**Base metals (mg/L)**	**Precious metals (mg/L)**	**Iron (mg/L)**
2012/2013	0.003	0.005	0.005	0.001
2014	0.004	0.006	0.005	0.001
2015	0.004	0.005	0.004	0.004
2016	0.008	0.006	0.003	0.003
2017	0.004	0.008	0.004	0.001
2018	0.006	0.006	0.004	0.003

Uranium concentrations have recently been added to the parameters required to be monitored and reported under the MDMER [5]. Table 2.5 presents the average uranium concentrations in treated effluent by metal mining sectors. As shown in table 2.5, the uranium sector had an average concentration of 0.0119 mg/L of uranium in 2018. Uranium mines have elevated natural uranium concentrations compared to other conventional mining operations. By way of comparison and to provide context, the action level in the environmental code of practice and the Saskatchewan regulatory limit for uranium is 0.3 mg/L and 2.5 mg/L, respectively. CNSC staff continue to verify that releases of uranium are controlled and reduced to the extent practicable through reviews of effluent quality data, scrutiny of proposed facility changes that could affect effluent quality, and validation of the effectiveness of licensee programs to minimize release of contaminants.

Table 2.5: Average uranium concentration in treated effluent by metal mining sector, 2017–18

Year	Metal mining sector			
	Uranium (mg/L)	**Base metals (mg/L)**	**Precious metals (mg/L)**	**Iron (mg/L)**
2017	0.0185*	0.0062	0.0027	0.0002
2018	0.0119*	0.0027	0.0010	0.0036

* Data not available from Environment and Climate Change Canada; value calculated from licensee annual reports.

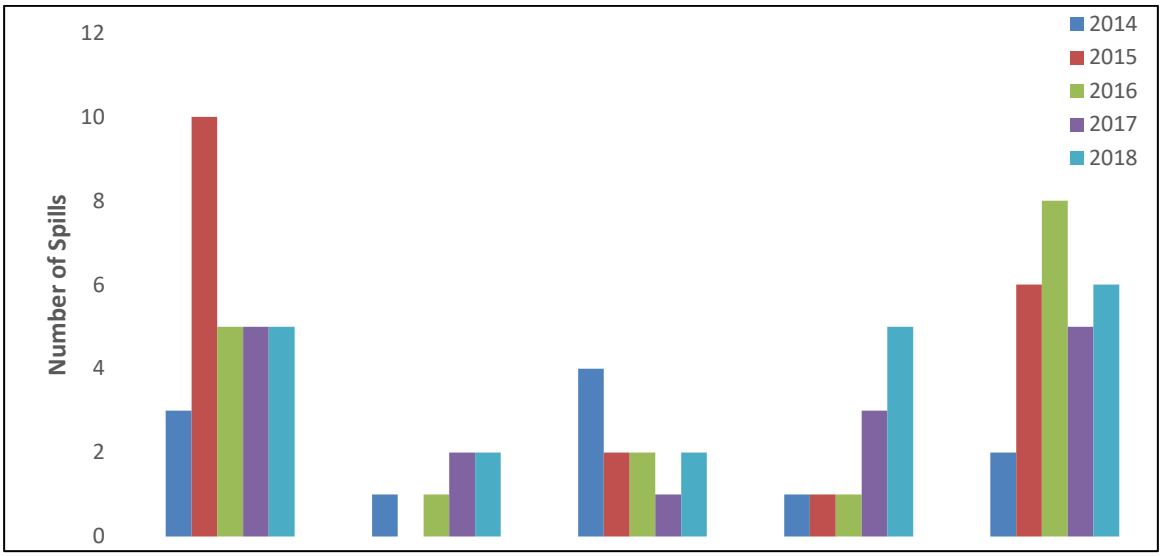
Uncontrolled releases

Licensees are required to report to the regulatory authorities, including the CNSC, any unauthorized releases (spills) of hazardous or radioactive substances to the environment.

Figure 2.12 depicts the number of environmental reportable spills for uranium mine and mill facilities during the 2014 to 2018 reporting period. In each case, CNSC staff reviewed and evaluated the licensee's actions to ensure effective remediation and prevention and were satisfied with actions taken by the licensee. CNSC staff rated all 2018 spills as "low significance" resulting in no residual impact to the environment.

The facility-specific sections and appendix I describe each reportable spill and any corrective actions taken by the licensee in response to the spill. The CNSC spill rating definitions are also found in appendix I-2.

Figure 2.12: Uranium mines and mills environmental reportable spills, 2014–18



	Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClean Lake
2014	3	1	4	1	2
2015	10	0	2	1	6
2016	5	1	2	1	8
2017	5	2	1	3	3
2018	5	2	2	5	6

Air emissions released to the environment

Uranium mines and mills environmental programs include monitoring the effects of operations on the surrounding air and soil. Licensees measure airborne particulate levels and concentrations of regulated contaminants and COPC, as well as the concentration of radon gas in ambient air. Soil and vegetation may be affected by atmospheric deposition of particulate containing adsorbed metals and radionuclides associated with onsite activities. Licensees monitor contaminant concentrations in soil and terrestrial vegetation to verify that operational impacts are below regulatory limits and follow the principle of ALARA.

Facilities with milling operations monitor atmospheric emissions from acid plants, yellowcake dryers, calciner operations, packaging, grinding and ammonium sulphate operations. Other measured parameters (e.g., ambient radon and stack testing for sulphur dioxide, uranium and heavy metals) verify facility design and evaluate the operation's performance against predictions made in ERAs.

CNSC staff verified that the mines and mills have demonstrated satisfactory performance mitigating and monitoring the effects of their operations on the surrounding air and soil. Soil monitoring results around the facilities indicated all measured parameters are within background level. As would be expected air monitoring for radon gas near tailings management facilities, and waste rock piles show results higher than the regional background of 25 Bq/m^3. For example, at Rabbit Lake, for the last six years, radon concentrations at a B-Zone sampling location ranged from 37 Bq/m^3 to 62.9 Bq/m^3. However the concentrations decreased to background levels within a short distance, less than 2 kilometres from the facility.The monitoring results indicate negligible impacts to the environment from atmospheric releases and confirm all uranium mines and mills are in compliance with their environmental programs and provincial standards.

2.4.3 Assessment and monitoring

In accordance with the *Uranium Mines and Mills Regulations* [7], each uranium mine and mill licensee has an environmental monitoring program that monitors concentrations of nuclear and hazardous substances in the environment and characterizes and monitors effects to the environment associated with the licensed facility. Nuclear and hazardous substances associated with monitoring programs are selected based on regulated COPCs identified through the licensee's ERA. COPCs identified through the ERA with the potential for adverse environmental effects are managed through increased monitoring, inclusion in the environmental code of practice, and further study or implementation of additional controls by licensees. CNSC staff review and evaluate environmental monitoring programs as criteria for assessing environmental performance.

The results of the licensee's environmental monitoring programs relative to the ERA predictions are provided in an Environmental Protection Report (EPR) that is typically completed every five years and provides environmental data collected over the previous five year period. The CNSC and the Saskatchewan Ministry of Environment staff review the EPRs when released.

2.4.4 Environmental risk assessment

The CNSC uses facility-specific licensee-developed environmental risk assessments (ERAs) as a regulatory tool throughout the lifecycle of uranium mine and mill facilities. Applicants use ERAs during initial environmental assessments for new facilities and for changes to existing facilities or activities at licensed operations where applicable. The ERA identifies the need for mitigation technologies or practices and predicts:

- physical disturbances;
- releases to the atmosphere;
- releases to surface water;
- air quality;
- soil and sediment quality;
- surface water quality;
- groundwater quality;
- changes to the physical environment; and
- biological and human health effects.

The results of the licensee's effluent and environmental monitoring programs relative to the ERA predictions are provided in an environmental protection report that is typically completed every five years. The CNSC and the Saskatchewan Ministry of Environment staff review licensee monitoring program results on a regular basis, and the environmental protection report(s) when released.

If required, ERAs are updated and the risks to the public and the environment are reassessed every five years. ERAs are updated based on changes to operational activities, revised predictions, environmental monitoring data collected over the previous five years, and the latest science. Table 2.6 displays the year of the most recent ERA submitted for each uranium mine and mill and the year for when the next update to the ERAs will be submitted to the CNSC for review. CNSC staff regularly review ERAs to determine the potential risks to human health and the environment and to verify that mitigation measures are adequate.

Table 2.6. ERAs - current and upcoming submissions

	Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClean Lake
Current ERA	2017	2015	2015	2015	2016
Upcoming ERA	2022	2020	2020	2020	2021

2.4.5 Protection of the public

According to regulatory requirements, each licensee must demonstrate that the public is protected from exposures to radiological and hazardous substances released from an operation. Protection of the public is assessed in the ERA, which contains a human health risk assessment (HHRA). The HHRA assesses hazardous and radiological releases from facilities and models resultant concentrations of contaminants in air, water, soil and traditional foods (such as fish, waterfowl and moose). The concentrations of contaminants consumed by a typical local resident are assessed against human health benchmarks in the HHRA. For all facilities, the HHRAs confirmed that concentrations of contaminants for a typical local resident are well below concentrations that could cause health effects. Therefore, it has been determined the health of persons in areas surrounding the facilities is protected.

Eastern Athabasca Regional Monitoring Program

The Eastern Athabasca Regional Monitoring Program (EARMP) is a well-recognized environmental monitoring program designed to gather data on long range environmental information and potential cumulative impacts downstream of uranium mining and milling operations. The program was initiated in 2011 with funding from the Saskatchewan government and the uranium mining industry (Cameco and Orano) as a sub-element of the Province of Saskatchewan's Boreal Watershed Initiative which ended in 2017. The CNSC became a funding partner in 2017/18 to support the publishing of an EARMP final report (2011 to 2017) with a five year long-term funding agreement (2018/19 to 2022/23) signed in 2018 between the Saskatchewan Government, the CNSC and industry. The community program monitors the safety of traditionally harvested country foods through analysis of water, fish, berries and wild meat, (e.g., grouse, rabbit, caribou, and moose) from representative northern Saskatchewan communities. The program contractor is a northern Saskatchewan Indigenous-owned business. Samples are collected from areas identified by community members with members either assisting in sample collection or providing samples from their own harvesting activities.

Harvesting and consuming traditional country foods are an important part of the culture in northern Saskatchewan. The intent of EARMP is to provide confidence and transparent communication with community members that traditional country foods remain safe to eat today and for future generations. The program has demonstrated that concentrations of chemicals of interest have been relatively consistent over time and generally within the regional reference range indicating no evidence of long-range transport of contaminants associated with uranium mining.

Evaluation of country food data from previous years confirmed uranium mines and mills are not affecting the safety of country foods at nearby communities. The results indicated that radiological and non-radiological exposures to residents consuming country foods were similar to exposures of the general Canadian population. The EARMP has proven to be a productive means of involving the community in monitoring the health of their local environment and provided them with confidence in the safety of their traditional foods. The conclusion of the EARMP is that water and country foods are considered safe for consumption.

The annual reports and data are available at earmp.ca. The CNSC continues to support the EARMP and CNSC staff are working to further collaborate on this valuable program.

2.5 Conventional Health and Safety

The conventional health and safety SCA covers the implementation of a program to manage workplace safety hazards and protect personnel and equipment. Uranium mines and mills must develop, implement and maintain effective safety programs to promote safe and healthy workplaces and to minimize incidences of occupational injuries and illnesses.

For 2018, CNSC staff rated the conventional health and safety SCA at uranium mine and mill facilities as "satisfactory" following acceptable performance in health and safety practices, awareness and performance.

Conventional health and safety ratings

Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClean Lake
SA	SA	SA	SA	SA

SA = satisfactory

Practices

The CNSC requires licensees to identify potential safety hazards, assess associated risks, and introduce the necessary materials, equipment, programs and procedures to effectively manage, control and minimize these risks. CNSC staff work in collaboration with the Saskatchewan Ministry of Labour Relations and Workplace Safety to provide regulatory oversight of conventional health and safety in uranium mines and mills. CNSC staff's compliance verification activities include inspections, reviews of compliance reports and health and safety events.

CNSC staff confirmed that licensees at uranium mines and mills implemented effective management of conventional health and safety in their activities. In addition to CNSC staff's regulatory oversight, the Province of Saskatchewan, through an agreement with the Government of Canada, conducts regular inspections in the areas of occupational health and safety, mine safety and fire protection.

Awareness

CNSC staff observed that the implementation of conventional health and safety programs continued to provide education, training, tools and support to workers (see figure 2.13). Each facility licensee promotes the idea that safety is the responsibility of all individuals; this message is reinforced by licensee management, supervisors and workers. Licensee management stresses the importance of conventional health and safety through regular communication, management oversight, and continual improvement of safety systems. Through onsite inspections, CNSC staff have identified a high level of communication and awareness in the area of conventional health and safety. CNSC staff concluded that in 2018, licensees of uranium mines and mills were committed to accident prevention, safety awareness, and a focus on safety culture.

Figure 2.13: Warning signage in underground work area

Performance

Key performance measures for conventional health and safety are the number of lost-time injuries (LTIs) and the total recordable incident rate (TRIR) that occur per facility. An LTI is a workplace injury that results in the worker being unable to return to work for a period of time. In reviewing each LTI, CNSC staff consider the injury's severity and frequency rates. The TRIR is the incident frequency rate measuring the number of fatalities, lost-time injuries, and other injuries requiring medical treatment. Table 2.7 shows the number of LTIs at the uranium mines and mills along with severity, frequency and total recordable incident rates.

Table 2.7: Lost-time injury statistics for uranium mines and mills, 2018 (including contractors)

	Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClean Lake
Lost-time injuries[1]	0	0	0	0	1
Severity rate[2]	0	23.2	0	0	4.8
Frequency rate[3]	0	0	0	0	0.3
Total Recordable Incident Rate[4]	1.0	5.02	5.03	2.59	0.75

[1] An injury that takes place at work and results in the worker being unable to return to work for a period of time.
[2] A measure of the total number of days lost to injury for every 200,000 person-hours worked at the facility.
Accident severity rate = [(# of days lost in last 12 months) / (# of hours worked in last 12 months)] x 200,000.
[3] A measure of the number of LTIs for every 200,000 person-hours worked at the facility.
Accident frequency rate = [(# of injuries in last 12 months) / (# of hours worked in last 12 months)] x 200,000.
[4] A measure of the number of fatalities, lost-time injuries, and other injuries requiring medical treatment for every 200,000 person-hours worked at the facility.
Recordable incident rate = [(#incidents in last 12 months) / # hours worked in last 12 months)] x 200,000.

Appendix K provides additional details on the 2018 LTI at the McClean Lake Operation and corrective actions taken. Information on these events can be found in section 7.4. CNSC staff and the Saskatchewan Ministry of Labour Relations and Workplace Safety monitor and review each reportable injury to ensure the cause is identified and corrective actions taken are satisfactory. When applicable, injury information is shared among the facilities for lessons learned to improve safety and prevent recurrences.

CNSC staff concluded through their compliance verification activities that the health and safety programs at all uranium mines and mills met regulatory requirements in 2018.

Lost-time injuries: Comparison of the uranium mining sector to other mining sectors in Saskatchewan

Table 2.8 displays the various safety statistics of mining sectors within Saskatchewan. When contractors are excluded, the uranium mining and milling sector exhibits performance similar to other mining sectors for LTIs and frequency rate. The uranium sector comparison excludes contractors because statistics for the other sectors does not include contractors.

Table 2.8: Safety statistics of mining sectors in Saskatchewan, 2018

Mining sector	Number of LTIs*	Accident frequency rate (200,000 person-hours)*	Accident severity rate (200,000 person-hours)*	Total Recordable Incident Rate (200,000 person-hours)***
Potash (underground)	4	0.1	6.8	1.3
Solution (potash)	3	0.4	5.8	0.77
Minerals (sodium sulphate, sodium chloride)	2	0.7	2.5	_ _
Hard rock (gold, diamond)	10	0.8	31.1	3.62
Coal (strip mining)	6	1.1	38.4	2.10
Uranium	1	0.08	8.5	1.74
Uranium (including contractors)**	1	0.06	14.0	2.74****

* Source: Saskatchewan Ministry of Labour Relations and Workplace Safety.
** Statistics for all the other mining sectors do not include contractors.
*** Source: Saskatchewan Mining Association, data provided voluntarily by member companies.
**** Source: See tables 3.3, 4.3, 5.4, 6.3 and 7.3 for the data for each individual licenced uranium operation.

CNSC staff completed a benchmarking effort to compare the injury frequency rate of Saskatchewan uranium mines and mills against national and international mining statistics. One limitation to consider when comparing safety related statistics is the variation in workplace injury definitions. However, efforts are made where possible to compare and assess licensee performance with respect to relevant national and international benchmarks. Table 2.9 shows various international benchmarks related to workplace frequency rates. The uranium mining and milling sector in Canada exhibits similar performance.

Table 2.9: National/International benchmarking related to workplace safety

Publication/Standard	Lost Time Frequency rate	Total Recordable Incident Rate	Notes
Government of Western Australia Department of Mines, Industry Regulation and Safety[1]	2.3, 3.1	N/A	2.3 across all mining sectors, and 3.1 in non-metal mining environments; rates are per million hours worked for 2016/2017
International Council on Mining and Metals[2]	4.3	N/A	Average rate are per million hours worked for 2016 based on statistics from 27 of the largest international mining companies
2017 Workplace Fatality and Injury Rate Report – Canada[3]	1.9	N/A	Average rate across all Canadian provinces and territories per million hours worked
The National Institute for Occupational Safety and Health[4] (US)	1.7	N/A	Average rate per 200,000 hours worked in 2015
International Council on Mining and Metals (ICMM)[5]	N/A	3.94	Total Recordable Injury Frequency Rate for ICMM Members. Rate per 200,000 hours worked in 2017
International Council on Mining and Metals (ICMM)[5]	N/A	4.26	Total Recordable Injury Frequency Rate for ICMM Members. Rate per 200,000 hours worked in 2016
International Council on Mining and Metals (ICMM)[5]	N/A	4.70	Total Recordable Injury Frequency Rate for ICMM Members. Rate per 200,000 hours worked in 2015

[1] Safety performance in the Western Australian mineral industry 2016-17, Government of Western Australia, Department of Mines, Industry Regulations and Safety, 2018.
[2.] Benchmarking 2016 Safety Data: Progress of ICMM Members, International Council on Mining and Metals.
[3] 2017 Workplace Fatality and Injury Rate, Tucker. S, University of Regina, 2017.
[4] Number and rate of mining nonfatal lost-time injuries by year, 2006-15, The National Institute for Occupational Safety and Health.
[5] Benchmarking 2017 safety data; progress of ICMM members, International Council on Mining & Minerals.
N/A not available

3 CIGAR LAKE OPERATION

Cameco Corporation is the operator of the Cigar Lake Operation, which is located approximately 660 kilometres north of Saskatoon, Saskatchewan.

The Cigar Lake Operation consists of an underground uranium mine with surface facilities for loading ore slurry into trucks, waste management facilities, water treatment plant, surface freeze plants, administration offices and warehouses. Figure 3.1 shows an aerial view of the Cigar Lake Operation.

Figure 3.1: Cigar Lake Operation – aerial view looking north

Table 3.1 presents the mining production data from 2014 through 2018. Commercial production commenced at the Cigar Lake mine in spring of 2014.

Table 3.1: Cigar Lake Operation - mining production data, 2014–18

	2014	2015	2016	2017	2018
Ore tonnage (Mkg/year)	3.32	26.1	37.27	36.49	43.06
Average ore grade mined (%U)	6.02	22.92	18.27	18.85	16.1
Uranium mined (Mkg U/year)	0.2	4.95	6.81	6.88	6.94
Authorized annual production (Mkg U/year)	9.25	9.25	9.25	9.25	9.25

CNSC staff confirmed the Cigar Lake Operation production remained within the authorized CNSC licence limit for the 2018 calendar year and is carrying forward a cumulative shortfall of 12.7 million kilograms of uranium. This shortfall can be recouped in future years by increased production.

Construction activities in 2018 focused on completing and maintenance of infrastructure to sustain production, which included commissioning of the brine system to freeze ground around the ore body and waste rock handling facilities.

3.1 Performance

The safety and control area (SCA) ratings at Cigar Lake for the 2014 to 2018 five-year period are shown in appendix E. For 2018, CNSC staff rated all 14 SCAs for the Cigar Lake Operation as "satisfactory".

In 2018, CNSC staff carried out compliance inspections covering the SCAs of waste management, management system, radiation protection, environmental protection, conventional health and safety, packaging and transport, and fitness for service. There were eight non-compliances resulting from CNSC inspections at the Cigar Lake Operation for the 2018 calendar year. These non-compliance items were low risk in nature and related to the management system, radiation protection, packaging and transport and environmental protection SCAs. Corrective actions were implemented by the licensee, reviewed, and accepted by CNSC staff. A complete list of these inspections, including the dates the reports were sent to licensees and SCAs assessed, can be found in appendix B.

This report focuses on the three SCAs that cover many of the key performance indicators for these mines and mills: radiation protection, environmental protection, and conventional health and safety.

3.2 Radiation Protection

For 2018, CNSC staff continued to rate the radiation protection SCA at Cigar Lake as "satisfactory" based on regulatory oversight activities.

Cigar Lake Operation - radiation protection ratings

2014	2015	2016	2017	2018
SA	SA	SA	SA	SA

SA = satisfactory

Radiological hazard control

The main source of radiological exposure at the Cigar Lake Operation is from mining high-grade uranium ore. The effective dose contributors to nuclear energy workers (NEWs) at Cigar Lake remained similar to previous years, with gamma radiation (40%), radon progeny (34%), and long-lived radioactive dust (LLRD) (26%). Gamma radiation hazards are controlled through the effective use of time, distance and shielding. Exposures to radon progeny and LLRD are controlled through source control, ventilation, contamination control and personal protective equipment.

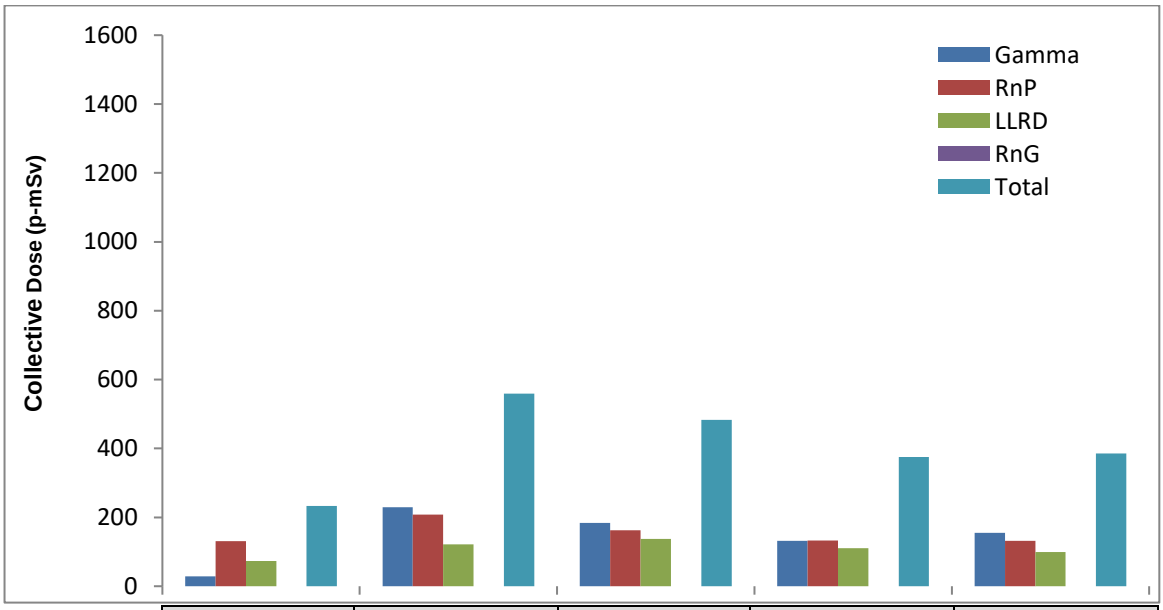
Radiation protection program performance

CNSC staff confirmed that the radiation protection program and practices at the Cigar Lake Operation remained effective in controlling radiological exposure to workers. There were two events that resulted in employees exceeding either weekly or quarterly action levels. In June, 2018 four workers exceeded the weekly action level of 1 mSv, and one also exceeded the quarterly action level of 5 mSv. In November 2018, one worker exceed both the weekly action level and quarterly action level. As a result of these two events, CNSC staff conducted a focused inspection of the Radiation Protection Program, and specific components of the Management System Program at Cigar Lake. CNSC staff verified that approved programs are followed by Cameco and that, as a result of the experience from the incidents in 2018, were improved and remained protective of workers.

Application of ALARA

In 2018, the collective radiation exposure to NEWs at the Cigar Lake Operation was 387 person-millisieverts (p-mSv), an approximate 2.8 percent increase from the 2017 value of 376 p-mSv but below the average value of 451 p-mSv for the past four years (see figure 3.2).

Figure 3.2: Cigar Lake Operation - annual collective dose, 2014–18



	2014	2015	2016	2017	2018
Gamma (p-mSv)	29	229	184	132	155
RnP (p-mSv)	131	208	162	133	132
LLRD (p-mSv)	73	122	137	111	99
RnG (p-mSv)	0	0	0	0	0
Total	233	559	483	376	387*

RnP = radon progeny; LLRD = long-lived radioactive dust; RnG = radon gas

* sum of all components does not add up to the 387 p-mSv total due to rounding errors.

Efforts to keep worker exposures as low as reasonably achievable (ALARA) included ongoing assessment of activities and areas with higher levels of risk for radon progeny exposures, such as jet-boring system operators. While the assessments have demonstrated that the procedural controls in place are effective, engineering improvements were applied to reduce or eliminate the risk of exposure to elevated levels of radon progeny. This target was modified in 2018 to focus on the top five workers for the facility and look for opportunities to reduce their exposures. In addition, Cameco is investigating new direct reading dosimeters, and developing prototype PRISM units to monitor radon progeny. CNSC staff concluded that the Cigar Lake Radiation Protection Program remained effective in ensuring that worker exposures remain consistent with the ALARA principle.

Worker dose control

During 2018, the average individual effective dose to NEWs was 0.47 millisieverts (mSv). This compares to an average effective dose of 0.34 mSv in 2017. The slight increase in the average dose is attributed to a significant reduction in the number of workers (824 in 2018 vs 1,107 in 2017), maintenance activities and is of low regulatory significance.

The increase in the maximum dose from 3.36 mSv in 2017 to 7.28 mSv in 2018 is attributed to an event which occurred in late 2018. A significant portion of the worker's annual dose (about 60%) was due to an exposure to elevated levels of radon progeny from this event. As indicated in figures 2.5 and 2.6, no worker exceeded the regulatory individual effective dose limit of 50 mSv in one year and 100 mSv in a five year dosimetry period. CNSC staff verified that improvements have been made at Cigar Lake operation to provide a higher level of assurance that radiological hazards are anticipated and that assumptions of the absence of hazard are verified through suitable radiological monitoring by Cameco.

Based on compliance verification activities that included inspections, reviews of licensees' reports, work practices, monitoring results and individual effective dose results for 2018, CNSC staff were satisfied that the Cigar Lake Operation continued to be effective in controlling radiation doses to workers.

3.3 Environmental Protection

For 2018, CNSC staff continued to rate the environmental protection SCA as "satisfactory". CNSC staff concluded that the licensee's environmental protection program was effectively implemented and met all regulatory requirements.

Cigar Lake Operation - environmental protection ratings

2014	2015	2016	2017	2018
SA	SA	SA	SA	SA

SA = satisfactory

Environmental management system

The environmental management system at the Cigar Lake Operation includes activities such as establishing annual environmental objectives, goals and targets. Cameco conducts internal audits of its environmental management program at the Cigar Lake Operation, as identified in the CNSC-approved management system program. CNSC staff reviewed and assessed the objectives, goals and targets through regular compliance verification activities. CNSC staff confirmed that Cameco had continued with routine inspections, internal audits, environmental training and periodic reviews of environmental monitoring data. These activities were conducted to ensure continual improvement and to confirm that the controls put into place to protect the environment are effective.

Effluent and emissions control

Treated effluent released to the environment

CNSC staff confirmed parameter concentrations in treated effluent were low and remained below treated-effluent discharge limits at the Cigar Lake Operation. CNSC staff verified that treated effluent released to the environment was well below regulatory requirements. At the Cigar Lake Operation throughout 2018, concentrations for molybdenum, selenium and uranium (shown in figures 2.7 to 2.9) remained below their respective action levels and well below provincial licence effluent discharge limits.

The Cigar Lake Operation is required to monitor concentrations of other regulatory contaminants and COPCs such as radium-226, arsenic, copper, lead, nickel, zinc, total suspended solids (TSS) and pH. CNSC staff reviewed and confirmed the Cigar Lake Operation continued to meet *Metal and Diamond Mining Effluent Regulations* (MDMER) [5] discharge limits (shown in section 2.4). There were no exceedances of the environmental code of practice action levels.

In 2016, the Cigar Lake Operation EPR identified an increasing arsenic trend in effluent. While below regulatory limits, arsenic concentrations in the treated effluent were above environmental assessment predictions and above concentrations previously measured in the effluent prior to achieving full ore production. In response, Cameco created a working group to identify causes of the elevated concentration and develop mitigation strategies. In 2018, Cameco implemented several mitigation techniques to reduce arsenic loadings to the environment, such as improving recycling of process water captured on site for usage in underground processes. As a result, arsenic loadings and mean concentrations decreased to 0.060 mg/L in 2018 compared to 0.075 mg/L in 2017 at Cigar Lake. CNSC staff are satisfied that Cameco is taking appropriate actions to lower arsenic concentrations in the effluent and will continue to follow-up throughout 2019.

CNSC staff will continue to review effluent quality results to ensure that effluent treatment performance remains effective.

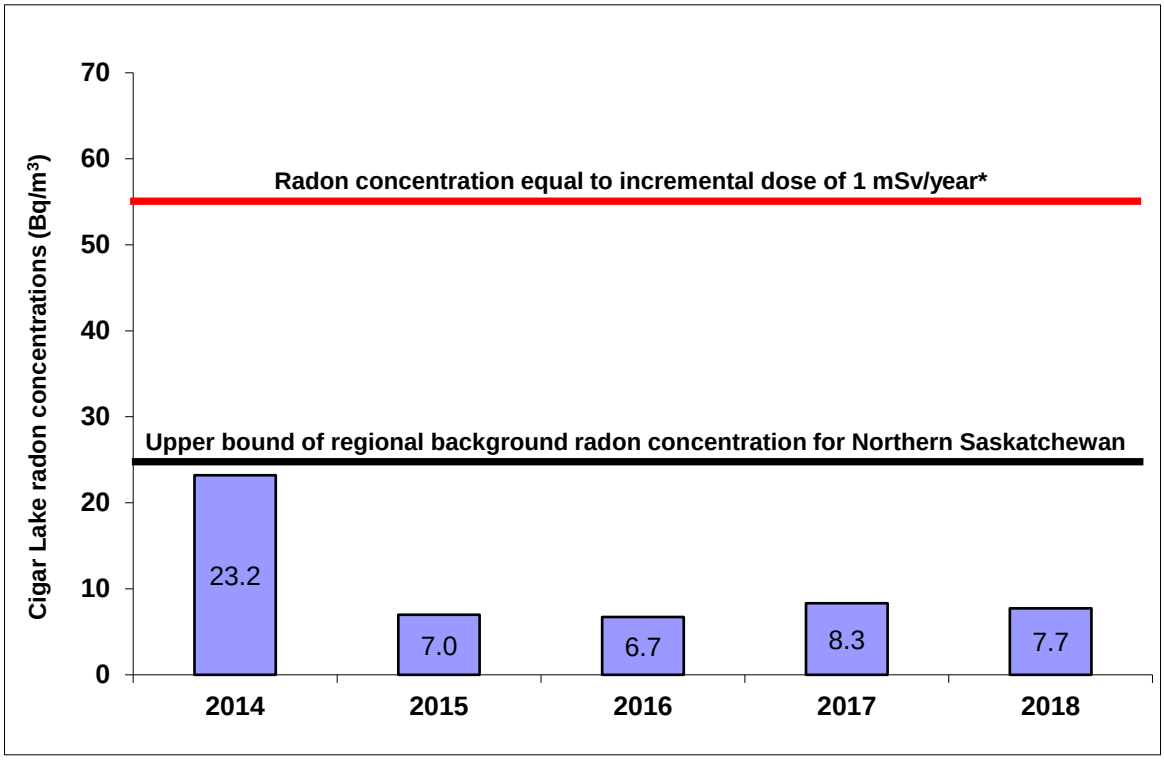
Air emissions released to the environment

As required by the CNSC, the Cigar Lake Operation maintains an air and terrestrial monitoring program. Air monitoring at the Cigar Lake facility includes ambient radon, total suspended particulate (TSP), soil sampling and lichen sampling to assess the impact of air emissions. Lichen samples are analyzed to determine the level of airborne particulate contaminants deposited on the surface of the lichen as a means of estimating the level of contamination, if any, entering lichen consumers, such as caribou.

Radon in ambient air is measured using passive track-etch cups at eight monitoring stations around the operation. The background concentration of radon in northern Saskatchewan ranges from less than 7.4 Bq/m^3 to 25 Bq/m^3.

Figure 3.3 illustrates that the average concentrations of radon in air at the Cigar Lake Operation over the period from 2014 to 2018, showing measured values are similar to values measured as northern Saskatchewan regional background. The average radon concentrations are less than a reference level of 55 Bq/m^3, which represents an incremental dose of 1 mSv per year over background. CNSC staff noted that concentrations remained well below the reference level.

Figure 3.3: Cigar Lake Operation - average concentrations of radon in ambient air, 2014–18



* Upper-bound of the incremental dose of 1 mSv per year above background (i.e., an incremental radon concentration of 30 Bq/m^3 above natural background) based on ICRP Publication 115. Values are calculated as geometric means.

A high-volume air sampler was used to collect and measure TSP in air. Results of the TSP levels were below provincial standards (see table 3.2). The mean concentrations of metal and radionuclides adsorbed to TSP were low and below the reference annual air quality levels identified in table 3.2.

Soil and terrestrial vegetation may be affected by atmospheric deposition of particulate and adsorbed metals and radionuclides associated with onsite activities. Lichen and soil samples were collected in 2016 as required by the triennial sampling program. COPC concentrations measured in the soil samples collected from the study area were comparable to historical results. Concentrations of metals remained below existing *Canadian Environmental Quality Guidelines* [8] set by the Canadian Council of Minister of the Environment, and radionuclide concentrations were low and near, or at background levels, and analytical detection limits. CNSC staff concluded that the level of airborne particulate contaminants produced by the Cigar Lake Operation is acceptable and does not pose a risk to the environment.

Table 3.2: Cigar Lake Operation - concentrations of metal and radionuclides in air, 2014–18*

Parameter	Reference annual air quality levels	2014	2015	2016	2017	2018
TSP (µg/m^3)	**60** [3]	24.7	15.8	11.4	12.9	18.9
As (µg/m^3)	**0.06** [1]	0.00025	0.00031	0.0003	0.00039	0.00023
Mo (µg/m^3)	**23** [1]	0.0001	0.0001	0.0002	0.0002	0.0003
Ni (µg/m^3)	**0.04** [1]	0.00067	0.00062	0.00105	0.00103	0.00083
Pb (µg/m^3)	**0.10** [1]	0.0013	0.0009	0.0009	0.0008	0.0008
Se (µg/m^3)	**1.9** [1]	0.00003	0.00003	0.00003	0.00005	0.00003
Pb-210 (Bq/m^3)	**0.021** [2]	0.00025	0.000315	0.000305	0.00036	0.00037
Po-210 (Bq/m^3)	**0.028** [2]	0.000086	0.000095	0.000099	0.00012	0.00013
Ra-226 (Bq/m^3)	**0.013** [2]	0.000008	0.000014	0.000020	0.000030	0.000026
Th-230 (Bq/m^3)	**0.0085** [2]	0.00001	0.000014	0.000012	0.000023	0.000018
U (µg/m^3)	**0.06** [1]	0.00008	0.00055	0.00113	0.00151	0.00103

[1] Reference annual air quality levels are derived from Ontario's 24-hour ambient air quality criteria (2012).

[2] Reference level is derived from International Commission on Radiological Protection (ICRP) Publication 96, *Protecting People Against Radiation Exposure in the Event of a Radiological Attack.*

[3] *Saskatchewan Environmental Quality Guidelines*, Table 20: Saskatchewan Ambient Air Quality Standards. Values are calculated as geometric means.

* Reference levels based on Province of Ontario Ambient Air Quality Criteria and are shown for reference only. No federal or Province of Saskatchewan limits were established at the time of this report.

The lichen chemistry results from exposure stations in 2016 were similar to that of the reference stations and historic data. CNSC staff concluded that the level of airborne particulate contaminants was acceptable and did not pose a risk to lichen consumers.

Uncontrolled releases

In 2018, five events reported to CNSC staff were submitted as releases of hazardous substances to the environment. All five spills listed below were low significance and reporting of these events met the requirements of REGDOC-3.2.1, *Public Information and Disclosure* [2]:

- On January 24, 2018 a decreasing trend in the level of treated effluent in monitoring pond "D" was observed. It was determined that approximately 1,200 m^3 of treated effluent had been released into the ground through a tear in the liner.
- On February 26, 2018 a purge valve on the condenser of Freeze Plant No.2 was leaking. Approximately 100 milliliters of anhydrous ammonia was released to the snow outside the plant.
- On April 12, 2018 a purge point on solenoid valve #4 at condenser #2 of Freeze Plant No. 1 was leaking ammonia; 9.2 kilograms of ammonia was released into the plant. It was determined that the probable cause of this leak was a worn teflon seal in the solenoid valve.
- On June 22, 2018, primary freeze plant No.2 was being restarted when ammonia was identified to be leaking from a flanged connection to a knife gate valve located above the heat exchanger. No more than 40 kilograms of ammonia was released to the air inside the plant.
- On September 9, 2018 primary freeze plant No.2 was being restarted. Ammonia was identified to be leaking from a knife gate valve used to isolate heat exchangers in the plant. Approximately 0.1 kilograms of ammonia was released to the air inside the plant.

The ammonia release events were attributed to failure of various mechanisms related to the ground freezing operation. There were no residual impacts to the environment as a result of releases of hazardous substance at the Cigar Lake Operation during 2018. CNSC staff were satisfied with the licensee's reporting of these spills and the corrective actions taken. CNSC staff rated all 2018 spills as low significance in accordance with the definitions provided in appendix I, table I-2. Figure 2.12 in section 2 displays the number of environmental reportable spills at the Cigar Lake Operation from 2014 to 2018.

Appendix I contains a brief description of the spills, corrective actions taken by the licensee, CNSC staff's assessment of those actions and the significance ratings for 2018.

Assessment and monitoring

CNSC staff confirmed that the licensee, in accordance with the Cigar Lake environmental protection program, successfully carried out required environmental monitoring.

Through compliance verification activities conducted and review of annual reports and EPRs, CNSC staff concluded that environmental monitoring conducted at the Cigar Lake Operation met regulatory requirements. Consequently, CNSC staff concluded that the environment remained protected.

Environmental risk assessment

The CNSC uses environmental risk assessments (ERAs) to ensure people and the environment are protected. With the exception of arsenic, the Cigar Lake ERA 2017 submission indicated that contaminant levels in the receiving water and sediment were within the predictions made in the 2011 environmental assessment. Although arsenic levels in Seru Bay of Waterbury Lake were above ERA predictions, they remain below the *Saskatchewan Surface Water Quality Objectives* of 5 µg/L. Cameco implemented measures to address arsenic in the effluent as noted above and CNSC staff verified that arsenic loading to the environment has been reduced steadily since 2016.

The Cigar Lake EPR and updated ERA for the period of 2011 to 2015 was submitted to CNSC and the Saskatchewan Ministry of the Environment in 2016 and 2017, respectively. CNSC staff reviewed the environmental monitoring results for air, soil, vegetation, water, groundwater, sediment and aquatic health indicators and confirmed that the results were within those predicted in the ERA.

After reviewing the EPR and ERA, CNSC staff concluded that adequate measures have been taken at the Cigar Lake Operation to protect the environment.

Protection of the public

Cameco is required to demonstrate that the health and safety of the public are protected from exposures to hazardous substances released from the Cigar Lake Operation. The effluent and environmental monitoring programs currently conducted by the licensee are used to verify that releases of hazardous substances do not result in environmental concentrations that may affect public health.

CNSC receives reports of discharges to the environment through the reporting requirements outlined in the licence and licence conditions handbook. The review of Cigar Lake Operation's hazardous (non-radiological) discharges to the environment indicates that the public and environment are protected. CNSC staff confirmed that environmental concentrations in the vicinity of the Cigar Lake Operation remained within those predicted in the 2017 ERA, and that human health remained protected.

Based on compliance verification activities that included inspections, reviews of licensee's reports, work practices, and monitoring results for 2018, CNSC staff concluded that the Cigar Lake Operation environmental protection program continued to be effective in protecting the public and the environment.

3.4 Conventional Health and Safety

For 2018, CNSC staff continued to rate the conventional health and safety SCA as "satisfactory".

Cigar Lake Operation - conventional health and safety ratings

2014	2015	2016	2017	2018
SA	SA	SA	SA	SA

SA = satisfactory

Practices

CNSC staff monitored the implementation of the Cigar Lake Operation's safety and health management program to ensure the protection of workers. The program includes planned internal inspections, a safety permit system, occupational health committees, training and incident investigations. Cameco's incident reporting system includes reporting, trending and investigation of near misses, which helps reduce future incidents that could cause injury.

CNSC staff noted the implementation of the Safety Through Empowering Employee Leadership Committee. This safety steering committee is unique to the Cigar Lake Operation along with the Good Catch reporting environment in which facility staff are recognized for pointing out near misses related to safety. These were found to be safety culture strengths at the Cigar Lake Operation.

CNSC staff verified that the conventional health and safety work practices and conditions at the Cigar Lake Operation continued to be effective in 2018.

Performance

Table 3.3 summarizes lost-time injuries (LTIs) at the Cigar Lake Operation from 2014 to 2018. There were no LTIs at the Cigar Lake Operation in 2018.

Included in this report is the total recordable incident rate (TRIR). The TRIR is the incident frequency rate measuring the number of fatalities, lost-time injuries, and other injuries requiring medical treatment per 200,000 person hours worked.

Table 3.3: Cigar Lake Operation - lost-time injury statistics, 2014-18

	2014	2015	2016	2017	2018
Lost-time injuries[1]	1*	4	1	0	0
Severity rate[2]	0.0	18.0	2.4	0	0
Frequency rate[3]	0.12*	0.56	0.14	0	0
Total Recordable Incident Rate[4]	---	---	2.0	1.58	1.00

1 An injury that takes place at work and results in the worker being unable to return to work for a period of time.
2 A measure of the total number of days lost to injury for every 200,000 person-hours worked at the facility.
Accident severity rate = [(# of days lost in last 12 months) / (# of hours worked in last 12 months)] x 200,000.
3 A measure of the number of LTIs for every 200,000 person-hours worked at the facility.
Accident frequency rate = [(# of injuries in last 12 months) / (# of hours worked in last 12 months)] x 200,000.
4 A measure of the number of fatalities, lost-time injuries, and other injuries requiring medical treatment for every 200,000 person-hours worked at the facility.
Recordable incident rate = [(#incidents in last 12 months) / # hours worked in last 12 months)] x 200,000.
* One event that occurred in 2014 was reclassified as an LTI in 2015. In the 2014 report, this number was 0.

Awareness

CNSC staff observed that the conventional health and safety program at the Cigar Lake Operation continued to provide education, training, tools and support to workers. CNSC staff confirmed that in 2018 Cameco implemented several initiatives as part of continuous program improvement at the Cigar Lake Operation. Changes implemented were to the safety program, including a Cameco-wide development of an ammonia code of practice. CNSC staff confirmed that conventional health and safety events at the operation were investigated and that effective corrective actions were implemented.

CNSC staff compliance verification activities concluded that the Cigar Lake Operation's health and safety program met regulatory requirements in 2018.

4 MCARTHUR RIVER OPERATION

Cameco Corporation operates the McArthur River mine which is located approximately 620 kilometres north of Saskatoon, Saskatchewan.

Facilities at the McArthur River Operation include an underground uranium mine, primary ore processing, ore slurry loading, waste management facilities, a water treatment plant, effluent storage ponds, surface freeze plants, administration offices and warehouse buildings (see figure 4.1).

Figure 4.1: McArthur River Operation - aerial view

High-grade uranium ore is mined, mixed with water and ground in a ball mill to form slurry, and pumped to the surface. The ore slurry is loaded into containers and transported to Cameco's Key Lake Operation for further processing.

Low-grade mineralized rock is also transported to the Key Lake facility in covered haul trucks. These materials are then blended with high-grade ore slurry to create the mill ore feed.

In October 2013, following a public hearing in La Ronge, Saskatchewan, the Commission issued a 10-year licence to Cameco for the McArthur River Operation. Cameco's licence expires on October 31, 2023.

CNSC staff confirmed that the McArthur River Operation production for 2018 remained less than the authorized annual production. Mining production data for the McArthur River Operation is provided in table 4.1.

Table 4.1: McArthur River Operation - mining production data, 2014–18

Mining	2014	2015	2016	2017	2018
Ore tonnage (Mkg/year)	108.39	88.24	89.28	91.44	2.79
Average ore grade mined (%U)	7.4	8.59	7.89	7.09	7.57
Uranium mined (Mkg U/year)	8.02	7.58	7.04	6.48	0.18
Authorized annual production (Mkg U/year)	8.1	9.6	9.6	9.6	9.6

4.1 Performance

The McArthur River Operation safety and control area (SCA) ratings for the five-year period of 2014 to 2018 are shown in appendix E. For 2018, CNSC staff rated all SCAs as "satisfactory". This report focuses on the three SCAs that cover many of the key performance indicators for mining operations: radiation protection, environmental protection, and conventional health and safety.

In 2018, CNSC staff carried out compliance inspections covering the SCAs of fitness for service, environmental protection, conventional health and safety, human performance management, physical design, and emergency management and fire protection.

There were five instances of non-compliances identified during CNSC inspections at the McArthur River Operation in 2018. These instances of non-compliances were of low risk and related to the human performance management, and emergency management and fire protection SCAs. The licensee implemented corrective actions, which were reviewed and accepted by CNSC staff. A complete list of inspections can be found in appendix B.

4.2 Radiation Protection

For 2018, CNSC staff continued to rate the radiation protection SCA as "satisfactory" based on regulatory oversight activities.

McArthur River Operation - radiation protection ratings

2014	2015	2016	2017	2018
SA	SA	SA	SA	SA

SA = satisfactory

Radiological hazard control

Mining of high-grade uranium ore is the main source of radiological exposure at the McArthur River Operation. The effective dose contributors to nuclear energy workers (NEWs) at the McArthur River facility were radon progeny (63%), gamma radiation (22%), and long-lived radioactive dust (LLRD) (15%). Gamma radiation hazards are controlled through practices related to the effective use of time, distance and shielding.

Exposures to radon progeny, radon gas and LLRD are controlled through source control, ventilation, contamination control and personal protective equipment.

Radiation protection program performance

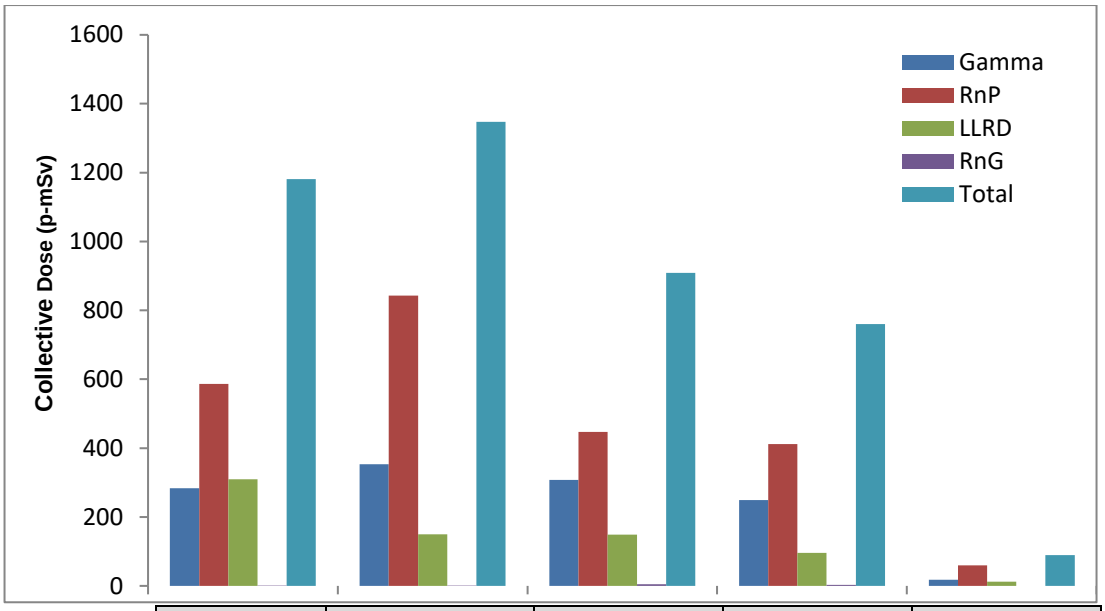
In 2018, CNSC staff were satisfied that the radiation protection program and practices at the McArthur River Operation remained effective in controlling radiological exposure to workers. The doses to workers remained below regulatory limits and as low as reasonably achievable (ALARA). There were no exceedances of action levels at the McArthur River Operation in 2018.

Application of ALARA

In 2018, the collective dose to NEWs at the McArthur River Operation was 89 person-millisieverts (p-mSv), an approximate 88 percent reduction from the 2017 value of 760 p-mSv (see figure 4.2). The reduction in collective dose was due to the placement of the facility into a state of care and maintenance.

LLRD exposures remain an ALARA focus area at the McArthur River Operation and these exposures continued to trend downward over the past five years. The decrease in LLRD exposures in 2018 is attributed primarily to the placement of the facility into a state of care and maintenance.

Figure 4.2: McArthur River Operation - annual collective dose, 2014–18



	2014	2015	2016	2017	2018
Gamma (p-mSv)	284	353	308	249	18
RnP (p-mSv)	586	843	447	412	59
LLRD (p-mSv)	310	150	149	96	12
RnG (p-mSv)	1	1	5	3	0
Total	1,181	1,347	909	760	89

RnP = radon progeny; LLRD = long-lived radioactive dust; RnG = radon gas

Worker dose control

The average individual effective dose to NEWs was 0.15 mSv. The maximum individual effective dose of 2.67 mSv was assigned to an underground worker. This compares to an average effective dose of 0.79 mSv and a maximum individual dose of 5.73 mSv in 2018. All individual effective doses were well below the annual regulatory limit of 50 mSv (as indicated in figures 2.5 and 2.6) and 100 mSv over five years.

Based on their compliance verification activities such as inspections, reviews of licensees' reports, work practices, monitoring results and individual effective dose results, CNSC staff were satisfied that the radiation doses to workers continued to be effectively controlled at the McArthur River Operation during 2018.

4.3 Environmental Protection

For 2018, CNSC staff continued to rate the environmental protection SCA as "satisfactory" based on regulatory oversight activities. CNSC staff verified that the environmental protection program was effectively implemented and met all regulatory requirements.

McArthur River Operation - environmental protection ratings

2014	2015	2016	2017	2018
SA	SA	SA	SA	SA

SA = satisfactory

Environmental management system

The environmental management system at the McArthur River Operation includes activities such as establishing annual environmental objectives, goals and targets. Cameco conducts internal audits of its environmental management program at the McArthur River Operation, as identified in their CNSC-approved management system program. CNSC staff reviewed and assessed the objectives, goals and targets through regular compliance verification activities. CNSC staff noted that Cameco had continued with routine inspections, internal audits, environmental training and periodic reviews of environmental monitoring data. These activities were conducted to ensure continual improvement and to confirm that the controls put into place to protect the environment are effective.

Effluent and emissions control

Treated effluent released to the environment

CNSC staff verified that treated effluent released to the environment was below regulatory requirements and has remained stable or improved over the past five years. As discussed in section 2.4, constituents of potential concern (COPC) with potential to adversely affect the environment in treated effluent at multiple uranium mine and mill operations are molybdenum, selenium and uranium (figures 2.7 to 2.9). Of the three COPCs, molybdenum posed an elevated risk at the McArthur River Operation. In response, process changes such as adjusting pH and reagent rebalancing were implemented to reduce molybdenum concentrations in treated effluent. From 2014 to 2017 concentrations of molybdenum were relatively stable and well below the operational action level as displayed in figure 2.7. In 2018, concentrations of molybdenum were reduced by approximately 90 percent as a result of placing the facility into a state of care and maintenance.

In addition to the COPC with a potential to adversely impact the environment, Cameco analyzed treated effluent from the McArthur River Operation for concentrations of various other COPCs such as radium-226, arsenic, copper, lead, nickel, zinc, total suspended solids (TSS) and pH. CNSC staff reviewed the effluent treatment concentrations and confirmed that the McArthur River Operation continued to meet *Metal and Diamond Mining Effluent Regulations* [5] discharge limits (section 2.4).

On March 9, 2018 Cameco reported an exceedance radium action level when they identified the averaged radium over 10 ponds exceeded 0.30 Bq/L. The licensee has resolved the issue and no impact on the environment or health and safety of persons resulted from this action level exceedance. Further information on this exceedance is included in appendix J.

The CNSC will continue to review effluent quality results to ensure that effluent treatment performance remains effective. Figure 4.3 shows a monitoring pond at the McArthur River Operation.

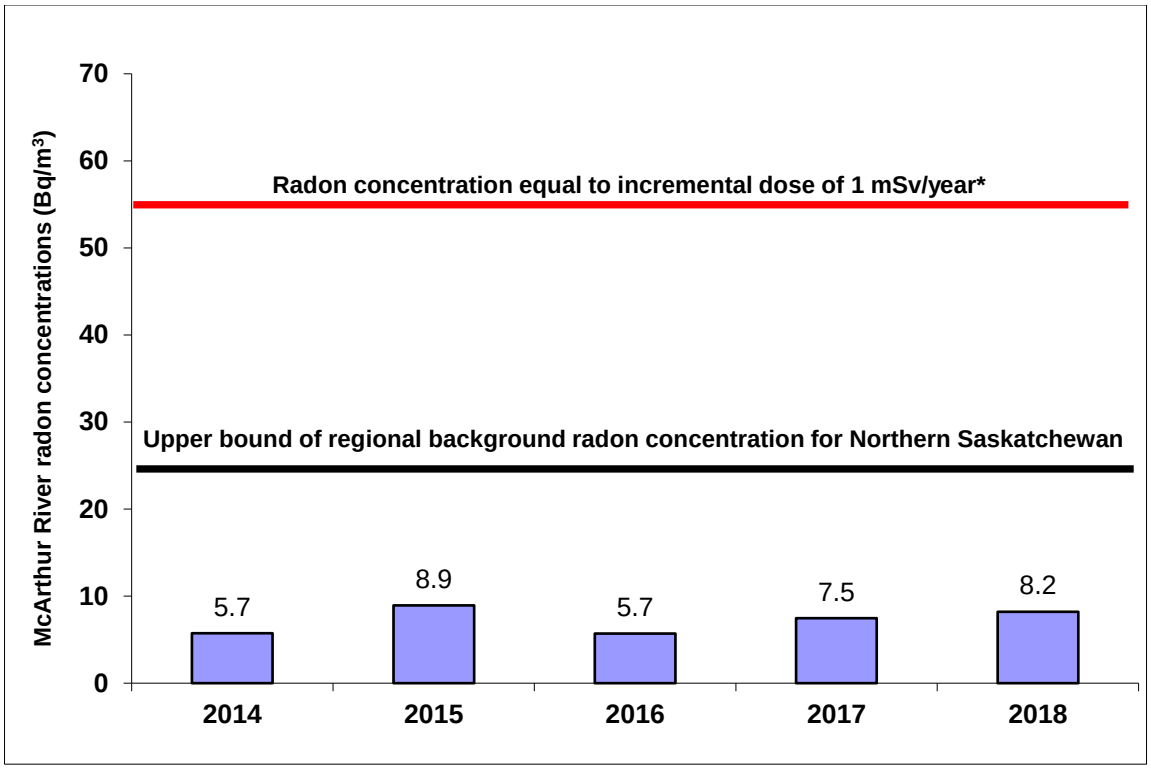
Figure 4.3: McArthur River Operation - monitoring pond

Air emissions released to the environment

The CNSC requires that Cameco maintain an air and terrestrial monitoring program at its McArthur River Operation. Air and terrestrial monitoring at the McArthur River facility includes ambient radon, total suspended particulate (TSP), soil sampling and lichen sampling to assess the impact of air emissions. An analysis of blueberry chemistry was also included to align with country food studies. Blueberry twigs are monitored to determine if soil-borne contaminants (when present) are being absorbed through the roots into the growing plant parts. Monitoring of soil and blueberry stems/twigs was completed in the summer of 2018. The results are within the historical range for the stations sampled.

Monitoring of radon in ambient air is carried out using passive track-etch cups at 12 monitoring stations around the operation. Figure 4.4 shows the average concentrations of radon in ambient air for 2014 to 2018 were similar to past performance with radon concentrations typical of the northern Saskatchewan regional background of less than 7.4 Bq/m^3 to 25 Bq/m^3. The average radon concentrations are less than the reference level of 55 Bq/m^3, which represents an incremental dose of 1 mSv/year above background.

Figure 4.4: McArthur River Operation - concentrations of radon in ambient air, 2014–18



* Upper-bound of the incremental dose of 1 mSv per year above background (i.e., an incremental radon concentration of 30 Bq/m^3 above natural background) based on ICRP Publication 115. Values are calculated as geometric means.

Two high-volume air samplers were used to collect and measure TSP in air. From the average of the two stations, the TSP levels were below provincial standards (see table 4.2). The mean concentrations of metal and radionuclides adsorbed to TSP were low and below the reference annual air quality levels identified in table 4.2.

Table 4.2: McArthur River Operation - concentrations of metal and radionuclides in air, 2014-2018*

Parameter	Reference annual air quality levels	2014	2015	2016	2017	2018
TSP (µg/m^3)	**60** [3]	8.94	6.31	2.24	3.24	1.69
As (µg/m^3)	**0.06** [1]	0.0001	0.0001	0.0001	0.0001	0.0006
Cu (µg/m^3)	**9.6** [1]	0.00835	0.00513	0.0065	0.0064	0.0072
Ni (µg/m^3)	**0.04** [1]	0.00085	0.00067	0.0007	0.0007	0.0006
Pb (µg/m^3)	**0.10** [1]	0.0012	0.00118	0.0011	0.0006	0.0008
Se (µg/m^3)	**1.9** [1]	0.0004	0.00004	0.00004	0.00004	0.00003
Zn (µg/m^3)	**23** [1]	0.01225	0.00980	0.0106	0.0084	0.0295
Pb-210 (Bq/m^3)	**0.021** [2]	0.00032	0.00032	0.0002	0.0004	0.0003
Po-210 (Bq/m^3)	**0.028** [2]	0.00009	0.00008	0.0001	0.0001	0.0001
Ra-226 (Bq/m^3)	**0.013** [2]	0.00002	0.00001	0.00004	0.00001	0.00001
Th-230 (Bq/m^3)	**0.0085** [2]	0.00001	0.00002	0.0001	0.0001	0.00001
U (µg/m^3)	**0.06** [1]	0.0005	0.0003	0.0004	0.0003	0.0001

[1] Reference annual air quality levels are derived from Ontario's 24-hour ambient air quality criteria (2012).

[2] Reference level is derived from International Commission on Radiological Protection (ICRP) Publication 96. *Protecting People Against Radiation Exposure in the Event of a Radiological Attack.*

[3] *Saskatchewan Environmental Quality Guidelines*, Table 20: Saskatchewan Ambient Air Quality Standards. Values are calculated as geometric means.

* Reference levels based on Province of Ontario ambient air quality criteria and are shown for reference only. No federal or Province of Saskatchewan limits were established at the time of this report.

Soil and terrestrial vegetation may be affected by atmospheric deposition of particulate and adsorbed metals and radionuclides associated with onsite activities. A terrestrial monitoring program is in place and includes triennial measurements of metals and radionuclides in soil and blueberry samples.

Soil, blueberry twig and lichen samples were last collected in 2018 as required by the triennial sampling program. The results indicated that parameters measured were within historical ranges.

CNSC staff concluded that the level of airborne particulate contaminants produced by the McArthur River Operation is acceptable and does not pose a risk to the environment.

Uncontrolled releases

In 2018, there were two events reported to the CNSC that were classified as a release (spill) of a hazardous substance to the environment. These spills were of low safety significance and reporting of this event met the requirements of REGDOC-3.2.1, *Public Information and Disclosure* [2]:

- On August 6, 2018, Cameco staff conducted a routine inspection of treated effluent monitoring ponds 3 and 4. This inspection revealed that the temporary repairs completed in May had failed. It was estimated that approximately 8,000 m^3 of treated water had been released from these ponds, through the liner into the ground.
- On August 25, 2018, a mechanic entering module 1 of the freeze plant identified that a small amount of ammonia had been released from a cracked vessel sight glass into the freeze plant. The exact amount of ammonia released is unknown, but none of the ammonia detectors in the plant displayed elevated concentrations of ammonia during this event.

There were no impacts to the environment as a result of the spills and CNSC staff were satisfied with the corrective actions taken. CNSC staff rated the spills as low significance. Appendix I contains a brief description of the spills and corrective actions taken by the licensee. CNSC spill rating definitions can be found in appendix I, table I-2.

Figure 2.12 in section 2 identifies the number of spills at the McArthur River Operation from 2014 to 2018.

Assessment and monitoring

CNSC staff confirmed that the licensee, in accordance with the McArthur River Environmental Protection Program, successfully carried out required environmental monitoring.

Through compliance verification activities conducted and review of annual reports and EPRs, CNSC staff concluded that environmental monitoring conducted at the McArthur River Operation met regulatory requirements. Consequently, CNSC staff concludes that the environment remains protected.

Environmental risk assessment

In 2015, The McArthur River EPR and updated ERA for 2010 to 2014 were submitted to the CNSC and the Saskatchewan Ministry of Environment. CNSC staff reviewed the environmental monitoring results for air, soil, vegetation, water, groundwater and sediment as well as health indicators for fish and their prey inhabiting sediment and confirmed that the results were within those predicted in the ERA.

After reviewing the EPR and ERA, CNSC staff concluded that adequate measures have been taken at the McArthur River Operation to protect the environment.

Protection of the public

Cameco is required to demonstrate that the health and safety of the public are protected from exposures to hazardous substances released from the McArthur River Operation. The effluent and environmental monitoring programs currently conducted by the licensee are used to verify that releases of hazardous substances do not result in environmental concentrations that may affect public health.

CNSC receives reports of discharges to the environment through the reporting requirements outlined in the licence and licence conditions handbook. The review of McArthur River Operation's hazardous (non-radiological) discharges to the environment indicates that the public and environment are protected. CNSC staff confirmed that environmental concentrations in the vicinity of the McArthur River Operation remain within those predicted in the 2015 ERA, and that human health remained protected.

Based on compliance verification activities that included inspections, reviews of licensees' reports, work practices, and monitoring results for 2018, CNSC staff concluded that the McArthur River Operation environmental protection program continued to be effective protecting the public and the environment.

4.4 Conventional Health and Safety

CNSC staff rated the conventional health and safety SCA as "satisfactory" based on regulatory oversight activities conducted during 2018.

McArthur River Operation - conventional health and safety ratings

2014	2015	2016	2017	2018
SA	SA	SA	SA	SA

SA = satisfactory

Practices

To promote continued effective safety performance, the McArthur River Operation has implemented a health and safety management program to identify and mitigate risks at the facility. The program includes a safety permit system, continued training, planned internal inspections, occupational health committees and incident investigations. The incident reporting system includes reporting on and investigation of near misses and reduces future incidents that could cause injury. CNSC staff verified that Cameco's conventional health and safety work practices and conditions at the McArthur River Operation met regulatory requirements in 2018.

Performance

As shown in table 4.3, there were no lost-time injuries (LTI) reported at the McArthur River Operation in 2018. The severity rating of 23.2 is related to ongoing time lost due to injuries that occurred in 2016 and 2017.

Included in this report is the total recordable incident rate (TRIR). The TRIR is the incident frequency rate measuring the number of fatalities, lost-time injuries, and other injuries requiring medical treatment per 200,000 person hours worked.

Table 4.3: McArthur River Operation – lost-time injury statistics, 2014–18

	2014	2015	2016	2017	2018
Lost-time injuries[1]	1*	0	2**	1	0
Severity rate[2]	14.6*	7.31*	0	12.11	23.2***
Frequency rate[3]	0.11*	0	0.24**	0.15	0
Total Recordable Incident Rate[4]	---	---	3.74	5.24	5.02

[1] An injury that takes place at work and results in the worker being unable to return to work for a period of time.

[2] A measure of the total number of days lost to injury for every 200,000 person-hours worked at the facility. Accident severity rate = [(# of days lost in last 12 months) / (# of hours worked in last 12 months)] x 200,000.

[3] A measure of the number of LTIs for every 200,000 person-hours worked at the facility. Accident frequency rate = [(# of injuries in last 12 months) / (# of hours worked in last 12 months)] x 200,000.

[4] A measure of the number of fatalities, lost-time injuries, and other injuries requiring medical treatment for every 200,000 person-hours worked at the facility. Recordable incident rate = [(#incidents in last 12 months) / # hours worked in last 12 months)] x 200,000.

* A lifting injury in 2014 eventually required surgery in 2015, resulting in lost time. As a result, 2014 LTIs were increased from 0 to 1, severity rate from 0 to 14.6 and frequency rate from 0 to 0.11. The 2015 severity rate was also affected due to lost time in 2015.

** A hip injury in 2016 resulted in the worker being unable to return to work in 2017, resulting in lost time. As a result 2016 LTIs increased from 1 to 2, and frequency rate from 0.12 to 0.24.

*** See explanation in preceding paragraph.

Compliance verification activities confirmed that the McArthur River Operation focuses on the prevention of accidents, reducing LTIs and the number of injuries requiring medical treatment.

Awareness

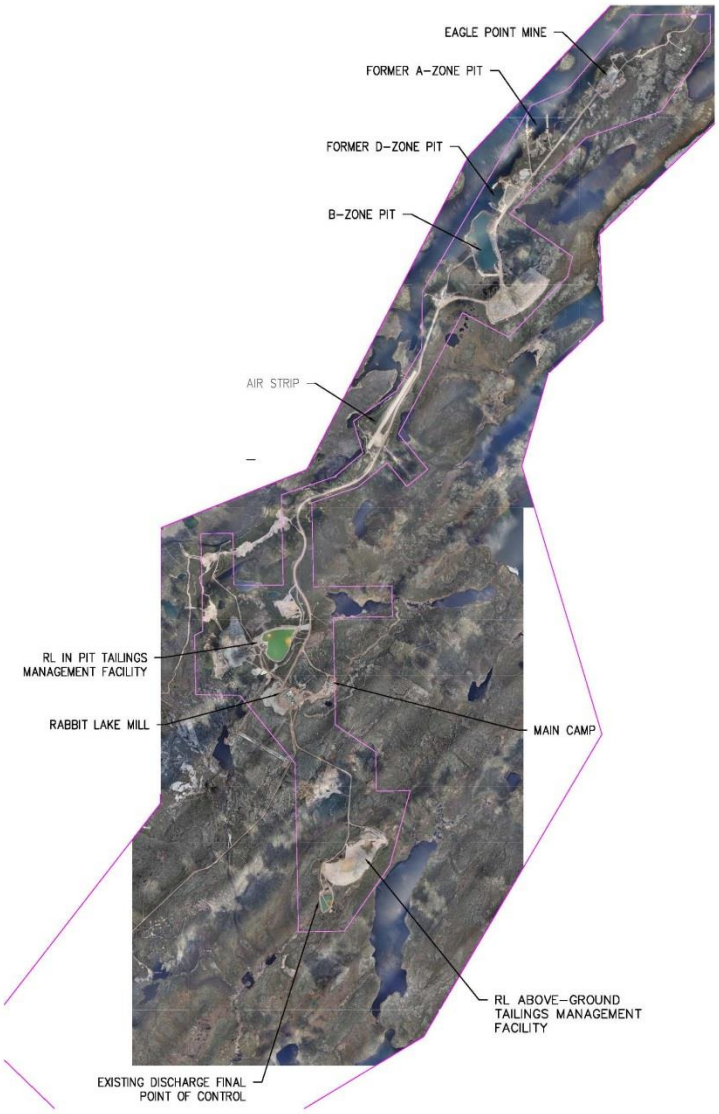
CNSC staff observed that the conventional health and safety programs at the McArthur River Operation continued to provide education, training, tools and support to workers. Managers, supervisors and workers share and promote the idea that safety is the responsibility of all individuals. Facility operation's management stresses the importance of conventional health and safety through regular communication, management oversight and continual improvement of safety systems.

CNSC staff verified that the health and safety program at the McArthur River Operation met regulatory requirements.

5 RABBIT LAKE OPERATION

The Rabbit Lake Operation is located 750 kilometres north of Saskatoon, Saskatchewan. Owned and operated by Cameco Corporation, the facility stretches across approximately 20 kilometres (see figure 5.1). The Eagle Point underground mine is located at the northern margin of the property. Moving southward, three mined-out pits, two reclaimed, A-Zone and D-Zone, and one flooded, B-Zone pit all bordering Collins Bay of Wollaston Lake. The B-Zone pit remains isolated from Collins Bay by an intact dyke. In the central part of the property, the mined-out Rabbit Lake pit was converted to a tailings management facility (TMF). Adjacent to the in-pit TMF is the mill. South of the mill is the above ground TMF, which has not received tailings since 1985. At the southern margin, after passage through settling ponds, all treated effluent which must meet discharge limits is continuously discharged and eventually reaches Hidden Bay of Wollaston Lake.

Figure 5.1: Rabbit Lake Operation - overview



In October 2013, the Commission issued a 10-year licence following a public hearing in La Ronge, Saskatchewan. Cameco's licence for the Rabbit Lake Operation expires on October 31, 2023.

Mining production data for the Rabbit Lake Operation are provided in table 5.1.

Table 5.1: Rabbit Lake Operation - mining production data, 2014-18

Mining	2014	2015	2016	2017	2018
Ore tonnage (Mkg/year)	328.13	309.50	79.87	0	0
Average ore grade mined (%U)	0.48	0.54	0.59	0	0
Uranium mined (Mkg U/year)	1.57	1.66	0.47	0	0

On April 21, 2016 Cameco formally announced that, due to market conditions, production at the Rabbit Lake Operation was to be suspended and the facility was placed into a safe state of care and maintenance. This decision allows Cameco the flexibility to resume production when market conditions improve.

There was no uranium concentrate produced and no ore production conducted at the Rabbit Lake Operation during the 2018 reporting period. Table 5.2 provides milling production data from 2014 to 2018.

Table 5.2: Rabbit Lake Operation - milling production data, 2014-18

Milling	2014	2015	2016	2017	2018
Mill ore feed (Mkg/year)	386.97	313.71	61.67	0	0
Average annual mill feed grade (%U)	0.42	0.53	0.69	0	0
Percent uranium recovery (%)	97.3	97.1	97.0	0	0
Uranium concentrate produced (Mkg U/year)	1.60	1.62	0.43	0	0
Authorized annual production (Mkg U/year)	4.25	4.25	4.25	4.25	4.25

Cameco has implemented the safe transition of the operations into care and maintenance. The focus was on three key areas: the preservation of facilities and equipment to ensure future availability; the ongoing collection and treatment of contaminated water from various areas of the operation; and the maintenance of operational compliance to applicable regulations, approvals and licensed programs.

The transition to care and maintenance relates to the suspension of production and the safe shutdown of related infrastructure and systems. The main functional areas to be managed include mill operations, mine operations and tailings management. A submission updating the plan and process to be followed and the status of the facility was provided to the CNSC and the Saskatchewan Ministry of Environment in October 2016. The submission has been reviewed by both agencies and the measures and activities outlined have been accepted. The following summarizes the transition initiatives.

Mill operations

The mill transition to care and maintenance is similar to a routine maintenance shutdown event:

- mill production circuits were emptied, flushed, cleaned and preserved;
- mill ore pad was emptied of remaining ore inventory;
- water treatment circuit was maintained and restored to normal operating status;
- sulphuric acid inventories were maximized and the acid plant operation suspended;
- mill ventilation was safely optimized for energy and heating use to reflect the mill circuits status;
- hazardous materials were transported to other Cameco facilities or returned to the supplier;
- inactive areas added to routine inspection schedules with checks conducted and documented on a regular basis; and
- required fire protection systems will continue to be maintained throughout the main mill complex.

Mine operations

No exploration, development or production activities took place in 2018. During the care and maintenance period, activities at the Eagle Point mine were minimized and the focus was on continued dewatering of the mine. Underground work consisted only of basic and required inspections and maintenance:

- all development and production work areas have been made safe, and ground conditions have been assessed for stability and verified by a qualified third-party evaluation;
- inactive areas have been sealed with bulkheads and mine service infrastructure removed from these areas;
- mine water collection and the dewatering system has been simplified and centralized;
- ventilation systems have been safely optimized for heat and energy use;
- mine mobile equipment has been stored in the mine;
- all explosives have been removed from underground and the remaining inventory removed by the vendor; and
- Non-essential surface facilities have been vacated and secured.

The licensee conducts and reports on routine inspections of the mine to ensure proper functioning of dewatering and ventilation systems and to monitor for unusual or changing conditions. Emergency response is maintained by the licensee in accordance with Saskatchewan Ministry of Labour Relations and Workplace Safety requirements.

Tailings management

The Rabbit Lake in-pit TMF continued to operate during the care and maintenance period. The primary operating functions involved storing solids produced by the mill water treatment system; providing ongoing dewatering of tailings solids and hydraulic containment of pore water, supernatant, surface runoff and groundwater from the existing catchment area; and providing short-term water storage capacity as part of the facility's water management system. Figure 5.2 shows an inspector measuring gamma dose rate on B-Zone reclamation area.

Figure 5.2: Rabbit Lake Operation - CNSC inspector measures gamma dose rate on B-Zone reclamation area

Reclamation

No changes to the existing preliminary decommissioning plan and cost estimate have occurred due to the suspension of production. Progressive reclamation activities will continue throughout the care and maintenance period. Cameco must notify CNSC staff if the scope of activities or timeline for decommissioning change relative to the current operating status.

CNSC staff have verified the care and maintenance status of the mine and mill and the continuation of reclamation activities through desktop reviews of applications, reports and onsite inspections. CNSC staff will continue to monitor and review the Rabbit Lake Operation's water management practices and reclamation activities to ensure the environment is protected during this period of care and maintenance.

5.1 Performance

For 2018, CNSC staff rated all 14 safety and control areas (SCAs) as "satisfactory" based on regulatory oversight activities. Ratings at the Rabbit Lake Operation for these 14 SCAs during the five-year period of 2014 to 2018 are shown in appendix E. This report focuses on the three SCAs that cover many of the key performance indicators for these facilities: radiation protection, environmental protection and conventional health and safety.

In 2018, CNSC staff carried out compliance inspections covering the SCAs of operating performance, emergency management and fire protection, fitness for service, conventional health and safety, radiation protection, management systems, environmental protection and safety analysis. There were nine non-compliances resulting from CNSC inspections at the Rabbit Lake Operation for the 2018 calendar year. These non-compliances were low safety significance in nature and related to the SCAs of conventional health and safety, management system and radiation protection. Corrective actions implemented by the licensee have been reviewed and accepted by CNSC staff. All actions resulting from non-compliances have been closed. A list of inspections is provided in appendix B.

5.2 Radiation Protection

For 2018, CNSC staff continued to rate the radiation protection SCA at Rabbit Lake as "satisfactory" based on regulatory oversight activities.

Rabbit Lake Operation - radiation protection ratings

2014	2015	2016	2017	2018
SA	SA	SA	SA	SA

SA = satisfactory

Radiological hazard control

The sources of radiological exposure at the Rabbit Lake Operation were from mining at the Eagle Point underground mine and from milling uranium ore into yellowcake at the Rabbit Lake mill. The effective dose contributors to nuclear energy workers (NEWs) at Rabbit Lake were radon progeny (75%), gamma radiation (17%), long-lived radioactive dust (LLRD) (6%) and radon gas (2%). Effective doses to NEWs from exposures to radon progeny, radon gas and LLRD are controlled through the effective use of source control, ventilation, contamination control and personal protective equipment (PPE). Gamma radiation exposure is controlled through practises related to the effective use of time, distance and shielding.

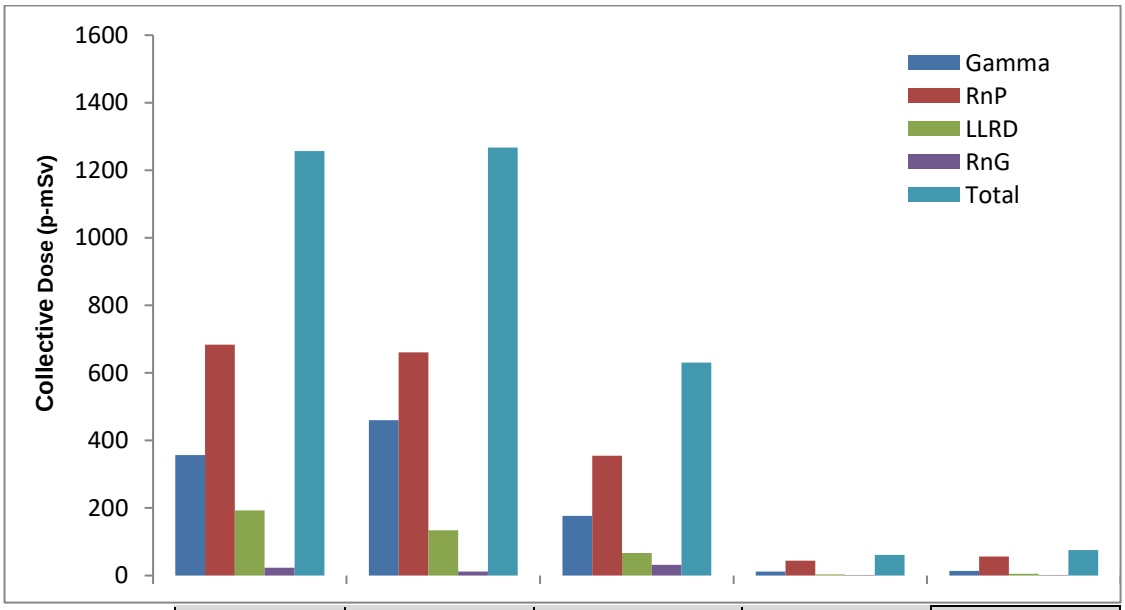
Radiation protection program performance

In 2018, CNSC staff were satisfied that the radiation protection program and practices at the Rabbit Lake Operation remained effective in controlling radiological exposure to workers. The doses to workers remained below regulatory limits and as low as reasonably achievable (ALARA). There were no exceedances of action levels reported at the Rabbit Lake Operation in 2018.

Application of ALARA

In 2018, the collective dose to NEWs at the Rabbit Lake Operation was 76 person-millisieverts (p-mSv), an approximate 20 percent increase from the 2017 value of 61 p-mSv (see figure 5.3). The increase is a result of changes to staffing and maintenance activities and is of low regulatory significance.

Figure 5.3: Rabbit Lake Operation - annual collective dose, 2014–18



	2014	2015	2016	2017	2018
Gamma (p-mSv)	357	460	177	12	13
RnP (p-mSv)	684	661	355	44	56
LLRD (p-mSv)	193	134	67	3	5
RnG (p-mSv)	23	12	32	2	1
Total	1,257	1,267	631	61	76

RnP = radon progeny; LLRD = long-lived radioactive dust; RnG = radon gas

In 2018, Rabbit Lake Operation identified two targets for the ALARA program. The first was to investigate, map, and develop an action plan to control radon progeny. The second was to reduce worker average and maximum effective dose.

CNSC staff have verified through regulatory oversight activities that Cameco continued to maintain worker exposures consistent with the ALARA principle.

Worker dose control

During 2018, the average individual effective dose for NEWs was 0.46 mSv and the maximum individual effective dose was 1.70 mSv. This is consistent with the average effective dose of 0.40 mSv and a maximum individual dose of 1.56 mSv in 2017. As shown in section 2 and figures 2.5 and 2.6, all individual effective doses for NEWs were below the annual regulatory limit of 50 mSv and 100 mSv in five years.

Based on CNSC staff compliance verification activities such as inspections, reviews of licensees' reports, work practices, monitoring results and individual effective dose results for 2018, CNSC staff were satisfied that the Rabbit Lake Operation continued to be effective in controlling radiation doses to workers.

5.3 Environmental Protection

For 2018, CNSC staff continued to rate the environmental protection SCA at Rabbit Lake as "satisfactory" based on regulatory oversight activities. CNSC staff concluded that the licensee's environmental protection program was effectively implemented and met all regulatory requirements.

Rabbit Lake Operation - environmental protection ratings

2014	2015	2016	2017	2018
SA	SA	SA	SA	SA

SA = satisfactory

Environmental management system

The environmental management system at the Rabbit Lake Operation includes activities such as establishing annual environmental objectives, goals and targets. Cameco conducts internal audits of its environmental protection program at the Rabbit Lake Operation as identified in their CNSC-approved management system program. CNSC staff review and assess the objectives, goals and targets through regular compliance verification activities. CNSC staff noted that Cameco had continued with routine inspections, internal audits, environmental training and periodic reviews of environmental monitoring data. These activities were conducted to ensure continual improvement and to confirm that the controls put into place to protect the environment are effective.

Effluent and emissions control

Treated effluent released to the environment

For previously identified constituents of potential concern (COPC) with the potential to adversely affect the environment (i.e., uranium, molybdenum and selenium), the effluent treatment system at the Rabbit Lake Operation continued to meet performance expectations in reducing the concentrations of these parameters (see figures 2.7 to 2.9 of section 2). CNSC staff verified molybdenum concentrations decreased from 2012 levels, were relatively consistent during 2014 to 2016, and showed a further decline in 2017 and 2018.

In 2006, a review titled *Uranium in Effluent Treatment Process* identified a concentration of uranium in effluent of 0.1 mg/L as a potential treatment design objective that could be achieved and is protective of the environment. The 2007 treatment circuit modifications have also been successful in meeting the uranium target objective of 0.1 mg/L. CNSC staff also confirmed selenium concentrations have remained consistent with previous years (figure 2.8) and showed a decline in the past four years.

Cameco also analyzed treated effluent for concentrations of various other contaminants such as radium-226, arsenic, copper, lead, nickel, zinc, total suspended solids (TSS) as well as pH levels. As shown in section 2.4, CNSC staff verified the Rabbit Lake Operation continued to meet *Metal Diamond Mining Effluent Regulations* discharge limits.

Cameco's environmental management system and effluent monitoring programs at Rabbit Lake met regulatory requirements and all treated effluent discharged to the environment complied with licence requirements. In 2018, the concentrations of regulated parameters in treated effluent released to the environment were well below the regulatory limits and there were no exceedances of environmental action levels at the Rabbit Lake Operation. Figure 5.4 shows the B-Zone settling pond at the Rabbit Lake Operation. CNSC staff will continue to review effluent quality results to ensure that effluent treatment performance remains effective.

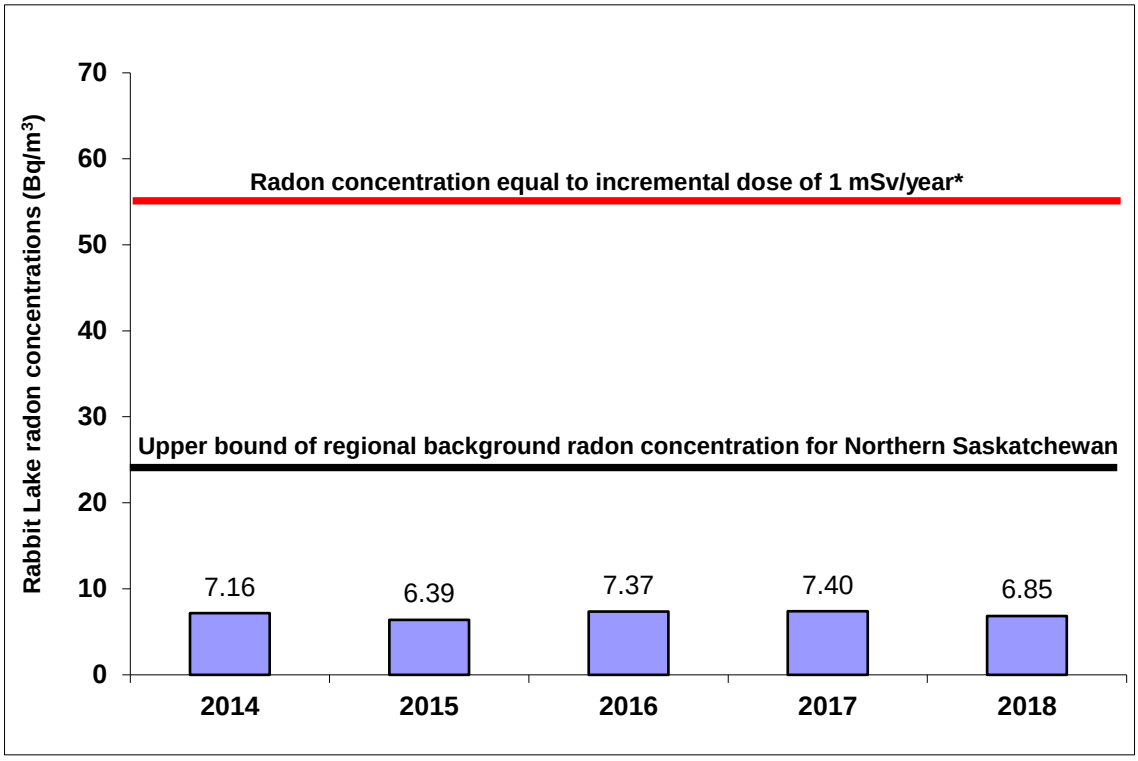
Figure 5.4: Rabbit Lake Operation - B-Zone settling pond

Air emissions released to the environment

Cameco also maintains an air and terrestrial monitoring program at Rabbit Lake. Air and terrestrial monitoring at the Rabbit Lake facility includes ambient radon, total suspended particulate (TSP), sulphur dioxide, soil sampling and lichen sampling to assess the impact of air emissions.

Radon in ambient air around the Rabbit Lake Operation is monitored at 18 stations using passive track-etch cups. Figure 5.5 shows that the average concentrations of radon in ambient air for 2014 to 2018 is similar to background concentrations for northern Saskatchewan regional baseline of less than 7.4 Bq/m^3 to 25 Bq/m^3. The average radon concentrations are less than the reference level of 55 Bq/m^3, which represents an incremental dose of 1 mSv/year above background.

Figure 5.5: Rabbit Lake Operation - concentrations of radon in ambient air, 2014–18



* Upper-bound of the incremental dose of 1 mSv per year above background (i.e., an incremental radon concentration of 30 Bq/m^3 above natural background) based on ICRP Publication 115. Values are calculated as geometric means.

Three high-volume air samplers were used to collect and measure TSP in air. The TSP levels from the average of the three stations were below provincial standards (see table 5.3). TSP samples were also analyzed for concentrations of metals and radionuclides. The mean concentrations of metals and radionuclides adsorbed to TSP are low and remained below the reference annual air quality levels identified in table 5.3.

Table 5.3: Rabbit Lake Operation - concentrations of metal and radionuclides in air, 2014-18

Parameter	Reference annual air quality levels*	2014	2015	2016	2017	2018
TSP (µg/m^3)	**60** [3]	6.21	6.87	4.97	4.79	3.91
As (µg/m^3)	**0.06** [1]	0.000337	0.000207	0.000290	0.000285	0.000365
Ni (µg/m^3)	**0.04** [1]	0.000138	0.000192	0.000540	0.000404	0.000183
Pb-210(Bq/m^3)	**0.021** [2]	0.000013	0.000015	0.000011	0.000013	0.000015
Ra-226(Bq/m^3)	**0.013** [2]	0.000002	0.000001	0.000002	0.000004	0.0000002
Th-230 (Bq/m^3)	**0.0085** [2]	0.000003	0.000001	0.000002	0.000004	0.0000003
U (µg/m^3)	**0.06** [1]	0.001960	0.002341	0.000899	0.000190	0.000277

[1] Reference annual air quality levels are derived from Ontario's 24-hour ambient air quality criteria (2012).
[2] Reference level is derived from International Commission on Radiological Protection (ICRP) Publication 96. *Protecting People Against Radiation Exposure in the Event of a Radiological Attack*.
[3] *Saskatchewan Environmental Quality Guidelines*, Table 20: Saskatchewan Ambient Air Quality Standards. Values are calculated as geometric means.
* Reference levels based on Province of Ontario ambient air quality criteria and are shown for reference only. No federal or Province of Saskatchewan limits were established at the time of this report.

Daily in-stack monitoring of sulphur dioxide emissions from the mill acid plant was discontinued as of 2017 for the duration of the care and maintenance period as the acid plant and mill processing circuits were not operating.

Soil and terrestrial vegetation may be affected by the atmospheric deposition of particulate and adsorbed metals and radionuclides associated with onsite activities. A terrestrial monitoring program is in place and includes measurements of metals and radionuclides in lichen.

Lichen sampling has been conducted for three decades at the Rabbit Lake Operation, and most recently in 2013. The next sampling is scheduled for 2019. CNSC staff concluded that the level of airborne particulate contaminants produced by the Rabbit Lake Operation does not pose a risk to lichen consumers, such as caribou.

Uncontrolled releases

In 2018, two events were reported to CNSC staff as a release (spill) of hazardous substances to the environment. The spill was minor and there were no residual impacts on the environment. The licensee's report of this event met the requirements of REGDOC-3.2.1, *Public Information and Disclosure* [2]:

- July 22, 2018 a discharge of liquid propane from the 68,100 litre shotcrete plant storage tank was identified during an inspection. The employees noticed frost buildup on a valve on the liquid side of the line feeding the tank for the offload point. The employees assessed the situation and approached the valve from a safe direction. Upon reaching the valve, the employees noted an audible hiss and a small amount of liquid propane visibly leaking from the tank.
- November 18, 2018 an odour of propane was identified near the Environment and Health Laboratory building, near the main camp. It was determined that a valve stem on the liquid offloading line at the main camp propane farm had a small leak. As a result, the Environment and Health Laboratory building was evacuated until the leak was repaired.

Appendix H provides a brief description of the spills and actions taken by the licensee. CNSC staff reviewed the corrective actions taken by the licensee and found them to be acceptable. CNSC staff rated the 2018 spills as low significance in accordance with the definitions provided in table I-2, appendix H of this report. Figure 2.12 in section 2 identifies the number of environmental reportable spills from 2014 to 2018 at the Rabbit Lake Operation.

Assessment and monitoring

CNSC staff confirmed that the licensee, in accordance with the Rabbit Lake environmental protection program, successfully carried out required environmental monitoring.

Through compliance activities conducted and review of annual reports and EPRs, CNSC staff concluded that environmental monitoring conducted at the Rabbit Lake Operation met regulatory requirements. Consequently, CNSC staff concluded that the environment remains protected.

Environmental risk assessment

The Rabbit Lake Operation EPR and updated ERA for 2010 to 2014 were submitted to the CNSC and the Saskatchewan Ministry of Environment in 2015. CNSC staff reviewed the environmental monitoring results for air, soil, vegetation, water, groundwater and sediment as well as health indicators for fish and their prey inhabiting sediment and confirmed that the results were within those predicted in the ERA.

After reviewing the EPR and ERA, CNSC staff concluded that adequate measures have been taken at the Rabbit Lake Operation to protect the environment.

Protection of the public

Cameco is required to demonstrate that the health and safety of the public are protected from exposures to hazardous substances released from the Rabbit Lake Operation. The effluent and environmental monitoring programs currently conducted by the licensee are used to verify that releases of hazardous substances do not result in environmental concentrations that may affect public health.

The CNSC receives reports of discharges to the environment through the reporting requirements outlined in the licence and licence conditions handbook. The review of Rabbit Lake Operation's hazardous (non-radiological) discharges to the environment indicates that the public and environment are protected. CNSC staff confirmed that environmental concentrations in the vicinity of the Rabbit Lake Operation remained within those predicted in the 2015 ERA, and that human health remained protected in 2018.

Based on compliance verification activities that included inspections, reviews of licensees' reports, work practices, and monitoring results for 2018, CNSC staff concluded that the Rabbit Lake Operation environmental protection program continued to be effective protecting the public and the environment.

5.4 Conventional Health and Safety

For 2018, CNSC staff continued to rate the conventional health and safety SCA as "satisfactory" based on regulatory oversight activities.

Rabbit Lake Operation - conventional health and safety ratings

2014	2015	2016	2017	2018
SA	SA	SA	SA	SA

SA = satisfactory

Practices

Cameco's Rabbit Lake Operation has implemented a safety and health management program to identify and mitigate risks. The program includes internal inspections, a safety permit system, occupational health committees, training and incident investigations. CNSC staff monitor this program through compliance activities to ensure the protection of workers.

The incident reporting system at the Rabbit Lake Operation includes reporting on and investigating near misses, with the aim of reducing future incidents that could cause injury. CNSC compliance verification activities confirmed the Rabbit Lake Operation continued to focus on the prevention of accidents and injuries through the implementation of its health and safety management program.

Performance

There were no lost–time injuries reported for the Rabbit Lake Operation in 2018. The lost-time injury (LTI) performance at the Rabbit Lake Operation from 2014 to 2018 is shown in table 5.4.

Included in this report is the total recordable incident rate (TRIR) for the last three years. The TRIR is the incident frequency rate measuring the number of fatalities, lost-time injuries, and other injuries requiring medical treatment per 200,000 person hours worked.

Table 5.4: Rabbit Lake Operation - lost-time injury statistics, 2014-18

	2014	2015	2016	2017	2018
Lost-time injuries[1]	1	2	1	0	0
Severity rate[2]	11.4	55.3	2.65	0	0
Frequency rate[3]	0.15	0.33	0.27	0	0
Total Recordable Incident Rate[4]	---	---	1.89	1.03	5.03

[1] An injury that takes place at work and results in the worker being unable to return to work for a period of time.
[2] A measure of the total number of days lost to injury for every 200,000 person-hours worked at the facility.
Accident severity rate = [(# of days lost in last 12 months) / (# of hours worked in last 12 months)] x 200,000.
[3] A measure of the number of LTIs for every 200,000 person-hours worked at the facility.
Accident frequency rate = [(# of injuries in last 12 months) / (# of hours worked in last 12 months)] x 200,000.
[4] A measure of the number of fatalities, lost-time injuries, and other injuries requiring medical treatment for every 200,000 person-hours worked at the facility.
Recordable incident rate = [(#incidents in last 12 months) / # hours worked in last 12 months)] x 200,000.

Awareness

CNSC staff observed that Cameco's conventional health and safety program at the Rabbit Lake Operation continued to provide education, training, tools and support to workers. Managers, supervisors and workers share and promote the idea that safety is the responsibility of all individuals. Facility management emphasizes the importance of conventional health and safety through regular communication, management oversight and continual improvement of safety systems.

CNSC staff verified that the conventional health and safety program at the Rabbit Lake Operation remained effective in managing health and safety risks.

6 KEY LAKE OPERATION

Located approximately 570 kilometres north of Saskatoon, Saskatchewan, the Key Lake Operation, shown in figure 6.1, is owned and operated by Cameco Corporation. The operation began with two open-pit mines and a mill complex. The Gaertner open pit was mined from 1983 to 1987, followed by the Deilmann open pit until 1997.

Figure 6.1: Key Lake Operation - aerial view

Milling of the stockpiled Deilmann ore continued until 1999, when the McArthur River Operation began supplying ore slurry to the Key Lake mill. The Key Lake Operation continues today as a mill operation that processes McArthur River ore slurry and residual special waste from previous mining at Key Lake.

After open-pit mining in the eastern pit of the Deilmann orebody was completed in 1995, the pit was converted into the engineered Deilmann tailings management facility (TMF), while mining continued in other parts of the pit area (see figure 6.2). Mill tailings continue to be deposited into this facility today.

Figure 6.2: Key Lake Operation - Deilmann tailings management facility

In October 2013, the Commission issued a 10-year licence following a public hearing in La Ronge, Saskatchewan. The Key Lake Operation licence expires on October 31, 2023.

On November 8, 2017 Cameco notified the CNSC that, effective January 2018, they would be temporarily suspending production at the Key Lake Operation. This included all activities directly related to processing of uranium ore. On July 25, 2018 Cameco notified the CNSC of its decision to suspend production at the Key Lake Operation for an indefinite period until economic conditions improve.

Milling data for the Key Lake Operation during the five-year reporting period are presented in table 6.1. The Key Lake Operation operated in a state of care and maintenance for 2018.

Table 6.1: Key Lake Operation - milling production data, 2014–18

Milling	2014	2015	2016	2017	2018
Mill ore feed (Mkg/year)	173.01	165.56	155.30	143.26	0
Average annual mill feed grade (% U)	4.29	4.47	4.51	4.37	N/A
Percentage of uranium recovery (%)	99.4	99.35	99.04	99.05	N/A
Uranium concentrate produced (Mkg U/year)	7.37	7.35	6.95	6.20	0.06*
Authorized annual production (Mkg U/year)	9.60	9.60	9.60	9.60	9.60

* processing of remaining ore slurry from 2017.

6.1 Performance

The Key Lake Operation's safety and control area (SCA) ratings for the five-year period from 2014 to 2018 are shown in appendix E. CNSC staff continued to rate all SCAs for 2018 as "satisfactory" based on regulatory oversight activities. This report focuses on the three SCAs that cover many of the key performance indicators for these uranium mine and mill operations: radiation protection, environmental protection and conventional health and safety.

In 2018, CNSC staff carried out compliance inspections covering multiple SCAs, as detailed in appendix B. There were five instances of non-compliances noted from CNSC inspections at the Key Lake Operation for the 2018 calendar year. These instances of non-compliances were of low risk in nature and related to the SCAs of physical design, conventional health and safety, and emergency management and fire protection. The licensee has implemented corrective actions which have been reviewed and accepted by CNSC staff. A list of inspections can be found in appendix B of this report.

6.2 Radiation Protection

Based on regulatory oversight activities during the reporting period, CNSC staff rated the radiation protection SCA at Key Lake as "satisfactory".

Key Lake Operation - radiation protection ratings

2014	2015	2016	2017	2018
SA	SA	SA	SA	SA

SA = satisfactory

Radiological hazard control

The effective dose contributors to nuclear energy workers (NEWs) at the Key Lake mill were gamma radiation (38%), radon progeny (40%) and long-lived radioactive dust (LLRD) (22%). Gamma radiation hazards are controlled through practices related to the effective use of time, distance and shielding. Radon progeny and LLRD are controlled through source control, ventilation contamination control and personal protective equipment (PPE).

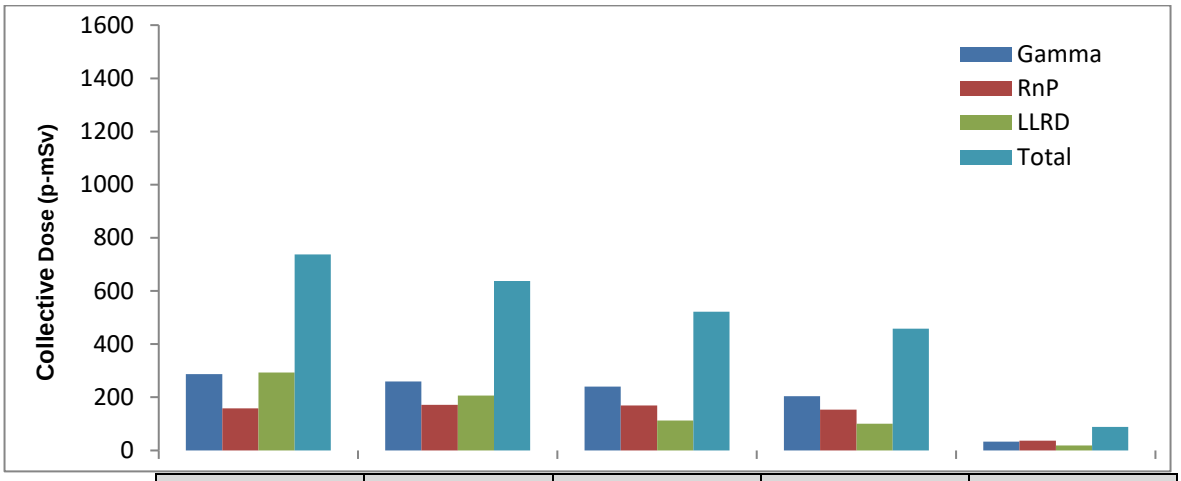
Radiation protection program performance

In 2018, CNSC staff were satisfied that the radiation protection program and practices at the Key Lake Operation remained effective in controlling radiological exposure to workers. The doses to workers remained below regulatory limits and as low as reasonably achievable (ALARA). There were no exceedances of action levels reported at the Key Lake Operation in 2018.

Application of ALARA

In 2018, the collective dose to NEWs at the Key Lake Operation was 88 person-millisieverts (p-mSv), an 80 percent reduction from the 2017 value of 451 p-mSv (see figure 6.3) due to the transition to care and maintenance.

Figure 6.3: Key Lake Operation – annual collective dose, 2014–18



	2014	2015	2016	2017	2018
Gamma (p-mSv)	287	259	240	199	33
RnP (p-mSv)	158	172	169	153	37
LLRD (p-mSv)	293	207	113	99	19
Total*	738	638	522	451	88

RnP = radon progeny; LLRD = long-lived radioactive dust
* The total collective dose may not match the individual components due to rounding errors.

Cameco continued to meet its objectives in 2018 for keeping doses as low as reasonably achievable (ALARA) at Key Lake. To support this objective, the radiation area monitoring program was revised for the transition to care and maintenance. Weekly audits were also completed to ensure workers were wearing radiation monitoring devices such as gamma dosimeters and dust pumps.

Worker dose control

In 2018, the average individual effective dose to NEWs was 0.19 mSv, while the maximum individual effective dose received was 2.02 mSv. This compares to an average effective dose of 0.66 mSv and a maximum individual dose of 5.39 mSv in 2017. The effective doses received by workers in 2018 were lower than historic values due to the facility being in a state of care and maintenance.

The maximum individual effective dose at the Key Lake Operation was identified in a mill operations worker, who worked in the leaching and solvent extraction circuits during the first quarter of 2018 and multiple areas for the remainder of 2018. No worker exceeded the regulatory individual effective dose limit of 50 mSv in one year and 100 mSv in a five year dosimetry period.

Based on their compliance verification activities such as onsite inspections, reviews of licensee reports, work practices, monitoring results and individual effective dose results, CNSC staff were satisfied that the Key Lake Operation continued to be effective in controlling radiation doses to workers in 2018.

6.3 Environmental Protection

For 2018, CNSC staff continued to rate the environmental protection SCA as "satisfactory" based on regulatory oversight activities. CNSC staff concluded that the licensees' environmental protection program was effectively implemented and met all regulatory requirements.

Key Lake Operation - environmental protection ratings

2014	2015	2016	2017	2018
SA	SA	SA	SA	SA

SA = satisfactory

Environmental management system

The environmental management system at the Key Lake Operation includes activities such as establishing annual environmental objectives, goals and targets. Cameco conducts internal audits of its environmental protection program at the Key Lake Operation as identified in its CNSC-approved management system program. CNSC staff review and assess the objectives, goals and targets through regular compliance verification activities. CNSC staff noted that Cameco had continued with routine inspections, internal audits, environmental training and periodic reviews of environmental monitoring data. These activities were conducted to ensure continual improvement and to confirm that the controls put into place to protect the environment are effective.

Effluent and emissions control

Treated effluent released to the environment

At the Key Lake Operation, two effluent streams are processed in separate treatment facilities before being released to the environment:

- The mill effluent is processed with a treatment system of chemical precipitation and liquid/solid separation, and then released to Wolf Lake in the David Creek system.
- Effluent from dewatering wells of the Gaertner pit and Deilmann pit hydraulic containment systems is treated with a reverse osmosis system before being released to Horsefly Lake in the McDonald Lake system.

Monitoring confirmed that this effluent is within design specifications and predictions outlined in the ERA. There were no exceedances of environmental action levels during the 2018 review period, however there was one event where approximately 10 m^3 of high pH (10.16) effluent was released from the reverse osmosis treatment plant to Horsefly Lake on October 12, 2018. Although only a small volume of discharge was released, the pH was above the upper pH limit specified in the *Metal and Diamond Mining Effluent Regulations* (9.5) [5] and was also above the maximum grab sample limit within the provincial operating approval (9.5). As a comparison to the volume of elevated pH discharged during the event, the average daily discharge of treated effluent to the environment in the month of October 2018 was approximately 14,860 m^3. An investigation was completed by Cameco and corrective actions developed to improve pH control. A review of the status of the follow-up actions proposed by Cameco was conducted by CNSC staff during an inspection and was found to be acceptable.

The treated effluent quality presented in table 6.2 refers only to the mill effluent as released to the David Creek system. CNSC staff verified the concentration of all regulated contaminants in the treated mill effluent released in 2018 met licence limits. There were no exceedances of environmental action levels at the Key Lake Operation.

As discussed in section 2.4, constituents of potential concern (COPC) with potential to adversely affect the environment in treated effluent at uranium mine and mill operations are molybdenum, selenium and uranium (see figures 2.7 to 2.9). Of these, molybdenum and selenium concentrations were the primary concerns at the Key Lake Operation. The licensee completed process changes to reduce concentrations in treated effluent.

Reductions of molybdenum and selenium occurred from 2007 to 2009 when additional treatment components were installed and optimized. Figures 2.7 and 2.8 displays stable or declining concentrations of molybdenum and selenium in treated effluent from 2014 to 2018, indicating these parameters are being effectively controlled. Cameco Corporation submitted a molybdenum and selenium follow-up program closure report in 2018. Based on the results of the follow-up program, Cameco proposed that current regulatory monitoring requirements were sufficient to monitor future changes in sediment and other environmental receptors, and that the formal follow-up program cease. CNSC staff confirmed in March 2019 that the follow-up program can conclude, and monitoring requirements could be added to the environmental monitoring program for the facility.

Figure 2.9 indicates that uranium concentrations in treated effluent released from the Key Lake mill remain low and are again effectively controlled. In addition to uranium, molybdenum, and selenium, Cameco also analyzed treated effluent for concentrations of other COPCs such as radium-226, arsenic, copper, lead, nickel, zinc, total suspended solids (TSS) as well as pH levels at Key Lake. As discussed in section 2.4, the Key Lake Operation continued to meet *Metal and Diamond Mining Effluent Regulations* [5] discharge limits.

CNSC staff will continue to review effluent quality results to ensure that treatment of effluent remains effective.

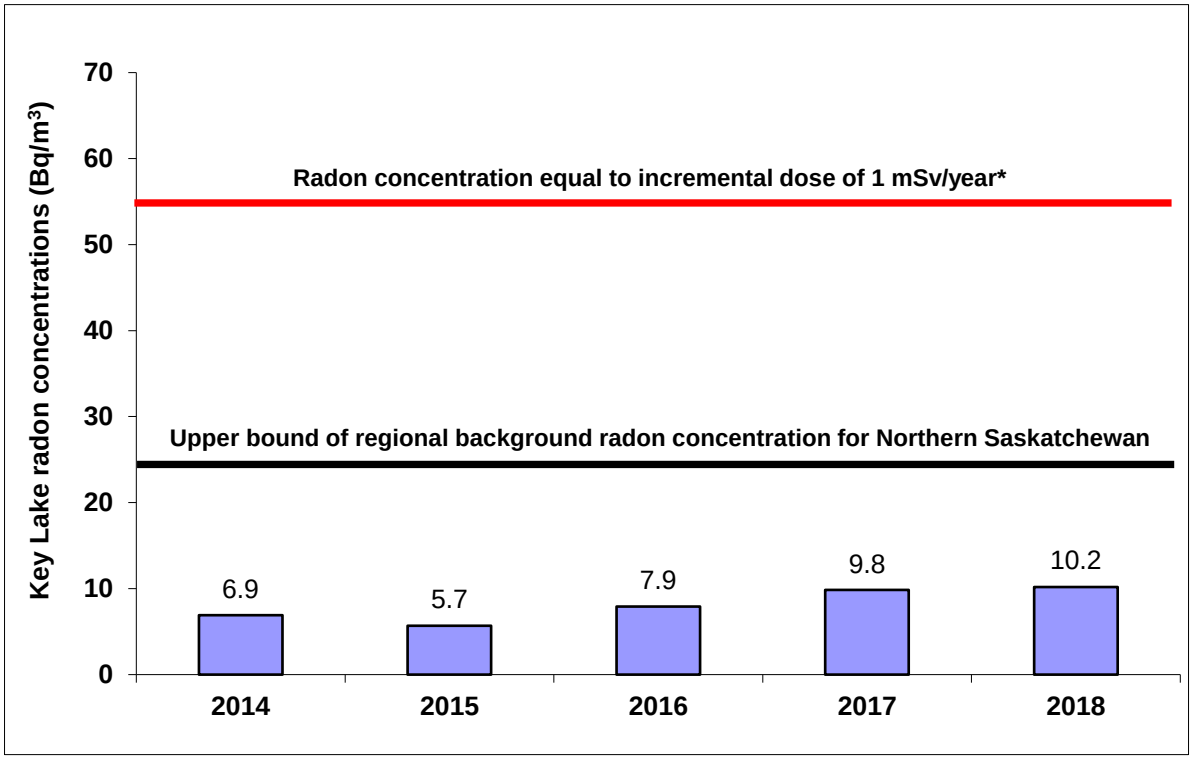
Air emissions released to the environment

The air and terrestrial monitoring program at the Key Lake Operation includes ambient monitoring for sulphur dioxide, radon and total suspended particulate (TSP) as well as soil and lichen sampling to assess air quality. Air emissions monitoring from the mill stacks are also included in the air-quality monitoring program.

The Key Lake calciner stack was not sampled in 2018 due to the shutdown of this area in 2018; the most recent stack test was completed in June 2017. Sulphur dioxide concentrations from the acid plant stack are monitored daily when in operation. In the beginning of 2018, concentrations were consistent with those reported since the commissioning of the new acid plant in 2012, however the plant only operated for 8 days in January 2018, and remained shut down for the remainder of the year.

Radon in air around the Key Lake Operation is monitored at five stations using passive track-etch cups. Figure 6.4 shows the average concentrations of radon in ambient air for 2014 to 2018. Ambient radon concentrations were typical of the northern Saskatchewan regional background of less than 7.4 Bq/m^3 to 25 Bq/m^3. The measured radon concentrations are also below a reference radon concentration of 55 Bq/m^3, which is equal to an incremental dose of 1 mSv per year above background.

Figure 6.4: Key Lake Operation - concentrations of radon in ambient air, 2014-18



* Upper-bound of the incremental dose of 1 mSv per year above background (i.e., an incremental radon concentration of 30 Bq/m^3 above natural background) based on ICRP Publication 115. Values are calculated as geometric means.

Five high-volume air samplers were used to collect and measure total suspended particulate (TSP). The TSP levels are below the province of Saskatchewan's authorized concentration of contaminants monitored for ambient air quality, as listed in the facility's approval to operate pollutant control facilities. TSP samples are also analyzed for concentrations of metals and radionuclides. The mean concentrations of metal and radionuclides adsorbed to TSP are low and below the reference annual air quality levels as identified in table 6.2.

Table 6.2: Key Lake Operation - concentrations of metal and radionuclides in air, 2014–18

Parameter	Reference annual air quality levels*	2014	2015	2016	2017	2018
TSP (µg/m^3)	**60** [3]	15.10	13.77	10.77	11.90	8.80
As (µg/m^3)	**0.06** [1]	0.00444	0.0016	0.0010	0.0045	0.0021
Ni (µg/m^3)	**0.04** [1]	0.00340	0.0013	0.0007	0.0029	0.0011
Pb-210 (Bq/m^3)	**0.021** [2]	0.00044	0.0003	0.0003	0.0004	0.0002
Ra-226 (Bq/m^3)	**0.013** [2]	0.00022	0.0001	0.0001	0.0003	0.0001
Th-230 (Bq/m^3)	**0.0085** [2]	0.00022	0.0001	0.0001	0.0002	0.0001
U (µg/m^3)	**0.06** [1]	0.00794	0.0080	0.0076	0.0091	0.0012

[1] Reference annual air quality levels derived from Ontario's 24-hour ambient air quality criteria (2012).

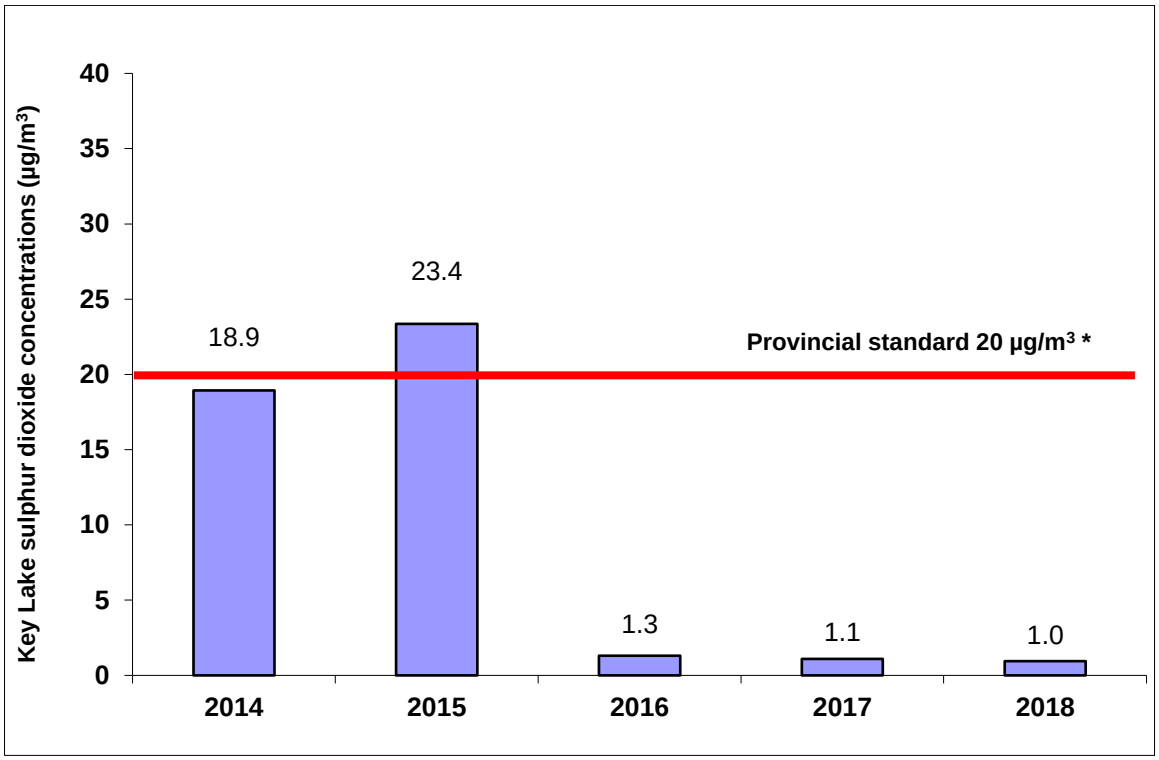
[2] Reference level from International Commission on Radiological Protection (ICRP) Publication 96, *Protecting People Against Radiation Exposure in the Event of a Radiological Attack*.

[3] *Saskatchewan Environmental Quality Guidelines*, Table 20: Saskatchewan Ambient Air Quality Standards. Values are calculated as geometric means. Current air quality standard for Key Lake Operation is 70 µg/m^3. The new Province of Saskatchwan standard will apply to the Key Lake Operation once the existing provincial approval is renewed or revised.

* Reference levels based on Province of Ontario ambient air quality criteria and are shown for reference only. No federal or Province of Saskatchewan limits were established at the time of this report.

A sulphur dioxide monitor, located approximately 300 metres downwind of the mill facility, is used to continuously measure the ambient sulphur dioxide associated with mill emissions. The measured sulphur dioxide monitoring data (see figure 6.5) show no exceedances of the annual standard of 20 µg/m^3 in 2018. The current air quality standard for Key Lake is 30 µg/m^3, but the new standard of 20 µg/m^3 will apply when the operation's existing provincial permit is renewed or revised.

Figure 6.5: Key Lake Operation- concentrations of ambient sulphur dioxide, 2014-18



* Province of Saskatchewan's ambient air quality standand, updated in 2015, is shown. The current air quality standard for Key Lake Operation is 30 µg/m^3. The new Province of Saskatchwan standard will apply to the Key Lake Operation once the existing provincial approval is renewed or revised.

There was a substantial decline in sulphur dioxide emissions following construction of a new acid plant in 2012. In 2016, there was a decline in acid production compared to past years. The concentrations recorded at the ambient monitoring station, which are directly impacted by weather conditions, showed a notable decline and these lower concentrations were observed again in 2017 and 2018 as acid production levels remained low.

In addition to ambient air monitoring for sulphur dioxide, sulphate levels have been monitored in four lakes to measure the effects of sulphur dioxide emissions from the operation. The results of the 2018 lake sampling program continued to show that sulphate concentrations remain relatively unchanged from historical concentrations. CNSC staff concluded that the operations at Key Lake, and the resulting sulphur dioxide emissions, do not have an adverse effect on the sulphate levels in nearby lakes.

Soil and terrestrial vegetation may be affected by atmospheric deposition of particulate, adsorbed metals and radionuclides associated with onsite activities. The terrestrial monitoring program in place includes measurements of metals and radionuclides in soil and in lichen. Lichen and soil samples were collected in 2016 and will be collected again in 2021.

Based on the 2016 soil and lichen sampling results, CNSC staff concluded that the level of airborne particulate contaminants produced by the Key Lake Operation is acceptable and does not pose a risk to the environment.

Uncontrolled releases

In 2018, five events reported to CNSC staff were considered to be releases of hazardous substances to the environment:

- On May 2, 2018 anhydrous ammonia was released to the atmosphere from an intermittent leak from two valves on ammonia storage tank No.2. The volume released could not be estimated due to the intermittent nature of the leaks, however there was no measurable change in the tank levels as a result of the leaks.
- On June 29, 2018 anhydrous ammonia was released to the atmosphere from a valve on ammonia storage tank No. 1. No release volume could be estimated, however there was no measurable change in the tank level as a result of the leak.
- On July 24, 2018 during an inspection of the fire suppression system valves, it was discovered that the low pressure carbon dioxide system level had dropped significantly in the storage tank. Approximately 170 kilograms of carbon dioxide was released to the atmosphere.
- On November 22, 2018, a propane leak to the atmosphere was detected from a 2 inch plug near a valve at the Reverse Osmosis water treatment plant propane tank. The release volume was very small and could not be estimated.
- In December 2018, after a review of groundwater monitoring data, Cameco reported that an onsite monitoring well showed an increase in uranium concentrations. Follow up samples were collected from this well and others in the area. The samples confirmed the increasing trend in uranium concentration. The investigation indicates that the likely source was sump #2 in the molybdenum extraction building. An Initial Event Report (IER) was discussed at a Commission meeting on May 15, 2019.

These spills were minor and reporting met the requirements of REGDOC-3.2.1, *Public Information and Disclosure* [2].

Appendix I provides a brief description of each spill and the actions taken by the licensee. With the exception of the elevated uranium observed in an onsite monitoring well, all corrective actions related to these spills have been completed. The investigation into the elevated uranium in a monitoring well is being undertaken. Cameco has been providing updates on the status of the investigation to CNSC staff, the province of Saskatchewan and local stakeholders/Indigenous groups. In addition, a complete facility assessment report will be developed and submitted in early 2020. The assessment is being completed in accordance with both federal and provincial requirements. The installation of monitoring wells and soil sampling was completed in the summer of 2019 and water quality and soil samples are being analysed. Although the investigation is not complete, the results to date continue to indicate that the elevated uranium is limited to the immediate area and there remains no risk to the surrounding environment. Once the assessment report is complete, this will be used to develop a corrective action plan. The corrective actions were reviewed and found acceptable by CNSC staff. CNSC staff rated the 2018 spills at the Key Lake Operation as low significance as defined in table I-2, appendix I.

In follow-up to ammonia releases in 2017, Cameco initiated a three-year staged project to refurbish the existing tanks and associated infrastructure at Key Lake. The project is intended to bring the ammonia tank system to current standards, addressing any tank corrosion and valving/piping concerns. It was originally proposed that in 2018, work on ammonia tank No. 1 would be conducted with internal and external inspections of the tank, insulation and cladding replacement, replacement of electrical and instrumentation components, and replacement of the existing tank valves. Additional isolation valves were also to be added to the vaporizers. This work was completed as planned in 2018, however in response to ammonia leaks in May 2018, Cameco expedited the three-year program and the remainder of the work is expected to be completed in 2019. In addition to the upgrading of ammonia tank No. 1 and associated valves and piping, the valves and piping on tank No.2 were also upgraded in 2018.

Figure 2.12 in section 2 displays the number of environmental reportable spills as well as the number of releases of hazardous material to the environment from the licensed activities at the Key Lake Operation from 2014 to 2018.

Assessment and monitoring

CNSC staff confirmed that the licensee, in accordance with the Key Lake environmental protection program, successfully carried out required environmental monitoring.

Through compliance activities conducted and review of annual reports and EPRs, CNSC staff concluded that environmental monitoring conducted at the Key Lake Operation met regulatory requirements. Consequently, CNSC staff concludes that the environment remains protected.

Environmental risk assessment

The Key Lake Operation EPR and updated ERA for 2010 to 2014 were submitted to the CNSC and the Saskatchewan Ministry of Environment in 2015. CNSC staff reviewed the environmental monitoring results for air, soil, vegetation, water, groundwater and sediment as well as health indicators for fish and their prey inhabiting sediment and confirmed that the results were within those predicted in the ERA.

After reviewing the EPR and ERA, CNSC staff concluded that adequate measures have been taken at the Key Lake Operation to protect the environment.

Protection of the public

Cameco is required to demonstrate that the health and safety of the public are protected from exposures to hazardous substances released from the Key Lake Operation. The effluent and environmental monitoring programs currently conducted by the licensee are used to verify that releases of hazardous substances do not result in environmental concentrations that may affect public health.

The CNSC receives reports of discharges to the environment through the reporting requirements outlined in the Key Lake licence and licence conditions handbook. Review of the hazardous (non-radiological) discharges to the environment indicates that the public and environment are protected. CNSC staff confirmed that environmental concentrations in the vicinity of the Key Lake Operation remained within those predicted in the 2013 ERA and that human health remained protected in 2018.

Based on compliance verification activities that included inspections, reviews of licensees' reports, work practices, and monitoring results for 2018, CNSC staff concluded that the Key Lake Operation environmental protection program continued to be effective protecting the public and the environment.

6.4 Conventional Health and Safety

For 2018, CNSC staff continued to rate the conventional health and safety SCA as "satisfactory" based on regulatory oversight activities.

Key Lake Operation - conventional health and safety ratings

2014	2015	2016	2017	2018
SA	SA	SA	SA	SA

SA = satisfactory

Practices

The Key Lake Operation's incident reporting system records health and safety-related events and uses several layers of review in investigations. Corrective measures are tracked and assessed for effectiveness prior to closure. The Key Lake Operation continued its planned health and safety inspection program in 2018. Any items of concern found during these inspections are included in the licensees' incident reporting system.

Performance

There were two lost-time injuries (LTIs) at the Key Lake Operation between 2014 and 2018 (see table 6.3). There were no LTIs in 2018.

Included in this report is the total recordable incident rate (TRIR) for the last three years. The TRIR is the incident frequency rate measuring the number of fatalities, lost-time injuries, and other injuries requiring medical treatment.

Table 6.3: Key Lake Operation - lost-time injury statistics, 2014–18

	2014	2015	2016	2017	2018
Lost-time injuries[1]	0	0	2	0	0
Severity rate[2]	0	0	71.0	0	0
Frequency rate[3]	0	0	0.41	0	0
Total Recordable Incident Rate[4]	---	---	6.17	3.48	2.59

[1] An injury that takes place at work and results in the worker being unable to return to work for a period of time.
[2] A measure of the total number of days lost to injury for every 200,000 person-hours worked at the facility.
Accident severity rate = [(# of days lost in last 12 months) / (# of hours worked in last 12 months)] x 200,000.
[3] A measure of the number of LTIs for every 200,000 person-hours worked at the facility.
Accident frequency rate = [(# of injuries in last 12 months) / (# of hours worked in last 12 months)] x 200,000.
[4] A measure of the number of fatalities, lost-time injuries, and other injuries requiring medical treatment for every 200,000 person-hours worked at the facility.
Recordable incident rate = [(#incidents in last 12 months) / # hours worked in last 12 months)] x 200,000.

Awareness

CNSC staff observed that Cameco's conventional health and safety programs at Key Lake continued to provide education, training, tools and support to workers. The idea that safety is the responsibility of all individuals is promoted by licensee managers, supervisors and workers. Licensee management stresses the importance of conventional health and safety through regular communication, management oversight and continual improvement of safety systems.

CNSC staff compliance verification activities concluded that Cameco's health and safety program at the Key Lake Operation met regulatory requirements in 2018.

7 MCCLEAN LAKE OPERATION

Orano Canada Inc. (Orano) is the operator of the McClean Lake Operation. In July 2018 a Commission panel approved the change of the licensee name from AREVA Resources Canada Inc. (AREVA) to Orano Canada Inc., and issued the amended licence UMOL-MINEMILL-McCLEAN.01/2027.

The McClean Lake Operation is a uranium mine and mill facility located approximately 750 kilometers north of Saskatoon in the Athabasca Basin of northern Saskatchewan. Ownership of the McClean Lake Operation is comprised of Orano (70%), Denison Mines Inc. (22.5%), and Overseas Uranium Resources Development Canada Co., Ltd. (7.5%). The McClean Lake Operation includes the John Everett Bates (JEB) milling area, Sue mining area, JEB tailings management facility (TMF) and the undeveloped McClean, Midwest and Caribou ore deposits.

An aerial view of the facility is presented in figure 7.1; figure 7.2 shows CNSC staff making observations at the McClean Lake Sue pit during an inspection.

Figure 7.1: McClean Lake Operation - aerial view of the JEB milling area and tailings management facility

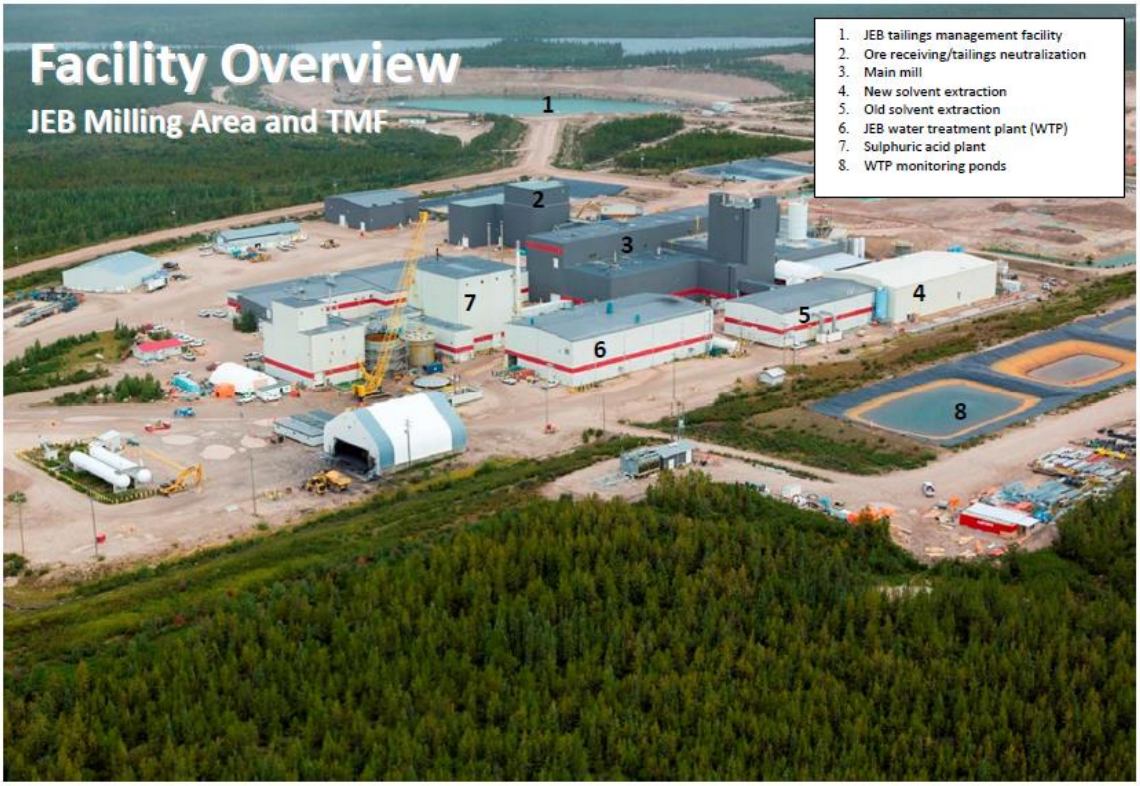


Figure 7.2: McClean Lake Operation – CNSC staff at McClean Lake Sue pit

Following a public hearing held on June 7 and 8, 2017 in La Ronge, Saskatchewan, the current operating licence was renewed on July 1, 2017 and expires on June 30, 2027. This licence authorized the operation of a nuclear facility for the mining of uranium ore, the processing of high grade ore slurry from Cameco Corporation's Cigar Lake Operation, the production of uranium concentrate and the disposal of tailings at the JEB TMF. The McClean Lake operating licence was amended by the Commission on July 1, 2018 to reflect the licensee corporate name change from AREVA Resources Canada Inc., to Orano Canada Inc.

Construction of the McClean Lake Operation began in 1994. Milling of ore and processing of yellowcake product began in 1999. The McClean Lake Operation was designed and constructed with radiation protection features (e.g., lead shielding, concrete enclosures for storage and leach tanks) for processing of undiluted high grade ore averaging from 20 percent uranium to as high as 30 percent uranium. Mining and milling of uranium ore from five open-pit mines has been completed and conventional mining has not been carried out at the McClean Lake Operation since 2008. Mill tailings have been deposited in the JEB TMF, which was engineered from the mined-out JEB open pit.

In July 2010, processing of ore at the McClean Lake Operation was suspended and the mill was temporarily shut down due to a shortage of ore. Shipments of the high-grade ore slurry from Cameco's Cigar Lake mine began in March 2014, and the McClean Lake Operation restarted in September 2014.

CNSC staff confirmed that the McClean Lake Operation production did not exceed the authorized annual production limit. Table 7.1 presents milling production data for the McClean Lake Operation for the five-year reporting period.

Table 7.1: McClean Lake Operation - milling production data, 2014–18

Milling	2014	2015	2016	2017	2018
Mill ore feed (Mkg/year)	7.83	25.52	37.20	36.35	42.9
Average annual mill feed grade (%U)	3.00	17.56	18.08	19.30	16.26
Percentage of uranium recovery (%)	97.54	98.99	99.10	99.03	98.94
Uranium concentrate produced (Mkg U)	0.200	4.30	6.67	6.93	6.94
Authorized annual production (Mkg U/year)	5.00	5.00	9.23	9.23	9.23

In April 2010, Orano submitted an application to the CNSC requesting approval for the JEB TMF Optimization Project. CNSC staff reviewed the application and approved the project in September 2010. A two-phase plan was proposed and stage 1 of the project was completed in 2012-13 (re-sloping of TMF 1V:1.5H slope, placement of manufactured soil bentonite liner, and placement of rip-rap protection). In 2017, Orano continued working on removal of infrastructure impacting stage 2 re-sloping work and completed the following projects:

- contaminated landfill relocation;
- tailings pipe bench relocation; and
- decommissioning of the JEB TMF infrastructure.

Orano completed optimization stage 2 in the summer of 2018. This involves re-sloping of the current TMF slope to a 1V:3H slope, placement of liner to the final elevation of 443 metres above sea level (mASL) and placement of rip-rap protection.

In June 2016, Orano submitted an application to expand the JEB TMF. Orano expects to generate approximately 2.4 million cubic metres of tailings over the next 18 years of operation. The TMF expansion would provide additional required tailings storage capacity during continued operation of the McClean Lake mill. The JEB TMF expansion application was accepted by CNSC staff and presented to the Commission as part of the 2017 licence renewal. Orano indicated the construction activities for the JEB TMF expansion would begin in either 2019 or 2020. CNSC staff will continue to monitor progress through ongoing compliance activities.

7.1 Performance

Ratings for all 14 safety and control areas (SCAs) for the five-year period from 2014 to 2018 are shown in appendix E. For 2018, CNSC staff continued to rate all SCAs as "satisfactory" based on regulatory oversight activities with the exception of radiation protection which continued to be rated as "fully satisfactory", as described in section 7.2. This report focuses on the three SCAs that cover many of the key performance indicators for the uranium mines and mills: radiation protection, environmental protection and conventional health and safety.

In 2018, CNSC staff carried out focused compliance inspections covering the SCAs of operating performance, conventional health and safety and waste management in addition to general inspections that included multiple SCAs. There were three instances of non-compliances noted during CNSC inspections at the McClean Lake Operation for the 2018 calendar year. These instances of non-compliance were of low risk and related to the conventional health and safety and fire protection and emergency management SCAs. The licensee implemented corrective actions which were reviewed and accepted by CNSC staff. A list of inspections can be found in appendix B.

7.2 Radiation Protection

From 2014 to 2016, CNSC staff continued to rate the radiation protection SCA at the McClean Lake Operation as "satisfactory". In 2017 the CNSC changed the rating to "fully satisfactory" based on the results of compliance inspections, desktop reviews and the determination that radiological hazard control, worker dose control and ALARA programs were highly effective. CNSC staff continue to rate the radiation protection SCA as "fully satisfactory" based on the result of compliance verification activities carried out in 2018.

McClean Lake Operation - radiation protection ratings

2014	2015	2016	2017	2018
SA	SA	SA	FS	FS

FS = fully satisfactory SA = satisfactory

Radiological hazard control

The source of radiological exposure at the McClean Lake Operation is the milling of high-grade uranium ore received from Cameco's Cigar Lake mine. The three primary dose contributors are gamma radiation (33%), radon progeny (RnP) (41%), and long-lived radioactive dust (LLRD) (26%). Gamma radiation hazards are controlled through practices related to the effective use of time, distance and shielding. Effective doses to nuclear energy workers (NEWs) from exposures to radon progeny and LLRD are controlled through the effective use of source control, ventilation, contamination control and personal protective equipment (PPE).

Orano has incorporated specific radiation protection features into its design to process undiluted, high-grade uranium ore at McClean Lake. These design features were established to limit radiological hazards (for all types) to specific design hazard objectives. Orano continues to implement a comprehensive monitoring program for all hazards to confirm that engineered control of hazards remain effective, design hazard objectives continue to be met, and to identify opportunities for improvement at the McClean Lake Operation.

CNSC staff concluded that Orano continues to implement a comprehensive monitoring program and that this program remains highly effective in controlling all radiological hazards at McClean Lake in 2018.

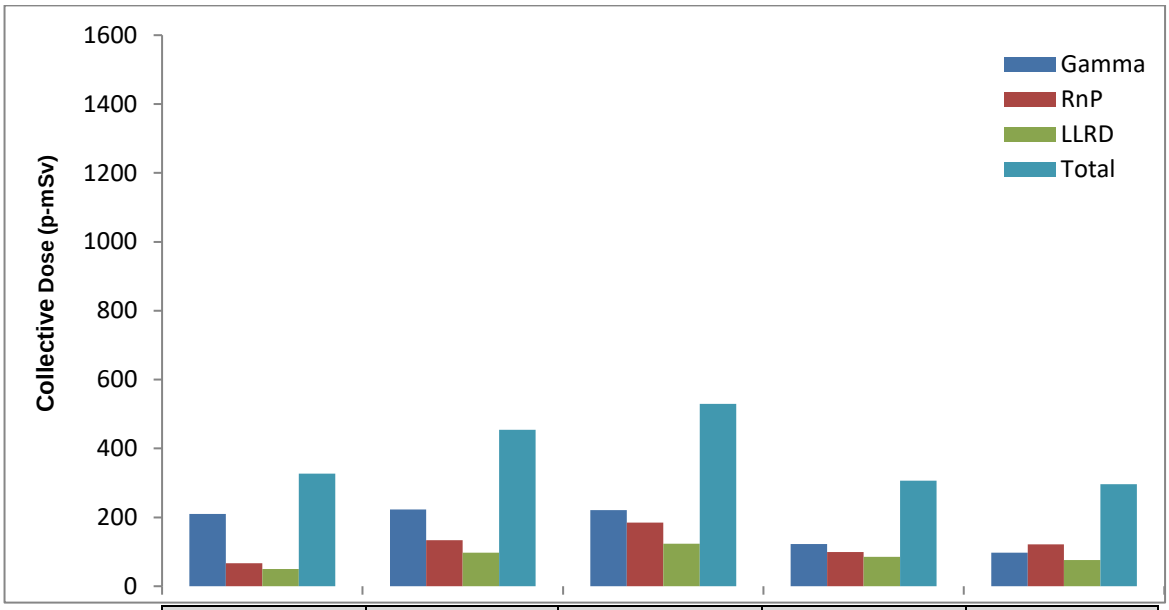
Radiation protection program performance

In 2018, there were no exceedances of action levels at the McClean Lake Operation. The radiation protection program and practices continued to effectively maintain worker doses ALARA.

Application of ALARA

In 2018, collective radiation exposure to NEWs at the McClean Lake Operation was 296 person-millisieverts (p-mSv), a 3.6 percent decrease from the 2017 value of 307 p-mSv (figure 7.3) and a decrease from 529 p-mSv in 2016.

Figure 7.3: McClean Lake Operation - annual collective dose, 2014–18



	2014	2015	2016	2017	2018
Gamma (p-mSv)	210	223	221	122	98
RnP (p-mSv)	67	134	185	100	122
LLRD (p-mSv)	50	97	123	85	76
Total	327	454	529	307	296

RnP = radon progeny; LLRD = long-lived radioactive dust

The collective dose values are a reflection of new and existing ALARA initiatives that were implemented at the McClean Lake Operation. These include, but are not limited to:

- cleaning or flushing of equipment prior to maintenance activities;
- incorporating shielding material during maintenance activities;
- suppressing dust with water;
- routine cleaning of radiation area equipment/vehicles;
- performing maintenance work away from radioactive source materials when practical;
- incorporating shielding material in heavy equipment (e.g., haul trucks and loader);
- quarterly dose trending information sessions with workers; and
- routine maintenance of building ventilation and containment control equipment, such as fans, furnaces, and doors.

Through reviews of radiation monitoring and exposure reports as well as inspections, CNSC staff confirmed that the radiation protection program was highly effective and that the program ensured that worker exposures remained consistent with the ALARA principle in 2018.

Worker dose control

Overall, doses remained consistent from 2017 to 2018, with 69 percent of annual effective doses remaining below 1.0 mSv in both years. The average individual effective dose to NEWs in 2018 was 0.90 mSv, while the maximum individual effective dose received by a NEW was 5.50 mSv. These values compare to an average individual effective dose of 0.91 mSv and a maximum individual dose of 5.12 mSv in 2017. All individual effective doses were well below the annual regulatory limit of 50 mSv and 100 mSv in a five year dosimetry period.

In 2018, Orano continued to set more challenging dose targets for workers in higher dose categories:

- average effective dose for top 10 NEWs (5.00 mSv from 5.50 mSv of 2017);
- average ore dust target for top 10 NEWs (2.00 mSv from 2.25 mSv of 2017); and
- average RnP dose target for top 10 NEWs (1.10 mSv from 1.30 mSv of 2017).

The first two targets were met. The third target (RnP) was not met but was still lower than the 2017 target of 1.30 mSv.

Based on their compliance verification activities, such as inspections, reviews of licensee reports, work practices, monitoring results and individual effective dose results in 2018, CNSC staff were satisfied that Orano controlled radiation doses to workers. CNSC staff concluded that the worker dose control measures at the McClean Lake Operation were highly effective and therefore rated Orano's performance for the radiation protection SCA as "fully satisfactory" in 2018.

7.3 Environmental Protection

For 2018, CNSC staff continued to rate the environmental protection SCA as "satisfactory" based on regulatory oversight activities. CNSC staff concluded that the licensee's environmental protection program was effectively implemented and met all regulatory requirements.

McClean Lake Operation - environmental protection ratings

2014	2015	2016	2017	2018
SA	SA	SA	SA	SA

SA = satisfactory

Environmental management system

The environmental management system at the McClean Lake Operation includes activities such as establishing annual environmental objectives, goals and targets. Orano conducts internal audits of its environmental management program at the McClean Lake Operation as identified in their CNSC-approved management system program. CNSC staff review and assess the objectives, goals and targets through regular compliance verification activities. CNSC staff noted that Orano continued with routine inspections, internal audits, environmental training and periodic reviews of environmental monitoring data. These activities were conducted to ensure continual improvement and to confirm that the controls put into place to protect the environment are effective.

Effluent and emissions control

Effluent and emissions monitoring programs serve to demonstrate that the facility emissions, wastes, tailings and effluent discharge of nuclear and hazardous substances are properly controlled at the McClean Lake Operation.

Treated effluent released to the environment

At the McClean Lake Operation, two effluent streams are processed in separate treatment facilities before being released to the environment:

- The mill effluent is processed at the JEB water treatment plant with a treatment system of chemical precipitation and liquid/solid separation. Treated water is released to the Sink/Vulture Treated Effluent Management System.
- The Sue water treatment plant treats effluent which is pumped to control the water level from the mined-out open pits, using a chemical precipitation and settling pond clarification process. This effluent is then released to the sink/vulture treated effluent management system.

The blended treated effluent is released in a controlled manner.

The 2016 Environmental Risk Assessment identified future potential risks to aquatic organisms in McClean Lake east due to exposure to selenium from the milling of Cigar Lake ore. In the *Regulatory Oversight Report for Uranium Mines, Mills, Historic and Decommissioned Sites in Canada: 2017*, CNSC staff reported on the selenium adaptive management plan, developed and implemented by Orano. There was no administrative or action level exceedance of the selenium concentration in the JEB water treatment plant effluent in 2018. CNSC staff continue to review reported selenium concentration in effluent through quarterly reports to ensure the receiving environment remains protected.

Orano submitted a selenium review and assessment report in July 2018. This report provided a technical evaluation of operating performance with implemented process improvements, feasibility of potential augmenting selenium removal technologies, and selenium risks in the environment. CNSC staff reviewed the report and provided comments, including recommendations for modifying the environmental monitoring program.

There was one action level and one discharge limit exceedance of the total suspended solids (TSS) concentration from the JEB water treatment plant effluent reported to CNSC staff. The follow-up report for the discharge limit exceedance indicated that the reportable TSS result was due to a delay in sample analysis that allowed calcium sulphate to precipitate out in the sample container, and TSS released in effluent did not exceed the regulatory limit. CNSC staff reviewed the events notification and the follow-up reports and were satisfied with the corrective actions implemented by the McClean Lake Operation. See appendix J for additional details on both the regulatory limit exceedance and the action level report.

Orano analyzed treated effluent for concentrations of various substances such as radium-226, arsenic, copper, lead, nickel, zinc, TSS and for pH levels at McClean Lake. As discussed in section 2.4, the McClean Lake Operation continued to meet *Metal and Diamond Mining Effluent Regulations* (MDMER) [5] discharge limits.

CNSC staff will continue to review results on the quality of effluent in order to ensure that the treatment of effluent remains effective.

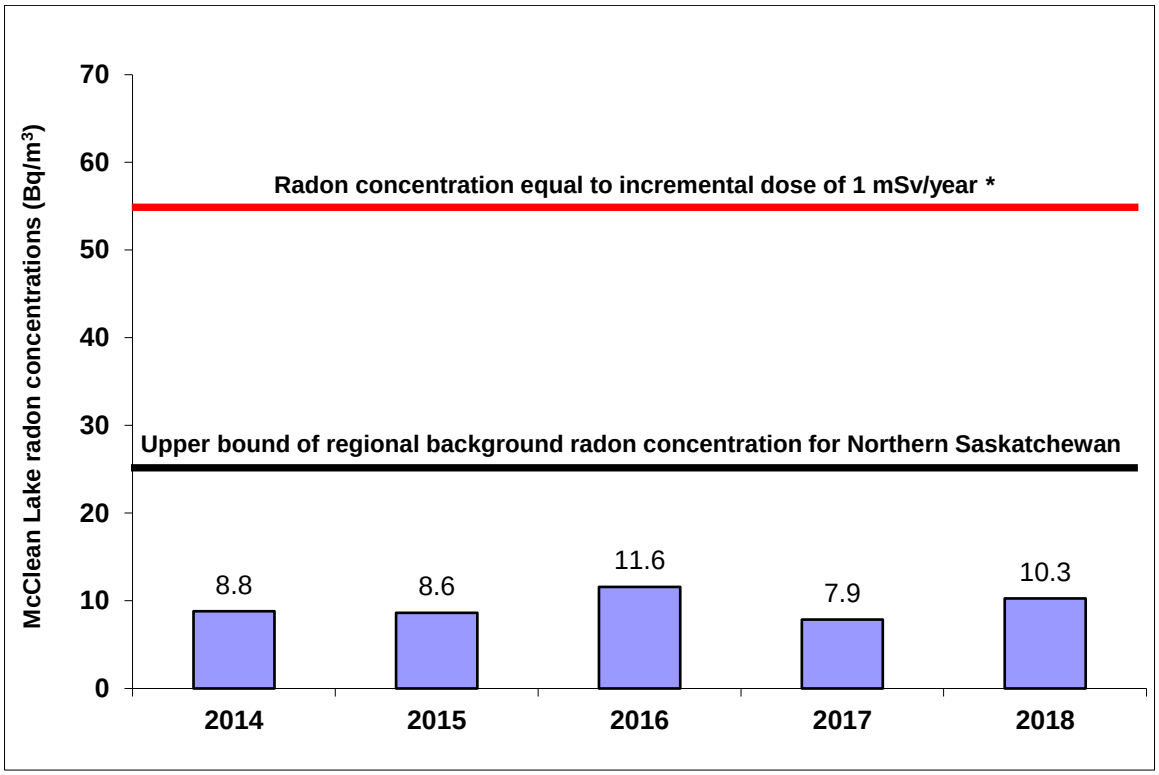
Air emissions released to the environment

Air quality at the McClean Lake Operation is monitored through direct measurement of emissions from the mill, ambient air quality near the operation and indirectly through measurements of metal accumulations in the terrestrial environment.

Air quality monitoring at the McClean Lake Operation includes ambient radon, total suspended particulate (TSP), sulphur dioxide and exhaust stack monitoring. Ambient sulphur dioxide and exhaust stack monitoring was commensurate with the mill commissioning activities and restart in September 2014. Terrestrial monitoring components include soil and vegetation sampling.

Environmental monitoring for radon concentrations is conducted using the passive method of track-etch cups. There are 23 monitoring stations in various locations around the site-lease boundary. Figure 7.4 shows the average concentrations of radon in ambient air for 2014 to 2018. Ambient radon concentrations were typical of the northern Saskatchewan regional background of less than 7.4 Bq/m^3 to 25 Bq/m^3. The measured radon concentrations were also below a reference radon concentration of 55 Bq/m^3, which is equal to an incremental dose of 1 mSv per year above background.

Figure 7.4: McClean Lake Operation - concentrations of radon in ambient air, 2014–18



* Upper-bound of the incremental dose of 1 mSv per year above background (i.e., an incremental radon concentration of 30 Bq/m^3 above natural background) based on ICRP Publication 115. Values are calculated as geometric means.

Five high-volume air samplers to monitor TSP are located at locations around the McClean Lake Operation. As shown in table 7.2, TSP values remained low in 2018 and well below the provincial standard of 60 µg/m^3.

TSP samples were also analyzed for concentrations of metals and radionuclides. The mean concentrations of metal and radionuclides adsorbed to TSP were low and below reference annual air quality levels identified in table 7.2.

Table 7.2: McClean Lake Operation - concentrations of metal and radionuclides in air, 2014–18

Parameter	Reference annual air quality levels*	2014	2015	2016	2017	2018
TSP (µg/m^3)	**60** [3]	5.66	8.37	5.12	4.96	8.00
As (µg/m^3)	**0.06** [1]	0.000420	0.003070	0.000032	0.000432	0.000354
Cu (µg/m^3)	**9.6** [1]	0.013888	0.019630	0.021613	0.017159	0.018107
Mo (µg/m^3)	**23** [1]	0.000721	0.000892	0.000145	0.001028	0.001154
Ni (µg/m^3)	**0.04** [1]	0.000420	0.000247	0.000259	0.000321	0.000262
Pb (µg/m^3)	**0.10** [1]	0.000501	0.000368	0.000762	0.000406	0.000417
Zn (µg/m^3)	**23** [1]	0.005939	0.005452	0.004703	0.003165	0.004684
Pb-210 (Bq/m^3)	**0.021** [2]	0.000277	0.000271	0.000285	0.000309	0.000253
Po-210(Bq/m^3)	**0.028** [2]	0.000088	0.000083	0.000087	0.000100	0.000087
Ra-226 (Bq/m^3)	**0.013** [2]	0.000010	0.000008	0.000009	0.000014	0.000022
Th-230 (Bq/m^3)	**0.0085** [2]	0.000005	0.000005	0.000005	0.000006	0.000004
U (µg/m^3)	**0.06** [1]	0.000576	0.001319	0.003138	0.002029	0.001654

1 Reference annual air quality levels are derived from Ontario 24-hour Ambient Air Quality Criteria (2012).

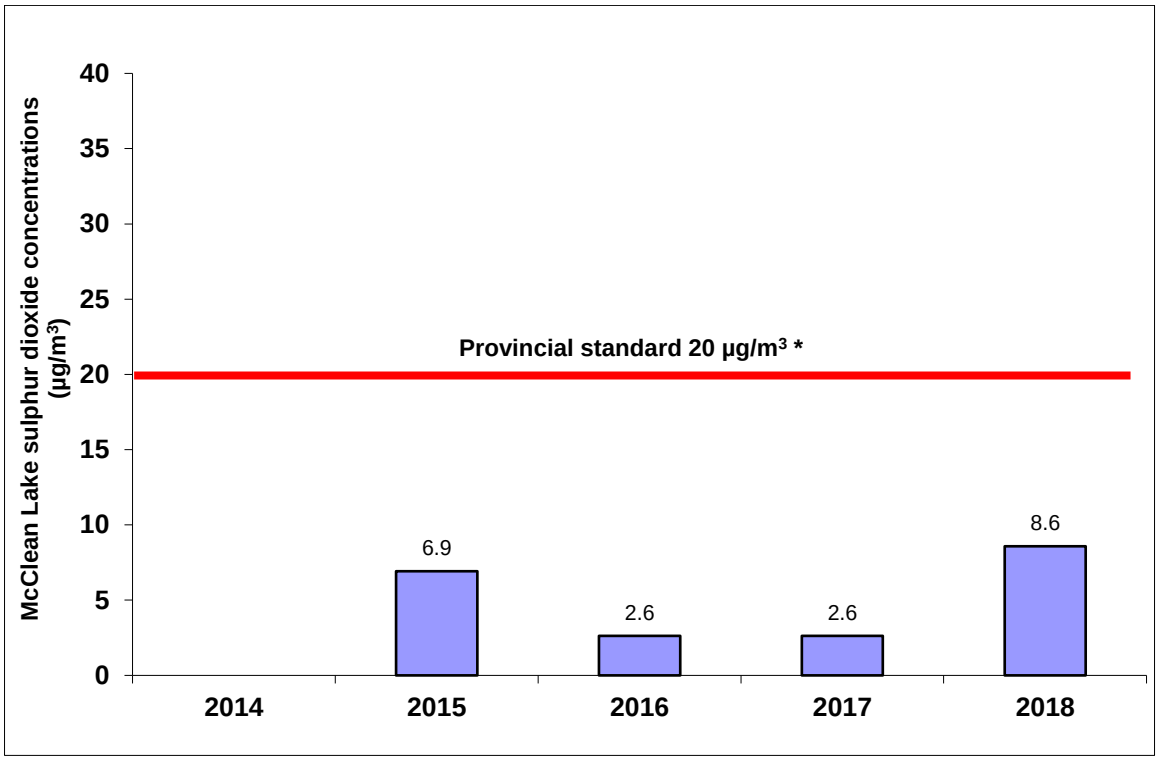
2 Reference level is derived from International Commission of Radiological Protection (ICRP) Publication 96. *Protecting People Against Radiation Exposure in the Event of a Radiological Attack*.

3 *Saskatchewan Environmental Quality Guidelines*, Table 20: Saskatchewan Ambient Air Quality Standards. Values are calculated as geometric means.

* Reference levels based on Province of Ontario ambient air quality criteria and are shown for reference only. No federal or Province of Saskatchewan limits were established at the time of this report.

A sulphur dioxide monitor is used during operations to continuously measure ambient sulphur dioxide concentrations associated with mill emissions. The monitor is located approximately 200 metres downwind of the sulphuric acid plant stack. The measured sulphur dioxide monitoring data (see figure 7.5) showed no exceedances of the annual standard of 20 µg/m^3 in 2018.

Figure 7.5: McClean Lake Operation - concentrations of ambient sulphur dioxide, 2014–18



2014: Ambient sulphur dioxide (SO_2) was not monitored during the temporary shutdown of the mill. Therefore, ambient SO_2 concentrations were not measured for the years 2011 to 2013. In 2014, measurement of ambient SO_2 concentrations began again on December 29, 2014 when the acid plant restarted.

* Province of Saskatchewan's ambient air quality standard is shown.

Orano's terrestrial monitoring program at McClean Lake determines if there is influence on the environment from aerial deposition. Soil and terrestrial vegetation may be affected by the atmospheric deposition of particulate and adsorbed metals and radionuclides associated with onsite activities. This program includes measurements of metals and radionuclides in soil and vegetation. Terrestrial monitoring was conducted in 2018 and the results will be included in the 2021 environmental performance report (EPR).

Soil monitoring results from soil samples collected in 2015 are presented in the 2016 EPR. The results showed that the soil metal parameter concentrations were below the *Canadian Environmental Quality Guidelines* [8] set by the Canadian Council of Ministers of the Environment. Radionuclide concentrations in soils were near or at background levels and analytical detection limits. CNSC staff concluded that the level of airborne particulate contaminants produced by the McClean Lake Operation is acceptable and does not pose a risk to the environment.

Vegetation sampling was also presented in the 2016 EPR and shows that most parameters are within the range of concentrations previously measured in lichen, Labrador tea and blueberry twig samples. The concentrations of metals and radionuclides in lichen, Labrador tea and blueberry twigs have higher than background concentrations for some samples located in the immediate vicinity of mining activity, although the concentrations decrease within a short distance. Overall, the results indicated that the McClean Lake Operation has had a localized effect on vegetation in areas of activity.

These higher concentrations were below levels that are toxic to plants and decreased to within background concentrations within a short distance from the facility. Therefore, no changes are predicted to terrestrial habitat, both within and outside the facility boundary. The elevated concentrations of contaminants within the facility boundary were modelled in an ERA, and no adverse effects were predicted for terrestrial non-human biota.

CNSC staff concluded that the level of airborne particulate contaminants produced by the McClean Lake Operation was acceptable and did not pose a risk to browse (twigs and Labrador tea) and lichen consumers such as caribou.

Uncontrolled releases

In 2018, six events reported to CNSC staff were identified as releases of hazardous substances to the environment:

- On June 23, 2018, a 150 kilogram discharge of molten sulphur to the ground occurred at the sulphur unloading location due to a mechanical failure of the rear trailer valve of the delivery truck.
- On July 19, 2018, while washing out the Sulphuric Acid Plant stack, the drain was blocked causing the water to build up inside the stack. When the drain line was cleared, approximately 0.655 m^3 of wash water leaked onto the mill terrace.
- On July 26, 2018, a hydrovac truck was removing water from the north Surface Access Borehole Recovery Extraction (SABRE) clarification pond. The operator noticed that mine water was leaking onto the ground from the rear door seal. Initial investigation revealed that the box liner in the truck had become detached and prevented the rear door from sealing properly. Approximately 2 m^3 of mine water was released to the ground.
- On August 25, 2018, during a routine pond inspection at the Sue Site Runoff Pond, water was detected under the pond liner. Approximately 25 m^3 of water was removed from under the liner.
- On September 29, 2018, the calciner scrubber had scale build up that dislodged and plugged the cone of the scrubber body. The scrubber solution backed up through the scrubber body and up to the fan which released material onto the mill terrace. It was determined that approximately 50 grams of calcined yellowcake was released to the mill terrace.
- On December 22, 2018, an Orano employee discovered an anhydrous ammonia drip coming from an offload valve that was not fully closed. It is estimated that approximately 60 litres of liquid anhydrous ammonia was released to the ground.

All spills were low safety significance and reporting met the requirements of REGDOC-3.2.1, *Public Information and Disclosure* [2]. Appendix I describes the spills and corrective actions taken. As a result of the actions taken by Orano, there were no residual impacts to the environment by the spills. CNSC staff were satisfied with the reporting of releases of hazardous materials to the environment and the corrective actions taken. CNSC staff rated all the 2018 spills as low significance.

Figure 2.12 in section 2 displays the number of environmental reportable spills that occurred at the McClean Lake Operation from 2014 to 2018.

Assessment and monitoring

CNSC staff confirmed that the licensee, in accordance with the McClean Lake environmental protection program, successfully carried out required environmental monitoring.

Through compliance activities conducted, review of annual reports and the Environmental Protection Technical Information Document, CNSC staff concluded that environmental monitoring conducted at the McClean Lake Operation met regulatory requirements. Consequently, CNSC staff concluded that the environment remains protected.

Environmental risk assessment

The McClean Lake Operation Environmental Protection Technical Information Document was submitted to the CNSC in 2016, which provided environmental monitoring data for 2011 to 2015 and an updated ERA. CNSC staff reviewed the environmental monitoring results for air, soil, vegetation, water, groundwater and sediment as well as health indicators for fish and their prey inhabiting sediment and confirmed that the results were within those predicted in the ERA, with the exception of predicted short-term exposure of aquatic organisms to selenium in McClean Lake east basin, which is considered an exposure lake. As stated previously, the 2016 ERA noted a potential future risk to aquatic organisms in McClean Lake east due to selenium releases from effluent. Orano submitted a selenium review and assessment report in July 2018. This report provided a technical evaluation of operating performance with implemented process improvements, feasibility of potential augmenting selenium removal technologies, and selenium risks in the environment. This was discussed in more detail at the December 2018 Commission meeting on the *Regulatory Oversight Report for Uranium Mines, Mills, Historic and Decommissioned Sites in Canada: 2017*. CNSC staff is satisfied that Orano continues to appropriately assess the risk to the aquatic environment due to selenium effluent releases and ensure selenium effluent releases remain at levels that will ensure the protection of aquatic organisms in McClean Lake east basin.

After reviewing the Environmental Protection Technical Information Document and on-going activities by Orano to ensure the protection of the environment due to selenium releases, CNSC staff concluded that adequate measures have been taken at the McClean Lake Operation to protect the environment.

Protection of the public

Orano is required to demonstrate that the health and safety of the public are protected from exposures to hazardous substances released from the McClean Lake Operation. The effluent and environmental monitoring programs currently conducted by the licensee are used to verify that releases of hazardous substances do not result in environmental concentrations that may affect public health.

The CNSC receives reports of discharges to the environment through the reporting requirements outlined in the licence and licence conditions handbook. The review of Orano's hazardous (non-radiological) discharges to the environment at McClean Lake in 2018 indicated that the public and environment were protected. CNSC staff confirmed the environmental concentrations in the vicinity of the McClean Lake Operation remained within those predicted in the 2016 ERA, and that human health remained protected.

Based on compliance verification activities that included inspections, reviews of licensee reports, work practices, and monitoring results for 2018, CNSC staff concluded that the McClean Lake Operation environmental protection program continued to be effective protecting the public and the environment.

7.4 Conventional Health and Safety

For 2018, CNSC staff continued to rate the conventional health and safety SCA as "satisfactory" based on regulatory oversight activities.

McClean Lake Operation - conventional health and safety ratings

2014	2015	2016	2017	2018
SA	SA	SA	SA	SA

SA = satisfactory

Practices

As required under the NSCA [1], Orano continued to improve performance and maintain health and safety programs at the McClean Lake Operation to minimize occupational health and safety risks. CNSC staff confirmed that Orano had an effective occupational health and safety committee and that it was completing regular reviews of its safety program at McClean Lake.

Orano's McClean Lake Operation investigates safety concerns and incidents, including near-miss events. In 2018, several investigations were completed using the cause mapping process to determine the cause of incidents, near misses, injuries or property damage. This methodology employs a collaborative group effort to identify a problem, analyze its causes and determine the best solutions. CNSC staff reviewed the investigation results and corrective actions and confirmed Orano's commitment to accident prevention and safety awareness with a focus on safety culture.

Performance

Table 7.3 shows that from 2014 to 2018, Orano's McClean Lake Operation reported 10 lost-time injuries (LTIs). There was one LTI in 2018.

An incident occurred on January 26, 2018 where a worker slipped and fell on icy ground (same elevation). Additional information regarding this LTI can be found in appendix K.

Included in this report is the total recordable incident rate (TRIR) for the last three years. The TRIR is the incident frequency rate measuring the number of fatalities, lost-time injuries, and other injuries requiring medical treatment.

Table 7.3: McClean Lake Operation - lost-time injury statistics, 2014–18

	2014	2015	2016	2017	2018
Lost-time injuries[1]	3	3	3	0	1
Severity rate[2]	4.3	27.7	10.9	67.8	4.8
Frequency rate[3]	0.4	0.4	0.6	0.0	0.3
Total Recordable Incident Rate[4]	---	---	2.9	1.4	0.75

[1] An injury that takes place at work and results in the worker being unable to return to work for a period of time.
[2] A measure of the total number of days lost to injury for every 200,000 person-hours worked at the facility.
Accident severity rate = [(# of days lost in last 12 months) / (# of hours worked in last 12 months)] x 200,000.
[3] A measure of the number of LTIs for every 200,000 person-hours worked at the facility.
Accident frequency rate = [(# of injuries in last 12 months) / (# of hours worked in last 12 months)] x 200,000.
[4] A measure of the number of fatalities, lost-time injuries, and other injuries requiring medical treatment for every 200,000 person-hours worked at the facility.
Recordable incident rate = [(#incidents in last 12 months) / # hours worked in last 12 months)] x 200,000.

Corrective actions, where necessary, were implemented with the effectiveness verified and documented by management. Details on the 2018 LTI, and corrective actions are included in appendix J. CNSC staff verified that Orano strives to involve all levels of its organization in the health and safety program at the McClean Lake Operation. Employees are encouraged and trained to continuously identify and assess risks, and propose solutions.

Awareness

CNSC staff observed that conventional health and safety programs provided education, training, tools and support to ensure worker protection at the McClean Lake Operation. An active onsite occupational health and safety committee completes regular reviews of the McClean Lake safety program. Through inspections, reviews of incidents and discussions with McClean Lake staff, CNSC staff verified that the McClean Lake Operation is committed to accident prevention and safety awareness. CNSC staff compliance verification activities concluded that the McClean Lake Operation's health and safety program met regulatory requirements in 2018.

A. LICENCE AND LICENCE CONDITIONS HANDBOOK(S)

Table A-1: Uranium mines and mills - Licence information

Licensee/site/licence #	Licence effective	Last licence amendment	Licence expiration
Orano Canada Inc. McClean Lake Operation Uranium mine and mill operating licence UMOL-MINEMILL-McCLEAN.01/2027	July 1, 2017	July 17, 2018	June 30, 2027
Cameco Corporation Cigar Lake Operation Uranium mine operating licence UML-MINE-CIGAR.00/2021	July 1, 2013	-	June 30, 2021
Cameco Corporation Key Lake Operation Uranium mill operating licence UMLOL-MILL-KEY.00/2023	November 1, 2013	-	October 31, 2023
Cameco Corporation Rabbit Lake Operation Uranium mine and mill operating licence UMOL-MINEMILL-RABBIT.00/2023	November 1, 2013	-	October 31, 2023
Cameco Corporation McArthur River Operation Uranium mine operating licence UMOL-MINE-McARTHUR.00/2023	November 1, 2013	-	October 31, 2023

Table A-2: Uranium mines and mills – Licence conditions handbook changes, 2018

Record of the issuance of licence conditions handbook (LCH)			
Licensee/site/licence #	**LCH revision**	**Summary of changes**	**Effective date of LCH**
Orano Canada Inc. McClean Lake Operation Uranium mine and mill operating licence UMOL-MINEMILL-McCLEAN.01/2027	4	No changes in 2018	October 6, 2017
Cameco Corporation Cigar Lake Operation Uranium mine operating licence UML-MINE-CIGAR.00/2021	1	No changes in 2018	January 23, 2014
Cameco Corporation Key Lake Operation Uranium mill operating licence UMLOL-MILL-KEY.00/2023	1	No changes in 2018	December 15, 2014
Cameco Corporation Rabbit Lake Operation Uranium mine and mill operating licence UMOL-MINEMILL-RABBIT.00/2023	0	No changes in 2018	January 23, 2014
Cameco Corporation McArthur River Operation Uranium mine operating licence UMOL-MINE-McARTHUR.00/2023	1	No changes in 2018	April 22, 2014

B. LIST OF INSPECTIONS

Table B-1: Inspections by facility and safety and control area

Facility	Safety and control area	Inspection report issued
Cigar Lake Operation	Management System, Radiation Protection, Conventional Health and Safety, Fitness for Service, Environmental Protection	March 22, 2018
	Fitness for Service, Conventional Health and Safety	April 5, 2018
	Conventional Health and Safety	May 18, 2018
	Environmental Protection	August 27, 2018
	Waste Management	November 5, 2018
	Packaging and Transport	January 11, 2019
McArthur River Operation	Human Performance Management, Operating Performance, Fitness for Service, Packaging and Transport	April 10, 2018
	Safety Analysis, Environmental Protection, Radiation Protection, Conventional Health and Safety, Waste Management	November 5, 2018
	Waste Management	November 20, 2018
	Conventional Health and Safety	December 18, 2018
	Operating Performance	January 21, 2019
	Conventional Health and Safety, Radiation Protection, Human Performance Management	January 31, 2019
Rabbit Lake Operation	Environmental Protection, Conventional Health and Safety, Radiation Protection	April 23, 2018
	Management System	August 17, 2018
	Environmental Protection, Conventional Health and Safety, Radiation Protection, Operating Performance	October 11, 2018
	Management System, Fitness for Service, Safety Analysis, Radiation Protection, Conventional Health and Safety, Emergency Management and Fire Protection	May 18, 2019

Facility	Safety and control area	Inspection report issued
Key Lake Operation	Physical Design, Conventional Health and Safety, Radiation Protection	March 20, 2018
	Operating Performance, Safety Analysis, Conventional Health and Safety, Radiation Protection, Human Performance Management, Waste Management, Security	May 15, 2018
	Environmental Protection, Conventional Health and Safety, Radiation Protection	December 21, 2018
	Safety Analysis, Environmental Protection, Conventional Health and Safety, Radiation Protection	July 31, 2018
	Environmental Protection, Conventional Health and Safety, Emergency Management and Fire Protection	January 3, 2019
McClean Lake Operation	Human Performance Management, Operating Performance, Fitness for Service, Packaging and Transport	April 10, 2018
	Safety Analysis, Environmental Protection, Radiation Protection, Conventional Health and Safety, Waste Management	November 5, 2018
	Waste Management	November 20, 2018
	Conventional Health and Safety	December 18, 2018
	Operating Performance	January 21, 2019
	Conventional Health and Safety, Radiation Protection, Human Performance Management	January 31, 2019

C. SAFETY AND CONTROL AREA DEFINITIONS

The CNSC evaluates how well licensees meet regulatory requirements and CNSC performance expectations for programs in 14 safety and control areas (SCAs). The SCAs are grouped into three functional areas: management, facility and equipment, and core control processes. The SCA definition for Conventional Health and Safety has been updated.

Table C-1: Safety and Control Area Framework

Safety and Control Area Framework			
Functional area	**Safety and control area**	**Definition**	**Specific areas**
Management	Management system	Covers the framework that establishes the processes and programs required to ensure an organization achieves its safety objectives, continuously monitors its performance against these objectives, and fosters a healthy safety culture.	▪ Management system ▪ Organization ▪ Performance assessment, improvement and management review ▪ Operating experience (OPEX) ▪ Change management ▪ Safety culture ▪ Configuration management ▪ Records management ▪ Management of contractors ▪ Business continuity
	Human performance management	Covers activities that enable effective human performance through the development and implementation of processes that ensure a sufficient number of licensee personnel are in all relevant job areas and have the necessary knowledge, skills, procedures and tools in place to safely carry out their duties.	▪ Human performance program ▪ Personnel training ▪ Personnel certification ▪ Initial certification examinations and requalification tests ▪ Work organization and job design ▪ Fitness for duty
	Operating performance	Includes an overall review of the conduct of the licensed activities and the activities that enable effective performance.	▪ Conduct of licensed activity ▪ Procedures ▪ Reporting and trending ▪ Outage management performance ▪ Safe operating envelope ▪ Severe accident management and recovery ▪ Accident management and recovery

Safety and Control Area Framework			
Functional area	**Safety and control area**	**Definition**	**Specific areas**
Facility and equipment	Safety analysis	Covers maintenance of the safety analysis that supports the overall safety case for the facility. Safety analysis is a systematic evaluation of the potential hazards associated with the conduct of a proposed activity or facility and considers the effectiveness of preventative measures and strategies in reducing the effects of such hazards**.**	▪ Deterministic safety analysis ▪ Hazard analysis ▪ Probabilistic safety analysis ▪ Criticality safety ▪ Severe accident analysis ▪ Management of safety issues (including R&D programs)
	Physical design	Relates to activities that impact the ability of structures, systems and components to meet and maintain their design basis given new information arising over time and taking changes in the external environment into account.	▪ Design governance ▪ Site characterization ▪ Facility design ▪ Structure design ▪ System design ▪ Component design
	Fitness for service	Covers activities that impact the physical condition of structures, systems and components to ensure that they remain effective over time. This area includes programs that ensure all equipment is available to perform its intended design function when called upon to do so.	▪ Equipment fitness for service / equipment performance ▪ Maintenance ▪ Structural integrity ▪ Aging management ▪ Chemistry control ▪ Periodic inspection and testing
Core control processes	Radiation protection	Covers the implementation of a radiation protection program in accordance with the *Radiation Protection Regulations* [4]. The program must ensure that contamination levels and radiation doses received by individuals are monitored, controlled and maintained ALARA.	▪ Application of ALARA ▪ Worker dose control ▪ Radiation protection program performance ▪ Radiological hazard control ▪ Estimated dose to public

Safety and Control Area Framework			
Functional area	**Safety and control area**	**Definition**	**Specific areas**
	Conventional health and safety	The implementation of a program to manage workplace safety hazards and to protect workers.	▪ Performance ▪ Practices ▪ Awareness
	Environmental protection	Covers programs that identify, control and monitor all releases of radioactive and hazardous substances and effects on the environment from facilities or as the result of licensed activities.	▪ Effluent and emissions control (releases) ▪ Environmental management system (EMS) ▪ Assessment and monitoring ▪ Protection of the public ▪ Environmental risk assessment
	Emergency management and fire protection	Covers emergency plans and emergency preparedness programs that exist for emergencies and for non-routine conditions. This area also includes any results of participation in exercises.	▪ Conventional emergency preparedness and response ▪ Nuclear emergency preparedness and response ▪ Fire emergency preparedness and response
	Waste management	Covers internal waste-related programs that form part of the facility's operations up to the point where the waste is removed from the facility to a separate waste management facility. This area also covers the planning for decommissioning.	▪ Waste characterization ▪ Waste minimization ▪ Waste management practices ▪ Decommissioning plans
	Security	Covers the programs required to implement and support the security requirements stipulated in the regulations, the licence, orders, or expectations for the facility or activity.	▪ Facilities and equipment ▪ Response arrangements ▪ Security practices ▪ Drills and exercises

Safety and Control Area Framework			
Functional area	**Safety and control area**	**Definition**	**Specific areas**
	Safeguards and non-proliferation	Covers the programs and activities required for the successful implementation of the obligations arising from the Canada/International Atomic Energy Agency (IAEA) safeguards agreements, as well as all other measures arising from the *Treaty on the Non-Proliferation of Nuclear Weapons*.	▪ Nuclear material accountancy and control ▪ Access and assistance to the IAEA ▪ Operational and design information ▪ Safeguards equipment, containment and surveillance ▪ Import and export
	Packaging and transport	Programs that cover the safe packaging and transport of nuclear substances to and from the licensed facility.	▪ Package design and maintenance ▪ Packaging and transport ▪ Registration for use
Other Matters of Regulatory Interest			
▪ Environmental assessment ▪ CNSC consultation – Indigenous ▪ CNSC consultation – other ▪ Cost recovery ▪ Financial guarantees ▪ Improvement plans and significant future activities ▪ Licensee public information program ▪ Nuclear liability insurance			

D. SAFETY AND CONTROL AREA RATING DEFINITIONS

Performance ratings used in this report are defined as follows:

Fully satisfactory (FS)

Safety and control measures implemented by the licensee are highly effective. In addition, compliance with regulatory requirements is fully satisfactory, and compliance within the safety and control area or specific area exceeds requirements and Canadian Nuclear Safety Commission (CNSC) expectations. Overall, compliance is stable or improving, and any problems or issues that arise are promptly addressed.

Satisfactory (SA)

Safety and control measures implemented by the licensee are sufficiently effective. In addition, compliance with regulatory requirements is satisfactory. Compliance within the safety and control area or specific area meets requirements and CNSC expectations. Any deviation is only minor, and any issues are considered to pose a low risk to the achievement of regulatory objectives and the CNSC's expectations. Appropriate improvements are planned.

Below expectations (BE)

Safety and control measures implemented by the licensee are marginally ineffective. In addition, compliance with regulatory requirements falls below expectations. Compliance within the safety and control area or specific area deviates from requirements or CNSC expectations to the extent that there is a moderate risk of ultimate failure to comply. Improvements are required to address identified weaknesses. The licensee or applicant is taking appropriate corrective action.

Unacceptable (UA)

Safety and control measures implemented by the licensee are significantly ineffective. In addition, compliance with regulatory requirements is unacceptable and is seriously compromised. Compliance within the overall safety and control area or specific area is significantly below requirements or CNSC expectations or there is evidence of overall non-compliance. Without corrective action, there is a high probability that the deficiencies will lead to an unreasonable risk. Issues are not being addressed effectively, no appropriate corrective measures have been taken, and no alternative plan of action has been provided. Immediate action is required.

E. SAFETY AND CONTROL AREA RATINGS

Table E-1: Safety and control area ratings, Cigar Lake Operation, 2014-2018

Safety and control areas	2014	2015	2016	2017	2018
Management system	SA	SA	SA	SA	SA
Human performance management	SA	SA	SA	SA	SA
Operating performance	SA	SA	SA	SA	SA
Safety analysis	SA	SA	SA	SA	SA
Physical design	SA	SA	SA	SA	SA
Fitness for service	SA	SA	SA	SA	SA
Radiation protection	SA	SA	SA	SA	SA
Conventional health and safety	SA	SA	SA	SA	SA
Environmental protection	SA	SA	SA	SA	SA
Emergency management and fire protection	SA	SA	SA	SA	SA
Waste management	SA	SA	SA	SA	SA
Security	SA	SA	SA	SA	SA
Safeguards and non-proliferation	SA	SA	SA	SA	SA
Packaging and transport	SA	SA	SA	SA	SA

Table E-2: Safety and control area ratings, McArthur River Operation, 2014-2018

Safety and control areas	2014	2015	2016	2017	2018
Management system	SA	SA	SA	SA	SA
Human performance management	SA	SA	SA	SA	SA
Operating performance	SA	SA	SA	SA	SA
Safety analysis	SA	SA	SA	SA	SA
Physical design	SA	SA	SA	SA	SA
Fitness for service	SA	SA	SA	SA	SA
Radiation protection	SA	SA	SA	SA	SA
Conventional health and safety	SA	SA	SA	SA	SA
Environmental protection	SA	SA	SA	SA	SA
Emergency management and fire protection	SA	SA	SA	SA	SA
Waste management	SA	SA	SA	SA	SA
Security	SA	SA	SA	SA	SA
Safeguards and non-proliferation	SA	SA	SA	SA	SA
Packaging and transport	SA	SA	SA	SA	SA

Table E-3: Safety and control area ratings, Rabbit Lake Operation, 2014-2018

Safety and control areas	2014	2015	2016	2017	2018
Management system	SA	SA	SA	SA	SA
Human performance management	SA	SA	SA	SA	SA
Operating performance	SA	SA	SA	SA	SA
Safety analysis	SA	SA	SA	SA	SA
Physical design	SA	SA	SA	SA	SA
Fitness for service	SA	SA	SA	SA	SA
Radiation protection	SA	SA	SA	SA	SA
Conventional health and safety	SA	SA	SA	SA	SA
Environmental protection	SA	SA	SA	SA	SA
Emergency management and fire protection	SA	SA	SA	SA	SA
Waste management	SA	SA	SA	SA	SA
Security	SA	SA	SA	SA	SA
Safeguards and non-proliferation	SA	SA	SA	SA	SA
Packaging and transport	SA	SA	SA	SA	SA

Table E-4: Safety and control area ratings, Key Lake Operation, 2014-2018

Safety and control areas	2014	2015	2016	2017	2018
Management system	SA	SA	SA	SA	SA
Human performance management	SA	SA	SA	SA	SA
Operating performance	SA	SA	SA	SA	SA
Safety analysis	SA	SA	SA	SA	SA
Physical design	SA	SA	SA	SA	SA
Fitness for service	SA	SA	SA	SA	SA
Radiation protection	SA	SA	SA	SA	SA
Conventional health and safety	SA	SA	SA	SA	SA
Environmental protection	SA	SA	SA	SA	SA
Emergency management and fire protection	SA	SA	SA	SA	SA
Waste management	SA	SA	SA	SA	SA
Security	SA	SA	SA	SA	SA
Safeguards and non-proliferation	SA	SA	SA	SA	SA
Packaging and transport	SA	SA	SA	SA	SA

Table E-5: Safety and control area ratings, McClean Lake Operation, 2014-2018

Safety and control areas	2014	2015	2016	2017	2018
Management system	SA	SA	SA	SA	SA
Human performance management	SA	SA	SA	SA	SA
Operating performance	SA	SA	SA	SA	SA
Safety analysis	SA	SA	SA	SA	SA
Physical design	SA	SA	SA	SA	SA
Fitness for service	SA	SA	SA	SA	SA
Radiation protection	SA	SA	SA	FS	FS
Conventional health and safety	SA	SA	SA	SA	SA
Environmental protection	SA	SA	SA	SA	SA
Emergency management and fire protection	SA	SA	SA	SA	SA
Waste management	SA	SA	SA	SA	SA
Security	SA	SA	SA	SA	SA
Safeguards and non-proliferation	SA	SA	SA	SA	SA
Packaging and transport	SA	SA	SA	SA	SA

F. FINANCIAL GUARANTEES

The following table outlines the financial guarantees as of December 31, 2018 for the five uranium mine and mill facilities.

Table F-1: Uranium mines and mills – Financial guarantees

Facility	Canadian dollar amount
Cigar Lake Operation	$49,200,000
McArthur River Operation	$48,400,000
Rabbit Lake Operation	$202,700,000
Key Lake Operation	$218,300,000
McClean Lake Operation	$107,241,000
Total	$625,841,000

G. WORKER DOSE DATA

Table G-1 shows the total number of nuclear energy workers (NEWs) monitored at each of the five uranium mines and mills for 2018. An individual who is required to work with a nuclear substance or in a nuclear industry is designated as a NEW if he or she has a reasonable probability of receiving an individual effective dose greater than the prescribed effective dose limit for a member of the public (i.e., 1 millisievert (mSv) in a calendar year).

Table G-1: Number of NEWs at uranium mines and mills, 2018

	Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClean Lake
Total NEWs	824	595	166	481	330

The following table compares the average and maximum individual effective dose for all five uranium mines and mills.

Table G-2: Radiation dose data for NEWs at uranium mines and mills, 2018

Facility	Average individual effective dose (mSv/year)	Maximum individual effective dose (mSv/year)	Regulatory limit
Cigar Lake Operation	0.47	7.28	**50 mSv/year**
McArthur River Operation	0.15	2.67	
Rabbit Lake Operation	0.46	1.70	
Key Lake Operation	0.19	2.02	
McClean Lake Operation	0.90	5.50	

Tables G-3 to G-7 show a five-year trend (from 2014 to 2018) of the average and maximum effective annual doses to NEWs at the five uranium mines and mills. Each of these tables also identifies the maximum five-year dose to an individual NEW at each uranium mine and mill. No radiation dose at any facility exceeded the regulatory effective dose limit during 2018.

Table G-3: Radiation dose data for NEWs, Cigar Lake Operation, 2014–18

Dose data	2014	2015	2016	2017	2018	Regulatory limit
Total NEWs	1,458	1,222	1,243	1,107	824	**N/A**
Average individual effective dose (mSv)	0.16	0.45	0.39	0.34	0.47	**50 mSv/year**
Maximum individual effective dose (mSv)	2.04	5.99	5.53	3.36	7.28	**50 mSv/year**
Maximum dose for an individual in current 5 year period (mSv) 2016–20	13.6					**100 mSv/5 year dosimetry period**

Table G-4: Radiation dose data for NEWs, McArthur Rive Operation, 2014–18

Dose data	2014	2015	2016	2017	2018	Regulatory limit
Total NEWs	1,149	1,360	1,064	958	595	**N/A**
Average individual effective dose (mSv)	1.03	1.00	0.85	0.79	0.15	**50 mSv/year**
Maximum individual effective dose (mSv)	7.91	7.40	7.02	5.73	2.67	**50 mSv/year**
Maximum dose for an individual in current 5 year period (mSv) 2016–20	12.2					**100 mSv/5 year dosimetry period**

Table G-5: Radiation dose data for NEWs, Rabbit Lake Operation, 2014-2018

Dose data	2014	2015	2016	2017	2018	Regulatory limit
Total NEWs	964	958	739	153	166	**N/A**
Average individual effective dose (mSv)	1.35	1.36	0.85	0.4	0.46	**50 mSv/year**
Maximum individual effective dose (mSv)	8.84	9.14	4.95	1.56	1.7	**50 mSv/year**
Maximum dose for an individual in current 5 year period (mSv) 2016–20	6.24					**100 mSv/5 year dosimetry period**

Table G-6: Radiation dose data for NEWs, Key Lake Operation, 2014–18

Dose data	2014	2015	2016	2017	2018	Regulatory limit
Total NEWs	1,170	1,191	837	684	481	**N/A**
Average individual effective dose (mSv)	0.63	0.55	0.62	0.66	0.19	**50 mSv/years**
Maximum individual effective dose (mSv)	6.21	7.56	5.37	5.39	2.02	**50 mSv/years**
Maximum dose for an individual in current 5 year period (mSv) 2016–20	11.2					**100 mSv/5 year dosimetry period**

Table G-7: Radiation dose data for NEWs, McClean Lake Operation, 2014-2018

Dose data	2014	2015	2016	2017	2018	Regulatory limit
Total NEWs	894	508	510	334	330	**N/A**
Average individual effective dose (mSv)	0.37	0.89	1.04	0.91	0.90	**50 mSv/year**
Maximum individual effective dose (mSv)	2.03	5.28	6.94	5.12	5.50	**50 mSv/year**
Maximum dose for an individual in current 5 year period (mSv) 2016–20	14.69					**100 mSv/5 year dosimetry period**

H. EXCEEDANCES OF RADIOLOGICAL ACTION LEVELS REPORTED TO THE CNSC

Canadian Nuclear Safety Commission (CNSC) staff reviewed and were satisfied with the remedial actions taken by the licensees for the radiological action level exceedances reporting in table H-1. Table H-1 notes the details of each event, the corrective actions taken by the licensee and the CNSC's associated significance ratings. Table H-2 lists the rating definitions and examples of safety significance across fuel cycle facilities.

Table H-1: Uranium mines and mills – exceedances of radiological action levels in 2018

Facility	Action level exceedance	Corrective action	Significance rating
Cigar Lake Operation	August 8, 2018, Cameco staff reported that a June 2018 Personal Alpha Dosimeter (PAD) result exceeded 1 mSv in a week. Analysis of June and July PAD results showed that four workers exceeded a weekly action level of 1 mSv per week, with effective doses of 1.18, 1.63, 1.48, and 1.12 mSv. One of the noted four workers also exceeded the quarterly action level of 5 mSv per quarter with an effective dose of 5.17 mSv. The event occurred during a project initiated to replace the medium pressure pumps on the 500 m level of the Cigar Lake mine. While the process of wash down has been an effective control in the past, investigation determined that the dust material that was present on the piping and electrical cables in this specific area was a clay based material. While visually it seemed that the wash down of the material was effective, a portion of the material actually stuck to the piping and electrical cables when combined with the water due to the clay content. This clay based material that was left behind is the source of the exposure that resulted in the	Operating, maintenance and radiation protection personnel received awareness information in order to assist in properly identifying hazards associated with the clay type material when working on piping, cable trays or other similar infrastructure that has the potential to lead to similar circumstances as those that resulted in this event. Appropriate operating, maintenance and radiation protection processes will be reviewed and revised to ensure that when work is required where this type of hazard may exist, (e.g. pipe replacement) prior to work commencing quantitative verification that the potential dust hazard has been mitigated will be obtained. When work is required in situations where this hazard may exist and it is confirmed through quantitative verification that it cannot be mitigated through normally effective means (washing), other controls such as respiratory protection will be put in place prior to work commencing.	Medium

Facility	Action level exceedance	Corrective action	Significance rating
	action level exceedances for the four workers.	CNSC staff conducted a review of this event and associated corrective actions as part of a reactive inspection conducted in August 2019.	
Cigar Lake Operation	In January 2019, Cameco reported November Personal Alpha Dosimeter (PAD) results for a worker who exceeded 1 mSv in a week. It was also confirmed the worker exceeded the quarterly action level of 5 mSv. A review of the documented work activities indicate that the unusual exposure most likely occurred on November 14, 2018. On this date, the worker and another employee were involved in replacing the preventer flush tube on JBS No. 4. It occurred when the JBS was in stand-by mode during the mining of a cavity. This resulted in the workers not recognizing the need to close the ball valve that would be used to isolate the preventer from the preventer flush tube prior to work being commenced on the flush tube. It is likely that the combination of not closing the ball valve and the positioning of the worker at the opening of the flush tube resulted in the individual receiving the exposure. The investigation identified that the change in the timing of the work on the preventer flush tube from the normal timing (between cavities) to the timing of this event (while on standby during a cavity) resulted in the presence of a hazard not normally inherent in the completion of this work.	Procedures for conducting maintenance on the JBS during an active cavity cycle were reviewed and revised as necessary to ensure risk mitigation for potential exposure to radon progeny is addressed, where appropriate. Operations, maintenance, and radiation personnel will receive awareness on the procedures noted above in order to assist them in recognizing when additional controls are necessary to mitigate this type of risk. CNSC staff conducted a reactive inspection in August 2019, following the review of investigation reports submitted by the licensee.	Medium

Facility	Action level exceedance	Corrective action	Significance rating
McArthur River Operation	None reported	N/A	N/A
Rabbit Lake Operation	None reported	N/A	N/A
Key Lake Operation	None reported	N/A	N/A
McClean Lake Operation	None reported	N/A	N/A

Table H-2: CNSC Radiation protection rating definitions and examples

Radiation protection		
Safety significance	**Definition**	**Fuel cycle facility specific examples**
High	Exposures to multiple workers in excess of regulatory limits. Widespread contamination to several persons or to a place.	Incident that results in, or has reasonable potential for, a worker to exceed regulatory limits. Examples: ▪ nuclear energy worker (NEW) exceeding 50 millisievert (mSv)/year or 100 mSv/five years ▪ non-NEW exceeding 1 mSv
Medium	Exposure to a worker in excess of regulatory limits. An incident that would result in a licensee exceeding action level. Limited contamination that could affect a few persons or a limited area.	Incident that results in or has reasonable potential to exceed an action level. Example: ▪ doses to workers of 1 mSv/week or 5 mSv/quarter
Low	Increased dose below reportable limits. Contamination that could affect a worker.	Incident that results in, or has reasonable potential to exceed, the highest administrative level.

I. REPORTABLE RELEASES TO THE ENVIRONMENT (SPILLS), AND CNSC RATING DEFINITIONS

Canadian Nuclear Safety Commission (CNSC) staff reviewed and were satisfied with the remedial actions taken by the licensees for the spills presented in table I-1 and concluded that these spills resulted in no residual impacts to the environment. Table I-1 notes the details of each spill, the corrective actions taken by the licensee and the CNSC's spill significance ratings. Table I-2 lists the spill rating definitions and examples of safety significance across fuel cycle facilities.

Table I-1: Uranium mines and mills reportable releases to the environment, 2018

Facility	Details	Corrective actions	Significance rating
Cigar Lake Operation	On January 24, 2018 a decreasing trend in the level of treated effluent in monitoring pond "D" was observed. The instrumentation was functioning properly and it was determined that approximately 1,200 m^3 of treated effluent had been lost. Surface ice can develop in ponds during the winter period. This ice then may create tears in pond liners when the pond level rises or falls during normal operation.	Monitoring pond D was locked out and remained locked out until repairs to the liner were made on June 11, 2018.	Low
Cigar Lake Operation	On February 26, 2018 a freeze plant operator was conducting routine rounds and noticed a faint smell of ammonia. A purge valve on the condenser of Freeze Plant No.2 was observed to be weeping. Approximately 100 millilitres was released to the snow outside the plant. The probable cause of this leak is a failed o-ring within the auto purge valve assembly.	The defective valve was repaired and the plant returned to service. Affected snow was removed and placed in the freeze plant sump.	Low
Cigar Lake Operation	On April 12, 2018 a freeze plant operator was conducting routine rounds and identified that a solenoid was leaking ammonia. 9.2 kilograms of ammonia were released. A purge point on solenoid #4 at condenser #2 of Freeze Plant No. 1 was determined to be the source of the leak. It was determined that the probable cause of this leak is a worn teflon seal in the solenoid valve.	The valve was taken out of service until maintenance was completed.	Low

Facility	Details	Corrective actions	Significance rating
Cigar Lake Operation	On June 22, 2018, primary freeze plant No.2 was being restarted following a power outage when ammonia was identified to be leaking from a flanged connection to a knife gate valve located above the heat exchanger. Approximately less than 40 kilograms of ammonia was released to the atmosphere. Probable cause of the leak is a gasket failure.	A refrigeration mechanic made repairs to the valve.	Low
Cigar Lake Operation	On September 9, 2018 primary freeze plant No.2 was being restarted following a power outage. A knife gate valve used to isolate heat exchangers in the plant was identified to be leaking. 0.1 kilograms of ammonia was released. The seal on the knife gate valve operates under negative pressure when the plant is running normally. This seal may have been worn prior to this event, but the negative pressure conditions kept all ammonia inside the system. When the plant restarted, the momentary increase in pressure allowed ammonia to leak past the seal. Approximately 4 ounces of ammonia was released to the atmosphere.	The leak was stopped and maintenance work to repair the system was completed.	Low
McArthur River Operation	On August 6, 2018 an inspection of treated effluent monitoring ponds 3 and 4 revealed that temporary repairs completed in May 2018 had failed and it was estimated that approximately 8,000 m^3 of treated water had been discharged from these ponds. There was no effect on the environment or the health and safety of personnel.	The ponds were repaired. The procedure for pond liner repairs was reviewed with all personnel performing the work, and an internal investigation completed.	Low

Facility	Details	Corrective actions	Significance rating
McArthur River Operation	On August 25, 2018, a mechanic entered module 1 of the freeze plant and noticed a slight smell of ammonia. The mechanic identified that a small amount of ammonia had been released from a cracked vessel sight glass. The exact amount of ammonia released is unknown, but none of the ammonia detectors in the plant displayed elevated concentrations of ammonia during this event. There was no effect on the environment or the health and safety of personnel.	Refrigeration mechanic isolated, purged, then repaired the vessel.	Low
Rabbit Lake Operation	At approximately 1600 hours on July 22, 2018, a discharge of liquid propane was reported when two Safety Department employees were inspecting an area near the 68,100 L propane tank that feeds the sand dryer and dry shotcrete plant at the Eagle Point mine. The employees noticed frost buildup on a valve on the liquid side of the line feeding the tank for the offload point. The employees assessed the situation and approached the valve from a safe direction. Upon reaching the valve, the employees noted an audible hiss and a small amount of liquid propane visibly leaking from the tank.	After confirming the presence of the leak, the employees immediately triggered emergency shutoff valves on all lines connected to the tank and retreated to a safe distance to allow residual propane to dissipate. With the tank isolated immediately and no occupied building within 100 m of the tank, this was not considered an emergency situation. Once the area was confirmed clear, the Rabbit Lake Environment department arrived and completed a visual site inspection. The tank has been repaired.	Low
Rabbit Lake Operation	On November 18, 2018, a Rabbit Lake Lab Technician noted the smell of propane near the Environment and Health (E&H) Lab. The Electrical Foreman, Plumber/Gasfitter and Safety staff arrived at the area and took gas readings outside the E&H Lab. The nearby occupied building (E&H Lab, <100 m) was evacuated and Incident Command (IC) was implemented. Upon investigation it was identified that the liquid offloading line had a small leak.	A maintenance employee was able to detect the source of the smell by performing a liquid soap bubble test. The maintenance employee immediately made the necessary repairs to the offloading line by re tightening the packing, resulting in the stoppage of the leak by 0738 hours. The source of the leak was quickly identified and repaired. With no detectable readings. E&H Lab staff were allowed to return	Low

Facility	Details	Corrective actions	Significance rating
		shortly after. All remaining propane facilities offloading lines and valves were checked immediately for leaks to ensure that no other lines/valves had been impacted by the weather change. No other leaks were identified on the remaining offloading lines/valves at the Operation. There is a daily preventative maintenance (PM) in place to check all propane farms on site and the plumber/gasfitter had completed his daily PM check on November 17 with no abnormal conditions noted. The weather conditions on the morning of November 18 may have contributed to this event. Overnight temperature had dropped approximately 20ºC in 18 hours to -33ºC at the time of the incident. The packing material and the valve material have two differing coefficients of expansion. The significant drop in temperature overnight likely caused the packing material to shift, resulting in the small leak. After the packing was re-tightened, it was rechecked and all other valves on the tank were checked to confirm no other leaks remained.	

Facility	Details	Corrective actions	Significance rating
Key Lake Operation	On May 2, 2018, an intermittent leak was discovered coming from two manual valves on #2 ammonia storage tank vapour line by the Solvent Extraction Facility. No release volume could be estimated due to the intermittent nature of the leaks. However, there was no measurable change in the tank levels as a result of the leaks, which indicates that the release volume was relatively minor.	Subsequent to discovering the initial leaks, maintenance personnel completed an inspection and exercised each valve on all three ammonia storage tanks. During this process, some minor leaks were discovered on four additional valves; one valve on tank #1, one more valve on tank #2 and two valves on tank #3. These additional four valves were not leaking prior to the maintenance team exercising them. The maintenance team continued to work on these valves and were able to stop all of the leaks. CNSC staff verified the status of the ammonia tank upgrade project as part of a compliance inspection.	Low
Key Lake Operation	On June 29, 2018 during an area inspection, mill operations found a valve leaking on ammonia storage tank #1. No release volume could be estimated, however, there was no measurable change in the tank level as a result of the leak, which indicates that the release volume was relatively minor.	The area was secured using danger tape to prevent unauthorized access to the ammonia storage tank area. Requirements to use respiratory protection when in the area were implemented. The valve was sealed and gas testing was completed to confirm that the leak had stopped. CNSC staff verified the status of the ammonia tank upgrade project as part of a compliance inspection.	Low

Facility	Details	Corrective actions	Significance rating
Key Lake Operation	On July 24, 2018 during an inspection of the fire suppression system valves, it was discovered that the low pressure carbon dioxide system level had dropped significantly in the storage tank. This occurred sometime within a two week period. Approximately 170 kilograms of carbon dioxide was released.	The area was secured to prevent unauthorized access. The storage tank was drained, repaired and inspected. The area was inspected by CNSC staff in follow-up to the event and the corrective actions were considered to be satisfactory.	Low
Key Lake Operation	November 22, 2018, a propane leak was detected was coming from a 2 inch plug near the 2 inch Fisher valve at the Reverse Osmosis Propane Tank. The release volume was very small and therefore cannot be estimated; however, the leak duration was in excess of 10 minutes.	A plumber and safety officer inspected and tightened the plug which stopped the leak. This was confirmed with gas monitoring. The event was reviewed at the site wide safety meeting and a site safety flash was issued on the importance to reporting if workers encounter a smell of propane. All propane systems have a daily walk-down inspection completed. The tank and valving were inspected during a CNSC inspection in follow-up to the event and the corrective actions were considered to be satisfactory.	Low
Key Lake Operation	In December 2018 Cameco reported an increase in uranium concentrations in groundwater well MT-802, after a review of the groundwater data. The elevated concentrations date back to June 2018. Follow up samples were collected from this well and others in the area. The samples confirmed the increasing trend in uranium concentration in MT-802. The investigation indicates the likely	An Initial Event Report (IER) was discussed at a Commission meeting on May 15, 2019. Cameco's actions completed to date include the following: ▪ report the spill ▪ investigate the source ▪ remove the source (water drained within the building sump areas)	Low

Facility	Details	Corrective actions	Significance rating
	source was sump #2 in the molybdenum extraction building.	▪ ensure that radiation protection measures were implemented within the building ▪ increase groundwater monitoring of the well and surrounding wells to confirm that the area of elevated uranium remains isolated ▪ develop an investigation plan The investigation into the elevated uranium in a monitoring well is being undertaken. Cameco has been providing updates on the status of the investigation to CNSC staff, the province of Saskatchewan and local stakeholders/Indigenous groups. In addition, a complete assessment report will be developed and submitted in early 2020. The assessment is being completed in accordance with both federal and provincial requirements. The installation of monitoring wells and soil sampling was completed in the summer of 2019 and water quality and soil samples are being analysed. Although the investigation is not complete, the results to date continue to indicate that the elevated uranium is limited to the immediate area and there remains no risk to the surrounding environment. Once the assessment report is complete this will be used to develop a corrective action plan.	

Facility	Details	Corrective actions	Significance rating
McClean Lake Operation	On June 23, 2018, a 150 kg discharge of molten sulphur from truck occurred at the sulphur unloading location due to a mechanical failure of the rear trailer valve.	In response, the offloading procedure has been updated to require the offloading hose to be connected before starting the steaming process. This change will ensure containment if any issues are encountered with the truck valves.	Low
McClean Lake Operation	On July 19, 2018 while washing out the Sulphuric Acid Plant stack, the drain was blocked causing the water to build up inside the stack. When the drain line was cleared approximately 0.655 m^3 of wash water leaked onto the mill terrace in a localized area immediately outside the Sulphuric Acid Plant.	The work to wash the stack was stopped immediately. The discharge area was barricaded to prevent anyone entering the area. The liquid was collected and transported to the Tailings Neutralization Facility for disposal. The impacted soil on the surface of the mill terrace was removed. Approximately 6 m^3 of affected soil was collected for disposal landfill. The ground was sampled after removal of affected soil to ensure complete clean up.	Low
McClean Lake Operation	On July 26, 2018, a hydrovac truck was removing water from the north SABRE clarification pond. The operator noticed that mine water was leaking onto the ground from the rear door seal. Initial investigation revealed that the box liner in the truck had become detached and prevented the rear door from sealing properly. Approximately 2 m^3 of mine water was released	The ponded water was disposed of in the Sue pre-sedimentation ponds to be treated and the affected soil was scraped up and taken to the contaminated landfill for disposal. Soil samples were collected post clean-up. The results showed that post clean-up soil chemistry was similar to baseline soil chemistry. In the future, the hydrovac operators will perform a visual inspection of the rear door seal prior to pumping and inspect the bed liner and fasteners routinely during use.	Low

Facility	Details	Corrective actions	Significance rating
McClean Lake Operation	On August 25, 2018 during a routine pond inspection at the Sue Site Runoff Pond, water was detected under the pond liner. Approximately 25 m^3 of water was removed from under the liner. Primary source of the water was likely due to the 1 in 500 year 24 hour storm event that occurred over July 14-15, 2018. Furthermore, the water level within the pond exceeded the 1 m freeboard level during the storm event, which would have facilitated water flowing through a failed patch. Sample results for the water had an elevated concentration of radium-226 (22.4 Bq/L), and uranium (1.42 mg/L).	The water under the liner was removed using a vacuum truck and the liner was repaired.	Low
McClean Lake Operation	On September 29, 2018 the calciner scrubber had scale build up that dislodged and plugged the cone of the scrubber body. The scrubber solution backed up through the scrubber body and up to the fan which released material onto the mill terrace, adjacent buildings, and equipment for approximately four minutes before it shut down. A small amount of additional material was released when the fan restarted two hours later. The material that exited the calciner stack was sampled and determined to be majority (>90%) ammonia sulphate crystal mixed with a small amount of calcined yellowcake. A release of 50 grams of calcined yellowcake meets the recordable radiological release criteria for reporting a radiological release. Although the total quantity released is difficult to estimate, it was determined to be >50 grams.	When the fan shut down, the feed to the calciner was also shut down and the blockage in the scrubber was cleared prior to restarting. The area where the material was deposited was barricaded. Clean-up occurred of all affected snow, buildings, and equipment and all contaminated material was disposed on the JEB Ore Pad.	Low

Facility	Details	Corrective actions	Significance rating
McClean Lake Operation	On December 22, 2018 an Orano employee discovered an anhydrous ammonia drip coming from an offload valve that was not fully closed. It is estimated that approximately 60 litres was released.	The employee contacted the area operator; they donned full face respirators, and obtained personal ammonia monitors, and barricaded the immediate area. The area operator closed the offload valve immediately after discovering the leak. The free product was then scraped up with a loader and disposed of in the hydrocarbon landfarm.	Low

Table I-2: CNSC environmental protection spill rating definitions and examples

Environmental protection		
Safety significance	**Definition**	**Fuel cycle facility-specific examples**
High	Nuclear or hazardous substances being released to the environment exceeding regulatory limits (including public exposure) or that results in significant impact to the environment.	Incident that results in, or has reasonable potential to have, a significant or moderate impact or extensive future remediation. Examples: ▪ impairment of ecosystem functions ▪ effluent licence limit exceedance ▪ spill into fish bearing water ▪ fish kill
Medium	Nuclear or hazardous substances being released to the environment exceeding action levels (including public exposure) or that result in impact to the environment outside the licensing basis.	Incident that results in, or has reasonable potential to have, a minor impact or that requires some future remediation. Examples: ▪ effluent action level exceedance ▪ spills to environment (including atmosphere) with short-term or seasonal impacts
Low	Release of hazardous or nuclear substances to the environment below regulatory limits.	Incident that results in, or has reasonable potential to have, a negligible impact. Examples: ▪ effluent administrative level-exceedance ▪ spills to environment (including atmosphere) with no future impacts

J. ENVIRONMENTAL ACTION LEVEL AND REGULATORY LIMIT EXCEEDANCES REPORTED TO THE CNSC

Canadian Nuclear Safety Commission (CNSC) staff reviewed and were satisfied with the corrective actions taken by the licensees for the environmental action level and regulatory exceedances reporting in table J-1. Table J-1 notes the details of each event, the corrective actions taken by licensees and the CNSC's associated significance ratings. Table J-2 lists the rating definitions and examples of safety significance across fuel cycle facilities.

Table J-1: Uranium mines and mills – environmental action level exceedances, 2018

Facility	Action level or regulatory limit exceedance	Corrective action	Significance rating
Cigar Lake Operation	None reported	N/A	N/A
McArthur River Operation	On March 9, 2018 Cameco reported three administrative level exceedances for radium (0.30 Bq/l). On March 10, 2018 Cameco notified CNSC staff of an action level (average concentration of a constituent in 10 ponds exceeds an administrative level) exceedance for radium. These exceedances were identified during a routine duplicate sample analysis. The duplicate sample analyzed by the Saskatchewan Research Council indicated radium concentrations higher than the duplicate sample analyzed by the McArthur River Operation sample. The transition of the McArthur River facility from operation to care and maintenance resulted in uranium ore production stopping at the McArthur River Operation. This caused a change in the chemistry of influent and the amount of reagent necessary to bring the	McArthur River Operation relied on Key Lake laboratory results for pond release until McArthur River analysis issue for radium was resolved. McArthur River increased frequency of sampling in receiving waters and concluded no increase in radium concentrations was evident. McArthur River carried out statistical analysis to determine radium level in situations where an archived sample was not available. All raw data and derived concentrations were submitted to the CNSC for review. Cameco adjusted the analytical methodology at the McArthur River lab to include a pre-treatment of the samples to remove any potential for the suppression of radium-226 during the analysis. Cameco has resolved the issue and no impact on the environment or health and safety of persons resulted from this action level exceedance.	Medium

Facility	Action level or regulatory limit exceedance	Corrective action	Significance rating
	water to concentrations necessary for release. The change in the volume of reagent used to account for the change in influent chemistry resulted in excess reagent remaining in the effluent which suppressed the analysis result of radium. Since the exceedance, Cameco has adjusted their treatment methodology and radium concentrations in effluent have been restored to historical levels. The Authorized Limit (0.37 Bq/L) under the *Metal Diamond Mining Effluent Regulations* was not exceeded as a result of this incident.		
Rabbit Lake Operation	None reported	N/A	N/A
Key Lake Operation	None reported	N/A	N/A
McClean Lake Operation	On May 11, 2018, Orano reported that a grab sample of effluent collected at the final discharge point at 0700 hours on March 6, 2018 exceeded the regulatory limit for TSS. This sample is a routine grab sample collected quarterly. The sample was submitted to an off-site laboratory for analysis. The results of the sample analysis indicated a TSS of 268 mg/L. As per MDMER [5], the McClean Lake Licence Conditions Handbook (Section 9.2), and the Saskatchewan Ministry of Environment Approval to Operate PO17-186, the Maximum Authorized	On March 12, 2018 when the unpreserved portion of the sample was analyzed, the laboratory noted that the sample bottle had a large amount of visible white particulate settled on the bottom which became suspended when shaken. A review of the grab sample analysis indicated that the concentration of calcium was the highest that has been measured in a grab sample from this final discharge point since effluent was first released in 1996, and the concentration of sulphate was also higher than most previous grab samples. With the time lag between the collection of the grab sample and its analysis, combined with	High – changed to Low CNSC staff determined that the reported event did not constitute a release of effluent because the sample was not representative of the actual release to the environment therefore there was no exceedance

Facility	Action level or regulatory limit exceedance	Corrective action	Significance rating
	Concentration of TSS in a Grab Sample is 30 mg/L.	significant temperature changes during transportation and storage, it is very likely that the solubility of the gypsum was reduced in the sample bottle and caused it to precipitate out of solution. In order to ensure that future sample analyses are representative of effluent deposited, the analyzing laboratory has agreed to treat TSS analysis of effluent as time critical. CNSC staff are satisfied with the corrective actions implemented. CNSC staff determined that the reported event did not constitute a release of effluent because the sample was not representative of the actual release to the environment therefore there was no exceedance of the action level or regulatory limit.	of the action level or regulatory limit.
McClean Lake Operation	On March 3, 2018, Orano reported that the 24-hour discharge sample from the JEB WTP had a concentration of 15 mg/L TSS. The action level as per the Environmental Code of Practice (ECOP) is 12 mg/L.	When the valves are turned to switch between ponds being discharged, scale and rust are dislodged which enters the sample line. The solution was to remove the sample line while ponds are being switched over.	Medium

Table J-2: CNSC Environmental Protection rating definitions and examples

Environmental protection		
Safety significance	**Definition**	**Fuel cycle facility-specific examples**
High	Nuclear or hazardous substances being released to the environment exceeding regulatory limits (including public exposure) or that results in significant impact to the environment.	Incident that results in, or has reasonable potential to have, a significant or moderate impact or extensive future remediation. Examples: ▪ impairment of ecosystem functions ▪ effluent licence limit exceedance ▪ spill into fish bearing water ▪ fish kill
Medium	Nuclear or hazardous substances being released to the environment exceeding action levels (including public exposure) or that result in impact to the environment outside the licensing basis.	Incident that results in, or has reasonable potential to have, a minor impact or that requires some future remediation. Examples: ▪ effluent action level exceedance ▪ spills to environment (including atmosphere) with short-term or seasonal impacts
Low	Release of hazardous or nuclear substances to the environment below regulatory limits.	Incident that results in, or has reasonable potential to have, a negligible impact. Examples: ▪ effluent administrative level-exceedance ▪ spills to environment (including atmosphere) with no future impacts

K. LOST-TIME INJURIES

A lost-time injury (LTI) is a workplace injury that results in the worker being unable to return to work for a period of time. Table K-1 outlines the LTI's reported in the 2018 reporting period at the five uranium mines and mills. Table K-2 lists the rating definitions.

Table K-1: Uranium mines and mills – Lost-time injuries (LTIs), 2018

Facility	Incident	Corrective action	Significance rating
Cigar Lake Operation	No LTIs were reported	N/A	N/A
McArthur River Operation	No LTIs were reported	N/A	N/A
Rabbit Lake Operation	No LTIs were reported	N/A	N/A
Key Lake Operation	No LTIs were reported	N/A	N/A
McClean Lake Operation	An incident occurred on January 26, 2018 where a worker slipped and fell on icy ground (same elevation). A worker parked a light duty vehicle. As the driver stepped out of vehicle, he lost his footing on the snow-packed icy surface and fell to the ground. While trying to break his fall, the driver extended his arm. He injured his left wrist, shoulder and lower back. The worker was wearing all required PPE footwear. The area had large amounts of ice build-up.	Immediate corrective actions included removal of snow build-up and sanding of the area. The McClean Lake Operation has sand readily available at all exits for employees to use. In addition, high traffic areas around the site are sanded on a regular basis.	Medium

Table K-2: CNSC Conventional health and safety rating definitions

Safety significance	Definition
High	Fatality or serious injury
Medium	Serious injury or lost-time accident
Low	Minor injury

L. ANNUAL RELEASES OF RADIONUCLIDES TO THE ENVIRONMENT

Introduction

Uranium mines and mills in northern Saskatchewan have process waters, which require capture, treatment and release through a final point of control. This appendix represents the total annual release of relevant radionuclides from these facilities from 2014 through 2018.

This appendix includes details on releases of radionuclides of interest, those belonging to the natural uranium decay series, specifically total uranium and the progeny of uranium-238. Total uranium as a metal is the contaminant of interest rather than specific uranium isotopes as uranium is more chemically toxic than radiologically toxic. The primary uranium-238 progeny of interest are alpha emitters with half-lives (> 10 days) long enough for them to participate in environmental and biological uptake processes of relevance to low dose chronic exposures. This includes the following radionuclides: thorium-230, radium-226, lead-210 and polonium-210. Uranium-234 with a half-life of 24,600 years is accounted for within the total uranium category.

Releases for total uranium are reported as kilograms (kg) while releases of uranium U-238 progeny are reported in megabecquerels (MBq).

Table L.1: Total annual load of uranium (kg) and relevant uranium-238 progeny (MBq) released in liquid effluent to surface waters from the northern Saskatchewan uranium mines and mills from 2014 to 2018.

Facility and Year	Uranium (kg)	Thorium-230 (MBq)	Radium-226 (MBq)	Lead-210 (MBq)	Polonium-210 (MBq)
Cigar Lake Mine					
2014	6.63	2.00	2.74	8.47	7.57
2015	38.00	3.73	3.13	8.00	10.70
2016	2.36	3.81	2.71	8.69	6.41
2017	0.72	3.27	3.05	9.27	4.86
2018	0.18	3.61	2.33	7.21	9.01
McArthur River Mine – Mine Water Treatment Plant Discharge					
2014	22.8	22.7	87.4	51.0	92.7
2015	21.2	23.6	152.9	55.9	184.4
2016	12.7	26.7	151.6	51.6	100.5
2017	12.9	24.5	161.5	49.0	96.4
2018	15.7	23.7	150.9	47.3	22.2
McArthur River Mine – Shaft #3 Discharge					
2014	0.2788	N/A	34.53	N/A	N/A
2015	0.0991	N/A	14.26	N/A	N/A
2016	0.0762	N/A	10.80	N/A	N/A
2017	0.1953	2.14	20.64	4.29	1.07
2018	0.2992	1.18	37.01	2.35	0.59
Rabbit Lake Mine and Mill					
2014	199.7	96.7	41.0	96.7	96.7
2015	220.7	84.9	30.0	339.5	106.1
2016	326.9	89.9	32.9	359.6	89.9
2017	274.0	117.0	25.6	311.9	78.0
2018	135.8	84.4	26.4	337.5	84.4
Key Lake Mill – Treated Mill Effluent Discharge					
2014	6.0	48.2	53.0	90.7	82.2
2015	7.5	65.8	64.4	75.2	16.4
2016	4.8	77.0	41.7	53.9	15.4
2017	7.3	69.2	61.8	23.8	7.7
2018	17.9	31.5	95.6	27.0	7.3
Key Lake Mill – Reverse Osmosis Plant Discharge					
2014	9.39	N/A	20	N/A	N/A
2015	13.1	N/A	17	N/A	N/A
2016	15.3	N/A	23	N/A	N/A
2017	6.5	N/A	23	N/A	N/A
2018	8.5	N/A	25	N/A	N/A
McClean Lake Mill – Combined release from the JEB and Sue Water Treatment Plants					
2014	2.3	12.1	7.2	48.6	13.3
2015	5.5	16.4	10.8	54.5	26.3
2016	6.5	20.2	12.0	122.1	61.3
2017	5.7	18.8	11.7	88.5	30.8
2018	9.9	21.2	13.5	86.1	32.7

Note: <DL means that the loading was reported as less than the detection limits.

M. LINKS TO WEBSITES

Benefits from Northern Mining

Cameco Corporation

Cameco Corporation – Cigar Lake Operation

Cameco Corporation – McArthur River/Key Lake Operations

Cameco Corporation – Rabbit Lake Operation

CNSC Fact Sheet on natural background radiation

CNSC Independent Environmental Monitoring Program

Eastern Athabasca Regional Monitoring Program

Northern Saskatchewan Environmental Quality Committee

Orano Canada Inc.

REFERENCES

1. *Nuclear Safety and Control Act*, S.C. 1997, c. 9.
2. CNSC, REGDOC-3.2.1, *Public Information and Disclosure*, Ottawa, Canada, 2018.
3. CNSC, REGDOC-3.2.2, *Aboriginal Engagement, 2016.*
4. *Radiation Protection Regulations* (2000), SOR/2000-203.
5. *Metal and Diamond Mining Effluent Regulations*, SOR/2002-222, 2018.
6. *Fisheries Act, R.S.C, 1985.*
7. *Uranium Mines and Mills Regulations, SOR/2000-206.*
8. *Canadian Environmental Quality Guidelines*, Canadian Council of Ministers of the Environment, 2014.
9. CNSC, REGDOC-3.6, *Glossary of CNSC Terminology*, 2016.

ACRONYMS AND ABBREVIATIONS

ALARA	As Low As Reasonably Achievable
AREVA	AREVA Resources Canada Inc. (now Orano Canada Inc.)
BE	Below Expectations
Bq/L	Becquerels per litre
Bq/m^3	Becquerels per cubic meter
CMD	Commission Member Document
CNSC	Canadian Nuclear Safety Commission
COPC	Contaminants of Potential Concern
EARMP	Eastern Athabasca Regional Monitoring Program
ECCC	Environment and Climate Change Canada
EMS	Environmental Management System
EQC	Environmental Quality Committee
EPR	Environmental Protection Report
ERA	Environmental Risk Assessments
ENGO	Environmental Non-governmental Organizations
FS	Fully Satisfactory
HHRA	Human Health Risk Assessment
IAEA	International Atomic Energy Agency
IC	Incident Command
ICMM	International Council on Mining and Metals
ICRP	International Commission on Radiological Protection
IER	Initial Event Report
JEB	John Everett Bates
Kg	Kilograms
LCH	Licence Conditions Handbook
LLRD	Long-lived Radioactive Dust
LTI	Lost-Time Injury
mASL	Metres Above Sea Level
Mkg	Million kilograms
MBq	megabecquerels

MDMER	*Metal and Diamond Mining Effluent Regulations*
mg/L	milligram per litre
MMER	*Metal Mines Effluent Regulations*
mSv	Millisievert
NEW	Nuclear Energy Workers
NSCA	*Nuclear Safety and Control Act*
Orano	Orano Canada Inc.
p-mSv	Person-millisieverts
PAD	Personal Alpha Dosimeter
PM	Preventative Maintenance
RnP	Radon Progeny
SA	Satisfactory
SABRE	Surface Access Borehole Recovery Extraction
SCAs	Safety and Control Area
SO_2	Sulphur Dioxide
SRO	Site Runoff
TMF	Tailings Management Facility
TRIR	Total Recordable Incident Rate
TSP	Total Suspended Particulate
TSS	Total Suspended Solids
UA	Unacceptable
WTP	Water Treatment Plant

GLOSSARY

For definitions of terms used in this document, see REGDOC-3.6 *Glossary of CNSC Terminology*, which includes terms and definitions used in the *Nuclear Safety and Control Act* (NSCA) and the regulations made under it, and in CNSC regulatory documents and other publications.