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Annual Program Report

Regulatory Oversight Report for Uranium Mines, Mills, Historic and Decommissioned Sites in Canada: 2017

Public Meeting

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Submitted by:

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Rapport annuel sur les programmes

Rapport de surveillance réglementaire des mines et usines de concentration d'uranium et des sites historiques et déclassés au Canada : 2017

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Summary

This Commission Member Document (CMD) is on the *Regulatory Oversight Report for Uranium Mines, Mills, Historic and Decommissioned Sites in Canada: 2017*.

This CMD addresses the Commission's action outlined in the June 7 and 8, 2017 Record of Decision for CNSC staff to report on the progress related to the selenium management plan and selenium effluent at the McClean Lake Operation.

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

Résumé

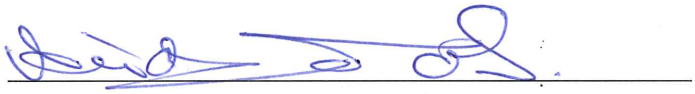
Le présent document à l'intention des commissaires (CMD) porte sur le *Rapport de surveillance réglementaire des mines et usines de concentration d'uranium et des sites historiques et déclassés au Canada : 2017*.

Le présent CMD adresse la mesure prise par la Commission décrite dans le compte rendu des décisions des 7 et 8 juin 2017 à l'intention du personnel de la CCSN de faire rapport sur les progrès relatifs au plan de gestion du sélénium et aux effluents de sélénium à l'usine de McClean Lake.

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

Signed/signé le

October 12, 2018



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EXECUTIVE SUMMARY

The *Regulatory Oversight Report for Uranium Mines, Mills, Historic and Decommissioned Sites in Canada: 2017* presents Canadian Nuclear Safety Commission (CNSC) staff's assessment of licensee performance for operating, historic and decommissioned uranium mines and mills regulated by the CNSC. This report also provides an update on staff activities related to public information, community engagement, and relevant aspects of the CNSC's Independent Environmental Monitoring Program.

CNSC staff use the safety and control area framework to evaluate the performance of each licensee. This report provides performance ratings for all 14 safety and control areas (SCAs) for operating uranium mines and mills and, where applicable, for historic and decommissioned uranium mines and mills. This report focuses on three SCAs that contain the majority of the key performance indicators for these facilities: radiation protection, environmental protection, and conventional health and safety. Information provided covers the 2017 calendar year for operating uranium mines and mills and the 2016 and 2017 calendar years for historic and decommissioned sites. Where possible, trends are shown and information is compared to previous years.

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

For the reporting year of 2016, CNSC staff rated all SCAs as "satisfactory" for all historic and decommissioned sites with the exception of the radiation protection SCA for Rayrock, Port Radium and Agnew Lake mines, which were rated "below expectations". CNSC staff determined that while these sites had specific elements of a radiation protection program (such as dosimetry, signage and limited access) the licensees' radiation protection programs were not comprehensive nor well structured.

For the reporting year of 2017, all SCAs for historic and decommissioned sites were rated "satisfactory" with the exception of the Elliot Lake historic sites which were rated "below expectations" for the environmental protection SCA. Nonetheless, CNSC staff have confirmed that safety to persons and the environment was not compromised at these sites.

CNSC staff confirmed that all operating uranium mine and mill sites in Canada operated safely during 2017, and that historic and decommissioned uranium mine and mill sites operated safely through 2016 and 2017.

CNSC staff concluded that the licensees for the regulated sites 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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1 INTRODUCTION

1.1 Background

For the purposes of the *Nuclear Safety and Control Act* (NSCA), and its associated Regulations, the Canadian Nuclear Safety Commission (CNSC) regulates Canada's operating, historic and decommissioned 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.

Each year, the CNSC produces a regulatory oversight report on the operating performance of Canada's uranium mines and mills licensees and licensed facilities. In addition, every two years, the report also provides updates on historic and decommissioned uranium mine and mill sites. This report includes data for the 2017 calendar year for operating uranium mines and mills, and data for the 2016 and 2017 calendar years for historic and decommissioned sites.

The report describes:

- the CNSC's regulatory efforts, public information and community engagement activities, and Independent Environmental Monitoring Program (IEMP);
- information on licensee operation, licence changes, major developments at licensed facilities and sites, as well as any significant events;
- the performance rating for each safety and control area (SCA) for operating, historic and decommissioned uranium mine and mill facilities regulated by the CNSC; and
- 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:

- operating facilities
  - Cigar Lake
  - McArthur River
  - Rabbit Lake
  - Key Lake
  - McClean Lake

- historic (remediating) sites
  - Gunnar
  - Lorado
  - Deloro
  - Madawaska
- decommissioned sites
  - Beaverlodge
  - Cluff Lake
  - Rayrock
  - Port Radium
  - Agnew Lake
  - Bicroft
  - Dyno
  - Elliot Lake
  - Denison and Stanrock

Throughout the review period, CNSC compliance activities, including inspections and reviews of licensee submissions and events, continued for all operating, historic and decommissioned uranium mine and mill sites.

1.2 CNSC Regulatory Efforts

1.2.1 Licensing

The CNSC regulates uranium mines, mills, historic, and decommissioned sites under separate licences. An approved licence under the NSCA contains the terms of the licence, licensed activities and licence conditions. Tables summarizing the operating, historic and decommissioned uranium mine and mill licences can be found in appendix A. Where referred to in the licence, a licence conditions handbook (LCH) accompanies each licence and contains compliance verification criteria used by CNSC staff to ensure compliance with the conditions comprising the licence. In some cases, LCHs for historic and decommissioned sites are currently being developed. Any changes made to the LCHs during this review period are provided in appendix A.

Following a public hearing held on June 7 and 8, 2017 the operating licence for McClean Lake was renewed by the Commission. This is discussed in detail in section 7. In 2017, Deloro and Rayrock licences were both renewed through a designated officer decision. This is discussed in detail in sections 11 and 15, respectively.

1.2.2 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. CNSC staff implement the compliance 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.

A breakdown of the number of CNSC staff inspections conducted at operating, historic and decommissioned uranium mine and mills is shown in tables 1.1 and 1.2. Enforcement actions from these inspections were provided to the licensees in detailed inspection reports and recorded in the CNSC regulatory information bank to ensure these actions were tracked to completion. CNSC staff verified that licensees have complied with the conditions of enforcement actions and that all actions have been closed.

Table 1.1: Compliance inspections at operating uranium mines and mills

Year	Inspections	Non-compliances
2017	30	23

Table 1.2: Compliance inspections at historic and decommissioned sites

Year	Inspections	Non-compliances
2016	18	10
2017	12	12

All non-compliances identified at operating, historic and decommissioned sites were of low safety significance. Additional details on the inspections covered in this reporting period can be found in appendix B. CNSC staff assessed and verified that licensee's corrective actions taken in response to identified non-compliances were appropriate and acceptable. All enforcement actions were addressed appropriately by licensees and have been closed by CNSC staff.

Other regulatory bodies that conduct inspections at the operating facilities include the Saskatchewan Ministry of Environment, the Saskatchewan Ministry of Labour Relations and Workplace Safety, the Ontario Ministry of Environment and Climate Change, the Ontario Ministry of Labour, and Environment and Climate Change Canada. These regulatory bodies focus primarily 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.

1.2.3 Safety and Control Area Framework

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

CNSC staff assess the licensees' performance in each applicable SCA according to the following four ratings:

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

A description of the above performance ratings are outlined in appendix D.

While this report provides CNSC staff's performance ratings for all applicable SCAs, particular focus is given to the three SCAs that cover many of the key performance indicators for these operations: radiation protection, environmental protection, and conventional health and safety.

For 2016, performance ratings for the historic and decommissioned sites were rated "satisfactory" with the exception of radiation protection at Rayrock, Port Radium, and Agnew Lake mines which were rated "below expectations". Although the SCAs were rated "below expectations" for these sites, CNSC staff determined that this was of low-risk significance due to the nature of the site activities and existing mitigation measures in place. Additional information is provided in sections 15 to 17 of this report.

For 2017, all historic and decommissioned sites were rated "satisfactory" with the exception of Elliot Lake historic sites which was rated "below expectations" in environmental protection. Additional information is provided in section 20.

For 2017, all SCA performance ratings for operating uranium mines and mills were rated "satisfactory", with the exception of radiation protection at McClean Lake which was rated "fully satisfactory". Additional information related to radiation protection at the McClean Lake Operation is provided in section 7.2.

Results from regulatory oversight activities conducted by CNSC staff concluded that uranium mine and mill facilities met the following requirements:

- radiation protection measures were effective and radiation doses received by workers remained as low as reasonably achievable (ALARA):
  - no worker exceeded regulatory effective dose limits; and
  - no action level exceedances were reported.

- environmental protection programs were effective and resulted in emissions and effluents remaining ALARA. Emissions and effluent management across all uranium mines and mills resulted in:
  - one exceedance of the *Metal Mining Effluent Regulation* (MMER) discharge limits; and
  - no exceedances of provincial limits.
- conventional health and safety programs continued to protect workers:
  - one lost-time injury (LTI) reported.

Appendix E contains the SCA performance ratings from 2013 to 2017 for the operating uranium mines and mills and 2015 to 2017 for historic and decommissioned sites.

1.2.4 Independent Environmental Monitoring Program

Under the NSCA, 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 releases to the environment related to the facility's nuclear activities. The results of these monitoring programs are submitted to the CNSC to ensure compliance with applicable guidelines and limits, as set out in regulations that oversee Canada's nuclear industry.

The CNSC implemented an Independent Environmental Monitoring Program (IEMP) to independently 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 the licensee to provide samples. CNSC staff or independent contractors obtain samples from publicly accessible areas around the facilities, measuring and analyzing the amount of radiological and hazardous substances in these samples.

As part of the CNSC's IEMP, samples were collected in three publicly accessible areas around the Cluff Lake site in 2017 and around the Deloro mine site in 2016. The IEMP results indicate that the public and the environment around the Cluff Lake site and the Deloro site are protected and there are no health impacts as a result of site operations. These results are consistent with results submitted by the respective licensees demonstrating that the licensee's environmental protection program protects the health and safety of people and the environment. Results from IEMP sampling campaigns are available on the CNSC's IEMP Web page.

1.3 Public Information and Community Engagement

The CNSC is committed to keeping the public informed of regulatory activities occurring at operating mine and mill facilities in accordance with the CNSC mandate to disseminate scientific, technical and regulatory information concerning activities of the CNSC and the effects on the environment.

Ongoing CNSC public engagement efforts include meetings, updating website information and maintaining a social media presence. During public engagement activities, the CNSC often staffs a booth to provide important information on its regulatory role and mandate, as well as to answer any questions community members may have.

To ensure licensees provide open and transparent information to the public, in 2013 the CNSC published new regulatory requirements in RD/GD-99.3, *Public Information and Disclosure*, which were incorporated into the LCH for each licence. According to RD/GD-99.3, licensees are required to implement and maintain public information and disclosure programs. These programs are supported by disclosure protocols which outline the type of information to be shared with the public on the operation or site and its activities (e.g., incidents, major changes to operations, periodic environmental performance reports) and how that information will be shared. This ensures timely information about the health and safety of persons, the environment and other issues associated with the lifecycle of nuclear facilities is effectively communicated. CNSC staff confirmed through regulatory oversight activities that licensees' implement public information and disclosure programs in compliance with RD/GD-99.3.

In 2017, licensees and CNSC staff continued regular communication with interested communities. As part of the public information program and outreach activities, licensees and CNSC staff 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, many of which are Indigenous. The EQC, established in 1995, enables northerners to learn more about uranium mining activities and to see first-hand the environmental protection measures being employed. Regularly scheduled meetings of the Northern Saskatchewan EQC resumed in 2017; CNSC staff participate in EQC meetings when requested. Further information can be found on the EQC Web page.

Indigenous and public engagement

The CNSC is committed to ongoing engagement and relationship building with interested Indigenous communities. First Nation and Métis communities with interest in Canada's uranium mines and mills were provided a copy of this regulatory oversight report. Through CNSC's Participant Funding Program (PFP), financial support was made available for participation in the review of this report. Last year, participant funding was awarded to five recipients for the review of the *Regulatory Oversight Report for Uranium Mines and Mills in Canada: 2016* (Yá'thi Néné Land and Resource Office; Buffalo River Dene Nation; Birch Narrows Dene Nation; Sydon Consulting; and Saskatchewan Environmental Society). In addition, CNSC staff provided interested Indigenous communities with updates on sampling campaigns for IEMPs at uranium mine, mill, historic and decommissioned sites.

To ensure licensees engage Indigenous communities, in February 2016 the CNSC published REGDOC-3.2.2, *Aboriginal Engagement*, which 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.

Activities attended and carried out by CNSC staff in 2017 included:

- April 25, 2017 - Saskatchewan Mining Association Exhibition and Information session. The meeting was attended by approximately 300 students and community members from La Loche and surrounding areas.
- June 22, 2017 - Northern Mine Monitoring Secretariat, update to the EQC. The meeting included EQC members, and various Government of Saskatchewan representatives.
- September 25-26, 2017 - Mining for Society. A two-day event for students showcasing the mining industry. The event targeted students in the Saskatoon area and was attended by approximately 700 students.
- October 17, 2017 - Fedoruk Center "Coffee Break" information session. This was a public event where CNSC staffed a presentation booth and answered questions.
- November 6, 2017 - Ya'thi Néné Land and Resource Office - PFP funding for the 2016 regulatory oversight report and information session. The meeting included representatives from the Athabasca Dene First Nations, CNSC, Cameco and AREVA. There were approximately 40 people in attendance.
- November 7, 2017 - Communication with Pinehouse, Kineepik Métis Local Inc. to answer questions regarding contaminated waste management at Key Lake.

A licence renewal hearing was held for the McClean Lake Operation in June 2017 in La Ronge, Saskatchewan. As part of this licence renewal, focused engagement activities and actions were undertaken by CNSC staff. Per the CNSC's public notification process for Commission proceedings, CNSC staff informed the public of the Commission hearing and availability of the PFP through the CNSC's website, email subscription list, social media channels, and radio and print advertisements in local northern Saskatchewan communities. Participant funding was awarded to Birch Narrows Dene Nation and Buffalo River Dene Nation for a meeting with CNSC staff on May 25, 2017 to discuss the McClean Lake Operation licence renewal. CNSC staff remain committed to working with the many communities to better understand their interests and concerns.

The northern communities are heavily engaged in the activities associated with mine and mill operations as employees, suppliers and participants in numerous agreements. A report produced by the province of Saskatchewan, titled *Benefits from Northern Mining, 2017 Summary* provides an overview of the benefits associated with mining in northern Saskatchewan. As of December 31, 2017 the northern mines employed over 2,400 people in direct and contract jobs. The mines maintain a high northern participation rate with 48 percent of mine employees classified as northerners. Northern mines are one of the largest employers of Indigenous peoples in Canada.

1.4 Decision on Radionuclide Reporting in National Pollutant Release Inventory

In response to a public request to add radionuclides to the National Pollutant Release Inventory (NPRI) substance list, this information has been made available and is provided in appendix K: Annual Releases of Radionuclides to the Environment.

The CNSC is making this data accessible as part of their commitment to open government and their mandate to disseminate this information to the public. The original request to add radionuclides to the NPRI, the Government of Canada response, and the subsequent request from the environmental non-governmental organizations (ENGOs) are available upon request by contacting the NPRI program.

SECTION 1 – OPERATING URANIUM MINES AND MILLS

2 OVERVIEW

This section of the report focuses on the performance of the five uranium mines and mills operating in Canada in 2017. The facilities listed are located within the Athabasca Basin of northern Saskatchewan and are shown in figure 2.1:

- Cigar Lake mine
- McArthur River mine
- Rabbit Lake mine and mill
- Key Lake mill
- McClean Lake mine and mill

Figure 2.1: Location of operating uranium mines and mills in Saskatchewan

The 2017 uranium production data for these operating mine and mill facilities are shown in table 2.1. CNSC staff confirmed all facilities operated within their authorized annual production limits in 2017.

Table 2.1: Uranium mines and mills production data, 2017

Production data	Cigar Lake	McArthur River	Rabbit Lake[1]	Key Lake[2]	McClean Lake[3]
Mining – ore tonnage (Mkg/year)	36.49	91.44	0	N/A	0
Mining – average ore grade mined (%U)	18.85%	7.09%	0%	N/A	0%
Mining – U mined (Mkg U/year)	6.88	5.88	0	N/A	0
Milling – mill ore feed (Mkg/year)	N/A	N/A	0	143.26	36.35
Milling – average mill feed grade (%U)	N/A	N/A	0%	4.32%	19.30%
Milling – mill recovery (%U)	N/A	N/A	0%	99.05%	99.03%
Milling – U concentrate produced (Mkg U/year)	N/A	N/A	0	6.20	6.93
Authorized annual production (Mkg U/year)	9.25	9.6	4.25	9.6	9.23

1 Rabbit Lake is currently in state of safe care and maintenance.
2 At Key Lake, McArthur River ore is blended with stockpiled lower grade material to produce a lower grade mill feed.
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 work activities are covered financially and work is guaranteed for completion with no liability to the Government. Financial guarantee values for the operating 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 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 licensing information. CNSC staff verified compliance with regulatory requirements through inspections, review and assessment of reports, and licensee programs, which are supplemented with meetings, presentations and facility visits.

In 2017, CNSC staff performed six inspections at each uranium mine and mill operation for a total of 30 onsite inspections (outlined in appendix B). These inspections resulted in the identification of 23 non-compliances, all of low safety significance. CNSC staff assessed and verified that licensees' corrective actions taken in response to non-compliances were appropriate and acceptable. All corrective actions implemented by licensees were verified by CNSC staff and are considered closed.

2.2 Performance

Safety and control area (SCA) performance ratings for operations were developed using professional judgment and expertise. 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 operating mines and mills and to the rating methodology defined in appendix D to ensure that consistent and defendable ratings are assigned. The SCA performance ratings of the operating mine and mill facilities are presented in table 2.2. For 2017, CNSC staff concluded that performance of the operating uranium mines and mills was either "satisfactory" or "fully satisfactory". The 2017 ratings for each operating facility are shown in the following table and appendix E contains the SCA ratings for each facility from 2013 to 2017.

Table 2.2: Uranium mines and mills SCA performance ratings, 2017

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 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.

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. CNSC staff reviewed and assessed program performance and key performance indicators across radiation protection, environmental protection, and conventional health and safety management systems through regular compliance verification activities throughout 2017.

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 and maintained below regulatory limits and as low as reasonably achievable (ALARA).

For 2017, CNSC staff rated the radiation protection SCA at all five operating facilities as "satisfactory" or "fully satisfactory" based on regulatory oversight activities.

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 confirm 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 (PPE).

Radiation protection program performance

During 2017, CNSC staff conducted regulatory oversight activities in the SCA of radiation protection at all five operating facilities to verify compliance of the licensees' implementation with regulatory requirements.

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. Actions identified in the radiation protection programs include:

- "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.

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 operating uranium mines and mills have the same individual radiation dose action level of 1 millisievert (mSv) per week and 5 mSv per quarter of a given year. No radiation related action levels were reported by the operating mines and mills in 2017.

Figure 2.2 shows a CNSC inspector taking a gamma dose rate measurement at the McArthur River water treatment holding pond.

Figure 2.2: McArthur River - CNSC inspector measuring gamma dose rate

CNSC staff confirmed the radiation protection programs and practices at operating mines and mills remained effective in controlling radiological exposure to workers. No action levels were reached in 2017.

Application of ALARA

The radiation protection programs established by uranium mine and mill facilities include responsibilities and processes used to ensure exposures to workers are maintained ALARA.

Through scheduled compliance oversight activities, 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 2017.

This report includes the reporting of nuclear energy workers (NEW) annual collective dose values for each operating 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 increasing or reducing site activities; for example, the transition of the Rabbit Lake Operation from actively mining and milling ore to care and maintenance status (figure 5.3) or ramping-up production at the McClean Lake Operation (figure 7.3).

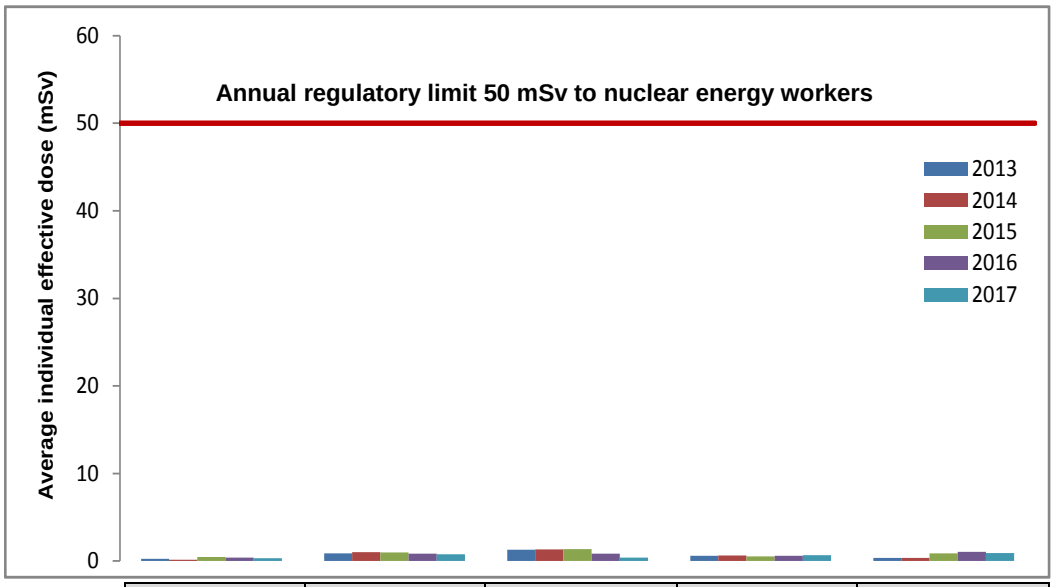
Worker dose control

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

At all operating uranium mines and mills, NEWs are issued optically stimulated luminescence dosimeters that measure external gamma radiation exposure and resulting doses. Where required, workers also wear personal alpha dosimeters (PADs) to measure alpha radiation exposure from radon progeny and radioactive dust. Optically stimulated luminescence dosimeters and PAD readings are measured by a CNSC-licensed dosimetry service provider. Where direct monitoring through dosimeters is not warranted, approved dose estimation methods (such as area/group monitoring and time cards) are used in accordance with CNSC regulatory guidance. CNSC staff confirmed all licensees met regulatory requirements for the use of licensed dosimetry.

Figures 2.3 and 2.4 show the average individual effective dose and maximum individual effective dose during the 2013 to 2017 reporting period for the five operating facilities. In 2017, 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 2.3: Uranium mines and mills comparison of average individual effective dose to nuclear energy workers, 2013–17 (mSv)

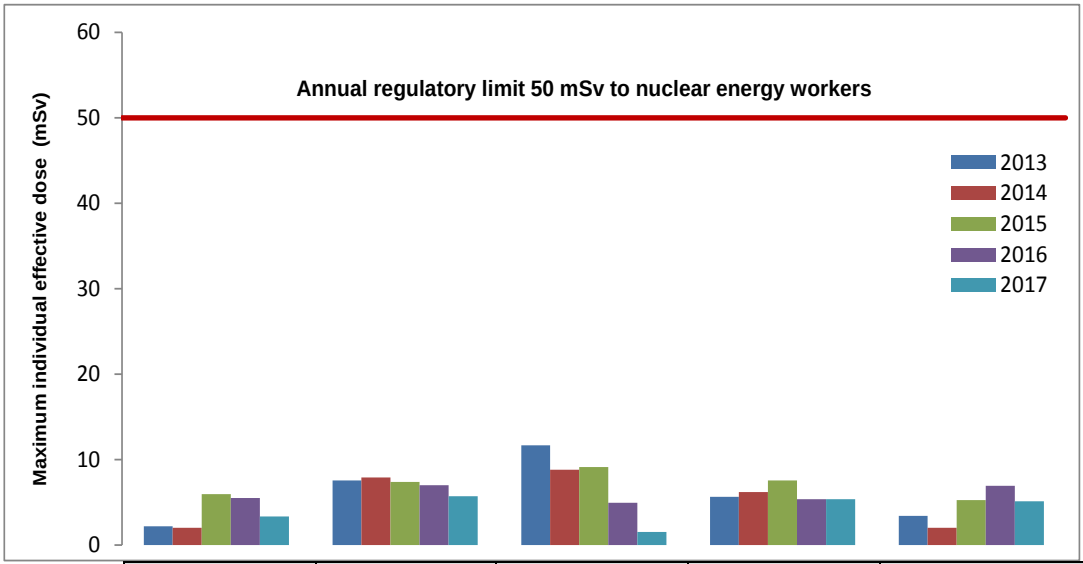


	Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClean Lake
2013	0.27	0.89	1.30	0.62	0.36
2014	0.16	1.03	1.35	0.63	0.37
2015	0.45	1.00	1.36	0.55	0.89
2016	0.39	0.85	0.85	0.62	1.04
2017	0.34	0.79	0.40	0.66	0.91

* 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 under “worker dose control”.

Figure 2.4: Uranium mines and mills comparison of maximum individual effective dose to nuclear energy workers, 2013–17 (mSv)



	Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClean Lake
2013	2.21	7.58	11.67	5.67	3.44
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

In 2017, the highest maximum individual effective dose to a uranium mine and mill worker occurred at the McArthur River facility. A dose of 5.73 mSv was assigned to an underground process worker that regularly worked in the semi-autogenous grinding mill area. This value is 11.5 percent of the annual dose limit of 50 mSv.

Appendix G displays the number of NEWs with the corresponding average individual effective dose and maximum individual effective dose for each operating facility during the 2013 to 2017 period.

Estimated dose to the public

Uranium mine and mill operations are remote from local populations. A public radiation dose limit of 1 mSv per year above natural background radiation has been set to ensure the protection of the public's health (including non-NEWs). Radiological exposures measured at the boundaries of these remote licensed facilities are near 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 2017, based on the outcome of inspections, reviews of the radiation protection programs, radiological hazard control, worker dose control and application of ALARA, CNSC staff were satisfied that uranium mine and mill licensees controlled radiation doses to persons at levels well below the regulatory limits, as well as keeping doses ALARA.

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 2017 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

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. Site-specific details are provided in sections 3.3, 4.3, 5.3, 6.3 and 7.3 of this report.

Environmental risk assessment

The CNSC uses site-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;
- surface water quality;
- groundwater quality;

- changes to the physical environment; and
- any biological effects.

Operating uranium mines and mills are required to submit updated ERAs every five years. ERAs are typically updated based on operational activities, revised predictions, historic monitoring information and the latest science. CNSC staff regularly review ERAs to determine the potential risks to human health and the environment and to verify that mitigation measures are adequate.

Assessment and monitoring

In accordance with the *Uranium Mines and Mills Regulations,* each uranium mine and mill licensee has an environmental monitoring program that monitors releases of nuclear and hazardous substances, and characterizes and monitors any effects to the environment associated with the licensed facility. Nuclear and hazardous substances associated with monitoring programs are selected based on regulated contaminants and constituents of potential concern (COPC) identified through the licensee's ERA. COPC 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 periodically review environmental monitoring programs as criteria for assessing environmental performance.

Environmental monitoring programs are associated with an environmental code of practice that sets out administrative levels and action levels for select 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 2017, there were no action level exceedances for treated effluent released to the environment.

CNSC staff have reviewed risk assessments and environmental monitoring results of uranium mine and mill facilities and concluded that the environment is protected.

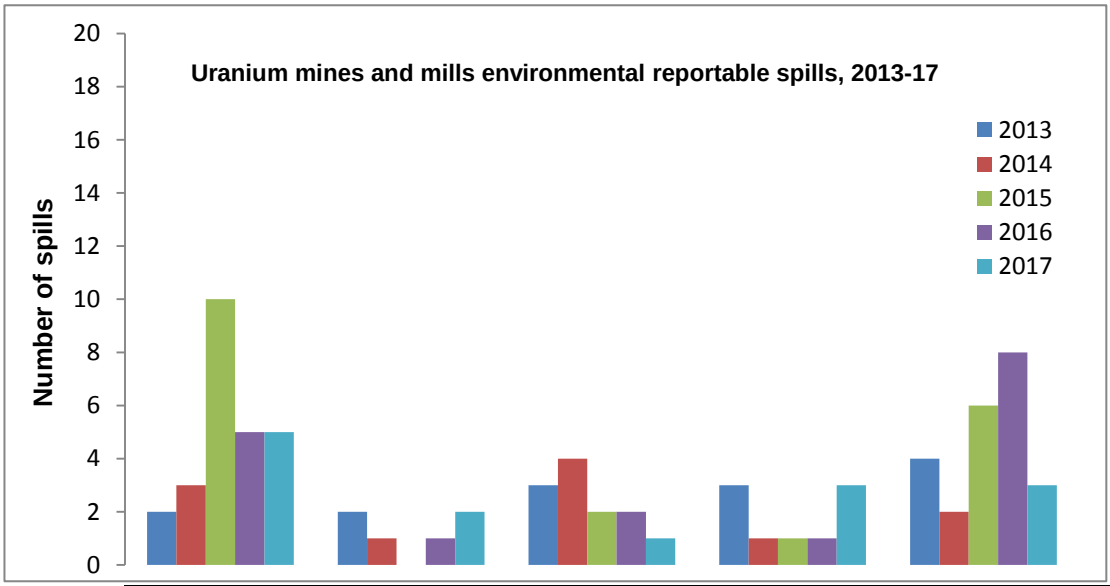
Uncontrolled releases

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 2.5 depicts the number of environmental reportable spills for uranium mine and mill facilities during the 2013 to 2017 reporting period. In each case, CNSC staff reviewed the licensee's actions to ensure effective remediation and prevention and were satisfied with actions taken by the licensee. CNSC staff rated all 2017 spills as "low significance" resulting in no residual impact to the environment.

The site-specific sections and appendix H 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 H.

Figure 2.5: Uranium mines and mills environmental reportable spills, 2013–17



	Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClean Lake
2013	2	2	3	3	4
2014	3	1	4	1	2
2015	10	0	2	1	6
2016	5	1	2	1	8
2017	5	2	1	3	3

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 operating 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 operating 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 the public in areas surrounding the operating facilities is protected.

Eastern Athabasca Regional Monitoring Program

The Eastern Athabasca Regional Monitoring Program (EARMP) is a well-recognized environmental monitoring program designed to gatherer data on long range environmental information and potential cumulative impacts downstream of uranium mining and milling operations. The program was established by the province of Saskatchewan in 2011, 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. The program involves the collection of samples 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 little evidence of long-range transport of contaminants associated with uranium mining.

Evaluation of country food data from previous years confirm operating 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 and were below values considered to be protective of health effects. 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 complete report and data are available at earmp.ca.

CNSC staff continue to support the EARMP and are working to further collaborate opportunities for this valuable program.

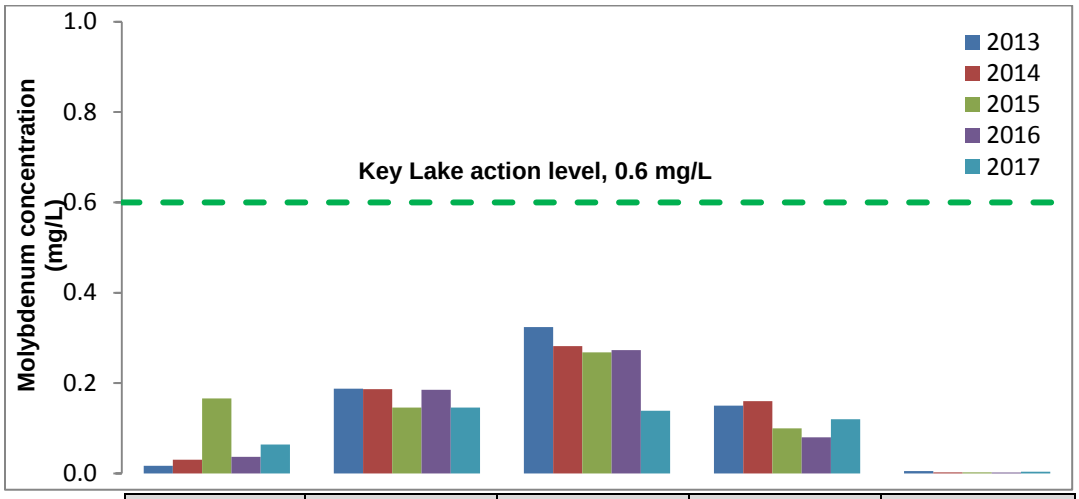
Effluent and emissions control

Treated effluent released to the environment

Licensee-developed ERAs identified releases of molybdenum, selenium and uranium as COPC with potential for adverse environmental effects across multiple operating 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 2017, the treatment technologies implemented continued to keep these contaminant concentrations stable, below regulatory limits and ALARA. Figures 2.6 to 2.8 display the 2017 average annual effluent concentrations for molybdenum, selenium and uranium at the five operating mine and mill facilities.

In the absence of federal or provincial limits for molybdenum, the CNSC required licensees to develop facility-specific effluent controls within their environmental protection program codes of practice. The 2013 to 2017 molybdenum average effluent concentrations for the five facilities were below the Key Lake code of practice action level. The Key Lake action level for molybdenum is the most stringent of the five operations and is shown for reference only.

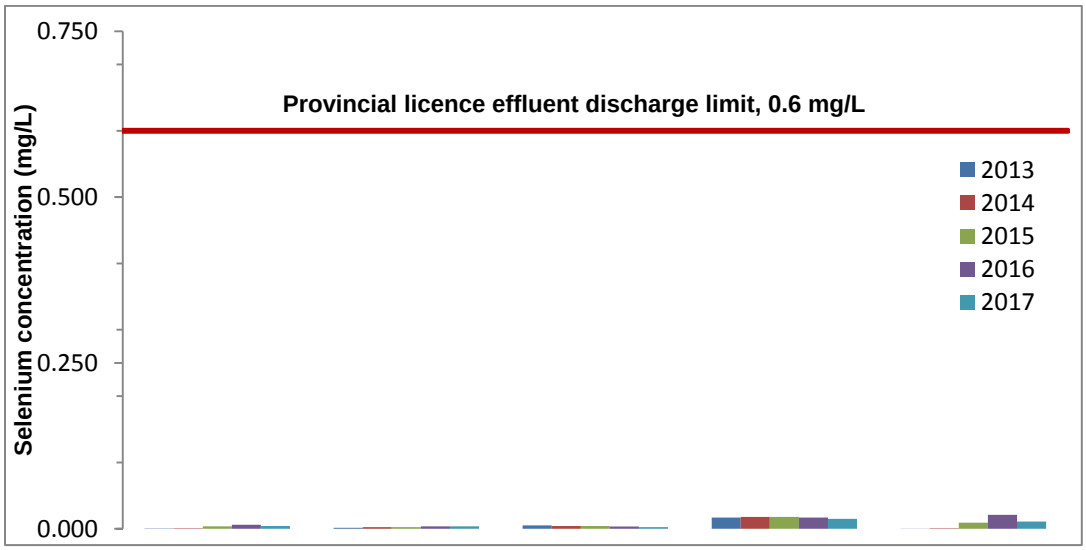
Figure 2.6: Annual average concentration of molybdenum in effluent released to the environment, 2013–17 (mg/L)



	Cigar Lake (mg/L)	McArthur River (mg/L)	Rabbit Lake (mg/L)	Key Lake (mg/L)	McClean Lake (mg/L)
2013	0.0169	0.1878	0.3240	0.1500	0.0052
2014	0.0303	0.1865	0.2820	0.1600	0.0024
2015	0.1662	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

Figures 2.7 and 2.8 demonstrate that both selenium and uranium concentrations in treated effluent released to the environment by operating mine and mill facilities in 2013 to 2017 remained below Saskatchewan's licensed effluent discharge limits of 0.6 mg/L and 2.5 mg/L for selenium and uranium, respectively. As indicated on figure 2.8, 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. 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 under development.

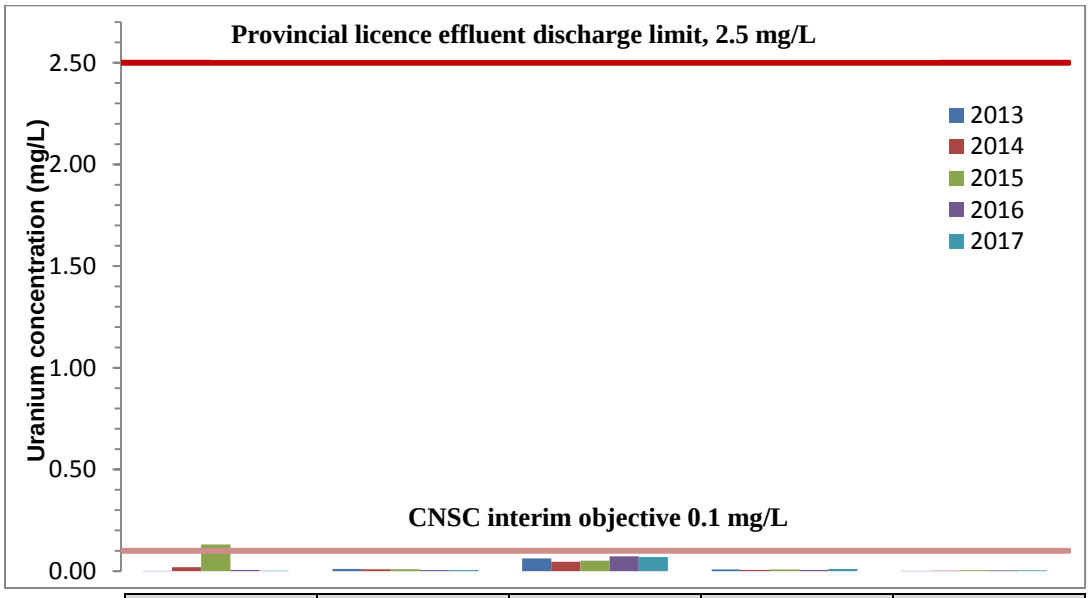
Figure 2.7: Annual average concentration of selenium in effluent released to the environment, 2013–17 (mg/L)



	Cigar Lake (mg/L)	McArthur River (mg/L)	Rabbit Lake (mg/L)	Key Lake (mg/L)	McClean Lake (mg/L)
2013	0.0005	0.0014	0.0052	0.0170	0.0004
2014	0.0009	0.0024	0.0042	0.0180	0.0007
2015	0.0038	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

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

Figure 2.8: Annual average concentration of uranium in effluent released to the environment, 2013–17 (mg/L)

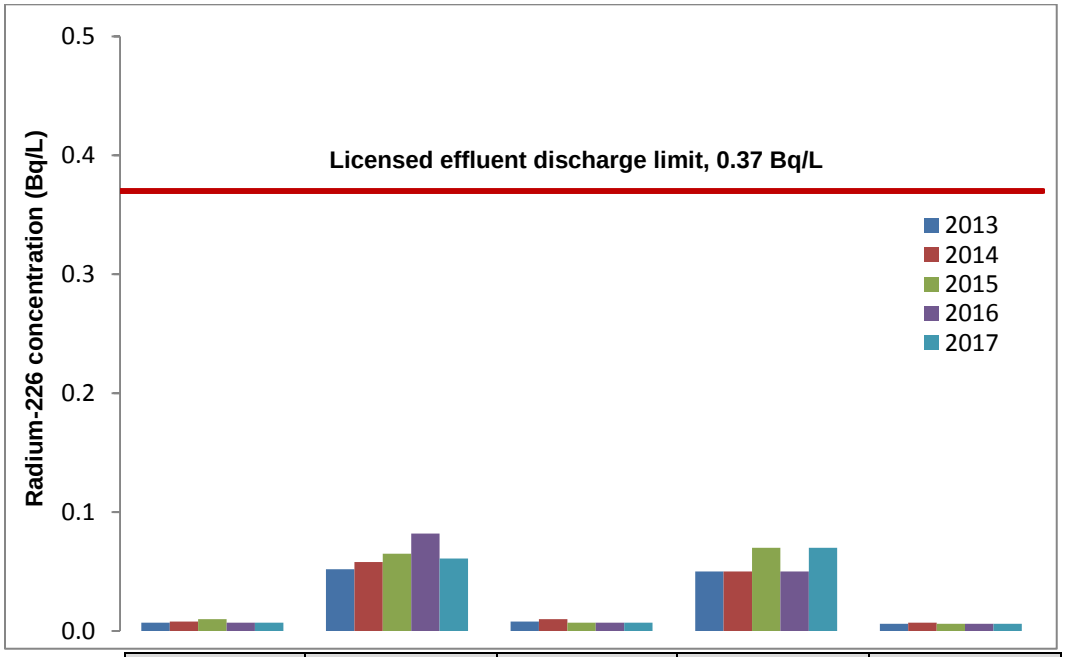


	Cigar Lake (mg/L)	McArthur River (mg/L)	Rabbit Lake (mg/L)	Key Lake (mg/L)	McClean Lake (mg/L)
2013	0.0011	0.0107	0.0630	0.0080	0.0015
2014	0.0193	0.0095	0.0460	0.0060	0.0018
2015	0.1310	0.0089	0.0520	0.0080	0.0042
2016	0.0063	0.0055	0.0730	0.0060	0.004
2017	0.0018	0.0056	0.0700	0.0110	0.004

*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 2.9. The 2013 to 2017 radium-226 annual average effluent concentrations for the five facilities were well below the CNSC's licence-authorized effluent discharge limit of 0.37 Bq/L.

Figure 2.9: Annual average concentration of radium-226 in effluent released to the environment, 2013–17 (Bq/L)



	Cigar Lake (Bq/L)	McArthur River (Bq/L)	Rabbit Lake (Bq/L)	Key Lake (Bq/L)	McClean Lake (Bq/L)
2013	0.007	0.052	0.008	0.050	0.006
2014	0.008	0.058	0.010	0.050	0.007
2015	0.010	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

* 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 2017, as well as the discharge limits described in the *Metal Mining Effluent Regulations* (MMER). All metal mines and mills in Canada are subject to MMER of the federal *Fisheries Act*. The CNSC incorporates the effluent limit requirements of MMER in uranium mine and mill licences. In 2017, 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, 2017

Parameters	MMER discharge limits	Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClean Lake
Arsenic (mg/L)	**0.5**	0.0750	0.0012	0.0010	0.0080	0.0260
Copper (mg/L)	**0.3**	0.0006	0.0010	0.0002	0.0230	0.0030
Lead (mg/L)	**0.2**	0.0001	0.0009	0.0001	0.0100	0.0020
Nickel (mg/L)	**0.5**	0.0008	0.0037	0.0017	0.1670	0.0150
Zinc (mg/L)	**0.5**	0.0259	0.0014	0.0006	0.0090	0.0030
Molybdenum (mg/L)	**N/A**	0.0640	0.1460	0.1390	0.1200	0.0040
Selenium (mg/L)	**N/A**	0.0042	0.0036	0.0024	0.0150	0.0110
TSS (mg/L)	**15**	1	1	1	3	2
pH range	**6.0–9.5**	7.3	7.4	7.3	6.5	7.2

In 2017, average treated effluent released to the environment from the licensed mining and milling activities met the effluent discharge limits stipulated in the CNSC operating licence documentation.

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

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 ALARA and below regulatory limits.

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 operating mines and mills have demonstrated satisfactory performance mitigating and monitoring the effects of their operations on the surrounding air and soil. The air and soil results around the facilities indicate slightly higher than background concentrations for some samples collected in the immediate vicinity of activities; however, the concentrations decrease to background levels within a short distance (less than 2 kilometres from the site boundary). The monitoring results indicate negligible impacts to the environment from atmospheric releases and confirm all uranium mines and mills are in compliance with their programs and provincial standards.

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 MMER of the federal *Fisheries Act*. Compliance with MMER 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.

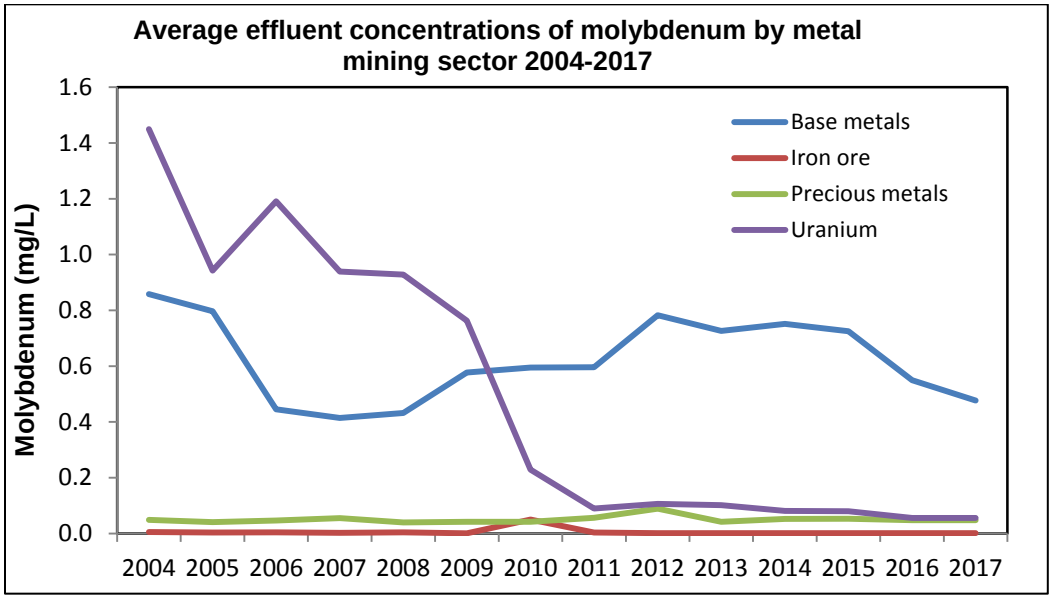
The data used for analysis and comparison are acquired from Environment and Climate Change Canada. MMER data from 2016 are used for comparison within this report since they comprise the most current sector-specific MMER information available with the exception of molybdenum, selenium and uranium, for which 2017 data are available. The mines that released treated effluent reporting under MMER 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) – 54 facilities; and
- iron – 8 facilities.

Molybdenum is a parameter requiring routine monitoring of treated effluent subject to MMER. 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 CNSC Commission members, licensees added administrative and treatment technology upgrades to their effluent management systems. The success of these actions is evident in figure 2.10, which shows molybdenum releases in the uranium mining sector have decreased substantially.

In 2017, 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 2.10: Average treated effluent concentration of molybdenum by metal mining sector, 2004–17



In mid-2012, 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 2013–17

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

Uranium concentrations have recently been added to the parameters required to be monitored and reported under the MMER. 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 0.0185 mg/L of uranium in 2017. 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 limits for uranium are 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

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

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

Metal Mining Effluent Regulations performance indicators

MMER specifies the maximum concentration limits in effluent for the following regulated parameters: arsenic, copper, lead, nickel, zinc, radium-226, TSS and an allowable pH range. Effluent must also be non-toxic, which is determined through rainbow trout acute lethality testing. The effluent treatment performance of the four metal mining sectors is compared using the following three performance indicators: compliance with the effluent concentration limits and pH; annual average effluent concentrations in the metal mining sectors; and toxicity test results. These three performance indicators are further described below.

1) Compliance with the effluent concentration limits and pH

Table 2.6 illustrates the number of mines out of compliance with MMER effluent standards for at least one regulated parameter (excluding acute-toxicity tests in 2016). These data are used to assess if compliance with the parameters of MMER is a sector-wide concern.

Two gold metal mines had effluent with radium concentrations above the MMER limit for portions of the year. The uranium mines were in full compliance with the provisions of MMER.

Table 2.6: Number of mines in non-compliance with MMER by mining sector, 2016*

Parameter	Mining sector			
	Uranium	Base metals	Precious metals	Iron
Arsenic	0	0	0	0
Copper	0	0	0	0
Lead	0	0	0	0
Nickel	0	1	0	0
Zinc	0	0	0	1
TSS	0	6	4	2
Radium-226	0	0	2	0
pH range	0	3	1	3
Mines out of compliance with at least one parameter**	0	10	6	5
Number of mines	5	47	54	8

* 2016 data is the most current sector-specific available from Environment and Climate Change Canada.
** A mine may have more than one parameter out of compliance; thus the number of mines out of compliance with at least one parameter may not equal the sum of the number of mines out of compliance by parameter.

2) Annual average effluent concentrations in the metal mining sectors

Table 2.7 compares the 2016 average effluent parameter concentrations in the metal mining sectors. CNSC staff note that the base metal and iron mine effluent concentrations for radium-226 are comparative to uranium mines.

Table 2.7: Sector comparison of average effluent parameter concentrations, 2016*

Parameter**	MMER discharge limits	Uranium	Base metals	Precious metals	Iron
Arsenic (mg/L)	**0.5**	0.022	0.005	0.022	0.003
Copper (mg/L)	**0.3**	0.003	0.009	0.014	0.006
Lead (mg/L)	**0.2**	0.0002	0.003	0.001	0.003
Nickel (mg/L)	**0.5**	0.027	0.045	0.018	0.008
Zinc (mg/L)	**0.5**	0.010	0.051	0.019	0.026
TSS (mg/L)	**15**	1.0	3.3	4.2	4.3
Radium-226 (Bq/L)	**0.37**	0.023	0.025	0.023	0.007
pH range	**6.0–9.5**	7.0	7.7	7.6	7.4

* 2016 data is the most current sector-specific available from Environment and Climate Change Canada.
** Uranium is required to be monitored and reported under the MMER. It is not regulated to a specified concentration.

3) Toxicity test results

Effluent toxicity is measured using the rainbow trout acute lethality test. As the world standard toxicity test for fresh-water, cool-climate conditions, this test has been part of Canadian regulations and guidelines for four decades. In this test, rainbow trout fingerlings or swim-up fry (0.3 g to 2.5 g wet weight) are reared under controlled conditions. They are then placed in undiluted effluent for 96 hours. If less than half of the fish survive, the effluent is deemed acutely lethal. Effluent must be non-acutely lethal to pass the test as a requirement of MMER.

Table 2.8 displays the number of pass and fail results of the rainbow trout acute lethality tests for the metal mining sectors in 2016. The uranium mining metal sector passed all required tests in 2016.

Table 2.8: Sector comparison of pass/fail results of rainbow trout acute lethality tests, 2016

	MMER limit	Uranium	Base metals	Precious metals	Iron
Rainbow trout acute lethality test	**Pass**	31	419	492	147
	Fail	0*	2	45	1

* Key Lake had one test that failed but the test was later confirmed to be invalid.

A mine is considered compliant if, throughout the year, the effluent passes all trout acute lethality tests. Table 2.9 summarizes the performance of the metal mining sectors. The uranium mine and mill facilities passed all acute lethality tests from 2012 to 2016.

Table 2.9: Percentage of mines in each metal mining sector passing all trout acute lethality tests, 2012–16

Metal mining sector	2012	2013	2014	2015	2016
Uranium	100%	100%	100%	100%	100%
Base metals	98%	93%	98%	92%	96%
Precious metals	94%	86%	96%	98%	91%
Iron	100%	100%	71%	75%	88%

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 minimize incidences of occupational injuries and illnesses.

For 2017, CNSC staff rated the conventional health and safety SCA at the 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 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 the mine and mill facilities 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 (figure 2.11). Each facility promotes the idea that safety is the responsibility of all individuals. This message is reinforced by management, supervisors and workers. 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 facilities are committed to accident prevention, safety awareness, and a focus on safety culture.

Figure 2.11: Cigar Lake – CNSC inspector observes test of emergency shower

Performance

A key performance measure for conventional health and safety is the number of lost-time injuries (LTIs) 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. Table 2.10 shows the number of LTIs at the uranium mine and mill facilities along with severity and frequency rates.

Table 2.10: Lost-time injury statistics, 2017 (including contractors)

	Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClean Lake
Lost-time injuries[1]	0	1	0	0	0
Severity rate[2]	0	12.1	0	0	67.8
Frequency rate[3]	0	0.15	0	0	0

[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] The accident severity rate measures the total number of days lost to injury for every 200,000 person-hours worked at the site. Severity = [(# of days lost in last 12 months) / (# of hours worked in last 12 months)] x 200,000.

[3] The accident frequency rate measuring the number of LTIs for every 200,000 person-hours worked at the site. Frequency = [(# of injuries in last 12 months) / (# of hours worked in last 12 months)] x 200,000.

Appendix I provides more detail on the 2017 LTI at McArthur River and corrective actions taken. The severity value for McClean Lake is due to events that took place prior to 2017 but resulted in lost time in 2017. 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 2017.

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

Table 2.11 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 do not include contractors.

Table 2.11: Safety statistics of mining sectors in Saskatchewan, 2017

Mining sector	Number of LTIs	Frequency rate (200,000 person-hours)	Severity rate (200,000 person-hours)
Potash (underground)*	9	0.2	7.3
Solution (potash)*	1	0.2	3.7
Minerals (sodium sulphate, sodium chloride)*	0	0	0
Hard rock (gold, diamond)*	6	0.4	34.8
Coal (strip mining)*	10	2.1	63.9
Uranium*	1	0.0	23.3
Uranium (including contractors)**	1	0.0	16

* Source: Saskatchewan Ministry of Labour Relations and Workplace Safety.
** Statistics for all the other mining sectors do not include contractors.

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 the licensee's performance with respect to relevant national and international benchmarks. Table 2.12 shows various international benchmarks related to workplace frequency rates. The uranium mining and milling sector in Canada exhibits similar if not more favorable performance.

Table 2.12: National/International benchmarking related to workplace safety

Publication/Standard	Frequency rate	Notes
Government of Western Australia Department of Mines, Industry Regulation and Safety[1]	2.3, 3.1	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	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	Average rate across all Canadian provinces and territories per million hours worked
US National Institute of Occupational Safety and Health[4]	1.7	Average 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, 2006-2015, The National Institute for Occupational Safety and Health (NIOSH).

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 and figure 3.2 provides an annotated map.

Figure 3.1: Cigar Lake – aerial view looking north

Figure 3.2: Cigar Lake - annotated aerial map

The Cigar Lake uranium deposit is mined by mass freezing the orebody and surrounding country rock. Hydraulic water jets then extract the ore as a slurry (mixture of rock and water), which is pumped to surface, loaded into containers and transported 70 kilometres by truck to AREVA's McClean Lake Operation for milling.

A public Commission hearing was held on April 3, 2013 in Saskatoon, Saskatchewan for the renewal of the Cigar Lake licence. The Commission issued an eight-year licence valid from July 1, 2013 to June 30, 2021.

Table 3.1 shows mining production data for 2013 through 2017. Cigar Lake mine commenced commercial production in the spring of 2014. Ore production increased during 2015 to achieve current production rate.

Table 3.1: Cigar Lake - mining production data, 2013–17

	2013	2014	2015	2016	2017
Ore tonnage (Mkg/year)	0.234	3.32	21.6	37.27	36.49
Average ore grade mined (%U)	17.09	6.02	22.92	18.27	18.85
Uranium mined (Mkg U/year)	0.04	0.2	4.95	6.81	6.88
Authorized annual production (Mkg U/year)	9.25	9.25	9.25	9.25	9.25

CNSC staff confirmed the Cigar Lake Operation production remains less than the authorized CNSC licence limit for the 2017 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 2017 focussed on additional infrastructure to sustain production plans, which include increased ground-freezing capacity and improved underground distribution of concrete.

3.1 Performance

The safety and control area (SCA) ratings at Cigar Lake for the 2013 to 2017 five-year period are shown in appendix E. For 2017, CNSC staff rated all 14 SCAs for the Cigar Lake Operation as "satisfactory".

In 2017, CNSC staff carried out compliance inspections covering the SCAs of waste management, packaging and transport, human performance management, physical design, operating performance, fitness for service, safety analysis, radiation protection, environmental protection, and conventional health and safety. There was one non-compliance resulting from CNSC inspections at the Cigar Lake Operation for the 2017 calendar year. This non-compliance was low risk in nature and related to the radiation protection SCA. Corrective actions were implemented by the licensee, reviewed and accepted by CNSC staff. A complete list of inspections can be found in appendix B.

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

3.2 Radiation Protection

For 2017, CNSC staff continued to rate the radiation protection SCA at Cigar Lake as "satisfactory" based on regulatory oversight activities.

Cigar Lake radiation protection ratings

2013	2014	2015	2016	2017
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 (34 percent), radon progeny (36 percent) and long-lived radioactive dust (LLRD) (30 percent). Gamma radiation hazards are controlled through 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

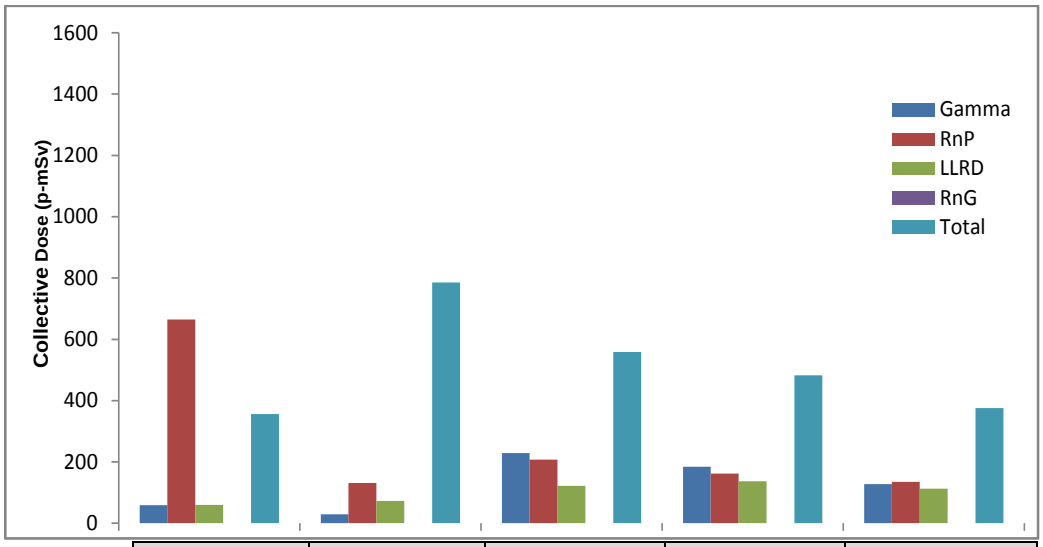
CNSC staff confirmed that the radiation protection program and practices at the Cigar Lake Operation remained effective in controlling radiological exposure to workers. There were no effective dose action levels or regulatory exceedances at the Cigar Lake Operation in 2017.

Application of ALARA

In 2017, the collective radiation exposure to NEWs at the Cigar Lake Operation was 376 person-millisieverts (p-mSv), an approximate 22.1 percent reduction from the 2016 value of 483 p-mSv (figure 3.3). This decrease is attributed to effective implementation of the Cigar Lake Operation's radiation protection program.

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. 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. Throughout 2017, Cameco focused on reducing radiation exposures to the hydraulic water jet machine operators (a higher dose workgroup at the Cigar Lake Operation). The effort resulted in a reduction in annual average operator exposure from 2.87 mSv in 2016 to 2.22 mSv in 2017. CNSC staff concluded that the radiation protection program remained effective in ensuring that worker exposures remain ALARA.

Figure 3.3: Cigar Lake - annual collective radiation exposures, 2013–17



	2013	2014	2015	2016	2017
Gamma (p-mSv)	59	29	229	184	132
RnP (p-mSv)	665	131	208	162	133
LLRD (p-mSv)	60	73	122	137	111
RnG (p-mSv)	0	0	0	0	0
Total	784	233	559	483	376

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

Worker dose control

During 2017, the average individual effective dose for NEWs was 0.34 millisieverts (mSv) and the maximum individual effective dose was 3.36 mSv. This compares to an average effective dose of 0.39 mSv and a maximum individual dose of 5.53 mSv in 2016. As indicated in figures 2.3 and 2.4, 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 compliance verification activities that included site inspections, reviews of licensee's reports, work practices, monitoring results and individual effective dose results for 2017, CNSC staff were satisfied that the Cigar Lake Operation continued to be effective in controlling radiation doses to workers.

3.3 Environmental Protection

For 2017, 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 environmental protection ratings

2013	2014	2015	2016	2017
SA	SA	SA	SA	SA

SA = satisfactory

Environmental management system

The CNSC-approved environmental management system is described in the Cigar Lake Operation environmental management program and includes activities such as establishing annual environmental objectives, goals and targets, all of which are reviewed by CNSC staff.

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. However, arsenic levels in Seru Bay of Waterbury Lake remain below the Saskatchewan *Surface Water Quality Objectives* of 5 µg/L. CNSC staff verified that Cameco is implementing measures to address the increase in arsenic in its effluent.

The Cigar Lake environmental performance report (EPR) assesses environmental performance over a five-year period. The most recent EPR for the period 2011 to 2015 was submitted to CNSC staff in 2016. CNSC staff reviewed the environmental monitoring data including water, groundwater and sediment quality as well as health indicators for fish and their preys inhabiting sediments. CNSC staff concluded that the monitoring programs and special studies were sufficiently comprehensive and provided the required information. The models used to predict environmental performance continued to be valid.

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

Assessment and monitoring

CNSC staff confirmed that the licensee, in accordance with the Cigar Lake environmental protection program, successfully carried out required effluent and environmental monitoring, site inspections, environmental awareness training and program implementation.

Through compliance activities conducted during 2017, CNSC staff concluded that environmental monitoring conducted at the Cigar Lake Operation met regulatory requirements and treated effluent discharge complied with licence requirements. There were no exceedances of the environmental code of practice action levels.

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.

Constituents of potential concern (COPC) with potential to adversely affect the environment in treated effluent at northern Saskatchewan uranium mine and mill operations are molybdenum, selenium and uranium. At the Cigar Lake Operation throughout 2017, concentrations for these constituents (shown in figures 2.6 to 2.8) remained below their respective action levels and well below provincial licence effluent discharge limits.

In addition, the Cigar Lake Operation is required to monitor concentrations of other regulatory contaminants and COPC such as radium-226, arsenic, copper, lead, nickel, zinc, total suspended solids (TSS) and pH. CNSC staff reviewed and confirmed the Cigar Lake Operation continues to meet *Metal Mining Effluent Regulations* (MMER) discharge limits (shown in section 2.4).

As noted above, 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. Throughout 2017, Cameco implemented several mitigation techniques to reduce arsenic loadings to the environment, such as altering the pH profile of the treatment system to create more favourable conditions for arsenic removal. CNSC staff are satisfied that Cameco is taking appropriate actions to lower arsenic concentrations in the effluent and will continue to follow-up throughout 2018.

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

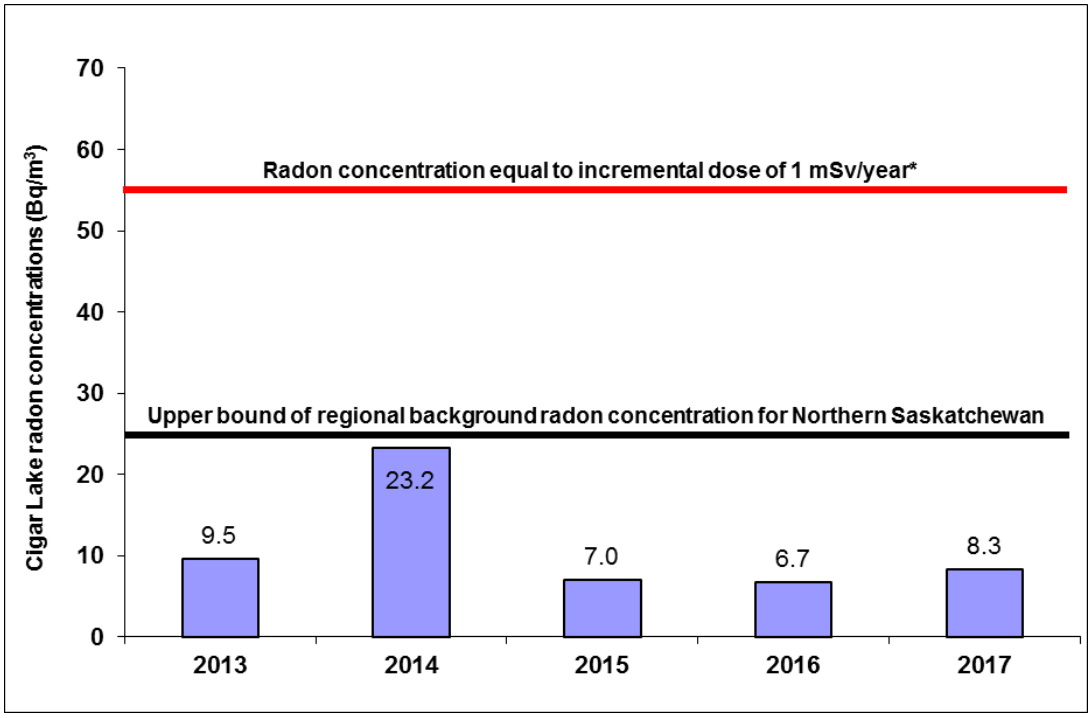
Air emissions released to the environment

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 3.4 illustrates that the average concentrations of radon in air at the Cigar Lake Operation over the period from 2013 to 2017, 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 3.4: Cigar Lake - average concentrations of radon in ambient air, 2013–17



* 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 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 (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 Council of Ministers of the Environment *Canadian Environmental Quality Guidelines* 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 - concentrations of metal and radionuclides in air, 2013–17*

Parameter	Reference annual air quality levels	2013	2014	2015	2016	2017
TSP (µg/m^3)	**60** [3]	30.2	24.7	15.8	11.4	12.9
As (µg/m^3)	**0.06** [1]	0.00025	0.00025	0.00031	0.0003	0.00039
Mo (µg/m^3)	**23** [1]	0.00021	0.0001	0.0001	0.0002	0.0002
Ni (µg/m^3)	**0.04** [1]	0.00104	0.00067	0.00062	0.00105	0.00103
Pb (µg/m^3)	**0.10** [1]	0.0007	0.0013	0.0009	0.0009	0.0008
Se (µg/m^3)	**1.9** [1]	0.00003	0.00003	0.00003	0.00003	0.00005
Pb^{210} (Bq/m^3)	**0.021** [2]	0.000268	0.00025	0.000315	0.000305	0.00036
Po^{210} (Bq/m^3)	**0.028** [2]	0.000074	0.000086	0.000095	0.000099	0.00012
Ra^{226} (Bq/m^3)	**0.013** [2]	0.000004	0.000008	0.000014	0.000020	0.000030
Th^{230} (Bq/m^3)	**0.0085** [2]	0.000011	0.00001	0.000014	0.000012	0.000023
U (µg/m^3)	**0.06** [1]	0.00007	0.00008	0.00055	0.00113	0.00151

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

2 Reference level 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 (µg/m^3). Values are calculated as geometric means.

* Reference levels based on Province of Ontario Ambient Air Quality Criteria are shown for reference only. No federal or Province of Saskatchewan limits are currently established.

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 2017, five events reported to CNSC staff were submitted as releases of hazardous substances to the environment. All five spills listed below were minor and reporting of these events met the requirements of RD/GD-99.3, *Public Information and Disclosure:*

- On February 22, 2017 approximately 4 kilograms of anhydrous ammonia was released into the atmosphere due to the failure of a modular freeze plant stem valve.
- On July 3, 2017 approximately 1 kilogram of anhydrous ammonia was released into the atmosphere due to a leak on the suction valve on compressor No. 4 of modular freeze plant No. 2.
- On July 26, 2017 approximately 4 kilograms of anhydrous ammonia was released into the atmosphere due to a fracture of the stand-by filter housing on modular freeze plant No. 1.
- On August 6, 2017 approximately 317 kilograms of anhydrous ammonia was released into the atmosphere due to a leak from the intercooler line on modular freeze plant No. 2.
- On December 6, 2017 approximately 13 kilograms of anhydrous ammonia was released into the atmosphere due to a leak from an isolation valve during a power outage.

All five 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 the 2017 releases of hazardous substance at the Cigar Lake Operation. CNSC staff were satisfied with the Cigar Lake Operation's reporting of these spills and the corrective actions taken. CNSC staff rated all 2017 spills as low significance in accordance with the definitions provided in appendix H, table H-2. Figure 2.5 in section 2 displays the number of environmental reportable spills at the Cigar Lake Operation from 2013 to 2017.

Appendix H 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 2017.

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 remain within those predicted in the 2017 ERA, and that human health remains protected.

Based on CNSC staff reviews of the programs at the Cigar Lake Operation, CNSC staff concluded that the public continues to be protected from operation emissions.

3.4 Conventional Health and Safety

For 2017, CNSC staff continued to rate the conventional health and safety SCA as "satisfactory".

Cigar Lake conventional health and safety ratings

2013	2014	2015	2016	2017
FS	SA	SA	SA	SA

FS = fully satisfactory 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 as well as the Good Catch reporting environment in which site 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 continues to be effective.

Performance

Table 3.3 summarizes lost-time injuries (LTIs) at the Cigar Lake Operation from 2013 to 2017. There were no LTIs at the Cigar Lake Operation in 2017.

Table 3.3: Cigar Lake - lost-time injury statistics, 2013–17

	2013	2014	2015	2016	2017
Lost-time injuries[1]	4	1*	4	1	0
Severity rate[2]	5.57	0.0	17.06	2.4	0
Frequency rate[3]	0.25	0.12*	0.56	0.14	0

[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] The accident severity rate measures the total number of days lost to injury for every 200,000 person-hours worked at the site. Severity = [(# of days lost in last 12 months) /(# of hours worked in last 12 months)] x 200,000.

[3] The accident frequency rate measuring the number of LTIs for every 200,000 person-hours worked at the site. Frequency = [(# of injuries in last 12 months) / (# of hours worked in last 12 months)] x 200,000.

* One event that occurred in 2014 was reclassified as a 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 Cameco has implemented several initiatives in 2017 as part of continuous improvement of its programs. Cigar Lake implemented changes to the safety program, including formation of a safety steering team and safety subcommittees, based on a formal safety assessment. CNSC staff confirmed that dangerous occurrences at the operation were investigated and corrective actions implemented.

CNSC staff compliance verification activities concluded that the Cigar Lake Operation’s health and safety program met regulatory requirements in 2017.

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 (figure 4.1).

Figure 4.1: McArthur River - 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 the 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 the McArthur River Operation production for 2017 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 - mining production data, 2013–17

Mining	2013	2014	2015	2016	2017
Ore tonnage (Mkg/year)	104.13	108.39	88.24	89.28	91.44
Average ore grade mined (%U)	7.49	7.4	8.59	7.89	7.09
Uranium mined (Mkg U/year)	7.8	8.02	7.58	7.04	6.48
Authorized annual production (Mkg U/year)	8.1	8.1	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 2013 to 2017 are shown in appendix E. For 2017, CNSC staff rated all SCAs as “satisfactory”. This report focuses on the three SCAs that cover many of the key performance indicators for these operations: radiation protection, environmental protection, and conventional health and safety.

In 2017, CNSC staff carried out compliance inspections covering the SCAs of human performance management, safety analysis, conventional health and safety, environmental protection, waste management, radiation protection, and packaging and transport.

There were six non-compliances resulting from CNSC inspections at the McArthur River Operation for the 2017 calendar year. These non-compliances were low risk in nature and related to the human performance management and radiation protection SCAs. Corrective actions were implemented by the licensee, reviewed and accepted by CNSC staff. A complete list of inspections can be found in appendix B.

4.2 Radiation Protection

For 2017, CNSC staff continued to rate the radiation protection SCA as “satisfactory” based on regulatory oversight activities.

McArthur River radiation protection ratings

2013	2014	2015	2016	2017
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 (54 percent), gamma radiation (33 percent), long-lived radioactive dust (LLRD) (13 percent) and radon gas (< 1 percent). Gamma radiation hazards are controlled through the effective use of time, distance and shielding while radon progeny, radon gas and LLRD are controlled through source control, ventilation, contamination control and personal protective equipment (PPE).

Radiation protection program performance

There were no action level exceedances at the McArthur River Operation in 2017.

Overall, the radiation protection program and practices at the McArthur River Operation remained effective in controlling radiological exposure to workers.

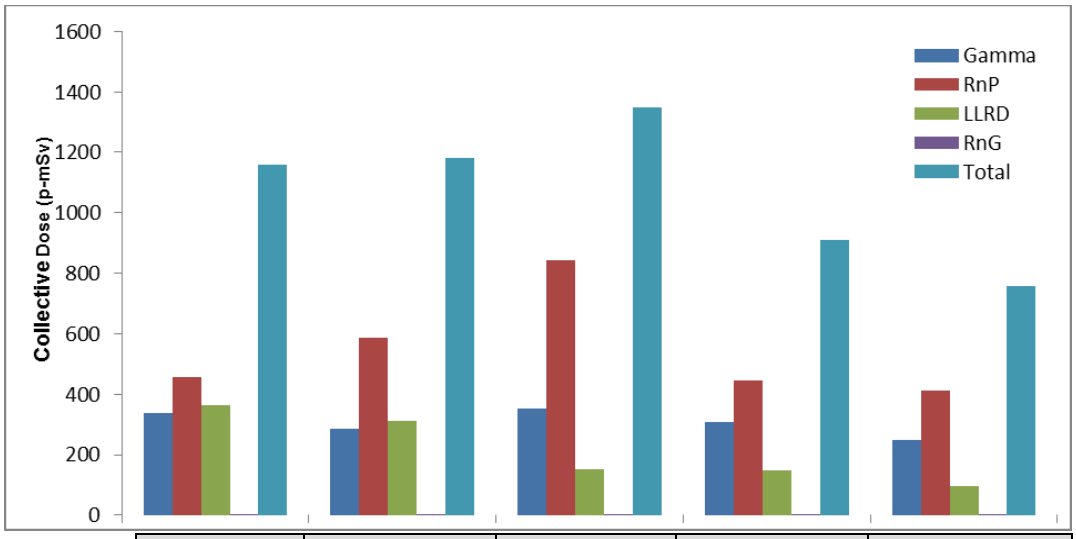
Application of ALARA

In 2017, the collective radiation exposure to NEWs at the McArthur River Operation was 760 person-millisieverts (p-mSv), an approximate 17 percent reduction from the 2016 value of 909 p-mSv (figure 4.2).

Radon progeny exposures continued to trend downward due to ventilation upgrades that were completed in 2015 and enhanced administrative controls in higher risk work areas that began in 2016.

LLRD exposures remains an ALARA focus area at the McArthur River Operation and these exposures continued to trend lower over the past five years. The decrease in LLRD exposures in 2017 is attributed to a decrease in work on contaminated equipment and the use of dose optimization methods (e.g., pre-cleaning prior to maintenance, use of dust suppression techniques).

Figure 4.2: McArthur River - annual collective radiation exposures, 2013–17



	2013	2014	2015	2016	2017
Gamma (p-mSv)	337	284	353	308	249
RnP (p-mSv)	456	586	843	447	412
LLRD (p-mSv)	365	310	150	149	96
RnG (p-mSv)	1	1	1	5	3
Total	1,159	1,181	1,347	909	760

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

Worker dose control

The average individual effective dose to NEWs was 0.79 mSv. The maximum individual effective dose of 5.73 mSv was assigned to an underground support worker. This compares to an average effective dose of 0.85 mSv and a maximum individual dose of 7.02 mSv in 2016. All individual effective doses were well below the annual regulatory limit of 50 mSv (figures 2.3 and 2.4) and 100 mSv over five years.

Based on CNSC staff compliance verification activities such as site inspections, reviews of licensees' reports, work practices, monitoring results and individual effective dose results for 2017, CNSC staff were satisfied that the radiation doses to workers continued to be effectively controlled at the McArthur River Operation.

4.3 Environmental Protection

For 2017, 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 environmental protection ratings

2013	2014	2015	2016	2017
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 review and assess the objectives, goals and targets through regular compliance verification activities.

Environmental risk assessment

The CNSC uses environmental risk assessments (ERAs) to ensure people and the environment are protected (section 2.4). The McArthur River environmental performance report (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 submissions for compliance with applicable criteria outlined in the McArthur River licence conditions handbook (LCH). CNSC staff's review confirmed the environment and human health in the vicinity of the McArthur River Operation remains protected.

CNSC staff concluded that the environmental protection SCA at the McArthur River Operation met performance objectives and all applicable regulatory requirements.

Assessment and monitoring

In accordance with Cameco's environmental protection program at McArthur River, audits were performed on effluent and environmental monitoring, site inspections, environmental awareness training and program implementation in 2017.

CNSC staff concluded that the McArthur River Operation's environmental management system and monitoring programs met regulatory requirements and the licensee complied with treated effluent discharge requirements. Figure 4.3 shows a discharge channel for treated effluent. There were no environmental action level exceedances during the 2013 to 2017 review period.

Figure 4.3: McArthur River - flow path for treated water

Following a February 29, 2012 “Letter of Advice” from the Department of Fisheries and Oceans to Cameco Corporation, the Read Creek conveyance channel was commissioned in 2014. As a result of this change, in 2017, Cameco proposed changes to the environmental monitoring program at McArthur River, including removing sampling station 2.3 (East Boomerang Lake at previous inflow from the muskeg receiving area) and replacing it with sampling station 2.3.1 (Read Creek downstream of former station 2.3). CNSC staff reviewed the request, followed-up during a compliance inspection and concluded that the location of sample station 2.3.1 was a suitable alternative site and sufficiently quantifies the effects on water quality from the muskeg area. Figure 4.4 shows the change from sample station 2.3 to 2.3.1.

Figure 4.4: McArthur River – environmental sampling stations 2.3 and 2.3.1

The following provides monitoring and assessment results for the McArthur River Operation.

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 2.6 to 2.8). Of the three COPC, 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. Reduction in concentration of molybdenum was observed in 2017 and concentrations have remained relatively stable from 2013 to 2017 as displayed in figure 2.6.

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 COPC such as radium-226, arsenic, copper, lead, nickel, zinc, total suspended solids (TSS) and pH. CNSC staff reviewed the effluent treatment concentrations and confirmed the McArthur River Operation continues to meet *Metal Mining Effluent Regulations* discharge limits (section 2.4).

The CNSC will continue to review effluent quality results to ensure that effluent treatment performance remains effective. Figure 4.5 shows a monitoring pond at the McArthur River Operation.

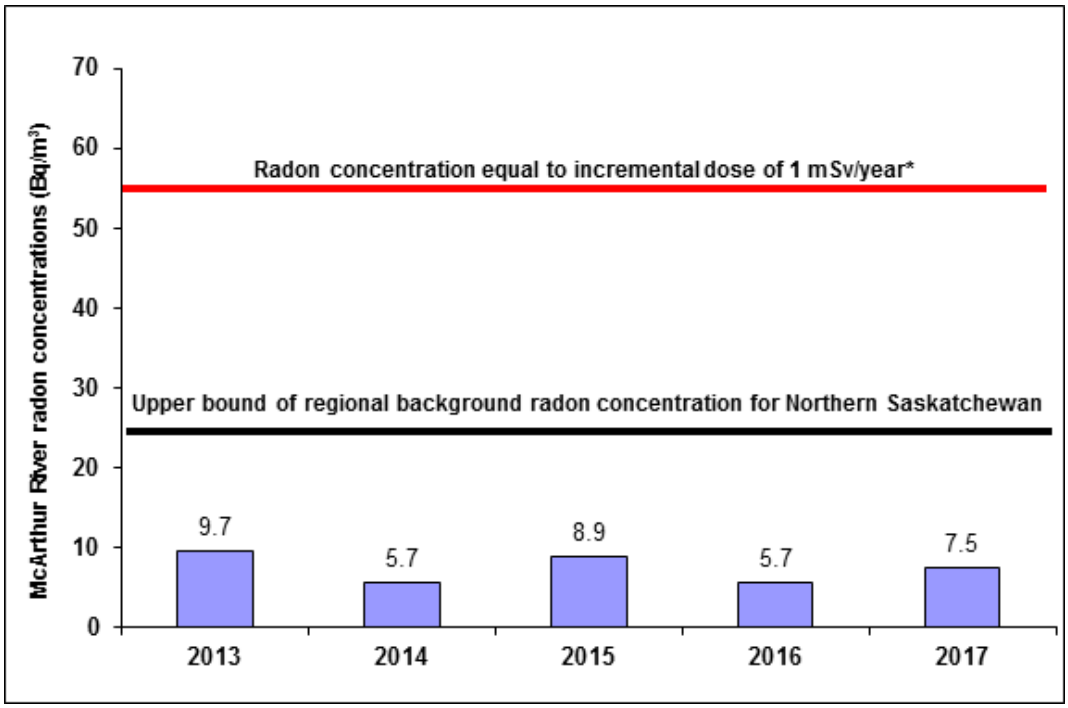
Figure 4.5: McArthur River - monitoring pond

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 radon in ambient air is carried out using passive track-etch cups at 12 monitoring stations around the operation. Figure 4.6 shows the average concentrations of radon in ambient air for 2013 to 2017 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 4.6: McArthur River - concentrations of radon in ambient air, 2013–17



* 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 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 (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 - concentrations of metal and radionuclides in air, 2013–17*

Parameter	Reference annual air quality levels	2013	2014	2015	2016	2017
TSP (µg/m^3)	**60** [3]	11.5	8.94	6.31	2.24	3.24
As (µg/m^3)	**0.06** [1]	0.0001	0.0001	0.0001	0.0001	0.0001
Cu (µg/m^3)	**9.6** [1]	0.0067	0.00835	0.00513	0.0065	0.0064
Ni (µg/m^3)	**0.04** [1]	0.0007	0.00085	0.00067	0.0007	0.0007
Pb (µg/m^3)	**0.10** [1]	0.0014	0.0012	0.00118	0.0011	0.0006
Se (µg/m^3)	**1.9** [1]	0.00003	0.0004	0.00004	0.00004	0.00004
Zn (µg/m^3)	**23** [1]	0.01065	0.01225	0.00980	0.0106	0.0084
Pb^{210} (Bq/m^3)	**0.021** [2]	0.00034	0.00032	0.00032	0.0002	0.0004
Po^{210} (Bq/m^3)	**0.028** [2]	0.00010	0.00009	0.00008	0.0001	0.0001
Ra^{226} (Bq/m^3)	**0.013** [2]	0.00001	0.00002	0.00001	0.00004	0.00001
Th^{230} (Bq/m^3)	**0.0085** [2]	0.00001	0.00001	0.00002	0.0001	0.0001
U (µg/m^3)	**0.06** [1]	0.0005	0.0005	0.0003	0.0004	0.0003

[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.

[3] *Saskatchewan Environmental Quality Guidelines*, Table 20: Saskatchewan Ambient Air Quality Standards (µg/m^3). Values are calculated as geometric means.

* Province of Ontario and ICRP annual air quality levels are shown for reference only. No federal or provincial limits are currently established.

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 and blueberry twig samples were last collected in 2015 as required by the triennial sampling program. The 2015 results indicated that parameters measured were within historical ranges. Concentrations of metals in soils remained below the *Canadian Environmental Quality Guidelines* set by the Canadian Council of Ministers of the Environment and radionuclide concentrations were near, or at, background levels and analytical detection limits. Triennial lichen sampling was last conducted in 2015. The results of the lichen monitoring were within historic ranges and do not suggest that COPC are accumulating in lichen tissues above background concentrations. The next lichen sampling will be conducted in 2018.

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 2017, 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 minor and reporting of this event met the requirements of RD/GD-99.3, *Public Information and Disclosure:*

- On December 2, 2017, because of low mass released, an unknown amount of ammonia was released into the atmosphere due to leaks on freeze plant skid No. 2.
- On December 31, 2017 an unknown amount (due to low mass released) of anhydrous ammonia was released into the atmosphere due to a worn shaft seal coupling within the main freeze plant.

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 H contains a brief description of the spills and corrective actions taken by the licensee, which included preventive maintenance. CNSC spill rating definitions can be found in appendix H, table H-2.

Figure 2.5 in section 2 identifies the number of spills at the McArthur River Operation from 2013 to 2017.

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 2017 ERA, and that human health remains protected.

Based on their reviews of the programs at McArthur River Operation, CNSC staff concluded that the public continues to be protected from operation emissions.

4.4 Conventional Health and Safety

CNSC staff rated the conventional health and safety SCA as "satisfactory" based on regulatory oversight activities conducted during 2017.

McArthur River conventional health and safety ratings

2013	2014	2015	2016	2017
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 McArthur River Operation. 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.

Performance

As shown in table 4.3, there was one lost-time injury (LTI) reported at the McArthur River Operation in 2017.

Table 4.3: McArthur River – lost-time injury statistics, 2013–17

	2013	2014	2015	2016	2017
Lost-time injuries[1]	1*	1**	0	2***	1
Severity rate[2]	0	14.6**	7.31**	0	12.11
Frequency rate[3]	0.11*	0.11**	0	0.24***	0.15

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 The accident severity rate measures the total number of days lost to injury for every 200,000 person-hours worked at the site. Severity = [(# of days lost in last 12 months) /(# of hours worked in last 12 months)] x 200,000.

3 The accident frequency rate measuring the number of LTIs for every 200,000 person-hours worked at the site. Frequency = [(# of injuries in last 12 months) / (# of hours worked in last 12 months)] x 200,000.

* One LTI was moved from 2012 to 2013, resulting in the number of LTIs in 2012 decreasing from 2 to 1 and the number of LTIs in 2013 increasing from 0 to 1. These changes resulted in a frequency rate change from 0.2 to 0.1 in 2012 and 0 to 0.11 in 2013.

** 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.

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.

On August 17, 2017 an incident resulting in the loss of the distal phalanx on the fifth digit of the left hand was verbally reported to the Commission. This incident did not result in an LTI and is not included in appendix I.

Awareness

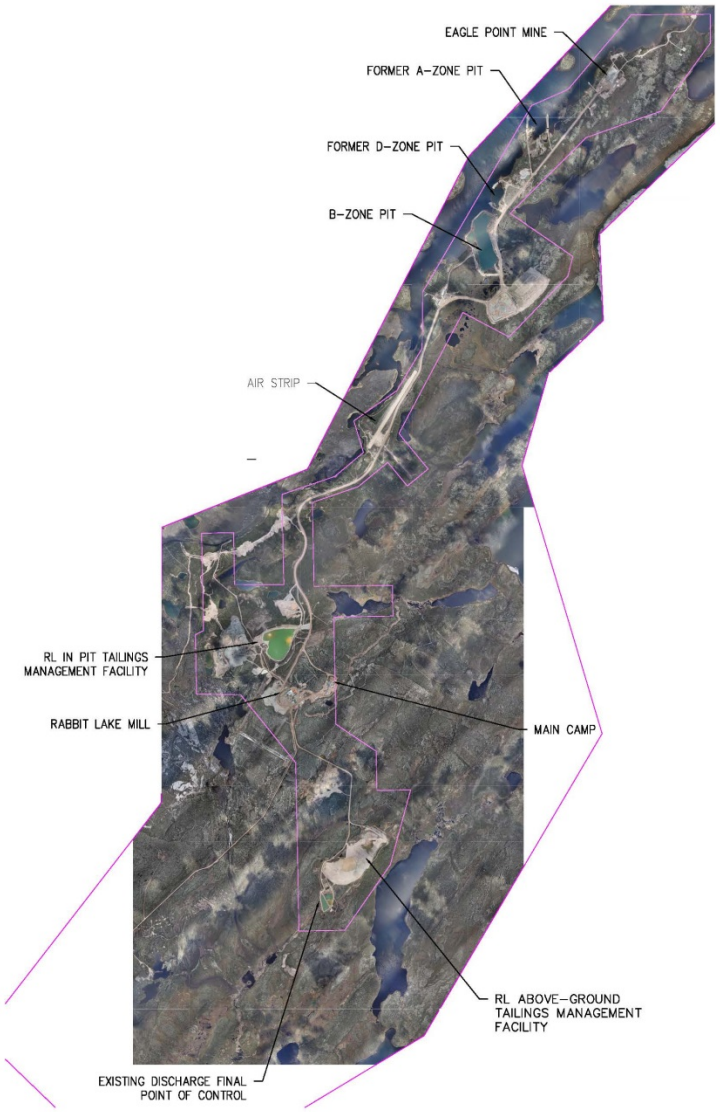
CNSC staff observed that the conventional health and safety programs at the McArthur River Operation continued to provide education, training, tools and support to workers. Managers, supervisors and workers share and promote the idea that safety is the responsibility of all individuals. Site operation's 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 site stretches across approximately 20 kilometres (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 polishing ponds, treated effluent continuously discharges and eventually reaches Hidden Bay of Wollaston Lake.

Figure 5.1: Rabbit Lake - site map



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 - mining production data, 2013-17

Mining	2013	2014	2015	2016	2017
Ore tonnage (Mkg/year)	255.15	328.13	309.50	79.87	0
Average ore grade mined (%U)	0.50	0.48	0.54	0.59	0
Uranium mined (Mkg U/year)	1.28	1.57	1.66	0.47	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 2017 reporting period. Table 5.2 provides milling production data from 2013 to 2017.

Table 5.2: Rabbit Lake - milling production data, 2013-17

Milling	2013	2014	2015	2016	2017
Mill ore feed (Mkg/year)	334.98	386.97	313.71	61.67	0
Average annual mill feed grade (%U)	0.49	0..42	0..53	0.71	0
Percent uranium recovery	97.2	97.3	97.1	97.0	0
Uranium concentrate produced (Mkg U/year)	1.59	1.60	1.62	0.43	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 relate to the suspension of production and the safe shutdown of related infrastructure and systems. The main functional areas to be maintained 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 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.

Fire protection systems will continue to be maintained throughout the main mill complex.

Mine operations

During the care and maintenance period, activities at the Eagle Point mine were minimized and the focus was on continued dewatering of the mine. There is no exploration, development or production planned. 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 optimized for heat and energy use.
- Mine mobile equipment has been stored and preserved in ventilated locations in the mine.

- All explosives have been removed from underground and the remaining inventory removed from site by the vendor.
- Non-essential surface facilities have been vacated and secured.

Routine inspections of the mine are conducted to ensure proper functioning of dewatering and ventilation systems and to monitor for unusual or changing conditions. Emergency response is maintained 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 site's water management system. Figure 5.2 provides an aerial view of the in-pit TMF.

Figure 5.2: Rabbit Lake - in-pit tailings management facility, 2017

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 based on 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 2017, 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 2013 to 2017 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 2017, CNSC staff carried out compliance inspections covering the SCAs of operating performance, fire protection, waste management and fitness for service in addition to those for which a detailed analysis is provided in the following sections. There were four non-compliances resulting from CNSC inspections at the Rabbit Lake Operation for the 2017 calendar year. These non-compliances were low risk in nature and related to the SCAs of management system and radiation protection. Corrective actions implemented by the licensee have been reviewed and accepted by CNSC staff. A list of inspections is provided in appendix B.

5.2 Radiation Protection

For 2017, CNSC staff continued to rate the radiation protection SCA at Rabbit Lake as "satisfactory" based on regulatory oversight activities.

Rabbit Lake radiation protection ratings

2013	2014	2015	2016	2017
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 (74 percent), gamma radiation (19 percent), long-lived radioactive dust (LLRD) (5 percent) and radon gas (3 percent). 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 the application of time, distance and shielding.

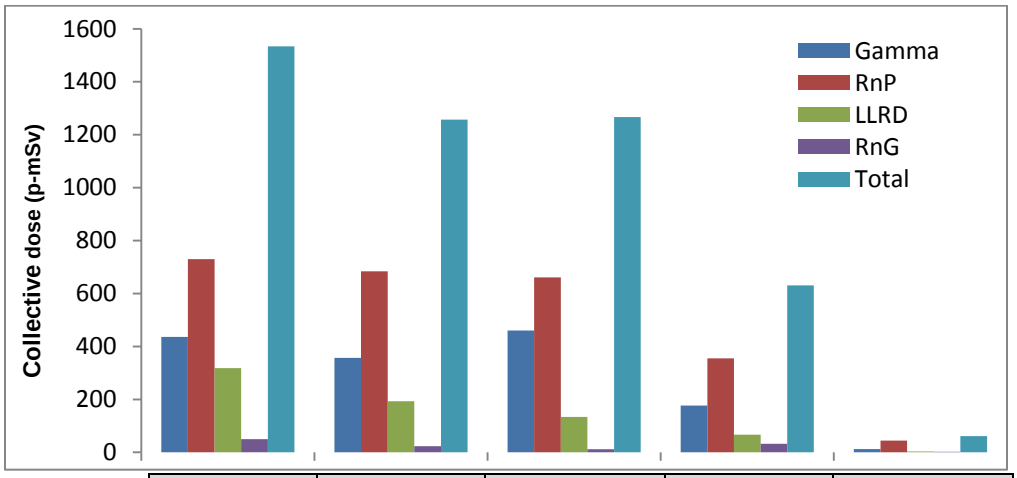
Radiation protection program performance

In 2017, 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 action level exceedances reported at the Rabbit Lake Operation in 2017.

Application of ALARA

In 2017, collective radiation exposure to NEWs at the Rabbit Lake Operation was 61 person-millisieverts (p-mSv), an approximate 90 percent reduction from the 2016 value of 631p-mSv (figure 5.3). The decrease is attributed to the suspension of production and placement of the operation into care and maintenance in 2016.

Figure 5.3: Rabbit Lake - annual collective radiation exposures, 2013–17



	2013	2014	2015	2016	2017
Gamma (p-mSv)	436	357	460	177	12
RnP (p-mSv)	730	684	661	355	44
LLRD (p-mSv)	318	193	134	67	3
RnG (p-mSv)	50	23	12	32	2
Total	1,534	1,257	1,267	631	61

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

In 2017, the Rabbit Lake Operation continued to develop the program initiated in 2015 to identify and minimize areas of elevated radon progeny in the mine. Mapped radon progeny levels were used to inform the ventilation configuration during transition to care and maintenance. Radon progeny monitoring was conducted throughout the mill to ensure hazard levels continue to meet hazard objectives throughout all ventilation adjustments.

CNSC staff have verified through regulatory oversight activities that Cameco continues to maintain worker exposures ALARA.

Worker dose control

During 2017, the average individual effective dose for NEWs was 0.4 mSv and the maximum individual effective dose was 1.56 mSv. This compares to an average effective dose of 0.85 mSv and a maximum individual dose of 4.95 mSv in 2016. This decrease is attributed to the suspension of mining and milling as the operation transitioned into care and maintenance. As shown in section 2 and figures 2.3 and 2.4, 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 site inspections, reviews of licensees' reports, work practices, monitoring results and individual effective dose results for 2017, CNSC staff were satisfied that the Rabbit Lake Operation continued to be effective in controlling radiation doses to workers.

5.3 Environmental Protection

For 2017, 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 environmental protection ratings

2013	2013	2015	2016	2017
SA	SA	SA	SA	SA

SA = satisfactory

Environmental management system

Cameco's environmental management system at Rabbit Lake is described in its CNSC approved environmental protection program and includes activities such as establishing annual environmental objectives, goals and targets. Cameco conducts internal audits of its environmental protection program at Rabbit Lake as identified in their CNSC approved management system program. CNSC staff review and assess the objectives, goals and targets through regular compliance verification activities.

Environmental risk assessment

The Rabbit Lake 2010 to 2014 Environmental Performance Report, which included an environmental and human health risk assessment, was submitted to the Saskatchewan Ministry of Environment and the CNSC in 2015. CNSC staff reviewed the submissions and concluded the monitoring programs and special studies were adequate, provided required information and contained sufficient information to complete a review. CNSC staff's assessment confirmed the environment and human health in the vicinity of the Rabbit Lake Operation remains protected.

Assessment and monitoring

During 2017, CNSC staff verified the Rabbit Lake environmental protection program was effectively implemented and met regulatory requirements.

CNSC staff concluded that Cameco's environmental management system and monitoring programs at Rabbit Lake met regulatory requirements and all treated effluent discharged to the environment complied with licence requirements. There were no exceedances of environmental action levels at the Rabbit Lake Operation during 2017.

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 continues to meet performance expectations in reducing the concentrations of these parameters (figures 2.6 to 2.8 of section 2). Substantial water treatment modifications have been completed at the Rabbit Lake Operation since 2007 to improve the quality of the treated effluent released to the environment. The licensee installed additional chemical treatment processes to reduce molybdenum. CNSC staff verified molybdenum concentrations displayed a marked reduction from 2012 levels, were relatively consistent from 2014 to 2016 and showed a decline in 2017.

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 2.7) and showed a decline in the past three 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) and pH. As shown in section 2.4, CNSC staff verified the Rabbit Lake Operation continues to meet *Metal Mining Effluent Regulations* discharge limits.

In 2017, the concentrations of regulated parameters in treated effluent released to the environment were well below the regulatory limits. 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.

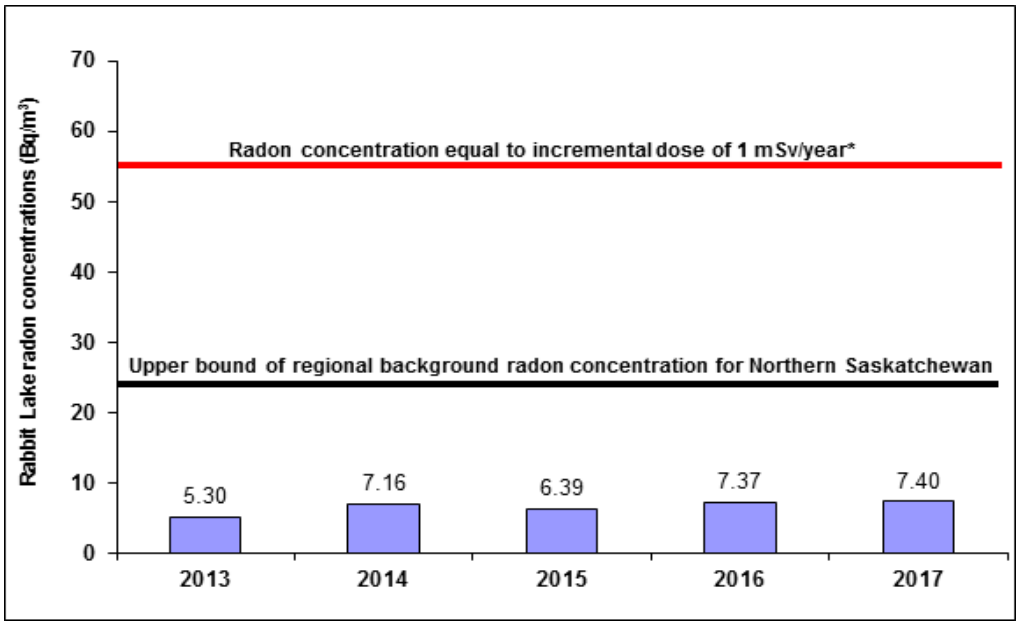
Figure 5.4: Rabbit Lake - B-Zone settling pond

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 2013 to 2017 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 - concentrations of radon in ambient air, 2013–17



* 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 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 are below provincial standards (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 - concentrations of metal and radionuclides in air, 2013–17

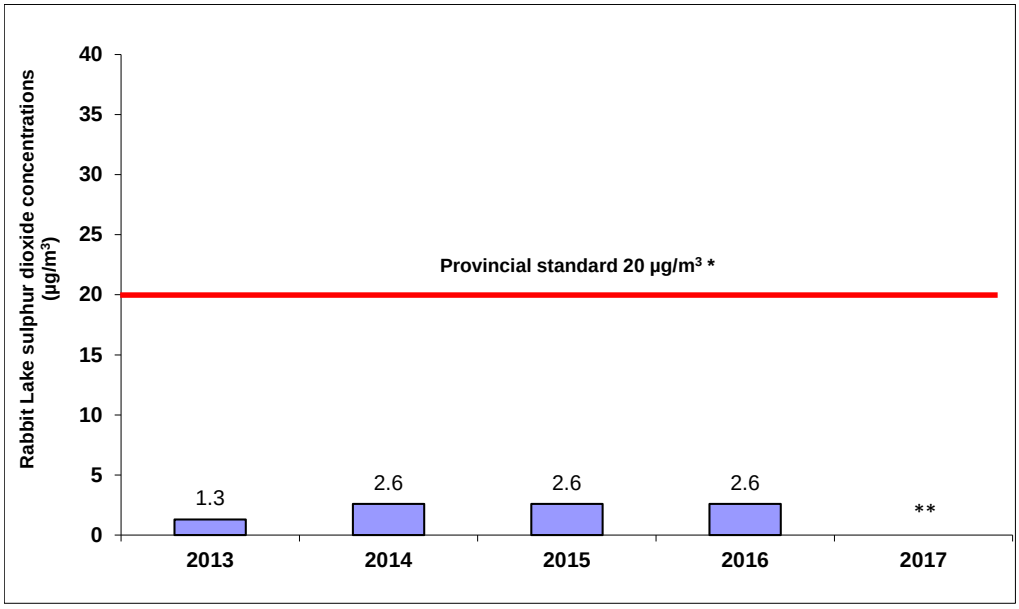
Parameter	Reference annual air quality levels*	2013	2014	2015	2016	2017
TSP (µg/m^3)	**60** [3]	7.67	6.21	6.87	4.97	4.79
As (µg/m^3)	**0.06** [1]	0.000175	0.000217	0.000207	0.000290	0.000285
Ni (µg/m^3)	**0.04** [1]	0.000007	0.000138	0.000192	0.000540	0.000404
Pb^{210} (Bq/m^3)	**0.021** [2]	0.000010	0.000013	0.000015	0.000011	0.000013
Ra^{226} (Bq/m^3)	**0.013** [2]	0.000002	0.000002	0.000001	0.000002	0.000004
Th^{230} (Bq/m^3)	**0.0085** [2]	0.000001	0.000003	0.000001	0.000002	0.000004
U (µg/m^3)	**0.06** [1]	0.001033	0.001960	0.002341	0.000899	0.000190

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.
3 *Saskatchewan Environmental Quality Guidelines*, Table 20: Saskatchewan Ambient Air Quality Standards (µg/m^3). Values are calculated as geometric means.
* Province of Ontario and ICRP annual air quality levels are shown for reference only. No federal or provincial limits are currently established.

In 2017, Cameco started comparing air quality data from Rabbit Lake to the Province of Saskatchewan's Ambient Air Quality Standards (table 20 of the *Saskatchewan Environmental Quality Standards*, June 2015). The implementation of the air quality standards in Saskatchewan was immediate for any new facility but did not come into effect for existing facilities until the existing approvals to operate were renewed and/or revised. The new standards are shown for TSP and sulphur dioxide for the Rabbit Lake Operation although the operation did not become subject to the new standards until February 2017.

Daily in-stack monitoring of sulphur dioxide emissions from the mill acid plant was discontinued in 2017 for the duration of the care and maintenance period as the acid plant and mill processing circuits were not operating. When in operation, a sulphur dioxide monitoring location monitors releases associated with mill operations. This sulphur dioxide monitoring station is located approximately 450 metres southwest of the acid plant. Sulphur dioxide monitoring results (figure 5.6) show there were no exceedances of the annual standard of 20 µg/m^3 when the acid plant was in operation. CNSC staff verified ambient sulphur dioxide levels remain at safe concentrations in the nearby environment.

Figure 5.6: Rabbit Lake - concentrations of ambient sulphur dioxide, 2013–17



* Province of Saskatchewan standard
** Monitoring discontinued in 2017

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, 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 2017, one event was reported to CNSC staff as a release (spill) of hazardous substances to the environment. The spill was minor and the reporting of this event met the requirements of RD/GD-99.3, *Public Information and Disclosure:*

- On December 3, 2017 an unknown quantity of propane was released into the atmosphere at the camp due to a broken seal on a threaded fitting on a propane gas line. It was estimated that approximately 17 litres of liquid propane was released over a period of 10 minutes.

Appendix H provides a brief description of the spill and actions taken by the licensee. There were no residual impacts on the environment. CNSC staff reviewed the corrective actions taken by the Rabbit Lake Operation and found them to be acceptable. CNSC staff rated the 2017 spill as low significance in accordance to the definitions provided in table H-2, appendix H. Figure 2.5 displays the number of environmental reportable spills from 2013 to 2017 at the Rabbit Lake Operation.

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.

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 remain within those predicted in the 2017 ERA, and that human health remains protected.

Based on their reviews of the programs at the Rabbit Lake Operation, CNSC staff concluded that the public continues to be protected from operation emissions.

5.4 Conventional Health and Safety

For 2017, CNSC staff continued to rate the conventional health and safety SCA as "satisfactory" based on regulatory oversight activities.

Rabbit Lake conventional health and safety ratings

2013	2014	2015	2016	2017
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, reducing future incidents that could cause injury. CNSC compliance verification activities confirmed the Rabbit Lake Operation continues to focus on the prevention of accidents and injuries through implementation of its health and safety management program.

Performance

There were no lost–time injuries reported for the Rabbit Lake Operation in 2017. The lost-time injury (LTI) performance at the Rabbit Lake Operation for 2013 to 2017 is shown in table 5.4.

Table 5.4: Rabbit Lake - lost-time injury statistics, 2013–17

	2013	2014	2015	2016	2017
Lost-time injuries[1]	0	1	2	1	0
Severity rate[2]	25.8	11.4	55.3	2.65	0
Frequency rate[3]	0.0	0.15	0.33	0.27	0

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 The accident severity rate measures the total number of days lost to injury for every 200,000 person-hours worked at the site. Severity = [(# of days lost in last 12 months) / (# of hours worked in last 12 months)] x 200,000.

3 The accident frequency rate measuring the number of LTIs for every 200,000 person-hours worked at the site. Frequency = [(# of injuries in last 12 months) / (# of 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. Site 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 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 - 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 processing 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 (figure 6.2). Mill tailings continue to be deposited into this facility today.

Figure 6.2: Key Lake - 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.

Milling data for the Key Lake Operation during the five-year reporting period are presented in table 6.1.

Table 6.1: Key Lake - milling production data, 2013–17

Milling	2013	2014	2015	2016	2017
Mill ore feed (Mkg/year)	184.10	173.01	165.56	155.30	143.26
Average annual mill feed grade (% U)	4.23	4.29	4.47	4.51	4.37
Percentage of uranium recovery	99.3	99.4	99.35	99.04	99.05
Uranium concentrate produced (Mkg U/year)	7.74	7.37	7.35	6.95	6.20
Authorized annual production (Mkg U/year)	7.85	9.60	9.60	9.60	9.60

CNSC staff confirmed the Key Lake Operation production remains less than the authorized annual production (table 6.1).

As reported in October 2016 in Commission member document, CMD 16-M49, Cameco constructed and began commissioning a new calciner. During the commissioning process, it was determined that the new calciner would not operate as designed. During initial commissioning of the calciner it was noted that excessive corrosion was occurring. Use of the new calciner ceased and an investigation was undertaken to determine the cause and next steps. Cameco continued to use the existing calciner throughout 2016 and 2017. The shaft and associated brickwork for the existing calciner were replaced during the 2017 summer maintenance shutdown and it is expected that this calciner will operate for the foreseeable future.

Cameco continues to investigate options for modifying or replacing the new calciner. Through regular compliance activities, CNSC staff verified the safe operation of the existing calciner.

6.1 Performance

The Key Lake Operation's safety and control area (SCA) ratings for the five-year period of 2013 to 2017 are shown in appendix E. CNSC staff continued to rate all SCAs for 2017 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 2017, CNSC staff carried out compliance inspections covering the SCAs of management system, fitness for service, conventional health and safety, radiation protection and packaging and transport in addition to a general inspection which included multiple SCAs. There were nine non-compliances resulting from CNSC inspections at the Key Lake Operation for the 2017 calendar year. These non-compliances were low risk in nature and related to the SCAs of management system, fitness for service, and radiation protection. Corrective actions have been implemented by the licensee, reviewed and accepted by CNSC staff. A list of inspections can be found in appendix B.

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 radiation protection ratings

2013	2014	2015	2016	2017
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 (44 percent), radon progeny (34 percent) and long-lived radioactive dust (LLRD) (22 percent). Gamma radiation hazards are controlled through 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

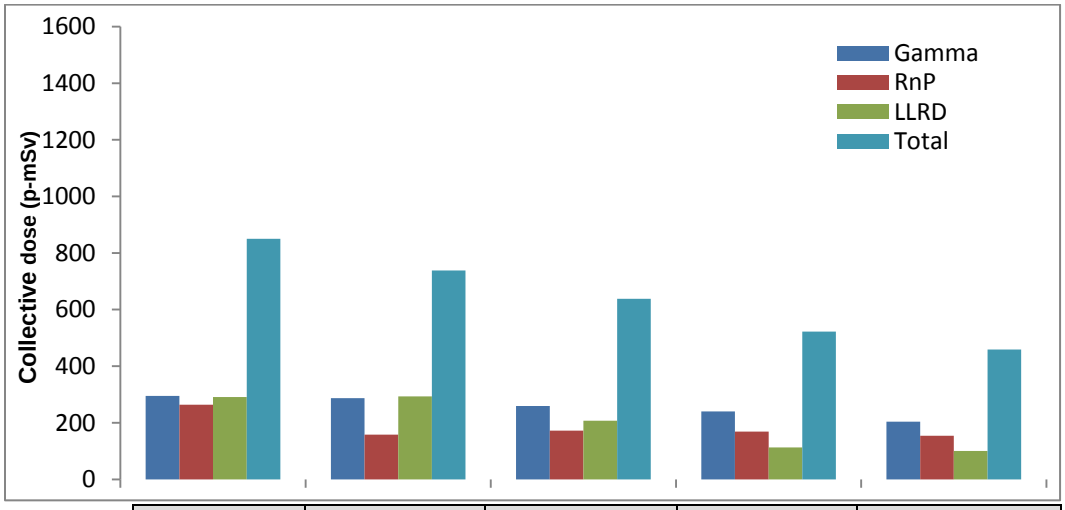
In 2017 there were no action level exceedances at the Key Lake Operation.

Overall, the radiation protection program and practices at the Key Lake Operation remained effective in controlling radiological exposure to workers.

Application of ALARA

In 2017, the collective radiation exposure to NEWs at the Key Lake Operation was 451 person-millisieverts (p-mSv), a 14 percent reduction from the 2016 value of 522 p-mSv (figure 6.3).

Figure 6.3: Key Lake - annual collective radiation exposures, 2013–17



	2013	2014	2015	2016	2017
Gamma (p-mSv)	295	287	259	240	199
RnP (p-mSv)	264	158	172	169	153
LLRD (p-mSv)	291	293	207	113	99
Total	850	738	638	522	451

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

Cameco maintained as low as reasonably achievable (ALARA) objectives in 2017, including the High-5 program that was initiated in 2010 at Key Lake. In search of opportunities to lower doses, the High-5 program provides enhanced reviews of exposures for the five employees and five contractors who had the highest quarterly effective dose. Site radiation awareness activities were performed throughout 2017. Radiation information related to incidents, events, trends, and changes to work instructions and radiation policy were shared with contractors and Cameco workers. The radiation protection department shared information through safety meetings, fact sheets, safety inspections and job task observations. CNSC staff concluded that the Key Lake radiation protection program remains effective in ensuring that worker exposures remain ALARA.

Worker dose control

In 2017, the average individual effective dose to NEWs was 0.66 mSv, while the maximum individual effective dose received was 5.39 mSv. This compares to an average effective dose of 0.62 mSv and a maximum individual dose of 5.37 mSv in 2016.

The maximum individual effective dose at the Key Lake Operation was identified in a mill operations worker who worked a large fraction of the year in the leaching circuit. 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 CNSC staff compliance verification activities such as onsite inspections, reviews of licensees' reports, work practices, monitoring results and individual effective dose results for 2017, CNSC staff were satisfied that the Key Lake Operation continued to be effective in controlling radiation doses to workers.

6.3 Environmental Protection

For 2017, CNSC staff continued to rate the environmental protection SCA as "satisfactory" based on regulatory oversight activities. CNSC staff concluded the licensee's environmental protection program was effectively implemented and met all regulatory requirements.

Key Lake environmental protection ratings

2013	2014	2015	2016	2017
SA	SA	SA	SA	SA

SA = satisfactory

Environmental management system

Cameco's 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 Key Lake as identified in their CNSC approved management system program. CNSC staff review and assess the objectives, goals and targets through regular compliance verification activities.

Environmental risk assessment

In 2015, the Key Lake environmental performance report (EPR) for the 2010 to 2014 period was submitted to CNSC and Saskatchewan Ministry of Environment staff. CNSC staff reviewed the EPR and found it contained sufficient information to complete a review of the environmental performance of the Key Lake Operation from 2010 to 2014 relative to predictions contained in the 2013 environmental risk assessment (ERA) for the Key Lake extension project. The monitoring programs and special studies were sufficiently comprehensive and provided the required information. The models used to predict environmental performance continued to be valid. Therefore, CNSC staff confirmed the environment and human health in the vicinity of the Key Lake Operation remains protected. Additional information on the ERA was also provided in section 2.4.

Assessment and monitoring

Effluent and environmental monitoring, site inspections, environmental awareness training and program implementation audits were performed in accordance with Cameco's environmental protection program at the Key Lake Operation.

CNSC staff concluded that Cameco's environmental management system and monitoring programs at Key Lake met regulatory requirements and the licensee complied with treated effluent discharge requirements. There were no exceedances of environmental action levels during the 2017 review period.

The following provides monitoring and assessment results for the Key Lake Operation.

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.

The McDonald Lake system receives effluent from the reverse osmosis plant. Monitoring confirms that this effluent is within design specifications and predictions outlined in the ERA. In August 2017, Cameco submitted the Key Lake 2016 McDonald Creek Drainage Environmental Monitoring Program report. The program included the collection and analysis of water, sediment and fish tissue as well as benthic invertebrate community and fish population monitoring. Overall, the results of the 2016 program indicated similar sediment and water quality and fish chemistry to previous monitoring years and little change to the benthic invertebrate community composition, density, taxon richness, biomass, and Simpson's index for diversity and evenness.

The treated effluent quality discussed in this report 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 2017 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 (figures 2.6 to 2.8). Of these, molybdenum and selenium concentrations were the primary concerns at the Key Lake Operation. The licensee has therefore targeted process changes to reduce concentrations in treated effluent.

Reductions of molybdenum and selenium occurred from 2008 to 2009 when additional treatment components were installed and optimized. Figures 2.6 and 2.7 show stable concentrations of molybdenum and selenium in treated effluent from 2013 to 2017, indicating these parameters are being effectively controlled. Figure 2.8 indicates that uranium concentrations in treated effluent released from the Key Lake mill remain low and are again effectively controlled.

In addition to the COPC, Cameco also analyzed treated effluent for concentrations of other COPC such as radium-226, arsenic, copper, lead, nickel, zinc, total suspended solids (TSS) and pH at Key Lake. As discussed in section 2.4, the Key Lake Operation continued to meet *Metal Mining Effluent Regulations* discharge limits.

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

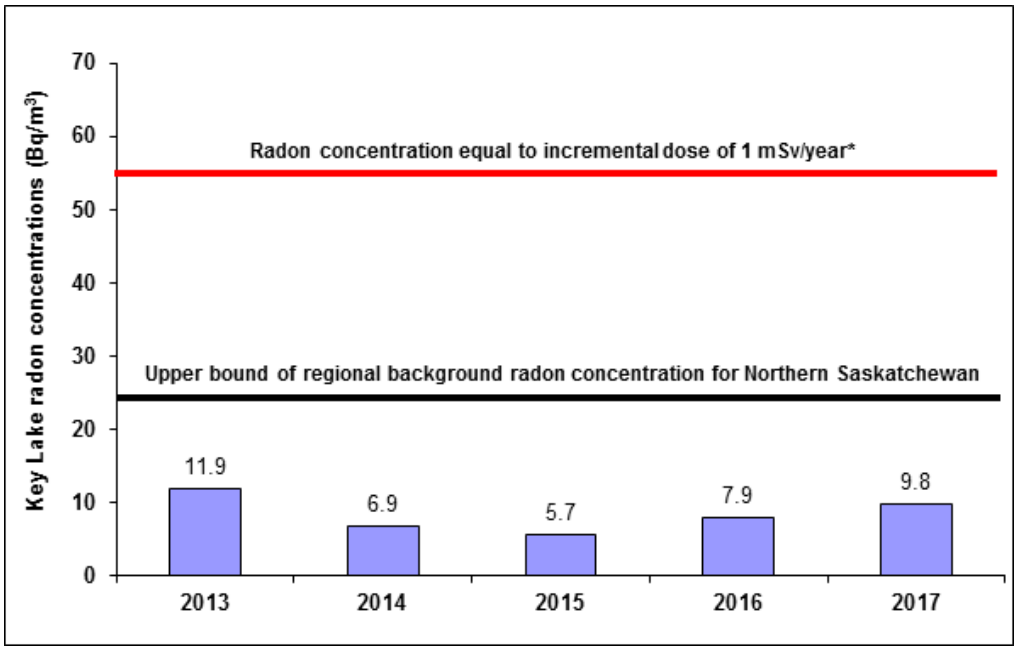
Air emissions released to the environment

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 is monitored annually; the most recent stack test was completed in June 2017. The stack emission results were within historical ranges and verified that operational controls are working as designed. Sulphur dioxide concentrations from the acid plant stack are monitored daily. Concentrations are consistent with those reported since the commissioning of the new acid plant in 2012.

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 2013 to 2017. 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 - concentrations of radon in ambient air, 2013–17



* 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 115. Values are calculated as geometric means.

Five high-volume air samplers were used to collect and measure 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 - concentrations of metal and radionuclides in air, 2013–17

Parameter	Reference annual air quality levels*	2013	2014	2015	2016	2017
TSP (µg/m^3)	**60 (3)**	14.07	15.10	13.77	10.77	11.90
As (µg/m^3)	**0.06 (1)**	0.00166	0.00444	0.0016	0.0010	0.0045
Ni (µg/m^3)	**0.04 (1)**	0.00118	0.00340	0.0013	0.0007	0.0029
Pb^{210} (Bq/m^3)	**0.021 (2)**	0.00032	0.00044	0.0003	0.0003	0.0004
Ra^{226} (Bq/m^3)	**0.013 (2)**	0.00010	0.00022	0.0001	0.0001	0.0003
Th^{230} (Bq/m^3)	**0.0085 (2)**	0.00010	0.00022	0.0001	0.0001	0.0002
U (µg/m^3)	**0.06 (1)**	0.00656	0.00794	0.0080	0.0076	0.0091

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

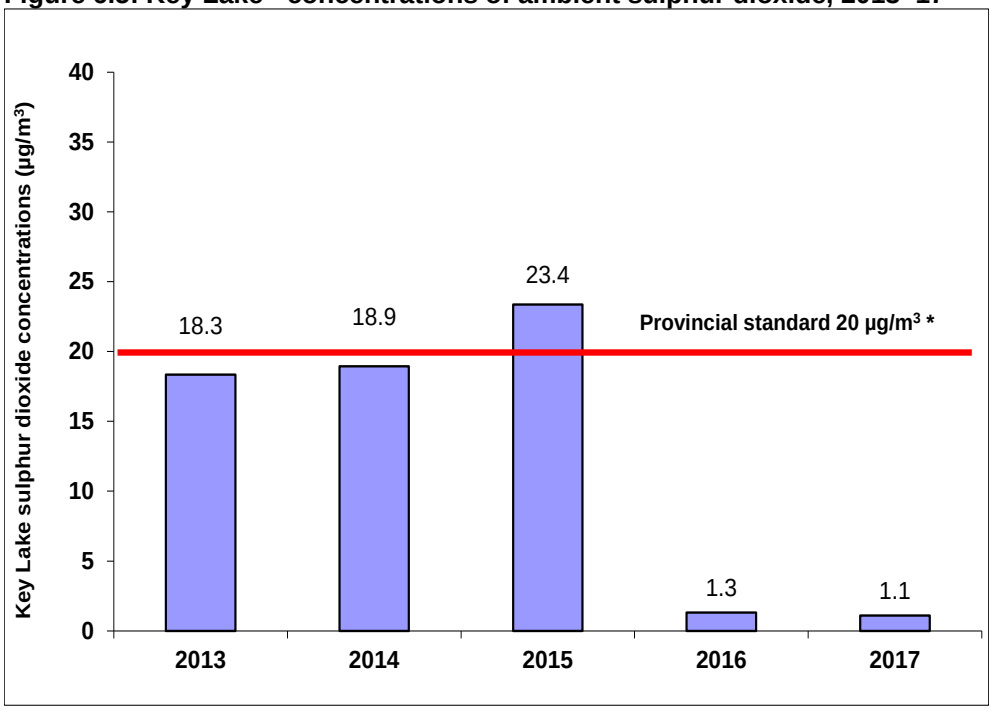
2 Reference level from International Commission on Radiological Protection (ICRP) publication 96, *Protecting People Against Radiation Exposure in the Event of a Radiological Attack*.

3 *Saskatchewan Environmental Quality Guidelines*, Table 20: Saskatchewan Ambient Air Quality Standards (µg/m^3). 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.

* Province of Ontario and ICRP reference annual air quality levels are shown for reference only. No federal or Province of Saskatchewan limits are currently established.

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 (figure 6.5) show no exceedances of the annual standard of 20 µg/m^3 in 2017. The current air quality standard for Key Lake's is 30 µg/m^3, but the new standard of 20 µg/m^3 will apply when their existing provincial permit is renewed or revised.

Figure 6.5: Key Lake - concentrations of ambient sulphur dioxide, 2013–17



* Province of Saskatchewan's ambient air quality standand, updated in 2015, is shown. 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 due to construction of a new acid plant in 2012. These lower emissions have been maintained throughout 2013 to 2017. 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.

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 2017 lake sampling program continued to show that sulphate concentrations remain relatively unchanged from historical concentrations. CNSC staff conclude 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 as required by the triennial sampling program.

Lichen samples were collected and analyzed from five monitoring stations around the operation. Exposure stations were within the regional historical ranges for each parameter, with the exception of Wheeler River. Results from one station indicated elevated concentrations of some metals and radionuclides compared to previous years. This station will continue to be monitored to determine if the elevated concentrations are a result of the fire disturbance, relocated sample area or conditions at this station.

CNSC staff assessed and concluded that the level of airborne particulate contaminants produced by the Key Lake Operation is acceptable and does not pose a risk to lichen consumers, such as caribou.

Soil samples were taken in the immediate vicinity of the mine. The soil metal parameter concentrations were below the *Canadian Environmental Quality Guidelines* set by the Canadian Council of Ministers of the Environment. Radionuclide concentrations in soils were low and near or at background levels and analytical detection limits. The concentrations of radionuclides and metals in 2016 were consistent with previous sampling results.

Based on soil 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 2017, three events reported to CNSC staff were considered as a release of hazardous substances to the environment:

- On April 15, 2017 approximately 130 kilograms of low grade ore was released from a front end loader bucket on the site road and on the mine shop parking lot.
- On June 24, 2017 anhydrous ammonia was released from piping on ammonia storage tank No. 2. The leak was intermittent and no liquid ammonia was observed near the piping. The volume released could not be estimated due to the intermittent nature of the leak.
- On December 8, 2017 anhydrous ammonia was released from a flange on a section of piping used for off-loading into ammonia storage tank No. 3. The volume released could not be estimated due to the intermittent nature of the leak.

These spills were minor and reporting met the requirements of RD/GD-99.3, *Public Information and Disclosure.*

Appendix H provides a brief description of each spill and the actions taken by the licensee. The spills were remediated with no residual impact on the environment. The corrective actions were reviewed and found acceptable by CNSC staff. CNSC staff rated the 2017 spills at the Key Lake Operation as low significance as defined in table H-2, appendix H.

In follow-up to the ammonia releases, Cameco initiated a 3-year staged project to refurbish the existing tanks and associated infrastructure at Key Lake. In 2018, work on ammonia tank No. 1 will include internal and external inspections of the tank, insulation and cladding replacement, replacement of electrical and instrumentation components, as well as replacement of the existing tank valves. Additional isolation valves will also be added to the vaporizers. This project will bring the 30 year (plus) ammonia tank system to current standards, addressing any tank corrosion and valving/piping concerns. As part of the staged project, tanks No. 2 and No. 3 will be refurbished in 2019 and 2020, respectively.

Figure 2.5 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 2013 to 2017.

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.

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 remain within those predicted in the 2013 ERA and that human health remains protected.

Based on their reviews of the programs at the Key Lake Operation, CNSC staff concluded the public continues to be protected from operation emissions.

6.4 Conventional Health and Safety

For 2017, CNSC staff continued to rate the conventional health and safety SCA as "satisfactory" based on regulatory oversight activities.

Key Lake conventional health and safety ratings

2013	2014	2015	2016	2017
SA	SA	SA	SA	SA

SA = satisfactory

Practices

Throughout 2017, CNSC staff monitored the implementation of the Key Lake Operation's operational health and safety program and concluded that this program continues to be effective.

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 2017. Any items of concern found during these inspections are included in the licensee's incident reporting system.

Performance

There were two lost-time injuries (LTIs) at the Key Lake Operation between 2013 and 2017 (table 6.3). There were no LTIs in 2017.

Table 6.3: Key Lake - lost-time injury statistics, 2013–17

	2013	2014	2015	2016	2017
Lost-time injuries[1]	0	0	0	2	0
Severity rate[2]	8.5	0	0	71.0	0
Frequency rate[3]	0.0	0	0	0.41	0

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 The accident severity rate measures the total number of days lost to injury for every 200,000 person-hours worked at the site. Severity = [(# of days lost in last 12 months) / (# of hours worked in last 12 months)] x 200,000.

3 The accident frequency rate measuring the number of LTIs for every 200,000 person-hours worked at the site. Frequency = [(# of injuries in last 12 months) / (# of 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 managers, supervisors and workers. Site 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 2017.

7 MCCLEAN LAKE OPERATION

AREVA Resources Canada Inc. (AREVA), now known as Orano Canada Inc. (Orano) is the operator of the McClean Lake Operation. 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 AREVA (70%), Denison Mines Inc. (22.5%), and Overseas Uranium Resources Development Canada Co., Ltd. (7.5%). The McClean Lake Operation includes the JEB milling area, Sue mining area, tailings management facility (TMF) and the undeveloped McClean, Midwest and Caribou ore deposits.

An aerial facility overview of the McClean Lake Operation is shown in figures 7.1 and 7.2.

Figure 7.1: McClean Lake - aerial view of the JEB milling area and TMF

Figure 7.2: McClean Lake – aerial view of the Sue mine area, summer 2015

In 1996, an operating licence was first issued to the McClean Lake Operation by the Atomic Energy Control Board, predecessor of the CNSC. Since then, the McClean Lake Operation's licence has been renewed several times. Following a public hearing held on June 7 and 8, 2017 in La Ronge, Saskatchewan the Commission issued a 10-year licence to authorize AREVA to continue to operate the McClean Lake Operation. The current operating licence was renewed on July 1, 2017 and expires on June 30, 2027. This licence authorized AREVA to operate a nuclear facility for the mining of uranium ore, process Cameco Corporation's Cigar Lake mine high grade ore slurry, production of uranium concentrate and disposal of tailings at the TMF.

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 and lined 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 TMF, which was engineered from the mined-out John Everett Bates (JEB) open pit.

Processing of ore at the McClean Lake Operation was suspended and the mill temporarily shut down in July 2010 due to a shortage of ore. The high-grade ore slurry shipments from Cameco's Cigar Lake mine began in March 2014, and the McClean Lake Operation restarted in September 2014. After restart and commissioning of the McClean Lake Operation with Cigar Lake ore slurry, CNSC staff focused their oversight activities on the implementation of AREVA's radiation protection program. CNSC staff verified that the McClean Lake Operation continued to keep worker doses as low as reasonably achievable (ALARA) while processing high-grade ore at higher production levels. CNSC staff also confirmed that AREVA's environmental management system continued to protect the environment and meet environmental performance objectives for the McClean Lake Operation.

CNSC staff confirmed the McClean Lake Operation production remains less than the authorized annual production. Milling production data for the McClean Lake Operation during the five-year reporting period are presented in table 7.1.

Table 7.1: McClean Lake - milling production data, 2013–17

Milling	2013	2014	2015	2016	2017
Mill ore feed (Mkg/year)	No milling*	7.83	25.52	37.20	36.35
Average annual mill feed grade (%U)	No milling*	3.00	17.56	18.08	19.3
Percentage of uranium recovery (%)	No milling*	97.54	98.99	99.10	99.03
Uranium concentrate produced (Mkg U)	No milling*	0.200	4.30	6.67	6.93
Authorized annual production (Mkg U/year)	5.00	5.00	5.00	9.23	9.23

* McClean Lake mill temporarily stopped producing uranium concentrate from July 2010 to September 2014.

In April 2010, AREVA submitted an application to the CNSC requesting approval of the JEB TMF Optimization Project. CNSC staff reviewed and approved the project in September 2010. A two-phase plan was proposed and optimization stage 1 was completed in 2012/2013 (re-sloping of TMF 1V:1.5H:1 slope, placement of manufactured soil bentonite liner, and placement of rip-rap protection). In 2017, AREVA continued working on removal of infrastructure impacting optimization stage 2 re-sloping work and completed the following projects:

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

AREVA plans to complete optimization stage 2 in the summer of 2018. This will involve re-sloping of the current TMF slope to a 1V:3H slope, placement of liner to the final elevation of 443 mASL and placement of rip-rap protection.

In June 2016, AREVA submitted an application for the JEB TMF expansion. AREVA 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. AREVA 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 2013 to 2017 five-year period are shown in appendix E. For 2017, CNSC staff continued to rate all SCAs as "satisfactory" based on regulatory oversight activities with the exception of radiation protection which is 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 these facilities: radiation protection, environmental protection and conventional health and safety.

In 2017, CNSC staff carried out focused compliance inspections covering the SCAs of radiation protection, fitness for service and physical design in addition to general inspections which included multiple SCAs. There were three non-compliances resulting from CNSC inspections at the McClean Lake Operation for the 2017 calendar year. These non-compliances were low risk in nature and related to the management system and fitness for service SCAs. Corrective actions have been implemented by the licensee and reviewed and accepted by CNSC staff. A list of inspections can be found in appendix B.

As part of McClean Lake's July 2017 licence renewal, CNSC staff added the following regulatory documents to the McClean Lake Operation licence conditions handbook (LCH):

- REGDOC-2.2.2, *Human Performance Management, Personnel Training*
- REGDOC-2.10.1, *Nuclear Emergency Preparedness and Response*
- REGDOC-2.12.3, *Security of Nuclear Substances: Sealed Sources*

CNSC staff will continue to monitor implementation of these documents through regulatory oversight activities including onsite inspections and desktop reviews.

7.2 Radiation Protection

From 2013 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.

McClean Lake radiation protection ratings

2013	2014	2015	2016	2017
SA	SA	SA	SA	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 (40 percent), radon progeny (RnP) (33 percent) and long-lived radioactive dust (LLRD) (27 percent). Gamma radiation hazards are controlled through the application of time, distance and shielding. The effective dose to NEWs (nuclear energy workers) from exposures to radon progeny and LLRD are controlled through the effective use of source control, ventilation, contamination control and personal protective equipment (PPE).

AREVA 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. AREVA continues to implement a comprehensive monitoring program for all hazards to confirm that these design hazard objectives are met, and to identify opportunities for improvement at the McClean Lake Operation.

Despite a slight increase in uranium feed grade and an approximate 4 percent production increase in 2017, gamma monitoring results remained consistent with 2016 results. However, in 2017 a reduction in hazard levels was observed for both RnP and LLRD.

CNSC staff concluded that AREVA continues to implement a comprehensive monitoring program and that this program was highly effective in controlling all radiological hazards at McClean Lake in 2017.

Radiation protection program performance

In 2017, there were no action level exceedances at the McClean Lake Operation.

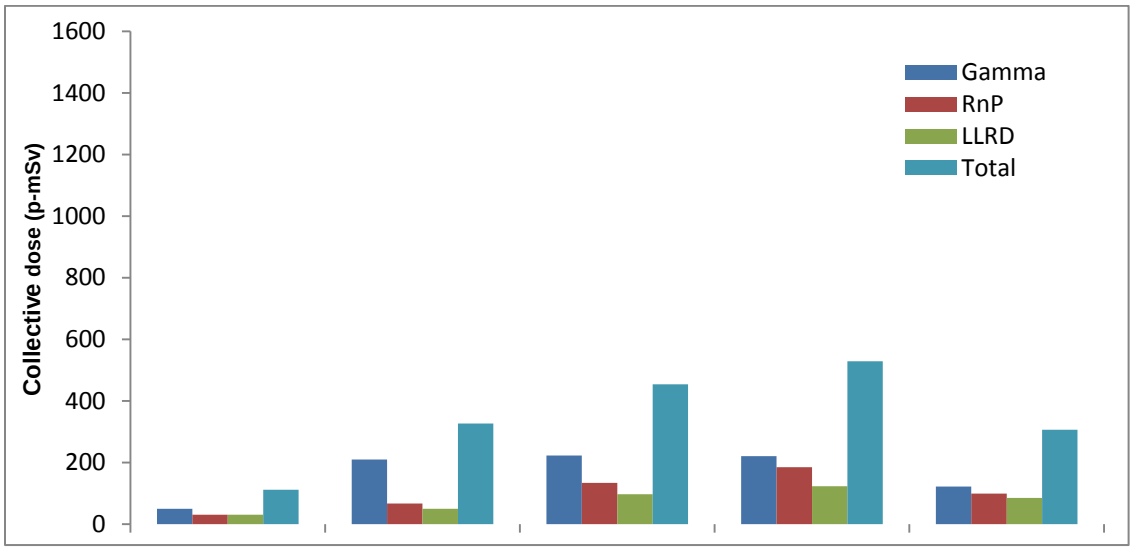
The radiation protection program and practices continued to effectively maintain worker doses ALARA.

Application of ALARA

In 2017, despite an approximate 4 percent production increase, collective radiation exposure (CRE) to NEWs at the McClean Lake Operation was 307 person-millisieverts (p-mSv), a 42 percent decrease from the 2016 value of 529 p-mSv (figure 7.3). This decrease in exposure was mainly due to a reduction in contract work.

In 2017, the CRE for contract workers was approximately 11 p-mSv compared to 152 p-mSv in 2016. However, dose reductions were not limited to contract workers. Specifically a CRE reduction of approximately 21 percent was observed for non-contract staff (from 377 p-mSv in 2016 to 296 p-mSv in 2017).

Figure 7.3: McClean Lake - annual collective radiation exposures, 2013–17



	2013	2014	2015	2016	2017
Gamma (p-mSv)	50	210	223	221	122
RnP (p-mSv)	31	67	134	185	100
LLRD (p-mSv)	31	50	97	123	85
Total	112	327	454	529	307

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

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

- cleaning or flushing of equipment prior to maintenance activities;
- implementing shielding material during maintenance activities;
- relocation and redesign of the calciner/packaging PPE donning/doffing station;
- reprogramming of slurry tote wash cycle to eliminate manual tote cleaning;
- relocation of the metallurgical laboratory storage sea-can to a lower occupancy area; and
- enhanced PPE requirements for slurry receiving pachuca enclosure.

Through reviews of radiation monitoring and exposure reports as well as inspections, CNSC staff confirmed the radiation protection program was highly effective in 2017 ensuring worker exposures remain ALARA.

Worker dose control

The average individual effective dose for NEWs in 2017 was 0.91 mSv, while the maximum individual effective dose received by a NEW was 5.12 mSv, which was received by a mill worker. This compares to an average individual effective dose of 1.04 mSv and a maximum individual dose of 6.94 mSv in 2016. All individual effective doses were well below the annual regulatory limit of 50 mSv and 100 mSv in a five year dosimetry period.

In 2017, more challenging dose targets were established for workers in higher dose categories. Specifically, average dose targets were set for the 10 NEWs with the highest:

- overall doses;
- LLRD doses; and
- RnP doses.

All three of these dose targets were met.

Based on CNSC staff's compliance verification activities, such as site inspections, reviews of licensees' reports, work practices, monitoring results and individual effective dose results in 2017, CNSC staff were satisfied that AREVA controlled radiation doses to workers and concluded that the worker dose control measures in place were highly effective at the McClean Lake Operation. As a result, CNSC staff rate AREVA's performance for the radiation protection SCA at the McClean Lake Operation as "fully satisfactory".

7.3 Environmental Protection

For 2017, CNSC staff continued to rate the environmental protection SCA as "satisfactory" based on regulatory oversight activities. CNSC staff concluded the licensee's environmental protection program was effectively implemented and met all regulatory requirements.

McClean Lake environmental protection ratings

2013	2014	2015	2016	2017
SA	SA	SA	SA	SA

SA = satisfactory

Environmental management system

AREVA has implemented and maintained an effective environmental management system. Internal audits are conducted by AREVA to ensure the system is effective and has been properly implemented. Any deficiencies and findings identified from the internal audit are documented and a plan is then devised to address any non-conformance items. CNSC staff verified the implementation of AREVA's environmental management system at McClean Lake through desktop reviews of quarterly environmental reports, annual compliance reports, and onsite inspections.

Environmental risk assessment

AREVA submitted an updated environmental risk assessment (ERA) in 2016. CNSC staff reviewed the document and noted the predicted ecological and human health risks from the McClean Lake Operation are within predictions of CNSC-accepted environmental impact statements and ERAs, with the exception of predicted short-term exposure of aquatic organisms to selenium in McClean Lake's east basin. McClean Lake's east basin is considered an exposure lake. AREVA proposed a selenium adaptive management plan, discussed below, to address this. CNSC staff concluded that the McClean Lake Operation is in compliance with regulatory requirements. Details on ERAs are also provided in section 2.4.

An environmental assessment under the *Nuclear Safety and Control Act* (NSCA) was conducted by CNSC staff for the McClean Lake Operation licence renewal in June 2017. CNSC staff concluded that AREVA had made, and will continue to make, adequate provision for the protection of the environment and the health of persons.

Selenium management plan update

After restart and commissioning of the McClean Lake mill in September 2014, AREVA identified an increasing trend in selenium concentration in the effluent from the JEB water treatment plant. The increase in concentrations in effluent was attributed to the milling of Cigar Lake ore. Although values remained well below the provincial limit of 0.6 mg/L, AREVA was proactive and implemented process improvements to control selenium including:

- an interim administrative level of 0.084 mg/L and action level of 0.112 mg/L; and
- a selenium adaptive management plan.

AREVA submitted a formal selenium adaptive management plan in March 2017 that included the following strategies:

- pollution prevention plan;
- best available technology economically achievable assessment plan; and
- active commissioning plan.

The selenium adaptive management plan outlines selenium-related continual improvement and adaptive management actions taken at the McClean Lake Operation such as changes to leaching and tailings preparation circuits, changes to the hydrogen peroxide concentration and delivery system and physical changes to improve hydrogen peroxide mixing.

CNSC staff reviewed the plan to verify that AREVA was taking adequate measures to manage and control selenium releases from the McClean Lake Operation, and to verify that the selenium adaptive management plan meets CNSC staff expectations. CNSC staff concluded that the plan meets regulatory requirements and was accepted in August 2017. CNSC staff continue to review reported selenium concentrations in effluent to ensure the receiving environment remains protected. This information is also provided to address the Commission request, as part of the 2017 McClean Lake licence renewal, to provide an update on the progress related to the selenium management program and selenium effluent at the McClean Lake Operation.

Assessment and monitoring

Environmental monitoring programs serve to demonstrate that the site emissions, wastes, tailings and effluent discharge of nuclear and hazardous substances are properly controlled at the McClean Lake Operation. CNSC staff review environmental effects monitoring information along with other routine or special investigations to ensure any impacts to the receiving environment and biota are identified. CNSC staff noted that AREVA had continued with routine site 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. CNSC staff assessed AREVA's environmental management system and monitoring programs at McClean Lake and concluded that they met regulatory requirements and the licensee complied with treated effluent discharge requirements during 2017.

The following provides monitoring and assessment results for the McClean Lake Operation.

Effluent and emissions control

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.
- Effluent, pumped to control the water level from the mined-out open pits, is treated in the Sue water treatment plant using a chemical precipitation and settling pond clarification process before being released to the Sink/Vulture Treated Effluent Management System.

The blended treated effluent is released in a controlled manner. Monitoring has verified ERA predictions supporting that this effluent poses no environmental concern. There were no action level exceedances associated with the JEB water treatment plant in 2017.

The Sue water treatment plant is operational only in summer months. In 2017, there were no action level exceedances associated with the Sue water treatment plant.

AREVA analyzed treated effluent for concentrations of various substances such as radium-226, arsenic, copper, lead, nickel, zinc, total suspended solids and pH at McClean Lake. As discussed in section 2.4, the McClean Lake Operation continues to meet *Metal Mining Effluent Regulations* (MMER) discharge limits.

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

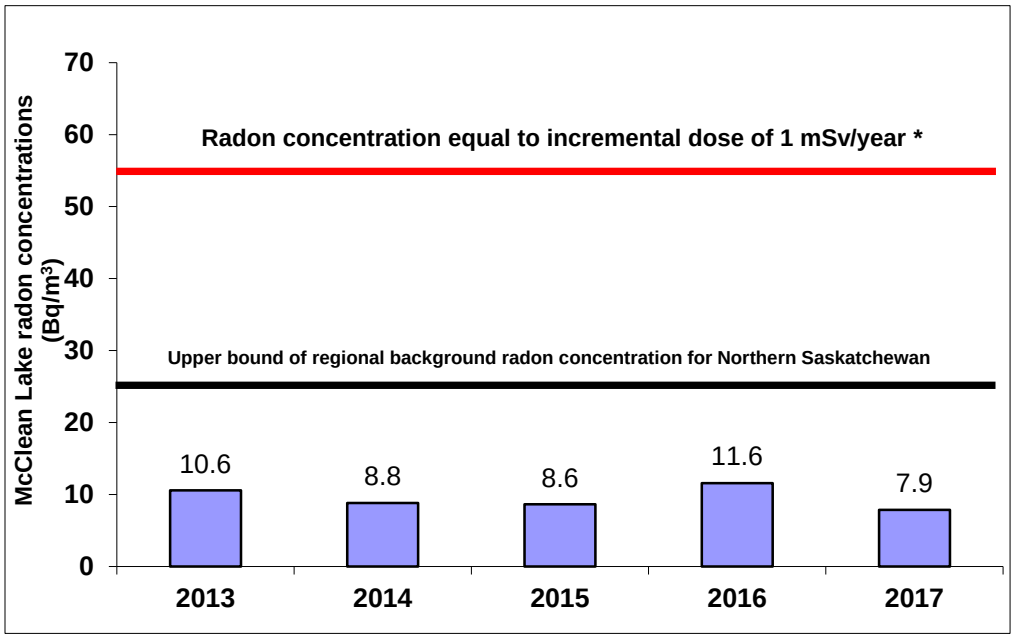
Air emissions released to the environment

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-etched 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 2013 to 2017. 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 - concentrations of radon in ambient air, 2013–17



* 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 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 2017 and well below the provincial standard of 60 µg/m^3.

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 reference annual air quality levels identified in table 7.2.

Table 7.2: McClean Lake - concentrations of metal and radionuclides in air, 2013–17

Parameter	Reference annual air quality levels*	2013	2014	2015	2016	2017
TSP (µg/m^3)	**60 (3)**	6.78	5.66	8.37	5.12	4.96
As (µg/m^3)	**0.06 (1)**	0.000226	0.000420	0.003070	0.000032	0.000432
Cu (µg/m^3)	**9.6 (1)**	0.036192	0.013888	0.019630	0.021613	0.017159
Mo (µg/m^3)	**23 (1)**	0.000657	0.000721	0.000892	0.000145	0.001028
Ni (µg/m^3)	**0.04 (1)**	0.000258	0.000420	0.000247	0.000259	0.000321
Pb (µg/m^3)	**0.10 (1)**	0.000422	0.000501	0.000368	0.000762	0.000406
Zn (µg/m^3)	**23 (1)**	0.005896	0.005939	0.005452	0.004703	0.003165
Pb^{210} (Bq/m^3)	**0.021 (2)**	0.000763	0.000277	0.000271	0.000285	0.000309
Po^{210} (Bq/m^3)	**0.028 (2)**	0.000159	0.000088	0.000083	0.000087	0.000100
Ra^{226} (Bq/m^3)	**0.013 (2)**	0.000013	0.000010	0.000008	0.000009	0.000014
Th^{230} (Bq/m^3)	**0.0085 (2)**	0.000000	0.000005	0.000005	0.000005	0.000006
U (µg/m^3)	**0.06 (1)**	0.000328	0.000576	0.001319	0.003138	0.002029

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

2 Reference level has been derived from ICRP Publication 96.

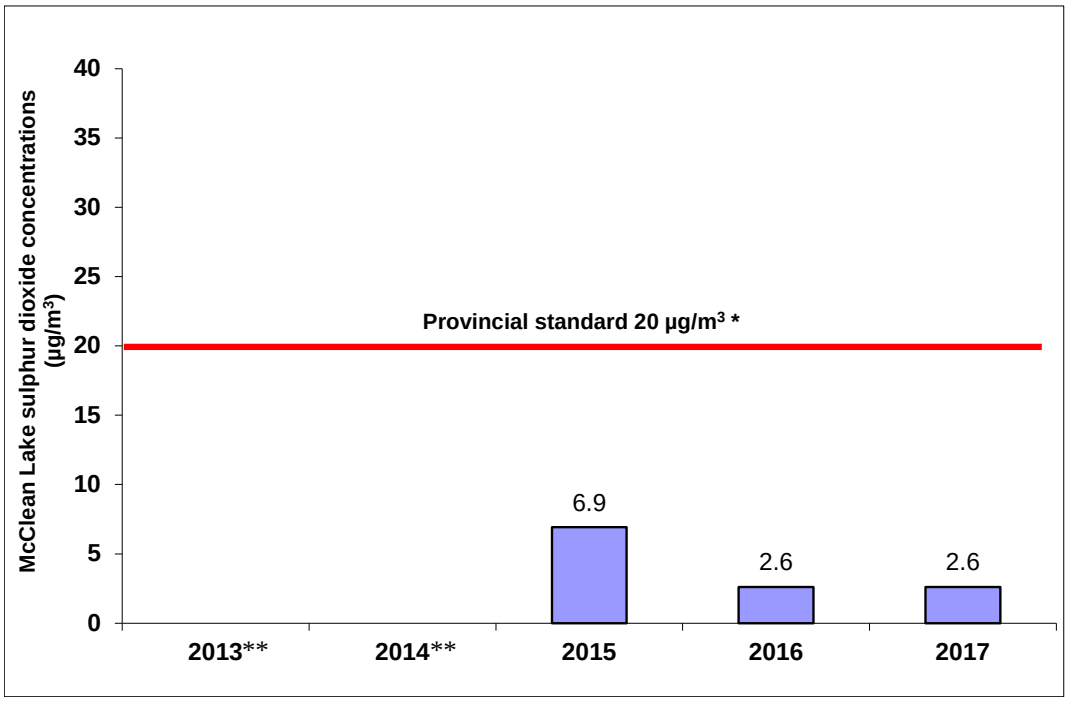
3 *Saskatchewan Environmental Quality Guidelines*, Table 20: Saskatchewan Ambient Air Quality Standards (µg/m^3). Values are calculated as geometric means.

* Province of Ontario and ICRP reference annual air quality levels are shown for reference only. No federal or provincial limits are currently established.

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 (figure 7.5) show no exceedances of the annual standard of 20 µg/m^3 in 2017.

Action levels have also been established for ambient sulphur dioxide concentrations. The 1-hour and 24-hour action levels are 0.170 parts per million (ppm) and 0.060 ppm, respectively. In 2017, there were two action level exceedance events for sulphur dioxide. These events were of short duration and were the result of acid plant start-ups. During acid plant start-up, until the plant reaches operating temperature, it is normal to have higher sulphur dioxide emissions. CNSC staff reviewed the follow-up reports and were satisfied with the corrective actions implemented by the McClean Lake Operation.

Figure 7.5: McClean Lake - concentrations of ambient sulphur dioxide, 2013–17



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

** 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.

AREVA'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.

Soil monitoring results from soil samples collected in 2015 are presented in the 2016 environmental performance report (EPR). The results show that the soil metal parameter concentrations were below the *Canadian Environmental Quality Guidelines* 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 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. Therefore, no changes are predicted to terrestrial habitat, both within and outside the site boundary. The elevated concentrations of contaminants within the site 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 is acceptable and does not pose a risk to browse (twigs and Labrador tea) and lichen consumers such as caribou.

Uncontrolled releases

In 2017, three events reported to CNSC staff were submitted as releases of hazardous substances to the environment:

- On January 12, 2017 approximately 2 litres of anhydrous ammonia leaked onto the ground during off-loading of the product.
- On June 26, 2017 approximately 1,000 litres of pond sludge at the surface access borehole resource extraction (SABRE) project site discharged to the ground while suctioning pond sludge into the hydrovac truck. Most of the material reported back to the pond.
- On August 29, 2017 approximately 50 kilograms of sulphuric acid discharged through the gap around the sump.

All three spills were minor and reporting met the requirements of RD/GD-99.3, *Public Information and Disclosure*. Appendix H describes the spills and corrective actions taken. Due to the actions taken by AREVA, 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 2017 spills as being of low significance.

Figure 2.5 in section 2 displays the number of environmental reportable spills that occurred at the McClean Lake Operation from 2013 to 2017.

Protection of the public

AREVA 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.

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

Based on their reviews of the programs at the McClean Lake Operation, CNSC staff concluded that the public continues to be protected from operation emissions.

7.4 Conventional Health and Safety

For 2017, CNSC staff continued to rate the conventional health and safety SCA as "satisfactory" based on regulatory oversight activities.

McClean Lake conventional health and safety ratings

2013	2014	2015	2016	2017
SA	SA	SA	SA	SA

SA = satisfactory

Practices

As required under the NSCA, AREVA 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 AREVA had an effective occupational health and safety committee and completes regular reviews of its safety program at McClean Lake.

AREVA's McClean Lake Operation investigates safety concerns and incidents, including near-miss events. In 2017, 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 AREVA's commitment to accident prevention and safety awareness with a focus on safety culture.

Performance

Table 7.3 shows that from 2013 to 2017, AREVA's McClean Lake Operation reported nine lost-time injuries (LTIs). There were no LTI's in 2017.

Table 7.3: McClean Lake - lost-time injury statistics, 2013–17

	2013	2014	2015	2016	2017
Lost-time injuries[1]	0	3	3	3	0
Severity rate[2]	0.0	4.3	27.7	10.9	67.8
Frequency rate[3]	0.0	0.4	0.4	0.6	0.0

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 The accident severity rate measures the total number of days lost to injury for every 200,000 person-hours worked at the site. Severity = [(# of days lost in last 12 months) / (# of hours worked in last 12 months)] x 200,000.
3 The accident frequency rate measuring the number of LTIs for every 200,000 person-hours worked at the site. Frequency = [(# of injuries in last 12 months) / (# of hours worked in last 12 months)] x 200,000.

In June 2017, CNSC staff reported the three 2016 LTIs during a Commission public hearing for the McClean Lake Operation licence renewal (CMD 17-H9).

The severity rate for McClean Lake LTI statistics is calculated from time lost in 2017 due to events occurring in previous years. An event that occurred in October 2014 resulted in a lost-time injury as a result of the worker experiencing respiratory health effects from being exposed to sulphur dioxide in the acid plant. In February, 2017 the worker was required to take time off work and has not yet returned to work. Another worker was exposed to ammonium sulphate in 2015 and experienced sensitivities to the chemical. As a result, this worker was required to take time off from July to December 2017.

Corrective actions, where necessary, were implemented with the effectiveness verified and documented by management. CNSC staff observed that AREVA strives to involve all levels of its organization in the health and safety program at McClean Lake. Employees are encouraged and trained to continuously identify and assess risks, and propose solutions.

Awareness

CNSC staff observed that conventional health and safety programs provide education, training, tools and support to ensure worker protection at McClean Lake. An active onsite occupational health and safety committee completes regular reviews of its 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 2017.

SECTION II: HISTORIC (REMEDIATING) AND DECOMMISSIONED URANIUM MINES AND MILLS

8 OVERVIEW

Section II of this report provides information on the four active remediation projects and nine decommissioned uranium mine and mill sites (figure 8.1). The objective of active remediation projects is to establish long-term, stable conditions that ensure the safe use of each site by current and future generations. Wherever possible, the remediation plans aim to return historic uranium mines and mills to previously existing environmental conditions or to land uses that will be sustainable in the long term. Active remediation projects consist of ongoing clean-up activities, full-time staff, and contractor management in different areas as well as frequent monitoring and reporting.

Figure 8.1: Location of historic and decommissioned sites in Canada

There are four sites currently undergoing remediation:

- Gunnar legacy uranium mine
- Lorado uranium mill
- Deloro mine
- Madawaska legacy uranium mine

The remaining nine sites have been decommissioned for several years and are currently in the long-term monitoring and maintenance phase:

- Beaverlodge mine and mill
- Cluff Lake uranium mine and mill
- Rayrock mine
- Port Radium mine
- Agnew Lake uranium mine
- Bicroft tailings storage facility
- Dyno closed mine
- Elliot Lake historic sites
- Denison and Stanrock mining facilities

8.1 CNSC Regulatory Efforts

CNSC staff provide risk-informed regulatory oversight of licensed activities at the active remediation projects and decommissioned sites. According to CNSC staff's risk-informed baseline inspection plan, all remediation projects and seven of nine decommissioned sites are required to have a minimum of one inspection per year. The Rayrock and Port Radium mine sites are inspected once every three years. Inspections for these two sites were completed in June 2016, as per CNSC staff's baseline compliance verification plan.

Table 8.1 presents CNSC staff's licensing and compliance efforts for the remediation projects and decommissioned sites in 2016 and 2017. CNSC staff performed 18 compliance inspections in 2016 and 12 compliance inspections in 2017 at these sites. Findings resulting from these inspections were provided to the licensees in detailed inspection reports. All enforcement actions arising from the findings were recorded in the CNSC regulatory information bank to ensure they are tracked to completion. CNSC staff reviewed and verified that the licensees' corrective actions taken were appropriate and acceptable. All non-compliances issued in 2016 and 2017 are considered closed by CNSC staff. Details of enforcement actions are provided in the following sections.

Table 8.1: CNSC regulatory oversight licensing and compliance activities for remediating and decommissioned sites, 2016–17

Site	2016			2017		
	Number of inspections	Compliance activities effort (person days)	Licensing activities effort (person days)	Number of inspections	Compliance activities effort (person days)	Licensing activities effort (person days)
Gunnar	1	59	71	1	53	17
Lorado	1	18	8	1	24	0
Deloro	2	85	31	2	41	80
Madawaska	1	20	0	0 **	2	1
Beaverlodge	1	39	18	1	59	7
Cluff Lake	1	70	25	1	69	71
Rayrock	1	8	1	0*	5	42
Port Radium	1	31	10	0*	8	1
Agnew Lake	1	6	1	1	12	2
Bicroft	1	6	0	1	19	0
Dyno	1	9	0	1	7	0
Elliot Lake	2	60	1	1	22	4
Denison	2	25	2	1	7	0
Stanrock	2	28	1	1	7	0

* Baseline compliance inspections are planned every three years. Inspection was completed in 2016. Next inspection planned in 2019.

** Inspection deferred to 2018/2019 due to poor weather conditions and ongoing maintenance onsite.

Licensing information for each site is found in appendix A.

The CNSC requires licensees to develop decommissioning plans for each site. Each plan, reviewed and approved by CNSC staff, is accompanied by a financial guarantee that provides the funding necessary to complete all decommissioning work. For sites that have been decommissioned, financial guarantees are still required to support monitoring and care and maintenance of the site.

The values of the financial guarantees for the historic and decommissioned sites are listed in appendix F.

8.2 Performance

The CNSC requires each licensee, as per their CNSC licence, to submit an annual compliance report which contains information pertaining to licensees' performances in the applicable safety and control areas (SCAs). CNSC staff review these reports to verify licensees are complying with their regulatory requirements and are operating safely. These reports are available on licensees' websites as applicable, and references to these websites are provided in appendix L of this report.

CNSC staff used licensee compliance reports, revisions to licensee programs, responses to events and incidents by licensees, as well as CNSC staff inspections to compile the performance ratings for the active remediation projects and decommissioned sites.

The following SCAs are not rated for any of the remediation projects and decommissioned sites:

- Human performance management is not applicable due to the routine monitoring and maintenance activities carried out at decommissioned mine and mill sites.
- Safety analysis has been completed at the licensing stage and is used throughout the lifecycle of each site. Due to the static nature of the sites, new safety analyses are not required.
- Waste management is not applicable as the authorized licence activities are all related to the management of wastes for the decommissioned sites.
- Safeguards and non-proliferation is not applicable because each site has been decommissioned and the risk for intervention is very low. Licensees are required to provide reasonable services and assistance to the International Atomic Energy Agency (IAEA) inspectors to carry out their duties and functions. During the 2016 and 2017 calendar year, there were no requests by IAEA inspectors to inspect any of these sites.
- Packaging and transport is not applicable to these sites because they do not ship radioactive materials.
- Operating performance was not rated as sites undergoing remediation and decommissioned sites are not operating.

The remaining applicable SCAs are presented in tables 8.2, 8.3 and 8.4 along with the rating for each site. Appendix E contains the applicable SCA performance ratings from 2015 to 2017 for the historic and remediating mines and mill sites.

For 2016 and 2017, CNSC staff rated all applicable SCAs as "satisfactory" for all but one remediation project and three decommissioned sites. For the year 2016, Rayrock, Port Radium and Agnew Lake mines were rated "below expectations" in the radiation protection SCA (see sections 15 to 17 for additional information). For 2017, Elliot Lake historic sites were rated "below expectation" in the environmental protection SCA (see section 20 for more information).

Table 8.2: Applicable SCA performance ratings for active remediation sites, 2016–17

Safety and control area	Gunnar	Lorado	Madawaska	Deloro
Management system	SA	SA	SA	SA
Physical design	SA	SA	SA	SA
Radiation protection	SA	SA	SA	SA
Conventional health and safety	SA	SA	SA	SA
Environmental protection	SA	SA	SA	SA
Emergency management and fire protection	SA	SA	SA	SA
Security	SA	SA	SA	SA

SA = satisfactory

Table 8.3: Applicable SCA performance ratings for decommissioned sites, 2016

Safety and control area	Beaverlodge	Cluff Lake	Rayrock	Port Radium	Agnew Lake	Bicroft	Dyno	Elliot Lake	Denison and Stanrock
Radiation protection	SA	SA	BE*	BE*	BE*	SA	SA	SA	SA
Conventional health and safety	SA	SA	SA	SA	SA	SA	SA	SA	SA
Environmental protection	SA	SA	SA	SA	SA	SA	SA	SA	SA

BE = below expectations SA = satisfactory
*See sections 15 to17

Table 8.4: Applicable SCA performance ratings for decommissioned sites, 2017

Safety and control area	Beaverlodge	Cluff Lake	Rayrock	Port Radium	Agnew Lake	Bicroft	Dyno	Elliot Lake	Denison and Stanrock
Radiation protection	SA	SA	SA	SA	SA	SA	SA	SA	SA
Conventional health and safety	SA	SA	SA	SA	SA	SA	SA	SA	SA
Environmental protection	SA	SA	SA	SA	SA	SA	SA	BE*	SA

BE = below expectations SA = satisfactory
* See section 20

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

8.3 Radiation Protection

The radiation protection SCA covers the implementation of a radiation protection program in accordance with the *Radiation Protection Regulations*. This program must ensure that contamination levels and radiation doses received by individuals are monitored, controlled and maintained as low as reasonably achievable (ALARA).

Radiological hazard control

Sources of radiation exposure at remediated and decommissioned sites include:

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

CNSC staff verification activities found that the licensees control these hazards through the effective use of time, distance and shielding, contamination control and personal protective equipment.

Radiation protection performance

CNSC staff conducted regulatory oversight activities in the area of radiation protection at all remediation projects and decommissioned sites during 2016 and 2017 in order to verify compliance of the licensees' performance against regulatory requirements.

Overall, CNSC staff concluded the active remediation projects and decommissioned site licensees had adequate radiation protection practices identified for the work activities being conducted in 2016 and 2017, and for ensuring the protection of health and safety of persons working at their sites.

Worker dose control

The maximum and average effective doses for nuclear energy workers (NEWs) at historic and decommissioned sites are provided in tables G-8 and G-9 in appendix G. The only sites currently with workers designated as NEWs are Gunnar, Deloro, Madawaska, Elliot Lake and Denison and Stanrock. In 2016, the maximum exposure of NEWs at these sites ranged from 0.6 mSv to 1.02 mSv. In 2017, the maximum exposure of NEWs at these sites ranged from 0.61 mSv to 1.37 mSv, all well below the regulatory dose limit of 50 mSv per year and 100 mSv in a five year dosimetry period.

Annual effective doses for NEWs are based on different work conditions and environments. Therefore, direct comparisons of effective doses among sites do not necessarily provide appropriate measures of the effectiveness of radiation protection programs.

Appendix G shows the corresponding effective doses and maximum individual effective doses at each of the remediating sites and facilities with workers onsite.

There were no workers designated as NEWs at the Beaverlodge, Cluff Lake, Rayrock, Port Radium, Agnew Lake, Bicroft and Dyno sites.

Application of ALARA

The CNSC requirement to apply the ALARA principle has consistently resulted in doses well below regulatory dose limits. Based on the review of the dose data provided above and the work activities conducted at remediation projects and decommissioned sites, CNSC staff are satisfied that all licensees are controlling radiation doses below regulatory dose limits for NEWs, and in accordance with the ALARA principle.

Estimated dose to the public

The maximum dose to the public from licensed activities at each of the remediation projects and decommissioned sites is based on a human health risk assessment and supported with monitoring data. Doses to the public from all sites continue to be well below the regulatory annual public dose limit of 1 mSv due to the limited site accessibility; this is confirmed through dose readings obtained during CNSC compliance inspections.

8.4 Environmental Protection

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

With the exception of Elliot Lake which was rated "below expectations" for the environmental protection SCA due to an exceedance of a monthly licence limit (section 20), CNSC staff rated the 2016 and 2017 performance of all remediation projects and decommissioned sites for the environmental protection SCA as "satisfactory".

In 2016 and 2017, environmental protection programs were effectively implemented and met regulatory requirements for all remediation projects and decommissioned sites. There were no exceedances of effluent discharge limits with the exception of Elliot Lake historic sites due to the exceedance of radium-226 at the Stanleigh effluent treatment plant (section 20). Despite the exceedance at Elliot Lake, the environment remains protected as CNSC staff requested the licensee to increase water quality monitoring and toxicity testing for aquatic biota. The sampling results, and a subsequent reactive inspection by CNSC staff, confirmed that the exceedance did not result in any radiological impacts to members of the public or the environment.

Water quality objectives

Water quality is typically compared to the *Canadian Water Quality Guidelines for the Protection of Aquatic Life, Health Canada's Drinking Water Guidelines* and/or to provincial levels where applicable. For example, for sites in Saskatchewan, water quality is compared to the province's *Surface Water Quality Objectives*. In some cases, there are site-specific objectives that are based on risk assessments at the time of licensing. Water quality objectives for each site are provided in their respective sections.

8.5 Conventional Health and Safety

The conventional health and safety SCA covers the implementation of programs to manage workplace safety hazards and to protect workers and equipment.

For 2016 and 2017, CNSC staff rated the conventional health and safety SCA at sites undergoing remediation and decommissioned sites as "satisfactory".

Practices

Each licensee is responsible for developing and implementing a conventional health and safety program for the protection of its staff and contract workers, which must comply with Part II of the *Canada Labour Code*. CNSC staff reviewed licensee annual reports and conducted site inspections where safety practices were observed. CNSC staff concluded that licensees implemented their conventional health and safety programs satisfactorily during 2016 and 2017, and their programs were effective in protecting the health and safety of persons working in their facilities.

Performance

A key performance measure for conventional health and safety is the number of lost-time injuries (LTIs) 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. There were no LTIs at the remediation projects and decommissioned sites during 2016 and 2017.

SECTION II-A: HISTORIC (REMEDIATING) URANIUM MINES AND MILLS

This section provides information on CNSC's oversight of four active remediation projects of historic uranium mine and mill sites in Saskatchewan and Ontario.

9 GUNNAR

The Gunnar legacy uranium mine site is located approximately 600 kilometres north of Saskatoon, on the north shore of Lake Athabasca in northwest Saskatchewan.

Gunnar was a commercial uranium mine that operated from 1955 to 1963. The site closed in 1964 with little decommissioning performed. The former uranium mine and mill is being remediated by the Saskatchewan Research Council (SRC). Following a November 2014 public hearing, the Commission issued SRC a waste nuclear substance licence for the Gunnar Remediation Project. SRC's licence is valid until November 30, 2024.

The remediation project consists of the clean-up of mine tailings, waste rock piles (figure 9.2), an open pit, a mine shaft and demolition debris. The remediation work is being carried out in three phases. Phase 1, which is now complete, involved characterizing and monitoring the onsite waste and developing remediation plans. Phase 2, which is ongoing, consists of implementing the remediation plans. Phase 3 will be the long-term monitoring and maintenance to ensure the site remains stable and safe.

When issued by the Commission, the CNSC licence for the Gunnar Remediation Project included a regulatory hold point for phase 2. Following a public hearing in September 2015, the Commission removed part of the Gunnar Remediation Project phase 2 hold point to allow for the remediation of the site's tailings area. A subsequent public Commission hearing was held on September 22, 2016 at SRC's request to remove the remainder of the hold point and authorize the remediation of the waste rock piles, open pit, mine shaft and demolition debris.

In 2016 and 2017, work conducted at the Gunnar site consisted of:

- procurement of a contractor to conduct tailings remediation work;
- initial mobilization and preparation for remediation activities;
- development of borrow areas and haul road construction;
- grading of Gunnar main tailings surface;
- excavation and placement of waste rock on Gunnar main tailings (figures 9.1 and 9.2); and
- planning for other clean-up aspects at the Gunnar site.

Figure 9.1: Gunnar - aerial view of main tailings, 2018

Figure 9.2: Gunnar - moving waste rock at site, 2017

9.1 Performance

For 2016 and 2017, CNSC staff were satisfied with SRC's performance at the Gunnar site in the radiation protection, conventional health and safety, environmental protection, security, and emergency management and fire protection SCAs. Details to support CNSC staff's ratings are provided below.

The CNSC's baseline inspection plan for 2016 and 2017 required CNSC staff to conduct one site inspection per year at the Gunnar site. CNSC staff conducted inspections of the site during the month of August, both in 2016 and 2017. The inspectors found that overall SRC was in compliance with their licence, with the exception of labelling radioactive material and controlling radiation zones. As a result of these non-compliances of low-safety significance, enforcement notices were issued to SRC who took immediate steps to correct the non-compliances; CNSC staff verified and closed the enforcement actions.

9.2 Radiation Protection

For 2016 and 2017, CNSC staff rated the radiation protection SCA as "satisfactory".

2016	2017
SA	SA

SA = satisfactory

Radiation protection program performance

CNSC staff reviewed radiation protection plans, worker dose records and radiation surveys submitted by SRC and conducted inspections at the Gunnar site. As a result, CNSC staff are satisfied with SRC's implementation of its radiation protection program at the Gunnar site in 2016 and 2017.

Worker dose control

In 2016 and 2017, workers onsite for total periods exceeding four weeks were classified as NEWs and assigned appropriate dosimetry. In 2016, all workers onsite received a dose of less than the annual public dose limit. The maximum dose received by a NEW was 0.6 mSv. In 2017, of the 98 workers onsite, 4 percent (4 people) received a dose greater than the public dose limit of 1 mSv/year. The maximum individual effective dose received by a worker was 1.37 mSv. All reported doses were below SRC's action levels (2.5 mSv/month), as well as below the CNSC's regulatory dose limit of 50 mSv per year and 100 mSv in a five year dosimetry period for workers designated as NEWs.

Passive radon emissions are monitored in the air. The radon monitored at the perimeter of the Gunnar site for 2016 and 2017 was within natural background levels and therefore contributed a negligible dose to workers. CNSC staff reviewed the results and confirmed that adequate radon monitoring is conducted to verify the public is protected. Long-lived radioactive dust is also monitored; CNSC staff reviewed the results and confirmed that workers are protected.

9.3 Environmental Protection

For 2016 and 2017, CNSC staff rated the environmental protection SCA as "satisfactory".

2016	2017
SA	SA

SA = satisfactory

Assessment and monitoring

CNSC staff verified that SRC has maintained an environmental protection program that ensures the protection of the public, and an environmental monitoring program that measures existing conditions at the site.

SRC performed semi-monthly surface water and groundwater monitoring and analyses over the 2016 and 2017 field seasons (May through October). CNSC staff reviewed the results of these analyses and found they were consistent with the previous year and with the 2014 Gunnar Environmental Impact Statement.

There is no liquid effluent at the Gunnar site; however, there is overland flow and seepage from the site into local water bodies.

In addition to water quality and air monitoring, during the construction phase, SRC hired an independent contractor who walked the site daily to identify any potential impacts to the environment to ensure compliance of the primary contractor.

CNSC staff are satisfied that SRC has maintained an environmental protection program to ensure the protection of the public and to establish baseline conditions for the site prior to remediation.

9.4 Conventional Health and Safety

For 2016 and 2017, CNSC staff rated the conventional health and safety SCA as "satisfactory".

2016	2017
SA	SA

SA = satisfactory

Health and safety program performance

CNSC staff confirmed that SRC's health and safety program is implemented effectively and employs the good practices of awareness, training, communication and reporting. Examples of these practices include daily toolbox meetings in which health and safety risks are assessed and health and safety meetings to discuss broader health and safety issues onsite.

This site has an active monitoring and reporting program for LTIs. There have been no LTIs at the Gunnar site in the reporting period of 2016 and 2017.

CNSC staff are satisfied with SRC's performance in the area of conventional health and safety for the Gunnar site.

10 LORADO

The Lorado tailings management site is located eight kilometres south of Uranium City, Saskatchewan (figure 10.1).

The Lorado uranium mill operated from 1957 to 1960 and was abandoned in the 1960s without any decommissioning or remedial work. The Province of Saskatchewan now has ownership of the site under the Saskatchewan Ministry of the Economy. The ministry has subsequently appointed the Saskatchewan Research Council (SRC) as the project manager to oversee the ongoing management and remediation of the Lorado site. Issued in 2014, SRC's waste nuclear substance licence for Lorado is valid until April 30, 2023.

Figure 10.1: Lorado – soil and vegetative cover on tailings area, 2017

SRC had completed remediation of the Lorado site which consisted of covering the mine tailings with an engineered cover, water treatment of Nero Lake to neutralize acidity, and reduce contaminant concentrations and environmental monitoring. In 2016, SRC completed the placement of till in the remaining areas of the cover, installed riprap on the shore of Nero Lake and initiated the revegetation of the cover. This concludes the active remediation activities planned for Lorado. In 2017, SRC continued to monitor the local environment and the progress of the revegetation of the cover.

The next step for the site is to transition to the long-term monitoring phase which is planned for 2018 or 2019. CNSC staff performed a review of the as-built plans for the remediation. The long-term objective is to transfer the remediated safe and stable site into the Saskatchewan Institutional Control Program after a period of 10 to 15 years post remediation.

10.1 Performance

As a result of the findings of desktop reviews and general compliance inspections, CNSC staff are satisfied with SRC's performance in 2016 and 2017 at the Lorado tailings management site in the applicable SCAs of radiation protection, conventional health and safety and environmental protection.

CNSC staff conducted inspections of the Lorado tailings management site in 2016 and 2017 and verified that SRC was in compliance with their licence. No compliance actions were issued as a result of the inspections.

10.2 Radiation Protection

For 2016 and 2017, CNSC staff rated the radiation protection SCA as "satisfactory".

2016	2017
SA	SA

SA = satisfactory

Worker dose control

For 2016, as the remediation work had been completed, all personnel at the Lorado site were treated as non-NEWs due to the very low radiation hazard risk. Gamma surveys, conducted upon the completion of remediation activities in 2016, showed that the average dose rate on the covered tailings was 0.14 µSv/hr. Radon and long-lived radioactive dust were also monitored onsite and found to pose a negligible radiation risk. In 2017, there were no workers or contractors on the Lorado site.

Due to the low dose rates on the covered tailings and short periods of time spent by workers on the site in 2016, the previously existing dosimetry program that was in place during the remediation was discontinued.

10.3 Environmental Protection

For 2016 and 2017, CNSC staff rated the environmental protection SCA as "satisfactory".

2016	2017
SA	SA

SA = satisfactory

Assessment and monitoring

SRC's environmental program ensures the environment and health and safety of persons are protected by identifying, controlling and monitoring all potential releases from remediation activities.

There is no liquid effluent at the Lorado site. SRC's environmental sampling program includes measurement of surface water concentrations for metals, radionuclides and general water quality parameters in local lakes and groundwater. CNSC staff verified that SRC conducted surface water monitoring at several locations to confirm water quality improvement in Nero Lake and Hanson Bay following the placement of the cover on the tailings. As more data is collected over time at the site, the effectiveness of the remediation works can be verified. The public has also been advised of those water bodies where fish consumption should be limited due to elevated selenium levels as a result of past mining and milling activities at the Beaverlodge site and milling at the nearby Lorado site.

10.4 Conventional Health and Safety

For 2016 and 2017, CNSC staff rated the conventional health and safety SCA as "satisfactory".

2016	2017
SA	SA

SA = satisfactory

Health and safety program performance

CNSC staff confirmed through inspections that SRC's health and safety program is implemented effectively and employs the good practices of awareness, training, communication and reporting. With the completion of the remediation work in early 2016 and no personnel remaining onsite, there were no LTIs reported for the 2016 or 2017 reporting period.

For 2016 and 2017, CNSC staff were satisfied with SRC's performance in the area of conventional health and safety for the Lorado site. CNSC staff have concluded this on the basis of desktop reviews of quarterly and annual reports and compliance inspections.

11 DELORO

The Deloro mine site is located approximately 65 kilometres east of Peterborough, Ontario. This site was an abandoned gold mine where metallurgical and refining processes related to the production of cobalt oxides and metal, and the extraction of silver, nickel and arsenic took place (figure 11.1).

Figure 11.1: Deloro - aerial view of Young's Creek Area (cell and sediment removal area), 2017 photo provided by MOECC

In 2017, the CNSC issued the Ontario Ministry of Environment and Climate Change (MOECC), now known as Ontario's Ministry of the Environment, Conservation and Parks, a waste nuclear substance licence to continue remediation work at the Young's Creek Area of the Deloro site as work at both the industrial and mine area and tailing management area are complete. The MOECC provided information in support of demonstrating that both areas were below conditional clearance levels. These two areas are now removed from licensing and the footprint of the site now only includes the Young's Creek Area. The Deloro licence is valid until October 31, 2022.

11.1 Performance

For 2016 and 2017, CNSC staff were satisfied with the MOECC's performance for the SCAs of physical design, radiation protection, environmental protection, conventional health and safety, emergency management and fire protection, security and management systems. An update was provided in the *Regulatory Oversight Report for Uranium Mines and Mills: 2016* (CMD 17-M47) explaining the change in rating for the management system SCA. CNSC staff verified the corrective measures and improvement undertaken by the licensee through inspections and other compliance verification and now rate the licensee's performance as "satisfactory" in this SCA.

11.2 Radiation Protection

For 2016 and 2017, CNSC staff rated the radiation protection SCA as "satisfactory".

2016	2017
SA	SA

SA = satisfactory

Radiation protection program performance

In 2016 and 2017, MOECC satisfactorily maintained a radiation protection program that ensured the protection of the workers and the public. Each contractor also has a specific radiation protection program for each clean-up project. All contractors and visitors attended radiation protection training prior to going onsite. In 2016 and 2017, CNSC staff verified that the licensee ensured that radiation protection training and records were up to date and maintained according to an approved dosimetry program.

Worker dose control

Contractors who are designated NEWs onsite either wore thermoluminescent dosimeters or electronic personal dosimeters, depending on the tasks assigned to them. The average individual effective dose to Deloro mine site NEWs was less than 0.1 mSv; the maximum individual effective dose was 0.35 mSv in 2016. In 2017, as the work on the cover at the Industrial Mine Area was completed, the previously existing dosimetry program that was in place during the remediation was discontinued due to low dose rates.

For 2016 and 2017, CNSC staff were satisfied with the MOECC's radiation protection program for the Deloro site.

11.3 Environmental Protection

For 2016 and 2017, CNSC staff rated the environmental protection SCA as "satisfactory". CNSC staff were satisfied that the MOECC maintained an environmental protection program that ensured the protection of the environment.

2016	2017
SA	SA

SA = satisfactory

Assessment and monitoring

The environmental monitoring program at the Deloro site includes monitoring of surface water and groundwater for radiological and non-radiological (hazardous) contaminants. Since 2011, the licensee has been responsible for enhanced environmental monitoring including air quality, noise, archaeological and biological monitoring. The licensee also ensures healthy habitat and suitable conditions for all resident fish and wildlife.

MOECC's surface water monitoring program consists of the collection and analysis of up to 22 sampling locations in and near the site. CNSC staff reviewed the 2016 and 2017 surface water results for radionuclides, which showed all samples were well below Health Canada's *Canadian Drinking Water Guidelines*. The main contaminant of concern at the site is arsenic, concentrations of which exceeded the CCME *Canadian Environmental Quality Guidelines* for assessing non-radiological contaminants in surface water in Young's Creek in 2016 and 2017. This finding is consistent with those in previous years. The concentration of arsenic is expected to decrease following completion of all remediation activities.

The site has a number of groundwater monitoring wells throughout the property. All radionuclides in groundwater were well below the *Ontario Drinking Water Quality Standards* (ODWQS).

Protection of the public

CNSC staff are satisfied that the MOECC had adequate measures in place at the Deloro site to protect the public and the environment from releases from its facility due to water treatment as well as the fact that the site is fenced off preventing access to the public.

Independent Environmental Monitoring Program

To complement ongoing compliance activities, the CNSC implements an Independent Environmental Monitoring Program (IEMP) to independently verify that all persons and the environment around licensed nuclear facilities are protected. The IEMP involves taking samples from public areas around the facilities, measuring and analyzing the amount of radioactive and hazardous substances in those samples. CNSC staff conducted independent environmental monitoring around the Deloro mine site in 2016. This included sampling locations along Young's Creek and the Moira River downstream from the site. The results are available on the CNSC's IEMP Web page. The IEMP results indicate that all persons and the environment in the vicinity of the Deloro site are protected, and there are no health impacts as a result of site activities.

11.4 Conventional Health and Safety

For 2016 and 2017, CNSC staff rated the conventional health and safety SCA as "satisfactory".

2016	2017
SA	SA

SA = satisfactory

Health and safety program performance

CNSC staff confirmed during an inspection that the MOECC's health and safety program is implemented effectively and employs the good practices of awareness, training, communication and reporting. Occupational health and safety training is required for everyone who requires to access to the site, including contractors and visitors. CNSC staff are provided with this training on an annual basis.

This site has an active monitoring and reporting program for lost-time injuries. There were no LTIs at the Deloro site in 2016 and 2017.

For 2016 and 2017, CNSC staff were satisfied with the MOECC's performance in the area of conventional health and safety for the Deloro site.

12 MADAWASKA

Madawaska, a legacy uranium mine located near Bancroft, Ontario, operated between 1957 to 1982 and was decommissioned in the 1980s. EWL Management Ltd. (EWL) is the licensee of the Madawaska mine site under a CNSC waste nuclear substance licence. The licence was issued on July 4, 2011 and is valid until July 31, 2021. For the foreseeable future, the site will remain under long-term monitoring and maintenance.

The site includes the footprint of the mining operation, a number of capped and sealed openings, underground workings and four tailings dams (figure 12.1).

Figure 12.1: Madawaska – Bentley Creek Dam

In 2016 and 2017, EWL continued rehabilitation/maintenance work on the two tailings management areas (TMA). In 2017 the rehabilitation work at TMA 2 was completed and approximately one-third of the area at TMA 1 was carried out. The new design contains features to reduce radon flux and increase the long term physical stability of the TMA. In addition, the maintenance work has eliminated any potential water ponding issues, decreased erosion and reduced future maintenance and monitoring requirements. A geotechnical inspection of the site is planned for the fall of 2018 to inspect the rehabilitated areas. The rehabilitation work at TMA 1 will be completed in 2019.

12.1 Performance

For 2016 and 2017, CNSC staff were satisfied with EWL's performance at Madawaska in the radiation protection, environmental protection, and conventional health and safety SCAs. EWL's performance over the reporting period of 2016 and 2017 has been stable and met the *Nuclear Safety and Control Act* (NSCA) requirements and its associated regulations.

In 2016 CNSC staff found the site was well managed and had no compliance issues. No enforcement actions were issued as a result of the inspection conducted in 2016. The baseline compliance inspection scheduled for 2017 was deferred to 2018 due to poor weather conditions and ongoing maintenance of the site.

12.2 Radiation Protection

For 2016 and 2017, CNSC staff rated the radiation protection SCA as "satisfactory".

2016	2017
SA	SA

SA = satisfactory

Radiation protection program performance

For maintenance activities on the tailings, CNSC staff verified EWL had an effective radiation protection program in place and all NEWs at the Madawaska site followed appropriate dosimetry programs. The reported doses were below the licensee's investigation levels and action levels, as well as below the regulatory limit of 50 mSv per year and 100 mSv in a five year dosimetry period.

Worker dose control

Contractors who are designated NEWs onsite either wore thermoluminescent dosimeters or electronic personal dosimeters, depending on the tasks assigned to them. In 2017, the average individual effective dose to NEWs at the Madawaska site was less than 0.07 mSv; the maximum individual effective dose was 0.61 mSv.

12.3 Environmental Protection

For 2016 and 2017, CNSC staff rated the environmental protection SCA as "satisfactory". EWL satisfactorily maintained an environmental protection program to ensure the protection of the environment at the Madawaska site.

2016	2017
SA	SA

SA = satisfactory

Concentrations in some water bodies adjacent to the site exceeded the *Canadian Water Quality Guidelines for the Protection of Aquatic Life* for uranium in 2016 and 2017. These measurements are consistent with those from previous years (i.e., the highest value measured was 50 µg/L in Bow Lake compared to water quality objective of 15 µg/L). Risk assessments conducted in 2012 concluded that those values would not result in adverse effects on any species of aquatic life from exposure to those concentrations in surface water, sediment and groundwater associated with the Madawaska decommissioned site. However, with the improvements to water flow and the new cover system partially completed for the site, future results should demonstrate that migration of contaminants into the surrounding environment have been limited.

CNSC staff are satisfied that EWL had adequate measures in place to protect the public and the environment from releases from the Madawaska site.

12.4 Conventional Health and Safety

For 2016 and 2017, CNSC staff rated the conventional health and safety SCA as "satisfactory".

2016	2017
SA	SA

SA = satisfactory

Health and safety program performance

CNSC staff confirmed that EWL's health and safety program is implemented effectively and employs the good practices of awareness, training, communication and reporting.

CNSC staff also verified that EWL has a robust health and safety program and all contractors and visitors were required to complete the site specific occupational health and safety training.

This site has an active monitoring and reporting program for LTIs. There have been no LTIs at the Madawaska site in the reporting period of 2016 and 2017.

CNSC staff are satisfied with EWL's performance in the area of conventional health and safety for the Madawaska site.

SECTION II-B: DECOMMISSIONED URANIUM MINES AND MILLS

Section II-B describes the nine uranium mine and mill sites that have been decommissioned and are in the long-term maintenance and monitoring phase. In general, given the limited nature of onsite work, outdoor setting and low radiation levels following remediation activities, the potential for radiation exposure to workers and the public is very low. In addition, CNSC staff have reviewed the risk assessments and monitoring data for all decommissioned sites and concluded that levels of exposure are much lower than regulatory radiation limits to non-NEWs. The doses for all NEWs performing monitoring, maintenance or visits to site were well below regulatory dose limits. The SCA rating for radiation protection for all decommissioned sites was “satisfactory” in 2016 and 2017 with the exception of Rayrock, Port Radium and Agnew Lake mines which were rated “below expectations” in 2016. Additional information regarding the ratings for these three sites is provided in sections 15, 16 and 17, respectively.

Activities at decommissioned sites involve routine monitoring and maintenance work. In most cases there are no permanent staff onsite. All sites maintain effective occupational health and safety programs that protect workers, contractors and visitors. The SCA rating for conventional health and safety at all sites was “satisfactory” in 2016 and 2017.

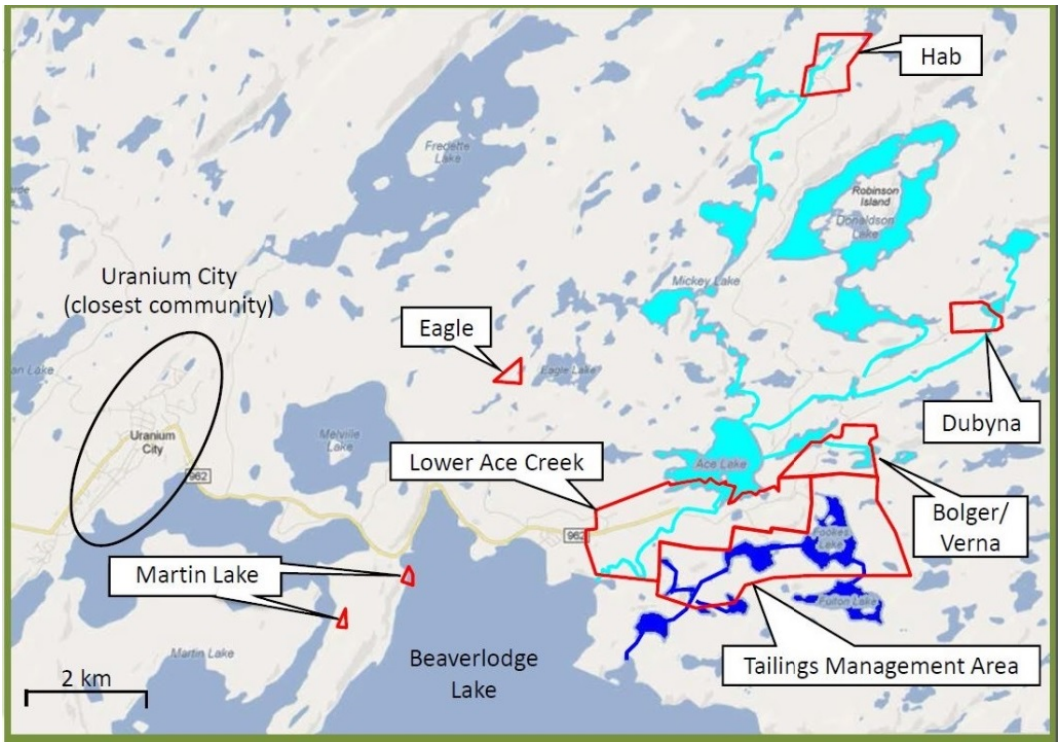
The environmental protection SCA is a key indicator for the effectiveness of past remediation measures and is highlighted for each site in this report. All decommissioned sites have environmental monitoring programs to ensure the continued protection of the environment and ongoing performance of remediation works. Once long-term environmental objectives for the site have been met, these sites may be released into institutional control or conditionally released from regulatory oversight. The SCA rating for environmental protection at all sites was “satisfactory” in 2016 and 2017. The only exception is a “below expectations” rating at the Elliot Lake historic sites for 2017. The following sections provide information about each decommissioned site, including any changes that occurred to the site in 2016 and 2017.

13 BEAVERLODGE

Beaverlodge was last reported on in the *Regulatory Oversight Report for Uranium Mines and Mills in Canada: 2016*; since then, there have been no significant changes to the site and the site remains stable. Activities at the site have focused on preparing various properties for eventual transfer to the Saskatchewan Institutional Control Program.

The decommissioned Beaverlodge uranium mine and mill site is located near Uranium City in northwest Saskatchewan (figure 13.1).

Figure 13.1: Beaverlodge - overview



Mining and milling activities began at the Beaverlodge site in 1952. The mine closed in 1982 and the site was decommissioned. The Beaverlodge site consisted of a central mill, underground mine and a tailings management area (TMA). The TMA is located on the Fulton Creek watershed (shown in dark blue in figure 13.1 and shown again in figure 13.2). There are also several smaller satellite mines that provided ore during the three decades of operation. Decommissioning commenced shortly after operations ended and was completed to the standards in place at the time of decommissioning (i.e., in 1985). Beaverlodge was the first uranium site in Canada to submit a formal decommissioning plan and be decommissioned under an Atomic Energy Control Board licence. On behalf of the federal government, Cameco Corporation is the licensee and manages the site conducting routine environmental monitoring, environmental investigations and maintenance work, to ensure the site remains safe and secure.

The site consisted of 70 properties that covered an area of approximately 744 hectares. Saskatchewan's *Reclaimed Industrial Sites Act* later came into effect and created an institutional control framework for the long-term provincial management of post-decommissioning properties. As a result, five decommissioned Beaverlodge properties were exempted from CNSC licensing by the Commission in 2009 and entered into institutional control (IC) registry in 2009. This decision by the Commission was taken following a presentation of information at a public hearing in February 2009.

Figure 13.2: Beaverlodge - tailings cover, May 2017

On May 27, 2013 the Commission issued a 10-year licence for the Beaverlodge site. As part of its application, Cameco provided a plan for the implementation of additional remediation to support natural recovery of the site and a timetable for final decommissioning of the site's various licensed areas. Since issuance of that licence, Cameco completed studies and additional remediation work to support an application to release additional portions of the Beaverlodge site into the Province of Saskatchewan's IC program. Cameco submitted an application in March 2016 for the proposed release of 14 properties and a separate application in March 2018 for an additional 6 properties, with the intent to have the request for the exemption of these properties presented to the Commission in 2019. Should the Commission approve this request, the properties will be exempted from the current licence and will thereafter be administered under the Saskatchewan IC program. The remaining 45 properties of the Beaverlodge site under CNSC licence will continue to progress to a point that they can be exempted from licensing. Cameco has expressed their intent to have the remaining properties be exempted and transferred to IC prior to the licence renewal in 2023.

In addition to continued monitoring activities in 2016 and 2017, Cameco conducted property specific activities including: completion of the Bolger flow path reconstruction project; installation of stainless steel caps over previously remediated mine openings; utility corridor infrastructure cleanup; concrete pad remediation; culvert removal from a small tributary of Ace Creek; bulk fuel tank dismantling; and the remediation of an area to reduce gamma radiation levels.

CNSC staff will continue oversight of the Beaverlodge site to verify regulatory compliance.

13.1 Performance

In 2016 and 2017, CNSC staff rated the Beaverlodge site performance as "satisfactory" for all applicable SCAs. The following sections contain addition information on the performance rating of the SCAs of radiation protection, environmental protection and conventional health and safety.

13.2 Radiation Protection

For 2016 and 2017, CNSC staff rated the radiation protection SCA as "satisfactory".

2016	2017
SA	SA

SA = satisfactory

There are no year-round workers at the Beaverlodge site. During 2016 and 2017, Cameco staff and contractors were onsite for limited periods of time for monitoring, mitigation activities and inspections. Based on the outcome of CNSC staff inspections and work practices, CNSC staff concluded that Cameco continued to be effective in controlling radiation doses to workers and the public at the Beaverlodge site.

13.3 Environmental Protection

For 2016 and 2017, CNSC staff rated the environmental protection SCA as "satisfactory".

2016	2017
SA	SA

SA = satisfactory

CNSC staff reviewed the water quality results from the 2016 and 2017 monitoring programs and found that the contaminant concentrations are generally stable and within the quantitative site model (QSM) predictions made by Cameco. Comparison of water quality monitoring results with the QSM predictions are one of the performance indicators used to determine if properties can be exempted from CNSC licensing and transferred into Saskatchewan's Institutional Control Program. In some areas, radium concentration in surface waters are above the QSM predictions. As part of the five year ERA update in 2018, Cameco will reassess the environmental risk of radium in these areas and propose mitigation, if necessary. CNSC staff will review the ERA update and ensure regulatory compliance.

There is a precautionary fish consumption advisory in effect which, in 2016, was renamed and is now referred to as a *Healthy Fish Consumption Guideline*. The public has been advised of the lakes and creeks in the area from which no fish should be consumed. The public has also been advised of those water bodies where fish consumption should be limited due to elevated selenium levels as a result of past mining and milling activities at the Beaverlodge site and, as previously discussed in section 10, at the nearby Lorado site.

Radon levels are monitored on and around the Beaverlodge site. As was observed in past years, during this 2016 and 2017 reporting period, the radon levels at historic mine locations were generally above background levels. Radon concentrations were highest at the Ace Creek monitoring station and concentrations ranged between 155 Bq/m^3 to a maximum of 350 Bq/m^3. Concentration at the Uranium City station ranged between 5 $Bq/m^3$and 54 Bq/m^3 in 2016 and 2017. The background concentration of radon in northern Saskatchewan ranges from less than 7.4 Bq/m^3 to 25 Bq/m^3. Radon levels for the far field and reference stations display a rapid decrease to background levels as the distance from the Beaverlodge site increases. Radon levels remain substantially below those observed prior to the decommissioning of the site.

For 2016 and 2017, CNSC staff were satisfied that Cameco had adequate measures in place to protect the public and the environment at the Beaverlodge site.

13.4 Conventional Health and Safety

For 2016 and 2017, CNSC staff rated the conventional health and safety SCA as "satisfactory".

2016	2017
SA	SA

SA = satisfactory

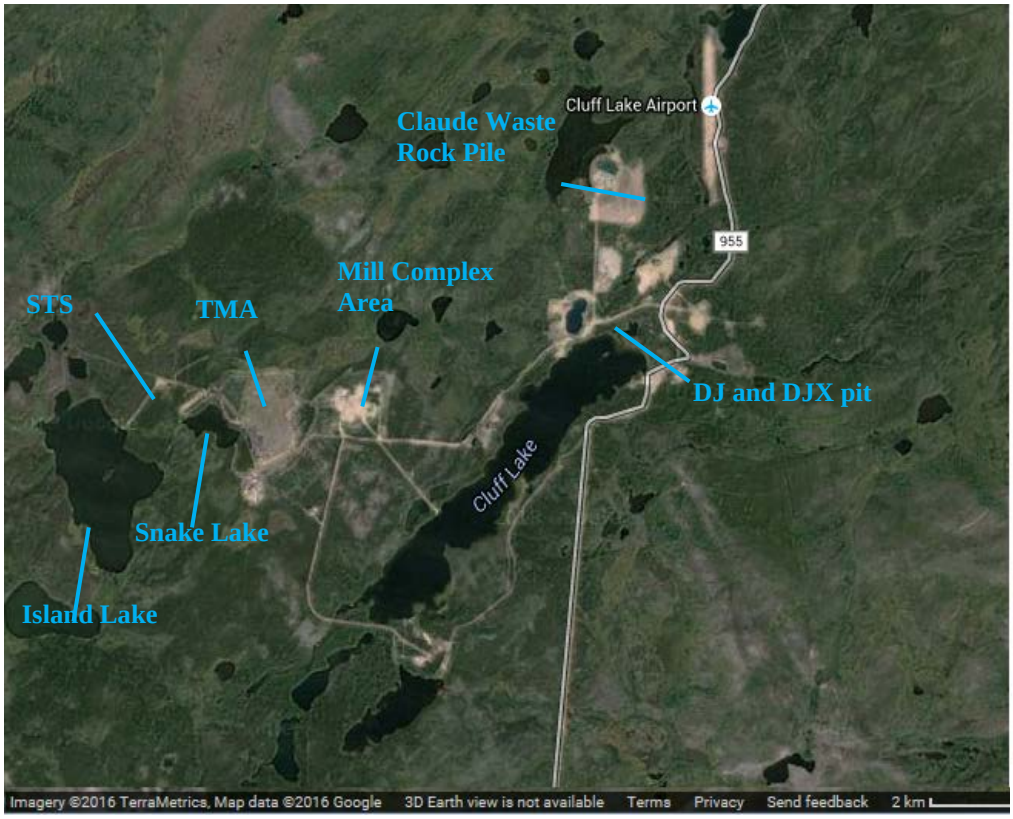
The health and safety risks at the Beaverlodge site are very low for this unoccupied site. The risks are associated with the management of contractors undertaking surveillance, maintenance and any remediation work. As required by the CNSC licence, a contractor management program is in place to mitigate this risk. CNSC staff concluded Cameco satisfactorily maintained a conventional health and safety program that protected the health and safety of workers.

14 CLUFF LAKE

Cluff Lake was last reported on in the *Regulatory Oversight Report for Uranium Mines and Mills in Canada: 2016;* since then, there have been no significant changes to the site and the site remains stable.

The decommissioned Cluff Lake uranium mine and mill is located in northern Saskatchewan, approximately 75 kilometres south of Lake Athabasca and 30 kilometres east of the provincial border with Alberta. Owned and operated by AREVA Resources Canada Inc., (AREVA), now known as Orano Canada Inc., the Cluff Lake Project operated from 1981 to 2002. Following closure, the major decommissioning activities commenced and were largely completed within five years. In September 2013, the Cluff Lake Project reached a major milestone when they decommissioned the remaining camp residence and airstrip. Site occupancy was ceased, and access to the site is no longer controlled. Figure 14.1 provides an aerial view of the Cluff Lake area showing key components of the operation.

Figure 14.1: Cluff Lake – area map



The former Cluff Lake Operation consisted of a central mill, above ground tailings management area (TMA), three open pits, two underground mines, associated waste rock piles, and site infrastructure including an airstrip and camp (figure 14.2).

Figure 14.2: Cluff Lake – pre-decommissioning view, 2009

As part of decommissioning activities, the Claude pit was completely filled in. The DJ/DJX and D pits were flooded and remain isolated from adjacent natural water bodies. Potentially problematic portions of the surface waste rock piles were placed into the pits, while the remainder of the surface waste rock was contoured, covered and revegetated. The portals and vents to the underground mines were closed and the TMA was contoured, covered and revegetated. All structures were dismantled and disposed of. Figure 14.3 shows the DJ and DJX pits with the Claude waste rock pile in the background.

Figure 14.3: Cluff Lake – DJ and DJX pits and Claude waste rock pile, 2014

In 2009, the CNSC issued AREVA a 10-year uranium mine decommissioning licence for Cluff Lake. The licence is valid until July 31, 2019. In 2017, AREVA completed the fourth year of campaign monitoring in compliance with its licence. There were no issues or concerns identified. The recovery of the site is proceeding as anticipated.

14.1 Performance

For 2016 and 2017, CNSC staff were satisfied with AREVA's performance in all relevant SCAs. AREVA's performance over the reporting period of 2016 and 2017 was rated as "satisfactory" and the site continues to be stable, safe and well managed.

14.2 Radiation Protection

For 2016 and 2017, CNSC staff rated the radiation protection SCA as "satisfactory".

2016	2017
SA	SA

SA = satisfactory

AREVA's radiation protection program is reflective of the low risk of radiation exposure at the site. Due to the nature of the site activities and mitigation measures in place, radiation doses to the workers and the public are well below the public dose limit of 1 mSv.

CNSC staff were satisfied with AREVA's radiation protection program at Cluff Lake and will continue to monitor the effectiveness of the program in future inspections.

14.3 Environmental Protection

For 2016 and 2017, CNSC staff rated the environmental protection SCA as "satisfactory".

2016	2017
SA	SA

SA = satisfactory

The environmental monitoring program at Cluff Lake measures the quality of groundwater, surface water and air. Groundwater monitoring confirmed that aquatic life in nearby lakes is protected. Water quality in Island Lake, which received treated effluent from the tailings impoundment area during operations, is generally stable or improving as predicted.

AREVA monitors radon gas in remediated areas. CNSC staff reviewed the results and concluded that the radon concentrations are consistent with values measured in previous years and generally reflective of concentrations naturally occurring in northern Saskatchewan. In 2016 and 2017, CNSC staff were satisfied with the environmental monitoring at Cluff Lake and will continue to assess results to ensure that mitigation measures remain effective and stable.

In 2016 and 2017, CNSC staff reviewed the environmental performance and environmental risk assessment updates for Cluff Lake. CNSC staff concluded that the air, surface water and sediment quality were similar to that predicted in the Cluff Lake Decommissioning Project Comprehensive Study Report and are satisfied with the results.

For 2016 and 2017, CNSC staff were satisfied that AREVA had adequate measures in place to protect the public and the environment from residual releases from the Cluff Lake site.

Independent Environmental Monitoring Program

To complement ongoing compliance activities, the CNSC implements an Independent Environmental Monitoring Program (IEMP) to independently verify that all persons and the environment around licensed nuclear facilities are protected. The IEMP involves taking samples from public areas around the facilities, and measuring and analyzing the amount of radioactive and hazardous substances in those samples. In 2017, CNSC staff collected samples of radon in ambient air, lake water, fish (Northern Pike and Lake Whitefish), blueberries and Labrador tea at a reference station at Saskatoon Lake, which was not exposed to activities at the Cluff Lake site, and at two exposure stations at Sandy Lake and Cluff Lake. The results are available on the CNSC's IEMP Web page. The IEMP results indicate that all persons and the environment in the vicinity of the Cluff Lake site are protected, and there are no health impacts as a result of site activities.

14.4 Conventional Health and Safety

For 2016 and 2017, CNSC staff rated the conventional health and safety SCA as "satisfactory".

2016	2017
SA	SA

SA = satisfactory

AREVA maintained a conventional health and safety program to protect the health and safety of workers at the Cluff Lake site. This program is reflective of the low risk and unique challenges of the isolated location of the work. Prior to each sampling campaign, safety meetings were held between AREVA and consultants.

For 2016 and 2017, CNSC staff were satisfied with AREVA's conventional health and safety program and will continue to monitor the program's effectiveness.

15 RAYROCK

Rayrock was last reported on in the *Regulatory Oversight Report for Uranium Mines, Mills, Historic and Decommissioned Sites in Canada: 2015*, since then there have been no significant changes to the site and the site remains stable.

The Rayrock idle mine site was formerly a uranium mine and mill. It is located in the Northwest Territories, 74 kilometres northwest from the community of Behchoko (formerly community of Rae) and 156 kilometres northwest of Yellowknife. Figure 15.1 presents an aerial view of the Rayrock idle mine site.

Figure 15.1: Rayrock – aerial view

The uranium mine and mill operated from 1957 until 1959 when the site was abandoned. The site was then decommissioned and rehabilitated in 1996 by Indigenous and Northern Affairs Canada (INAC). A CNSC designated officer renewed INAC's waste nuclear substance licence on June 30, 2017 for a period of 10 years. Subsequently, CNSC staff issued a licence conditions handbook to provide guidance on the compliance strategy for the Rayrock mine site. The Rayrock licence is valid until June 30, 2027.

15.1 Performance

For 2016 and 2017, CNSC staff were satisfied with INAC's performance in the environmental protection and conventional health and safety SCAs. For 2016, CNSC staff rated Rayrock's performance in the radiation protection SCA as "below expectations" due to the lack of a documented radiation protection program. After the establishment of a specific program, this SCA was rated "satisfactory" in 2017. INAC's performance over the reporting period of 2016 and 2017 has been stable and met the requirements of the NSCA and its associated regulations.

In 2016 and 2017, INAC undertook site stabilization activities as part of on-going site monitoring and maintenance work. The on-going site stabilization work program includes increasing site accessibility for the licensee and their contactors to ensure that maintenance activities can continue in a safe manner.

According to the CNSC risk-informed baseline inspection plan, Rayrock is subject to a minimum of one compliance inspection every three years. CNSC staff conducted an inspection in 2016. In 2017, CNSC staff reviewed INAC's response to the findings from this inspection and are satisfied with INAC's corrective actions.

15.2 Radiation Protection

For the year 2016, CNSC staff rated the radiation protection SCA as "below expectations" while for 2017, CNSC staff rated the SCA as "satisfactory".

2016	2017
BE	SA

BE = below expectations SA = satisfactory

In preparation for the 2016 inspection, CNSC staff became aware that while the licensee had some good practices and elements of a radiation protection program in place, these were not consistently followed nor formally documented in one program. Although there was no specific radiation protection program, this non-compliance was considered low risk due to the nature of the site activities and existing mitigation measures in place. CNSC staff verified that radiation doses to the workers and the public are well below the public dose limit of 1 mSv through onsite measurements. The licensee submitted a radiation protection program for CNSC specialist review in late 2016, prior to the renewal of the Rayrock licence. A radiation protection program is a regulatory requirement and due to the lack of a documented radiation protection program, CNSC staff rated this SCA as "below expectations" in 2016. For 2017, CNSC staff rated this SCA as "satisfactory" following the establishment of a specific program. CNSC staff will verify the implementation of the radiation protection program in the next scheduled compliance inspection in 2019.

15.3 Environmental Protection

For 2016 and 2017, CNSC staff rated the environmental protection SCA as "satisfactory".

2016	2017
SA	SA

SA = satisfactory

Assessment and monitoring

The Rayrock site is the subject of a long-term post-remediation monitoring program. Surface water quality monitoring is carried out every three years and radon and gamma monitoring is carried out every five years.

For 2016, CNSC staff's inspection results confirmed INAC's 2015 monitoring results and found the contaminant concentrations in water bodies in and around the site were typically below the *Canadian Water Quality Guidelines for the Protection of Aquatic Life*, however, there were some exceedances for aluminum, copper, and iron at some locations in onsite lakes. There was one exceedance of the water quality guidelines for uranium in Mill Lake, due to the presence of historic uranium mine tailings at the bottom of the lake.

There were no monitoring activities at the site in 2017, as the focus was on field activities and data collection to update the human health and environmental risk assessment for the site.

Environmental risk assessment

In 2017, INAC undertook a field program to collect additional data to support the updated human health and ecological risk assessment (HHERA). In 2018, INAC submitted an updated HHERA which is currently under review by CNSC staff. The results of the HHERA will be used to support additional remediation activities and a revised post-remediation monitoring plan.

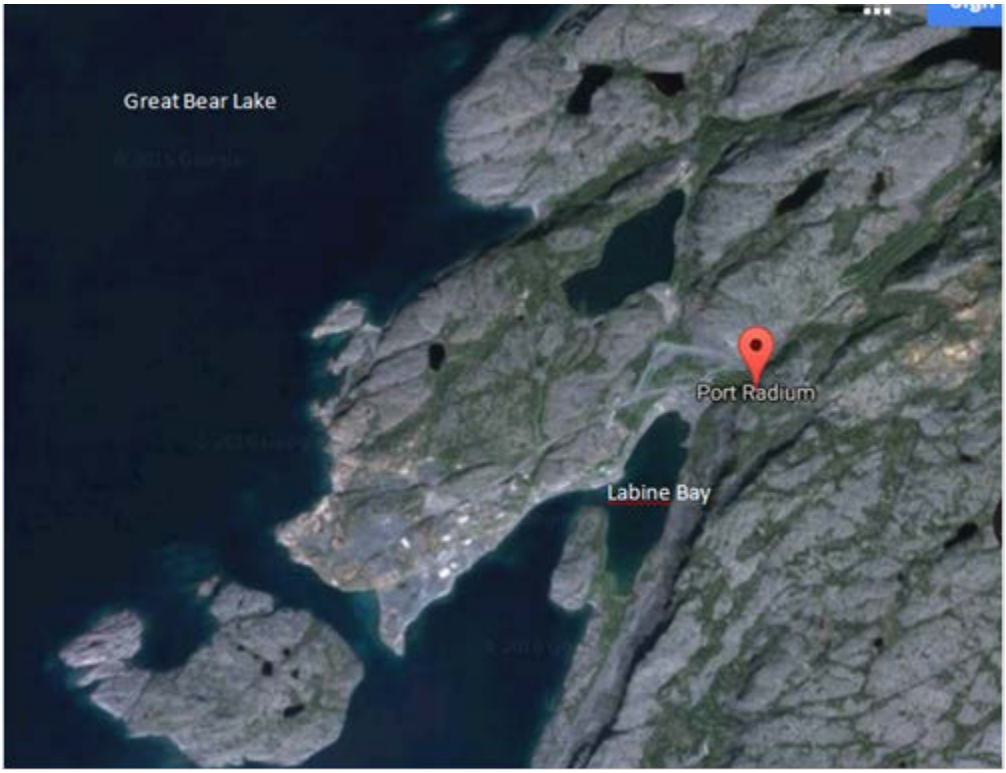
For 2016 and 2017, CNSC staff concluded that INAC had adequate measures in place to protect the public and the environment for the Rayrock site.

16 PORT RADIUM

Port Radium was last reported on in the *Regulatory Oversight Report for Uranium Mines and Mills in Canada: 2016*; since then, there have been no significant changes to the site and the site remains stable.

The Port Radium idle mine site is located in the Northwest Territories at Echo Bay on the eastern shores of Great Bear Lake, about 265 kilometres east of the Déné community of Déline at the edge of the Arctic Circle (figure 16.1).

Figure 16.1: Port Radium - idle mine site



The mine was in operation for 50 years, from 1932 to 1982. The site covers approximately 12 hectares and is estimated to contain 1.7 million tons of uranium and silver tailings. The site was partially decommissioned in 1984, according to the standards at that time. In 2006, the Government of Canada reached an agreement with the local community and completed the remediation of the site in 2007 under a CNSC licence. A CNSC designated officer renewed Indigenous and Northern Affairs Canada's (INAC) waste nuclear substance licence for a period of 10 years on December 31, 2016 in order to continue the long-term maintenance and monitoring of the Port Radium site. In 2017, CNSC staff issued a licence conditions handbook to provide guidance on the compliance strategy for the Port Radium site. The licence is valid until December 31, 2026.

16.1 Performance

For 2016 and 2017, CNSC staff were satisfied with INAC's performance in the environmental protection and conventional health and safety SCAs. For 2016, CNSC staff rated the radiation protection SCA as "below expectations" due to the lack of a documented radiation protection program. After the establishment of a specific program, this SCA was rated "satisfactory" in 2017. INAC's performance over the 2016 and 2017 reporting period has been stable and met the requirements of the NSCA and its associated regulations.

According to CNSC's risk-informed baseline inspection plan, Port Radium is subject to a minimum of one compliance inspection every three years. CNSC staff conducted an inspection in 2016. In 2017, CNSC staff reviewed INAC's response to the findings from this inspection and are satisfied with INAC's corrective actions.

16.2 Radiation Protection

For the year 2016, CNSC staff rated the radiation protection SCA as "below expectations" while for 2017, CNSC staff rated the SCA as "satisfactory".

2016	2017
BE	SA

BE = below expectations SA = satisfactory

In preparation for the 2016 inspection, CNSC staff became aware that while the licensee had some good practices and elements of a radiation protection program in place, these were not consistently followed nor formally documented in one program. Although there was no specific radiation protection program, this non-compliance was considered low risk due to the nature of the site activities and existing mitigation measures in place. CNSC staff verified that radiation doses to the workers and the public are well below the public dose limit of 1 mSv through onsite measurements. The licensee submitted a radiation protection program for CNSC specialist review in late 2016, prior to the renewal of the Port Radium licence. A radiation protection program is a regulatory requirement and due to the lack of a documented radiation protection program, CNSC staff rated this SCA as "below expectations" in 2016. For 2017, CNSC staff rated this SCA as "satisfactory" following the establishment of a specific program. CNSC staff will verify the implementation of the radiation protection program in the next scheduled compliance inspection in 2019.

16.3 Environmental Protection

For 2016 and 2017, CNSC staff rated the environmental protection SCA as "satisfactory".

2016	2017
SA	SA

SA = satisfactory

INAC conducted water quality sampling in 2016; therefore measurements from that year form the basis of the CNSC's environmental rating for this site. There were some elevated concentrations of several contaminants including arsenic, uranium, copper and zinc in onsite water bodies. These results are consistent with INAC's historical monitoring data. Concentrations of contaminants in nearby Great Bear Lake and Labine Bay were all below the *Canadian Water Quality Guidelines for the Protection of Aquatic Life*. INAC is in the process of updating their environmental monitoring plan; as such, no monitoring activities were undertaken in 2017.

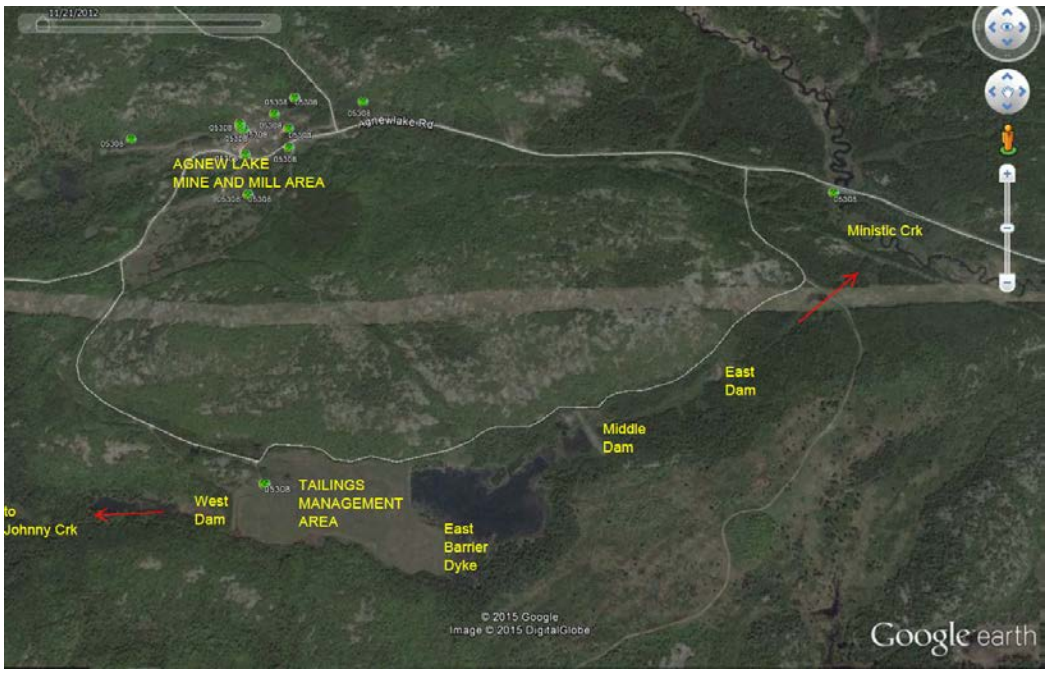
For 2016 and 2017, CNSC staff were satisfied that INAC had adequate measures in place to protect the public and the environment for the Port Radium site.

17 AGNEW LAKE

Agnew Lake was last reported on in the *Regulatory Oversight Report for Uranium Mines, Mills, Historic and Decommissioned Sites in Canada: 2015*; since then, there have been no significant changes to the site and the site remains stable.

The Agnew Lake mine is located about 25 kilometres northwest of Nairn Centre, Ontario (figure 17.1). The uranium mine site was decommissioned and monitored by Kerr Addison Mines from 1983 until 1988. The site was then turned over to the Province of Ontario in the early 1990s. The CNSC issued Ontario's Ministry of Northern Development and Mines (MNDM) a waste nuclear substance licence for Agnew Lake on January 20, 2011. The licence is valid until January 31, 2021. For the foreseeable future, the site will remain under long-term monitoring and maintenance.

Figure 17.1: Agnew Lake - remediation spillway



17.1 Performance

For 2016 and 2017, CNSC staff were satisfied with MNDM's performance in the environmental protection and conventional health and safety SCAs. For 2016, CNSC staff rated the radiation protection SCA as "below expectations" due to the lack of a documented radiation protection program. After the establishment of interim measures and significant improvements to radiation protection on the site, this SCA was rated "satisfactory" in 2017. MNDM's performance over the reporting period has been stable and met the requirements of the NSCA and its associated regulations.

During a 2015 inspection, CNSC staff found sections of the tailings areas were exposed where the TMA cover had degraded and some locations measured dose rates of greater than 1 μSv/h. In 2016, MNDM conducted a gamma dose rate survey and public dose assessment of the Agnew Lake TMA and found incremental dose rates ranged from 0 to 8.1 μSv/h, with an average of 1.085 μSv/h.

Repair to the cover of the TMA is planned and MNDM has proposed to add niobium ore and tailings classified as naturally occurring radioactive material (NORM) from the former Beaucage Mine near North Bay to cover these tailings. MNDM has proposed that the placement of the niobium waste will provide shielding for the existing tailings and the soil cover over the niobium waste will prevent contact with the niobium waste and reduce gamma doses to background levels.

17.2 Radiation Protection

For the year 2016, CNSC staff rated the radiation protection SCA as "below expectations" while for 2017, CNSC staff rated the SCA as "satisfactory".

2016	2017
BE	SA

BE = below expectations SA = satisfactory

In preparation for the 2016 inspection, CNSC staff became aware that while the licensee had some good practices and elements of a radiation protection program in place, these were not consistently followed nor formally documented in one program. Although there was no specific radiation protection program, this non-compliance was considered low risk due to the static state of the site, infrequent access to the site and results of a gamma dose rate survey. MNDM conducted a public dose assessment of the Agnew Lake TMA, confirming the estimated dose to the public is below the regulatory limit of 1 mSv/year.

Additionally in 2017, MNDM installed two new radiation warning signs on the west end and east end of the Agnew Lake TMA to inform the public of potential radiation hazards onsite. CNSC staff observed hunting blinds erected near the TMA in 2016 and 2017. MNDM posted signage on the hunting blinds alerting the owners of radon risks and informing them the blinds would be removed. MNDM have since removed these hunting blinds from this area.

A radiation protection program is a regulatory requirement and due to the lack of a radiation protection program at Agnew Lake and findings from the 2016 inspection, CNSC staff rated this SCA as "below expectations" in 2016. CNSC staff have communicated expectations and the licensee has been receptive and incorporated interim measures. In 2017, CNSC staff rated this SCA as "satisfactory" due to a number of improvements to the site's radiation protection program. The licensee has committed to submitting a consolidated radiation protection program in support of their request for a licence amendment to support upgrades to their tailings cover.

17.3 Environmental Protection

For 2016 and 2017, CNSC staff rated the environmental protection SCA as "satisfactory".

2016	2017
SA	SA

SA = satisfactory

Assessment and monitoring

MNDM measures contaminant concentrations in surface water at several locations around the site. The last reported measurements were submitted to the CNSC in 2017. CNSC staff reviewed the results and found that contaminant concentrations in water bodies in and around the site were below Ontario's *Surface Water Quality Objectives*.

For 2016 and 2017, CNSC staff were satisfied that MNDM had adequate measures in place at Agnew Lake to protect the public and the environment for releases from the site.

18 BICROFT

Bicroft was last reported on in the *Regulatory Oversight Report for Uranium Mines, Mills, Historic and Decommissioned Sites in Canada:* 2015; since then, there have been no significant changes to the site and the site remains stable.

The Bicroft tailings storage facility, owned and operated by Barrick Gold Corporation, is located on the south side of Highway 118, approximately 2 kilometres west of Cardiff, Ontario. On December 14, 2010 the CNSC issued Barrick Gold a waste nuclear substance licence for Bicroft; this licence is valid until February 28, 2021. For the foreseeable future, the site will remain under long-term monitoring and maintenance (figure 18.1).

Figure 18.1: Bicroft - spillway of Pond A at the tailings management facility, 2017

The Bicroft facility was constructed to contain tailings from mining operations that were carried out at the nearby Bicroft mine, which operated from 1956 to 1962. The uranium tailings stored in the Bicroft tailings storage site resulted from processing low-grade uranium ore at the Bicroft mine. Remediation work included vegetation of exposed tailings in 1980 and upgrading of dams in 1990 and 1997. Areas of the site are now used for occasional recreational use by the local snowmobile club.

18.1 Performance

For 2016 and 2017, CNSC staff were satisfied with Barrick Gold Corporation's performance in the SCAs of radiation protection, environmental protection and conventional health and safety at the Bicroft site. The licensee's performance over the 2016 and 2017 reporting period has been stable and met the requirements of the NSCA and its associated Regulations.

In 2016 and 2017, CNSC staff found the site was well managed and maintained and satisfactory environmental protection measures and procedures were in place such as, licensee's continued maintenance improvements by removing vegetation on certain dams and beaver cuttings to ensure the overall integrity of the dams.

18.2 Radiation Protection

For 2016 and 2017, CNSC staff rated the radiation protection SCA as "satisfactory".

2016	2017
SA	SA

SA = satisfactory

There are no year-round workers at the Bicroft site. During 2016 and 2017, licensee staff and contractors were onsite for limited periods of time for monitoring, mitigation activities and inspections. Based on the outcome of CNSC staff inspections and work practices, CNSC staff concluded that Barrick Gold is effectively controlling radiation doses at the Bicroft site.

Barrick Gold's radiation protection program is reflective of the low risk of radiation exposure at the site. Due to the nature of the site activities and mitigation measures in place, radiation doses to the workers and the public are well below the public dose limit of 1 mSv.

18.3 Environmental Protection

For 2016 and 2017, CNSC staff rated the environmental protection SCA as "satisfactory".

2016	2017
SA	SA

SA = satisfactory

Water quality sampling is carried out every five years at the site. Sampling last occurred during the 2015 field season. Barrick Gold has an environmental sampling program for the Bicroft site and sampling results were provided to the CNSC in its 2015 annual report.

CNSC staff reviewed the Bicroft site's 2016 Dam Safety Review and provided recommendations to enhance the dam safety program. The licensee responded to these recommendations and CNSC staff is currently reviewing the responses.

For 2016 and 2017, CNSC staff remain satisfied that Barrick Gold Corporation had adequate measures in place to protect the public and the environment for the Bicroft site.

19 DYNO

Dyno was last reported on in the *Regulatory Oversight Report for Uranium Mines, Mills, Historic and Decommissioned Sites in Canada: 2015*; since then, there have been no significant changes to the site and the site remains stable.

The Dyno closed mine property is located at Farrel Lake, about 30 kilometres southwest of Bancroft, Ontario. The mill circuit at Dyno operated between 1958 and 1960. The property consists of an abandoned, sealed underground uranium mine; a mill, which has been demolished; capped openings; a tailings area; one dam with a toe berm; and various roadways (figure 19.1). The site is managed and monitored by EWL Management Ltd. (EWL), which holds a CNSC waste nuclear substance licence for Dyno. The licence was issued on September 23, 2009 and is valid until January 31, 2019. CNSC staff are currently reviewing the licensee's renewal application. For the foreseeable future, the site will remain under long-term monitoring and maintenance.

Figure 19.1: Dyno closed mine site – dam and toe berm, 2017

19.1 Performance

For 2016 and 2017, CNSC staff were satisfied with EWL's performance in the SCAs of radiation protection, environmental protection and conventional health and safety. Performance over the reporting period of 2016 and 2017 at the Dyno site has been stable and met the NSCA requirements and its associated regulations.

During baseline compliance inspections in 2016 and 2017, CNSC staff found the site was well managed and maintained. There were satisfactory environmental protection measures and procedures in place.

19.2 Radiation Protection

For 2016 and 2017, CNSC staff rated the radiation protection SCA as "satisfactory".

2016	2017
SA	SA

SA = satisfactory

There are no year-round workers at the Dyno site. During 2016 and 2017, licensee staff and contractors were onsite for limited periods of time for monitoring, mitigation activities and inspections. Gamma dose rates around the site are also very low. Based on the low exposure times and dose rates, and the outcome of CNSC staff inspections and work practices, CNSC staff concluded that EWL is effectively controlling radiation doses to workers and the public.

The licensee's radiation protection program is reflective of the low risk of radiation exposure at the site. Due to the nature of the site activities and mitigation measures in place, radiation doses to the workers and the public are well below the public dose limit of 1 mSv.

19.3 Environmental Protection

For 2016 and 2017, CNSC staff rated the environmental protection SCA as "satisfactory".

2016	2017
SA	SA

SA = satisfactory

The Dyno site has an environmental sampling program. EWL provided sampling results to the CNSC in its 2016 and 2017 annual reports. Water quality sampling is carried out every two years at the site and was last conducted during the 2016 field season. CNSC staff reviewed the results and concluded that all locations for uranium surface water samples met provincial water quality objectives.

The Dyno site is also the subject of a geotechnical monitoring and inspection program for its tailings dam. In 2016, CNSC staff reviewed the geotechnical report and found that the dam met the safety standards in the Canadian Dam Association's *Dam Safety Guidelines*. CNSC staff are planning a geotechnical inspection at the Dyno site in the fall 2018.

For 2016 and 2017, CNSC staff were satisfied that EWL had adequate measures in place to protect the public and the environment for the Dyno site.

20 ELLIOT LAKE

Elliot Lake was last reported on in the *Regulatory Oversight Report for Uranium Mines and Mills in Canada: 2016*, since then there have been no significant changes to the site and the site remains stable.

Rio Algom Limited (RAL) is the owner and licensee of nine decommissioned uranium mines in the Elliot Lake area of northeastern Ontario: Stanleigh, Quirke, Panel, Spanish, American, Milliken, Lacnor, Buckles and Pronto and some peripheral areas (figure 20.1).

Figure 20.1: Elliot Lake historic sites – re-designed spillway at Panel Mine

The mine sites and associated tailings management areas (TMAs) are managed under one CNSC waste facility operation licence which is of indefinite term. The sites have all been decommissioned and the TMAs are in the long-term care and maintenance phase. RAL conducts site-specific and regional environmental monitoring programs, operates the effluent treatment plants, inspects and maintains the sites in the Elliot Lake area. The long-term plan for the site is to reach a state where water treatment is no longer required and reliance on physical works can be reduced.

In 2017 and as part of the *Regulatory Oversight Report for Uranium Mines and Mills in Canada: 2016*, CNSC staff provided the Commission with a status update on environmental performance at the Elliot Lake Historic Mine and Tailings Management Sites (CMD-17-M47, appendix K) which also includes the separately licensed Denison and Stanrock properties. In that update CNSC staff provided a summary of their review of the State of the Environment Report (SOE) for 2010 to 2014.

20.1 Performance

CNSC staff conducted annual compliance inspections in 2016 and 2017 and found the sites were in good condition and well managed by the licensee. No enforcement actions were issued during this period as the result of these inspections.

For 2016 and 2017, CNSC staff were satisfied with RAL's performance in the radiation protection, and conventional health and safety SCAs. For 2016, CNSC staff rated RAL's performance in the environmental protection SCA as "satisfactory"; however, in 2017 their performance was rated as "below expectations" due to a licence limit exceedance for radium releases from the Stanleigh effluent treatment plant. This exceedance resulted in the issuance of an information request pursuant to subsection 12(2) of the *General Nuclear Safety and Control Regulations.* The 12(2) required RAL to conduct an analysis of past corrective actions, and develop a new corrective action plan to address the exceedance. RAL was also required to perform a best available technology and techniques economically achievable (BATEA) assessment and provide a timeline for the implementation of the corrective action plan and when radium levels would return to compliance. This exceedance was reported to the Commission on January 17, 2018.

20.2 Radiation Protection

As a result of CNSC staff reviews of the licensee's radiation protection data for 2016 and 2017, CNSC staff rated the radiation protection SCA as "satisfactory".

2016	2017
SA	SA

SA = satisfactory

CNSC staff verified there were no gamma doses recorded for NEWs at the RAL properties using either the thermoluminescent dosimeter or optically stimulated luminescence dosimeter gamma badges in 2016 and 2017.

20.3 Environmental Protection

For 2016, CNSC staff rated the environmental protection SCA as "satisfactory". In 2017, the release to the environment of radium in treated water from the Stanleigh effluent treatment plant was above the monthly licence limit for the month of December. This release resulted in a rating of "below expectations".

2016	2017
SA	BE

BE = below expectations SA = satisfactory

Assessment and monitoring

RAL has an extensive water treatment and monitoring program at all licensed TMAs. RAL's monitoring program is coordinated with Denison Mines Inc. and consists of three integrated aspects: the TMA Operational Monitoring Program, the Source Area Monitoring Program and the Serpent River Watershed Monitoring Program. Data from these programs is reported to the CNSC monthly, annually, and is compiled into a State of the Environment (SOE) report every five years.

Licence limit exceedance for radium at Stanleigh TMA

On January 11, 2018 RAL reported an exceedance of the monthly average discharge limit for radium-226 at the Stanleigh effluent discharge location for the month of December 2017. The monthly average limit in the licence is 0.37 Bq/L and the reported value for December 2017 was 0.415 Bq/L. RAL notified the CNSC through the duty officer and also notified the Ontario Ministry of the Environment and Climate Change. The monthly average limit in the licence is based on the *Metal Mining Effluent Regulations* and is protective of the environment. The Commission was notified of the exceedance on January 17, 2018.

Despite the exceedance, radium-226 concentrations in the undiluted effluent continue to be below Health Canada's *Canadian Drinking Water Guidelines* (0.5 Bq/L). CNSC staff requested RAL carry out a toxicity test of the effluent. RAL confirmed all tested fish survived when exposed to effluent. Concentrations of radium-226 in the receiving environment are also below both drinking water standards and levels considered to pose a risk to aquatic biota. Based on the preliminary information, CNSC staff concluded there are no radiological impacts to members of the public or the environment as a result of this exceedance. As reported to the Commission in December 2017 in the *Regulatory Oversight Report for Uranium Mines and Mills in Canada: 2016* (CMD 17-M47), all annual mean concentrations of constituents of concern in the receiving environment, including radium-226 are below CCME's *Canadian Environmental Quality Guidelines* and Health Canada's *Canadian Drinking Water Guidelines*.

Prior to the licence limit exceedance, RAL reported an action level exceedance for radium-226 in November 2017. RAL is implementing measures to control radium-226 concentrations and understand the cause of the exceedance. These include limiting flow, assessing the impact of settling times and adding pre-formed barite as a treatment measure. CNSC staff continue ongoing communication with RAL regarding the progress of this work.

As requested by CNSC staff and to ensure continued protection of the environment, the licensee implemented supplementary monitoring protocols, which include toxicity testing of the effluent at the discharge location, and additional downstream monitoring.

CNSC staff confirm that there are no radiological impacts to members of the public or the environment as a result of this exceedance. However, CNSC staff have increased compliance oversight, which will continue until the situation is stable.

CNSC staff issued a request pursuant to subsection 12(2) of the *General Nuclear Safety and Control Regulations* to RAL on January 22, 2018 regarding what steps are required to modify the treatment facility to lower radium-226 to below compliance limits, how long it will take to implement the changes and an updated assessment to ensure the environment remains protected. In accordance with the 12(2), RAL provided a corrective actions plan on April 12, 2018 which outlined the proposed measure to correct the exceedance and a timeline. However, the 12(2) request remains open until the licensee has provided all requested information. CNSC staff will review the information submitted and consider whether additional enforcement action is required.

21 DENISON AND STANROCK

Denison and Stanrock was last reported on in the *Regulatory Oversight Report for Uranium Mines and Mills in Canada: 2016*, since then there have been no significant changes to the site and the site remains stable.

Denison Mines Inc. is the licensee for the two closed uranium mines of Denison and Stanrock in the Elliot Lake area of northeastern Ontario. The Denison site is licensed under UMDL-MINEMILL-DENISON-01/indf while the Stanrock site is licensed under UMDL-MINEMILL-STANROCK.02/indf. Both licenses have indefinite licence periods.

The licence covers the physical works associated with the decommissioned mine and mill tailings such as dam structures, effluent treatment plants and fencing. The licensee conducts onsite inspection programs and ensures local and area-wide environmental monitoring programs are in place (figure 21.1).

Figure 21.1: Denison – repairs to spillway at TMA 2

In 2017, CNSC staff provided the Commission with a status update on environmental performance at the Elliot Lake historic mine and tailings management sites which included both the Denison and Stanrock licences, as well as the properties managed by Rio Algom (CMD-17-M47, appendix K). In that update, CNSC staff provided a summary of their review of the State of the Environment Report (SOE) for 2010 to 2014.

The mine sites have been decommissioned and there are no mining or milling structures remaining. The tailings management areas (TMA) are in the long-term care and maintenance phase which includes water treatment, source and watershed monitoring. The Denison mine site contains two TMAs that are covered by water and contain a total of 63 million tonnes of uranium mine tailings. The Stanrock site is a dry TMA with a head pond upstream of Dam A and contains 6 million tonnes of uranium mine tailings.

21.1 Performance

For 2016 and 2017, CNSC staff were satisfied with the licensee's performance for the SCAs of radiation protection, environmental protection and conventional health and safety. The licensee's performance at the Denison and Stanrock sites has been stable and has met NSCA requirements and its associated regulations.

In 2016 and 2017, CNSC staff inspected the sites and found they were well managed and had no compliance issues. CNSC staff confirmed the dams and associated structures were found to be in good operating condition and appeared well maintained. Effluent water quality at all discharge locations was in compliance with licence limits.

21.2 Radiation Protection

For 2016 and 2017, CNSC staff rated the radiation protection SCA as "satisfactory".

2016	2017
SA	SA

SA = satisfactory

CNSC staff verified that there were no gamma doses recorded for NEWs at the Denison properties using either the thermoluminescent dosimeter or optically stimulated luminescence dosimeter gamma badges in 2016 and 2017.

21.3 Environmental Protection

For 2016 and 2017, CNSC staff rated the environmental protection SCA as "satisfactory". An environmental protection program was satisfactorily maintained at the Denison and Stanrock facilities to ensure the protection of the environment.

2016	2017
SA	SA

SA = satisfactory

Effluent and emissions

CNSC staff reviewed air emissions monitoring results for radon annual averages for 2016 and 2017 and are satisfied with the results at the Denison and Stanrock facilities.

CNSC staff verified that the effluent water quality for constituents of potential concern consistently achieved discharge criteria at all TMAs.

For 2016 and 2017, CNSC staff were satisfied that adequate measures are in place to protect the public and the environment for the sites.

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A. LICENCE AND LICENCE CONDITIONS HANDBOOK(S)

Table A-1: Uranium mines and mills – Licensing information

Licensee/licence #	Licence effective	Last licence amendment	Licence expiration
AREVA Resources Canada Inc. McClean Lake Operation Uranium mine and mill operating licence UMOL-MINEMILL-McCLEAN.00/2027	July 1, 2017	-	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: Historic and decommissioned sites - Licensing information

LICENSING INFORMATION – Historic and decommissioned sites			
Licensee/licence #	**Licence effective**	**Last licence amendment**	**Licence expiration**
Saskatchewan Research Council Gunnar Legacy Uranium Mine Site WNSL-W5-3151.00/2024	January 14, 2015	-	November 30, 2024
Saskatchewan Research Council Lorado Tailings Management Site WNSL-W5-3150.00/2023	April 29, 2014	-	April 30, 2023
Ontario Ministry of Environment Deloro Mine Site WNSL-W1-3301.00/2022	November 1, 2017	-	October 31, 2022
Cameco Corporation Beaverlodge Mine and Mill WFOL-W5-2120.0/2023	June 1, 2013	-	May 31, 2023

LICENSING INFORMATION – Historic and decommissioned sites			
Licensee/licence #	**Licence effective**	**Last licence amendment**	**Licence expiration**
AREVA Resources Canada Inc. Cluff Lake Mine and Mill UMDL-MINEMILL-CLUFF.00/2019	August 1, 2009	-	July 31, 2019
Indigenous and Northern Affairs Canada Rayrock Idle Mine Site WNSL-W5-3208.0/2027	June 27, 2017	-	June 30, 2027
Indigenous and Northern Affairs Canada Port Radium Idle Mine Site WNSL-W5-3207.0/2026	January 1, 2017	-	December 31, 2026
Ontario Ministry of Northern Development and Mines Agnew Lake Tailings Management Area WNSL-W1-3102.3/2021	January 20, 2011	December 18, 2012	January 31, 2021
EWL Management Ltd. Madawaska Decommissioned Mines and Tailings Management Site WNSL-W5-3100.1/2021	July 4, 2011	December 18, 2012	July 31, 2021
Barrick Gold Corporation Bicroft Tailings Storage Facility WNSL-W5-3103.1/2021	December 14, 2010	February 24, 2011	February 28, 2021
EWL Management Ltd. Dyno Idle Mine Site WNSL-W5-3101.4/2019	September 23, 2009	July 31, 2013	January 31, 2019
Rio Algom Limited Elliot Lake Historic Sites Facility WFOL-W5-3101.03/indf	January 1, 2006	June 7, 2007	Indefinite
Denison Mines Inc. Denison Mining Facility UMDL-MINEMILL-DENISON-.01/indf	October 16, 2002	December 15, 2004	Indefinite
Denison Mines Inc. Stanrock Mining Facility UMDL-MINEMILL-STANROCK-.02/indf	October 16, 2002	December 15, 2004	Indefinite

There were no changes to the licence conditions handbooks for historic and decommissioned sites during the years of 2016 and 2017.

Table A-3: Uranium mines and mills – Licence conditions handbook changes, 2017

Record of the issuance of licence conditions handbook			
Licensee/licence #	**Licence conditions handbook revision**	**Summary of changes**	**Effective date**
AREVA Resources Canada Inc. McClean Lake Operation Uranium Mine and Mill Operating Licence UMOL-MINEMILL-McCLEAN.00/2027	4	▪ Section G.1: Added text for disposal of tailings up to 448 meters above sea level ▪ Section 4.1: Moved text related to ERA from the safety analysis SCA to the environmental protection SCA ▪ Section 9.2: Added authorized effluent discharge limits ▪ General: updated licence documents, licensing basis and guidance references and, formatted the LCH to the latest template	October 6, 2017

B. LIST OF INSPECTIONS

Table B-1: List of inspections and date reports issued

Facility	Safety and control area	Inspection report issued
Cigar Lake Operation	Environmental protection, radiation protection, conventional health and safety, operating performance, fitness for service	March 6, 2017
	Safety analysis	May 5, 2017
	Radiation protection	July 19, 2017
	Operating performance, environmental protection, radiation protection, physical design, fitness for service, packaging and transport	October 20, 2017
	Waste management, radiation protection, packaging and transport, conventional health and safety, human performance management	December 8, 2017
	Operating performance, packaging and transport	January 9, 2018
McArthur River Operation	Human performance management	May 8, 2017
	Environmental protection, waste management, safety analysis, conventional health and safety, radiation protection	April 26, 2017
	Safety analysis	August 14, 2017
	Conventional health and safety, human performance management	September 25, 2017
	Conventional health and safety, human performance management, radiation protection	November 7, 2017
	Packaging and transport	December 11, 2017
Rabbit Lake Operation	Safety analysis	March 14, 2017
	Management system, human performance management	July 11, 2017
	Radiation protection, operating performance, fitness for service, emergency management and fire protection	August 31, 2017
	Waste management, environmental protection	September 7, 2017
	Physical design, operating performance, radiation protection, conventional health and safety, packaging and transport	January 10, 2018
	Radiation protection, environmental protection, conventional health and safety	January 9, 2018

Facility	Safety and control area	Inspection report issued
Key Lake Operation	Fitness for service, conventional health and safety, environmental protection, radiation protection	March 31, 2017
	Management system	July 26, 2017
	Conventional health and safety	October 6, 2017
	Radiation protection	October 20, 2017
	Packaging and transport	December 15, 2017
	Fitness for service, operating performance, conventional health and safety, safety analysis	January 9, 2018
McClean Lake Operation	Radiation protection	April 19, 2017
	Management system, human performance management, operating performance, conventional health and safety, environmental protection, waste management, radiation protection	July 5, 2017
	Management systems, radiation protection, conventional health and safety	July 18, 2017
	Fitness for service	September 8, 2017
	Physical design, conventional health and safety, environmental protection	November 3, 2017
	Operating performance	January 26, 2018
Gunnar	Operating performance, radiation protection, conventional health and safety, emergency management and fire protection,	January 25, 2017
	Radiation protection, conventional health and safety, environmental protection, physical design, waste management, management system	October 30, 2017
Lorado	Radiation protection, conventional health and safety, environmental protection, physical design	January 16, 2017
	Fitness for service, radiation protection, environmental protection, waste management	November 6, 2017
Deloro	Radiation protection, environmental protection, conventional health and safety	May 17, 2017
	Management system, fitness for service, physical design, radiation protection, conventional health and safety, waste management, environmental protection	March 23, 2018
Madawaska	Radiation protection, environmental protection, conventional health and safety	May 5, 2016
Beaverlodge	Operating performance, public information and disclosure, radiation protection, conventional health and safety, environmental protection	July 18, 2017

Facility	Safety and control area	Inspection report issued
Cluff Lake	Operating performance, conventional health and safety, environmental protection, radiation protection, other: public information and disclosure	October 17, 2017
Rayrock	Operating performance, radiation protection, conventional health and safety	October 14, 2016
Port Radium	Operating performance, radiation protection, conventional health and safety	October 14, 2016
Agnew Lake	Conventional health and safety, radiation protection, environmental protection	May 26, 2017
	Conventional health and safety, radiation protection, environmental protection	February 1, 2018
Bicroft	Conventional health and safety, radiation protection, fitness for service, security	August 18, 2016
	Conventional health and safety, radiation protection, fitness for service, security	July 20, 2017
Dyno	Conventional health and safety, radiation protection, fitness for service, security	August 31, 2016
	Conventional health and safety, radiation protection, environmental protection, fitness for service, security	August 8, 2017
Elliot Lake	Conventional health and safety, radiation protection	February 14, 2018
	Environmental protection	July 28, 2017
Denison and Stanrock	Conventional health and safety, radiation protection, environmental protection,	February 14, 2018
	Conventional health and safety, radiation protection, environmental protection, fitness for service, security	September 26, 2016

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.

Table C-1: 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

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 preventive 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 research and development 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.	▪ equipment fitness for service/equipment performance ▪ maintenance ▪ structural integrity ▪ aging management ▪ chemistry control ▪ periodic inspection and testing

Functional area	Safety and control area	Definition	Specific areas
Core control processes	**Radiation protection**	Covers the implementation of a radiation protection program in accordance with the *Radiation Protection Regulations*. The program must ensure that contamination levels and radiation doses received by individuals are monitored, controlled and maintained as low as reasonably achievable (ALARA).	▪ application of ALARA ▪ worker dose control ▪ radiation protection program performance ▪ radiological hazard control ▪ estimated dose to public
	Conventional health and safety	Covers the implementation of a program to manage workplace safety hazards and to protect personnel and equipment.	▪ 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 ▪ 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

Functional area	Safety and control area	Definition	Specific areas
Core control processes	**Security**	Covers programs required to meet 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
	Safeguards and non-proliferation	Covers programs and activities required to meet obligations of 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 assessments ▪ CNSC consultation – Indigenous communities ▪ 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 METHODOLOGY

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 summary, Cigar Lake Operation, 2013–17

Safety and control areas	2013	2014	2015	2016	2017
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	FS	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 summary, McArthur River Operation, 2013–17

Safety and control areas	2013	2014	2015	2016	2017
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 summary, Rabbit Lake Operation, 2013–17

Safety and control areas	2013	2014	2015	2016	2017
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 summary, Key Lake Operation, 2013–17

Safety and control areas	2013	2014	2015	2016	2017
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 summary, McClean Lake Operation, 2013–17

Safety and control areas	2013	2014	2015	2016	2017
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

Table E-6: Applicable SCA performance ratings for active remediation sites, 2015

Safety and control area	Gunnar*	Lorado	Deloro
Management system	N/A	SA	BE**
Operating performance	N/A	SA	SA
Physical design	N/A	SA	SA
Radiation protection	SA	SA	SA
Conventional health and safety	SA	SA	SA
Environmental protection	SA	SA	SA
Emergency management and fire protection	SA	SA	SA
Security	SA	SA	SA

BE = below expectations SA = satisfactory N/A = not applicable

* The management systems, physical design, and emergency management and fire protection SCAs were not rated for 2015 because remediation work had not yet begun and there were no workers onsite.

** Addressed in CMD 16-M49

Table E-7: Applicable SCA performance ratings for active remediation sites, 2016–17

Safety and control area	Gunnar	Lorado	Madawaska*	Deloro
Management system	SA	SA	SA	SA
Physical design	SA	SA	SA	SA
Radiation protection	SA	SA	SA	SA
Conventional health and safety	SA	SA	SA	SA
Environmental protection	SA	SA	SA	SA
Emergency management and fire protection	SA	SA	SA	SA
Security	SA	SA	SA	SA

SA = satisfactory

* Began maintenance and rehabilitation work at Madawaska site.

Table E-8: Applicable SCA performance ratings for decommissioned sites, 2015

Safety and control area	Beaverlodge	Cluff Lake	Rayrock	Port Radium	Agnew Lake	Madawaska	Bicroft	Dyno	Elliot Lake	Denison and Stanrock
Radiation protection	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
Conventional health and safety	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
Environmental protection	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA

BE= below expectations SA = satisfactory

Table E-9: Applicable SCA performance ratings for decommissioned sites, 2016

Safety and control area	Beaverlodge	Cluff Lake	Rayrock	Port Radium	Agnew Lake	Bicroft	Dyno	Elliot Lake	Denison and Stanrock
Radiation protection	SA	SA	BE*	BE*	BE*	SA	SA	SA	SA
Conventional health and safety	SA	SA	SA	SA	SA	SA	SA	SA	SA
Environmental protection	SA	SA	SA	SA	SA	SA	SA	SA	SA

BE = below expectations SA = satisfactory
*See sections 15 to17

Table E-10: Applicable SCA performance ratings for decommissioned sites, 2017

Safety and control area	Beaverlodge	Cluff Lake	Rayrock	Port Radium	Agnew Lake	Bicroft	Dyno	Elliot Lake	Denison and Stanrock
Radiation protection	SA	SA	SA	SA	SA	SA	SA	SA	SA
Conventional health and safety	SA	SA	SA	SA	SA	SA	SA	SA	SA
Environmental protection	SA	SA	SA	SA	SA	SA	SA	BE*	SA

BE = below expectations SA = satisfactory
* See section 20

F. FINANCIAL GUARANTEES

The following table outlines the financial guarantees as of December 31, 2017 for the five operating 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**

The following table outlines the financial guarantees as of December 31, 2017 for the listed historic and decommissioned sites.

Table F-2: Historic and decommissioned site – Financial guarantees

Facility	Canadian dollar amount
Gunnar	Responsibility of Provincial Government
Lorado	Responsibility of Provincial Government
Deloro	Responsibility of Provincial Government
Madawaska	$4,041,472
Beaverlodge	Responsibility of Canadian Government
Cluff Lake	$33,600,000
Rayrock	Responsibility of Canadian Government
Port Radium	Responsibility of Canadian Government
Agnew Lake	Responsibility of Provincial Government
Bicroft	$1,837,000
Dyno	$1,871,543
Elliot Lake	$32,749,000
Denison and Stanrock	$2,480,000

G. WORKER DOSE DATA

Table G-1 shows the total number of nuclear energy workers (NEWs) monitored at each of the five operating mines for 2017. 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: Total number of NEWs at the five operating facilities, 2017

	Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClean Lake
Total NEWs	1,107	958	153	684	334

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

Table G-2: Radiation dose data to NEWs at uranium mines and mills, 2017

Facility	Average individual effective dose (mSv/year)	Maximum individual effective dose (mSv/year)	Regulatory limit
Cigar Lake Operation	0.34	3.36	**50 mSv/year**
McArthur River Operation	0.79	5.73	
Rabbit Lake Operation	0.40	1.56	
Key Lake Operation	0.66	5.39	
McClean Lake Operation	0.91	5.12	

The following tables provide a five-year trend (2013 to 2017) of the average and maximum effective annual doses received at the various operations. Each table also identifies the maximum five-year dose for a worker at each operating uranium mine and mill. In 2017, no radiation dose at any operating facility exceeded a regulatory effective dose limit.

Table G-3: Worker effective dose, Cigar Lake Operation, 2013–17

Dose data	2013	2014	2015	2016	2017	Regulatory limit
Total NEWs	3,039	1,458	1,222	1,243	1,107	**N/A**
Average individual effective dose (mSv)	0.27	0.16	0.45	0.39	0.34	**50 mSv/year**
Maximum individual effective dose (mSv)	2.21	2.04	5.99	5.53	3.36	**50 mSv/year**
Maximum five-year dose for an individual (mSv) 2016–20	8.59					**100 mSv/5 year dosimetry period**

Table G-4: Worker effective dose, McArthur River Operation, 2013–17

Dose data	2013	2014	2015	2016	2017	Regulatory limit
Total NEWs	1,302	1,149	1,360	1,064	958	**N/A**
Average individual effective dose (mSv)	0.89	1.03	1.00	0.85	0.79	**50 mSv/year**
Maximum individual effective dose (mSv)	7.58	7.91	7.40	7.02	5.73	**50 mSv/year**
Maximum five-year dose for an individual (mSv) 2016–20	9.73					**100 mSv/5 year dosimetry period**

Table G-5: Worker effective dose, Rabbit Lake Operation, 2013–17

Dose data	2013*	2014	2015	2016	2017	Regulatory limit
Total NEWs	1,178	964	958	739	153	**N/A**
Average individual effective dose (mSv)	1.30	1.32	1.36	0.85	0.4	**50 mSv/year**
Maximum individual effective dose (mSv)	11.67	8.84**	9.14	4.95	1.56	**50 mSv/year**
Maximum five-year dose for an individual (mSv) 2016–20	6.30					**100 mSv/5 year dosimetry period**

* In 2013, the 2012 maximum individual effective dose was modified from 14.37 mSv (as stated in the *previous CNSC Staff Report on the Performance of Canadian Uranium Fuel Cycle and Processing Facilities: 2012*), as a result of approved dose changes following an injury to an underground worker (for further information see section 5.2 of the 2013 report).

** *During a dosimetry database upgrade, some errors associated with timecard and database entries were identified that affected some dose assignments at Rabbit Lake, Cigar Lake, and McArthur River. The errors were not significant and did not result in any changes to the data reported in last year's CNSC Regulatory Oversight Report with the exception of the 8.84 mSv value, which was previously reported as 8.64 mSv.*

Table G-6: Worker effective dose, Key Lake Operation, 2013–17

Dose data	2013	2014	2015	2016	2017	Regulatory limit
Total NEWs	1,380	1,170	1,191	837	684	**N/A**
Average individual effective dose (mSv)	0.62	0.63	0.55	0.62	0.66	**50 mSv/years**
Maximum individual effective dose (mSv)	5.67	6.21	7.56	5.37	5.39	**50 mSv/years**
Maximum five-year dose for an individual (mSv) 2016–20	9.6					**100 mSv/5 year dosimetry period**

Table G-7: Worker effective dose, McClean Lake Operation, 2013–17

Dose data	2013	2014	2015	2016	2017	Regulatory limit
Total NEWs	308	894	508	510	334	**N/A**
Average individual effective dose (mSv)	0.36	0.37	0.89	1.04	0.91	**50 mSv/year**
Maximum individual effective dose (mSv)	3.44	2.03	5.28	6.94	5.12	**50 mSv/year**
Maximum five-year dose for an individual (mSv) 2016–20	11.05					**100 mSv/5 year dosimetry period**

Historic and Decommissioned Sites

The following tables compare the maximum and average individual effective doses in 2016 and 2017 for historic and decommissioned sites where there are workers designated as NEWs. The Cluff Lake, Beaverlodge, Lorado, Rayrock, Port Radium, Agnew Lake, Bicroft and Dyno sites do not have NEWs.

Table G-8: Radiation dose data for NEWs at the historic and decommissioned sites, 2016

Facility	Maximum individual effective dose in 2016 (mSv/yr)	Average individual effective dose in 2016 (mSv/yr)	Regulatory limit
Gunnar	0.6	0.12	**50 mSv/yr**
Deloro	0.35	<0.1	
Madawaska	0.61	<0.07	
Denison and Stanrock	1.02	0.49	
Elliot Lake	1.02	0.49	

Table G-9: Radiation dose data for NEWs at the historic and decommissioned sites, 2017

Facility	Maximum individual effective dose in 2017 (mSv/yr)	Average individual effective dose in 2017 (mSv/yr)	Regulatory limit
Gunnar	1.37	0.12	**50 mSv/yr**
Deloro	N/A*	N/A*	
Madawaska	0.61	<0.07	
Denison and Stanrock	0.59	0.40	
Elliot Lake	0.59	0.40	

* In 2017, as the work on the cover was completed, the previously existing dosimetry program that was in place during the remediation was discontinued due to low dose rates.

H. REPORTABLE RELEASES TO THE ENVIRONMENT (SPILLS) AND CNSC RATINGS DEFINITIONS

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

Table H-1: Uranium mines and mills reportable releases to the environment, 2017

Facility	Details	Corrective actions	Significance rating
Cigar Lake Operation	On February 22, 2017, anhydrous ammonia was released from a Modular Freeze Plant stem valve installed on the sub-cooler equalizer line, resulting in ~4 kg released to the atmosphere. The cause of the release was due to failure of a stem valve on the sub-cooler portion of the system. This failure was caused by low frequency vibration in the system.	To prevent a reoccurrence the stem valve was repaired and tested, and placed back into service. Further dampening of the system to reduce vibration was evaluated. CNSC staff are satisfied with the corrective actions implemented.	Low
Cigar Lake Operation	On July 3, 2017, the seal on the suction valve on compressor No. 4 of Modular Freeze Plant No. 2 had a small leak, allowing approximately 1 kg of anhydrous ammonia was released to the atmosphere.	To prevent future similar occurrences, assessment will be completed on valve seating to inspect valves for proper seating tolerances and provide recommendations whether valves need to be replaced. CNSC staff are satisfied with the corrective actions implemented.	Low
Cigar Lake Operation	On July 26, 2017, during operation of Modular Freeze Plant No. 1, the stand-by oil filter housing fractured resulting in a release of approximately 4 kg of ammonia gas.	To prevent similar occurrences bypass filters on all other Modular Freeze Plants were checked for pressure build up or external visual concerns. Several long term corrective actions are being assessed for implementation. These include: • Third party examination of oil filter housings from Modular Freeze Plant No.1 to determine failure mode and other non-destructive testing. • Based on the results of the above testing, change the maintenance plan for the oil filter housings (if required).	Low

Facility	Details	Corrective actions	Significance rating
		• Remove and visually inspect remaining oil filter housings. • Ensure work process for filter replacement is documented clearly. • Review FMEA for the compressor system to determine if there are other areas that may require regular inspection. CNSC staff are satisfied with the corrective actions implemented.	
Cigar Lake Operation	On August 6, 2017 the intercooler line on Modular Freeze Plant No. 2 leaked, releasing small amounts of ethylene glycol and hydraulic oil. Further investigation into the event identified that the system lost approximately 317 kg of ammonia. This event was the result of a failure, likely caused by corrosion, of a tube or tubes in the freeze plant's shell and tube heat exchanger.	To prevent future occurrences, several corrective actions have been implemented or are currently being assessed for implementation. These include: • Periodically testing fluids from the heat exchangers to see if the fluids had intermixed as that would be a potential indicator of future heat exchanger problems. • Assessing the corrosion inhibitor in the glycol system to determine if changes can be made to improve performance. • Altering the inspection protocol of the system to improve monitoring of ammonia receiver site glass levels. CNSC staff are satisfied with the corrective actions implemented.	Low
Cigar Lake Operation	On December 6, 2017, a temporary power loss to the Primary Freeze Plant caused an isolation valve on a line to leak approximately 13 kg of ammonia.	To prevent similar occurrences, the valve in question will be examined to determine the failure mode and actions put in place to mitigate future releases of this type. CNSC staff are satisfied with the corrective actions implemented.	Low

Facility	Details	Corrective actions	Significance rating
McArthur River Operation	On December 2, 2017 personnel entering the South Freeze Plant reported the smell of ammonia. Upon investigation refrigeration mechanics identified two small leaks on a socket weld 90 fitting on the inlet of the relief 3-way value on Skid No. 2 and a small leak from a threaded union on Skid No. 1 resulting in the release of trace amounts of ammonia.	To prevent a reoccurrence Skid No. 2 was taken out of service, a repair plan was developed with the refrigeration contractor and the leak repaired. The small leak on Skid No. 1 was repaired immediately after discovery. While the exact amount of ammonia released could not be determined, none of the ammonia detectors in the plant displayed elevated concentrations of ammonia during this event, indicating the plant remained at safe levels well below the 8-hour average regulatory limit of 25 ppm. CNSC staff are satisfied with the corrective actions implemented.	Low
McArthur River Operation	On December 31, 2017 a refrigeration mechanic entered the Main Freeze Plant and noticed the smell of ammonia. The mechanic identified a trace amount of ammonia had been released from a worn shaft seal coupling.	To prevent similar occurrences the compressor was shut down and shaft seal replaced. The exact amount of ammonia released is unknown; none of the ammonia detectors in the plant displayed elevated concentrations of ammonia during this event, indicating the plant remained at safe levels well below the 8-hour average regulatory limit of 25 ppm. CNSC staff are satisfied with the corrective actions implemented.	Low
Rabbit Lake Operation	On December 3, 2017 a Rabbit Lake Mill Line Patrol Operator called the Mill Control Room Operator to report the smell of propane near the Environment and Health Lab. Investigation following the event determined that a mechanical seal on the supply side of one of the propane pumps that serves camp failed. Due to the failed mechanical seal, propane gas was released from a weep hole at the bottom of the pump. The mechanical seals are designed to release propane from the weep hole in case of failure. Based on the relatively short time frame the pump was known to be leaking at operational pressure and flows (~10 minutes), it was estimated that approximately 17 L of liquid propane was released.	To prevent reoccurrence the faulty pump was replaced with a new pump and leak tested before being made available for service. Cameco will assess if the propane pumps for the Camp Propane Farm can be bypassed; they are not currently required for use during care and maintenance. A two year preventative maintenance program to replace mechanical seals in all propane pumps used at the Rabbit Lake Operation will also be instituted to reduce the likelihood of future mechanical seal failures. In addition, it was identified to aid in detection of a propane release from the Camp Propane Farm that installing a Lower Explosive Limit Alarm to a beacon should be completed. CNSC staff are satisfied with the corrective actions implemented.	Low

Facility	Details	Corrective actions	Significance rating
Key Lake Operation	On April 15, 2017 approximately 130 kg of low grade ore used to feed the Crushing and Grinding Plant as blend material was released to a site road at one location adjacent to the ore pad, as well as to ground at the Mine Shop parking rail from a front end loader bucket. All material, including the remaining material in the loader bucket involved with the event was transported back to the ore stockpile to be used as blend material in the mill process. Following clean-up of the affected areas, a gamma scan was performed and gamma levels were consistent with background gamma radiation levels for the two areas affected.	To prevent a reoccurrence the Key Lake Operation initiated preventative actions under the employee relations personal accountability and corrective action process. CNSC staff inspected the area as part of a compliance inspection and are satisfied with the corrective actions implemented.	Low
Key Lake Operation	On June 24, 2017 an intermittent leak was discovered coming from piping on No. 2 ammonia storage tank by the Solvent Extraction Facility. Upon inspection of the tank, the leak was determined to be on the liquid draw line at the bottom of the tank that leads to the vaporizer. No release volume could be estimated due to the intermittent nature of the leak. The tank was drained and repairs to the piping were completed.	To prevent a reoccurrence of this and similar events the Key Lake Operation initiated a 3-year staged ammonia tank refurbishment project for all three ammonia tanks at the mill. The refurbishment program will take place in 2018-2020, with one ammonia tank and associated infrastructure being refurbished per year. CNSC staff are satisfied with the corrective actions implemented.	Low
Key Lake Operation	On December 8, 2017, an intermittent leak was discovered on a vapour line from No. 3 Ammonia Storage Tank by the Solvent Extraction Facility. Upon inspection of the line the leak was determined to be at a flange. No release volume could be estimated due to the intermittent nature of the leak.	To prevent a reoccurrence of this and similar events the Key Lake Operation initiated a 3-year staged ammonia tank refurbishment project for all three ammonia tanks at the mill. The refurbishment program will take place in 2018-2020, with one ammonia tank and associated infrastructure being refurbished per year. CNSC staff are satisfied with the corrective actions implemented.	Low

Facility	Details	Corrective actions	Significance rating
McClean Lake Operation	On January 12, 2017, AREVA personnel noticed approximately 2 L of anhydrous ammonia had leaked onto the ground at the anhydrous ammonia offloading station during previous night shift. Temperatures overnight dipped to -41.3^{o}C and averaged -36.1^{o}C. The consistent low temperatures kept the anhydrous ammonia in liquid form. Under warmer conditions, such a small amount would have dissipated as a gas. AREVA personnel followed up with Northern Resource Trucking (NRT) and it was confirmed with the truck operator that there had been a small leak on a valve housing on the anhydrous ammonia trailer during the offload. The affected ground was scraped up and the material taken to the hydrocarbon landfarm for disposal.	The release was a result of a leak caused by loose bolts on the anhydrous ammonia offload line valve on the delivery trailer. The container itself was not a factor in the spill and was found to be in good condition. The trailer that leaked had been a temporary rental trailer and did not belong to NRT. Their regular trailer was out of service for repairs. To prevent a reoccurrence, NRT confirmed with the rental company that all valves would be checked prior to any future rentals. CNSC staff are satisfied with the corrective actions implemented.	Low
McClean Lake Operation	The incident occurred on June 26, 2017 during pond cleaning operations at the SABRE project site while suctioning pond slurry into the hydrovac truck. Upon filling of the tank, rather than hitting the button on the remote to stop the vacuum pump, the operator inadvertently pressed the button that activated the rear gate. The discharge door lock-out valve failed, the gate opened and discharged the load to the ground next to the ponds. Most of the material immediately ran back to the pond, with approximately 1,000 litres falling on the ground. Clean up started immediately with the hydrovac and was completed the next day. All material was scraped up. A post clean-up soil sample was collected and a control sample was collected from soil nearby on the berm of the pond. Results for both the control and post clean up samples are largely consistent. In addition, the post clean up gamma survey was conducted and demonstrated that all values were within 0.5 µSv per hour of background values.	To prevent a reoccurrence, the discharge door lock-out valve was replaced with a more robust valve that has a locking cover and a lock pin to ensure the valve remains closed. Also, during replacement of the lock-out valve that was done immediately post incident, it was noticed that there was air in the discharge door lock-out hydraulic system, which could also have caused the mechanism to fail. The discharge door lock-out hydraulic system was also bled to remove any air in the system. CNSC staff are satisfied with the corrective actions implemented.	Low

Facility	Details	Corrective actions	Significance rating
McClean Lake Operation	On August 29, 2017 during start-up of the Sulphuric Acid Plant after the summer shutdown, acid leaked from the drying tower into the blower, and through the blower out onto the floor in the acid plant. After the acid was cleaned out of the area, the floor was inspected. It was determined that there was a gap around the sump that penetrated below the concrete slab of the floor. It is normal practice to leave a gap between slab edge and a sump wall, however, the gap is normally filled with a flexible expansion joint material. In this case the material had deteriorated. It was estimated approximately 50 kg of sulphuric acid could have been discharged through the gap. The cause of the discharge of acid to the sump and floor in that area was due to the drying tower return line being plugged.	To prevent a reoccurrence the gap was repaired with a Silkaflex sealant which is a polyurethane based sealant that cures with moisture and is not affected by chemicals or solvents. Various operation, maintenance and inspection processes were implemented and/or revised in order to prevent future blockages of the acid return line. CNSC staff are satisfied with the corrective actions implemented.	Low

Table H-2: CNSC spill rating definitions

Functional area:	Radiation protection		Environmental protection	
Safety significance	**Definition**	**Directorate-specific examples**	**Definition**	**Directorate-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 20 millisievert (mSv)/year or 100 mSv/five years ▪ Non-NEW exceeding 1 mSv	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	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	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	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.	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

I. 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 I-1 outlines the LTI's reported in the 2017 reporting period at the five uranium mines and mills operating in Canada.

Table I-1: Uranium mines and mills – Lost-time injuries (LTIs), 2017

Facility	Incident	Corrective action	Significance rating
Cigar Lake Operation	No LTIs reported in 2017.		
McArthur River Operation	Original injury had occurred in April 2016 where a worker felt hip pain while stepping off mining equipment. Worker received first aid medical treatment before being placed on restricted work status. In October 2017, the worker was seen by a doctor and deemed unable to fly to site, resulting in lost time.	Cameco is currently conducting an analysis on the potential causal factors of the injury and will provide CNSC staff with any corrective actions to be implemented, if applicable.	Medium
Rabbit Lake Operation	No LTIs reported in 2017.		
Key Lake Operation	No LTIs reported in 2017.		
McClean Lake Operation	No LTIs reported in 2017.		

J. RADIOLOGICAL ACTION LEVEL EXCEEDANCES REPORTED TO THE CNSC

Table J-1: Uranium mines and mills – Radiological action level exceedances in 2017

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

K. ANNUAL RELEASES OF RADIONUCLIDES TO THE ENVIRONMENT

Introduction

Operating uranium mines and mills in northern Saskatchewan, and the waste management operations in the Elliot Lake region 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 2013 through 2017.

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 becquerels (Bq).

Liquid releases to surface waters

The uranium mines and mills in northern Saskatchewan and the Elliot Lake regions tailings waste management areas have process waters requiring interception, collection and treatment prior to release. At the uranium mines and mills in northern Saskatchewan total uranium and a number of uranium-238 progeny are monitored. The Elliot Lake region's waste management facilities are less dynamic operations with monitoring focusing on total uranium and radium-226. The total annual load of relevant radionuclides from these facilities is provided in the tables K-1 and K-2.

Table K-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/or mills from the years 2013–17

Facility and year	Uranium (kg)	Thorium-230 (MBq)	Radium-226 (MBq)	Lead-210 (MBq)	Polonium-210 (MBq)
Cigar Lake Mine					
2013	0.23	1.76	2.92	14.10	3.56
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
McArthur River Mine					
2013	24.4	22.7	117.7	45.5	106.8
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
Rabbit Lake Mine and Mill					
2013	266.8	85	32.7	<DL	138.2
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
Key Lake Mill					
2013	9.5	88.3	56.6	97.5	31.5
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
McClean Lake Mill – Combined release from the JEB and Sue Water Treatment Plants					
2013	1.8	19.6	6.0	74.4	17.7
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

Table K-2 Total annual load of uranium (kg) and radium-226 for the tailings waste management facilities in the Elliot Lake region for the years 2013–17

Facility and Year	Uranium (kg)	Radium-226 (MBq)
Pronto Effluent Treatment Plant Final Discharge		
2013	16.3	238.4
2014	13.3	205.8
2015	8.8	155.4
2016	10.3	145.9
2017	15.4	217.1
Nordic Effluent Treatment Plant Final Discharge		
2013	14.6	245.0
2014	25.1	250.9
2015	9.3	146.2
2016	7.2	122.8
2017	10.8	152.7
Panel Effluent Treatment Plant Final Discharge		
2013	13.2	238.7
2014	11.7	283.6
2015	7.3	105.7
2016	9.9	237.0
2017	16.0	365.5
Quirke Effluent Treatment Plant Final Discharge		
2013	56.5	364.2
2014	41.4	215.7
2015	38.9	157.9
2016	35.4	205.4
2017	42.9	417.3
Denison Tailings Management Area - 1 Effluent Treatment Plant Final Discharge		
2013	109.6	266.7
2014	79.0	376.9
2015	44.2	120.1
2016	52.5	202.7
2017	75.0	236.6
Denison Lower Williams Effluent Treatment Plant Final Discharge		
2013	3.3	56.7
2014	1.5	47.3
2015	1.4	41.5
2016	0.9	28.7
2017	2.4	60.5
Stanrock Effluent Treatment Plant Final Discharge		
2013	4.0	77.5
2014	2.7	89.7
2015	2.8	83.5
2016	3.7	62.2
2017	8.1	138.5

L. LINKS TO WEBSITES

Barrick Gold Corporation

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

Denison Environmental Services

Eastern Athabasca Regional Monitoring Program

Indigenous and Northern Affairs Canada

Northern Saskatchewan Environmental Quality Committee

Ontario Ministry of Environment, Conservation and Parks- Deloro

Orano Canada Inc.

Saskatchewan Research Council - Gunnar

M. ACRONYMS

ALARA	as low as reasonably achievable
BATTEA	best available technology and techniques economically achievable
CCME	Canadian Council of Ministers of the Environment
CMD	Commission member document
CNSC	Canadian Nuclear Safety Commission
COPC	constituents of potential concern
CRE	collective radiation exposure
EARMP	Eastern Athabasca Regional Monitoring Program
ENGO	environmental non-governmental organizations
EPR	environmental performance report
EQC	Environmental Quality Committee
ERA	environmental risk assessment
EWL	EWL Management Ltd.
FMEA	failure modes and effect analysis
HHERA	human health and ecological risk assessment
HHRA	human health risk assessment
IAEA	International Atomic Energy Agency
IC	institutional control
ICRP	International Commission on Radiological Protection
IEMP	Independent Environmental Monitoring Program
INAC	Indigenous and Northern Affairs Canada
JEB	John Everett Bates
LCH	licence conditions handbook
LLRD	long-lived radioactive dust
LTI	lost-time injury
MMER	*Metal Mining Effluent Regulations*
MNDM	Ministry of Northern Development and Mines
MOECC	Ontario Ministry of Environment and Climate Change

NEW	nuclear energy worker
NORM	naturally occurring radioactive material
NPRI	National Pollutant Release Inventory
NRT	Northern Resource Trucking
NSCA	*Nuclear Safety and Control Act*
ODWQS	Ontario Drinking Water Quality Standards
PAD	personal alpha dosimeters
PFP	Participant Funding Program
PPE	personal protective equipment
ppm	parts per million
QSM	quantitative site model
RAL	Rio Algom Limited
RnG	radon gas
RnP	radon progeny
SABRE	surface access borehole resource extraction
SCA	safety and control area
SOE	state of the environment
SRC	Saskatchewan Research Council
TMF	tailings management facility
TMA	tailings management areas
TSP	total suspended particulate
TSS	total suspended solids