Canada's Nuclear Regulator

Regulatory Oversight Report for Uranium Mines and Mills in Canada: 2014





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Canadian Nuclear Safety Commission
280 Slater Street
P.O. Box 1046, Station B
Ottawa, Ontario K1P 5S9
CANADA

Tel.: 613-995-5894 or 1-800-668-5284 (in Canada only)
Facsimile: 613-995-5086
Email: cnsc.information.ccsn@canada.ca
Website: nuclearsafety.gc.ca
Facebook: facebook.com/CanadianNuclearSafetyCommission
YouTube: youtube.com/cnscccsn
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Cover images

From left to right:
Cigar Lake Mine
McArthur River Mine
Rabbit Lake Mine and Mill
Key Lake Mill
McClean Lake Mill

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EXECUTIVE SUMMARY

This report presents the performance of the operating uranium mine and mill facilities regulated by the Canadian Nuclear Safety Commission (CNSC). It covers the 2014 calendar year and, when applicable, shows trends and compares information to previous years. Furthermore, it includes information on the CNSC's Independent Environmental Monitoring Program, follows up on the two 2015 Key Lake calciner events, and incorporates changes from Commission member recommendations made during the Commission meeting for the Regulatory Oversight Report for Uranium Mines and Mills in Canada : 2013 .

The report focuses on the three safety and control areas (SCAs) of radiation protection, environmental protection and conventional health and safety, which cover the key performance indicators for these facilities. The report also highlights rating changes for all 14 SCAs, along with major events and significant facility modifications. Finally, it describes measures taken by licensees, the CNSC and other regulatory bodies to protect the environment, and the health and safety of the public and workers.

Evaluations conducted by CNSC staff concluded that uranium mine and mill facilities in Canada operated safely during 2014 and met the following performance expectations:

- Radiation protection measures were effective and doses remained as low as reasonably achievable (ALARA), and well below the regulatory limit.
- Conventional health and safety programs continued to protect workers.
- The environmental protection programs were effective, with all spills cleaned up appropriately with no residual impact to the environment.

This conclusion was based on assessments of licensee activities, site inspections, reviews of reports submitted by licensees, event and incident reviews, Commission hearings and meetings, and ongoing exchanges of information with licensees.

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REGULATORY OVERSIGHT REPORT FOR URANIUM MINES AND MILLS IN CANADA: 2014

1 Introduction

1.1 Background

The *Regulatory Oversight Report for Uranium Mines and Mills in Canada: 2014* summarizes the Canadian Nuclear Safety Commission (CNSC) staff's assessment of the safety performance of operating uranium mine and mill facilities. The assessment aligns with the legal requirements of the *Nuclear Safety and Control Act* (NSCA) and its associated regulations, facility licences, applicable standards and regulatory documents. The report highlights areas of regulatory focus for CNSC staff, including information on requirements and expectations, and provides information on significant events, licence changes, major developments and overall performance. The report summarizes performance data on the safety and control areas (SCAs) of radiation protection, environmental protection, and conventional health and safety. The information presented covers the 2014 calendar year and, when applicable, compares information to previous years. The report also includes information on the CNSC's Independent Environmental Monitoring Program, a follow-up to the two 2015 Key Lake calciner events, and a discussion on the Mount Polley event follow-up.

The report has 11 appendices:

- Appendix A: Safety and Control Area Framework for Uranium Mines and Mills
- Appendix B: Rating Methodology and Definitions
- Appendix C: Trends in Safety and Control Area Ratings
- Appendix D: Financial Guarantees
- Appendix E: Decommissioning and Reclamation Activities
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- Appendix G: Environmental Reportable Spills in 2014 and CNSC Spill Rating Definitions
- Appendix H: Lost-Time Incidents in 2014
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- Appendix J: Licence Conditions Handbook Changes 2014
- Appendix K: Acronyms

1.2 CNSC regulatory efforts

As part of its mission, the CNSC regulates Canada's uranium mines and mills to protect the health, safety and security of Canadians 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. The CNSC achieves part of this mission by ensuring licensee compliance through verification, enforcement and reporting.

CNSC staff establish compliance plans for each facility based on risk-informed regulatory oversight of the facility's activities to identify appropriate levels of regulatory monitoring and control. Modifications to the compliance plans are made on an ongoing basis in response to events, facility modifications and changes in licensee performance.

Completed inspections in 2014 included six each at Cigar Lake, McArthur River, Rabbit Lake and McClean Lake, while five were completed at Key Lake. Table 1-1 shows that, in 2014, CNSC staff performed 29 inspections at the five uranium mines and mills. These inspections resulted in 33 directives and action notices as well as 25 recommendations. CNSC staff have reviewed the corrective actions taken by the licensees and verified that they were appropriate and acceptable. All enforcement actions have been closed by CNSC staff. The table also presents the estimated inspection person-days to conduct these inspections.

Table 1-1: CNSC staff inspection efforts at uranium mines and mills

	Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClean Lake	Total
Number of inspections	6	6	6	5	6	29
Estimated inspection person-days*	104	94	80	64	121	463
Directives	1	0	0	0	0	1
Action notices	10	3	9	5	6	32
Recommendations	12	4	3	4	2	25

* Includes the time to plan, execute and complete the inspection report.

Inspections conducted by CNSC staff covered various aspects of applicable safety and control areas, and utilized a risk-informed decision process commensurate with the risk associated with these facilities. The inspections confirmed the following:

- Radiation protection measures were effective and results remained as low as reasonably achievable (ALARA). No worker at any uranium mine or mill facility exceeded the regulatory individual effective dose limit in 2014.
- Conventional health and safety programs continued to protect workers.
- The environmental protection programs were effective and results remained ALARA. There were 11 reportable spills in 2014. All were of low significance and were cleaned up appropriately with no residual impact to the environment.

CNSC staff also verify compliance through desktop reviews of reports, applications and licensee programs, which are supplemented with meetings, presentations and facility visits.

The CNSC continues to apply an inspector training and qualification program. This program standardizes the core training courses required for inspectors to ensure uniform and consistent training throughout the CNSC. The CNSC also developed and implemented “conduct of inspections” and “on-the-job training” procedures to ensure a consistent approach among new and experienced inspection staff.

Figure 1-1: Commission hearing in La Ronge, Saskatchewan, October 2013

1.2.1 Licence conditions handbooks

Licence conditions handbooks accompany each facility licence and form the licensing basis for each regulated facility. The licence conditions handbooks for mine and mill facilities are updated to reflect approved changes to programs and supporting documentation. Appendix J summarizes changes made to the licence conditions handbooks in 2014.

1.3 Eastern Athabasca Regional Monitoring Program – country foods

The Eastern Athabasca Regional Monitoring Program (EARMP) was established by the Province of Saskatchewan in 2011 and continued to make progress in 2014. This community program monitors the safety of traditionally harvested country foods through the analysis of water, fish, berry and mammal chemistry from representative communities located in northern Saskatchewan. The program contractor is a northern Saskatchewan, Aboriginal-owned business. Community members take part in the program by collecting samples for analysis. The harvesting and consumption of traditional country foods are important parts of northern Saskatchewan culture. The intent of the EARMP is to assure community members that traditional country foods remain safe to eat today and for future generations. The complete report and data is available on the EARMP website.

CNSC staff fully support the EARMP and are working towards collaboration opportunities on this valuable program. Collaboration may include using the Participant

Funding Program to further promote community involvement, and sharing data collected through the CNSC Independent Environmental Monitoring Program.

The evaluation of the country food data from previous years including 2013 and 2014 confirmed that most chemical concentrations were below available guidelines and were similar to concentrations expected for the region. The results indicated that non-radiological exposures to residents from consuming country foods were similar to exposures of the general Canadian population and were below values that are considered to be protective of health effects. Moreover, the 2013–14 report also referred to an additional study conducted in collaboration with the Northern Saskatchewan Population Health Unit that indicated caribou, moose, rabbit and fish are low-calorie, nutrient-dense, healthy servings of meat and meat alternatives. Overall, the results indicated that traditional harvesting of country foods did not present health risks to northern Saskatchewan residents.

Potential radiological exposure to residents in the communities of the eastern Athabasca region from consumption of country foods indicated that radiological exposures to residents from consuming country foods were similar to exposures of the general Canadian population. CNSC staff concluded that the doses received from consumption of country foods is not a concern to human health.

CNSC staff agree with the provincial Human Health Risk Assessment (2013), which used the EARMP community data to confirm that the country foods as assessed were safe to consume.

Figure 1-2: Key Lake water sampling

1.4 The CNSC's Independent Environmental Monitoring Program – 2014 Key Lake mill

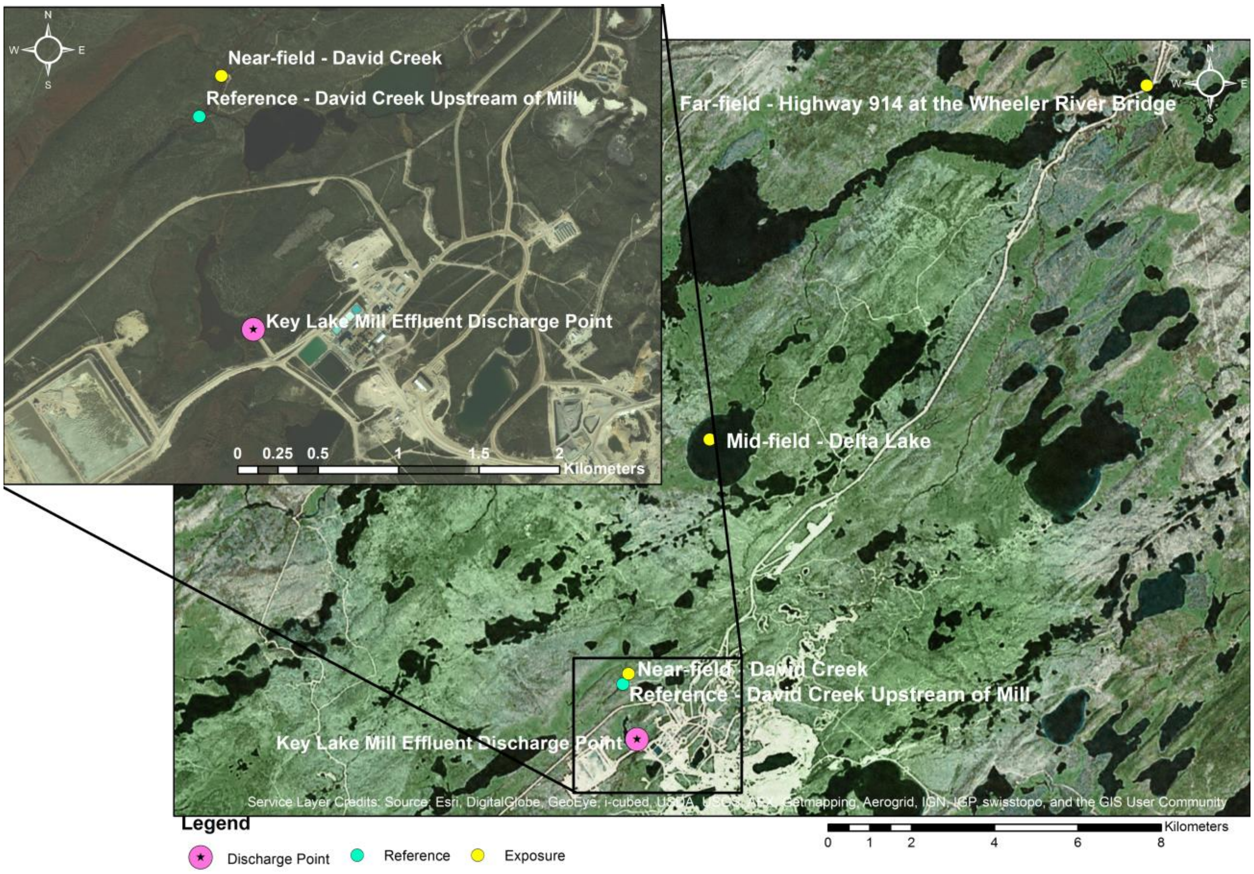
Under the NSCA, each nuclear facility licensee is required to implement an environmental monitoring program that demonstrates the continued protection of workers, the public and the environment from emissions related to the facility's activities. The results of these monitoring programs are submitted to the CNSC to ensure regulatory compliance with applicable limits, regulatory documents and standards that oversee Canada's nuclear industry.

The CNSC has implemented an Independent Environmental Monitoring Program (IEMP) for all areas of the nuclear fuel cycle: uranium mines and mills, nuclear processing facilities, nuclear power plants, research reactors and waste management facilities. The IEMP is part of the CNSC's ongoing compliance verification program at these facilities. The program involves collecting environmental samples from surrounding areas, and analyzing these to measure the amount of metals and radionuclides to verify the protection of workers, the public and the environment from facility emissions.

In 2014, a site-specific sampling plan was developed for the Key Lake operation based on Cameco's CNSC-approved environmental monitoring program, the CSA Group standards for environmental monitoring, and the CNSC's regulatory experience with the site. The results obtained from the IEMP were consistent with environmental monitoring results reported by Cameco and did not raise any new concerns. The concentrations of analyzed metals and radionuclides in water were below the water quality guidelines and within the range of the regional natural background levels. No environmental impacts are expected at these levels.

The sampling plan focused on collecting surface water samples from outside the surface lease boundary downstream of the effluent release point. Samples were collected from a near-field station (approximately 2.3 km downstream from the effluent release point), a mid-field station (approximately 12.3 km downstream from the effluent release point) and far-field station (approximately 21.5 km downstream from the effluent release point) (see figure 1-3). A nearby watercourse that was not exposed to mill effluent was sampled as a reference station.

Figure 1-3: Exposure and reference station locations at the Key Lake mill



The water samples were analyzed for the uranium decay series radionuclides (radium-226, lead-210, polonium-210) and several metals and metalloids known to occur in uranium mill effluent (arsenic, copper, lead, nickel, selenium, molybdenum, uranium and zinc). The water quality results from the near-field, mid-field and far-field stations were compared to those from the reference station and regional natural background values for the northern Athabasca region, as well as water quality guidelines for the protection of aquatic life and drinking water quality guidelines for the protection of human health. The results are presented in table 1-2.

Table 1-2: Results of the 2014 IEMP water sampling conducted at the Key Lake mill

Parameter	Near-field (Station 3.8 David Creek ~2.3 km downstream)	Mid-field (Station 3.3 Delta Lake ~12.3 km downstream)	Far-field (Highway 914 at the Wheeler River Bridge ~21.5 km downstream)	Reference (David Creek – Upstream of mill)	Drinking water quality guideline(1)	Aquatic life water quality guideline(2)	Regional natural background (min-max)(3)
Metals (µg/L)							
Arsenic	3.35	0.95	0.18	0.31	10	5	0.05–8
Copper	0.48	0.14	0.19	0.17	(AO)<1000	2–4	0.1–15
Lead	0.07	< 0.03	0.05	0.17	10	1–7	0.05–20
Molybdenum	**86.61**	**121.63**	4.19	<1.5	–	73	0.05–78
Nickel	9.65	2.63	0.32	0.14	–	25–150	0.05–94
Selenium	**2.8**	0.70	< 0.11	< 0.11	50	1	0.05–3
Uranium	0.41	0.06	0.09	0.04	20	15	0.005–6
Zinc	1.08	< 0.12	3.06	< 0.12	(AO)<5000	30	0.25–50
Radionuclides (Bq/L)							
Lead-210(4)	< 1	< 1	< 1	< 1	0.2	-	0.002–0.07
Polonium-210	< 0.01	< 0.01	< 0.01	< 0.01	0.1	-	0.002–0.16
Radium-226	0.01	0.008	0.005	0.007	0.5	-	0.00005–0.1

1 Health Canada *Guidelines for Canadian Drinking Water*; AO = Aesthetic objective (odour, taste).
2 Canadian Council of Ministers of the Environment *Surface Water Quality Guidelines for the Protection of Aquatic Life*.
3 Regional background taken from the CNSC report, *Environmental Performance of Uranium Mine or Mill Regulated Under the Nuclear Safety and Control Act: Based on Environmental Data Associated with Operating Uranium Mines and Mills (2000 – 2012)* presented at the Quebec Bureau d'audiences publiques sur l'environnement in 2014.
4 The laboratory detection limit used for lead-210 in this study was higher than the drinking water quality guideline value. Duplicate samples analyzed by Cameco's Key Lake operation were within the regional natural background.

Note:
The < symbol indicates that a result is below the provided laboratory analytical detection limit.
Bold text denotes exceedance of protection of aquatic life surface water quality guideline.

Drinking water quality guidelines are not regulatory limits and are applicable only to drinking water sources such as drinking water plants or wells. They are presented here to provide perspective on water quality. Metals and radionuclides measured in surface water samples were below the applicable maximum allowable concentration or aesthetic objective in Health Canada's *Guidelines for Canadian Drinking Water Quality* (2012) and within the range of the regional background levels. No health impacts are expected at the measured levels.

The *Water Quality Guidelines for the Protection of Aquatic Life* (WQGAL) are developed by the Canadian Council of Ministers of the Environment on a Canada-wide basis to protect all forms of aquatic life and all aspects of aquatic life cycles. These guidelines consider effects on the most sensitive life stages of the most sensitive species over the long term, based on published toxicological data. The limits they set are often substantially lower than human drinking water quality guidelines. The aquatic life guidelines are not regulatory limits. Due to their conservative nature (i.e., highly protective) they serve as screening criteria to indicate when there is a potential risk to aquatic life that may merit further risk assessment, monitoring or specialized investigations.

The concentrations of analyzed substances in water were below the WQGAL and within the range of the regional natural background levels. No environmental impacts are expected at these levels. Molybdenum (near-field and mid-field) and selenium (near-field) concentrations exceeded the WQGAL. Cameco's Environmental Monitoring Program has reported exceedances of these guidelines for these contaminants as well. It is not unusual for some effluent constituents to exceed WQGALs in the near-field and mid-field, particularly when mine or mill effluent releases are discharged to low-dilution (i.e., low flow and volume) headwaters as is common in mining operations. This is addressed through site-specific risk assessments and environmental monitoring programs with predicted exceedances carefully monitored (chemical and biological effects monitoring) and unpredicted exceedances triggering investigations to assess the potential ecological effects of the exceedance and whether mitigating action is required. Selenium and molybdenum received additional CNSC regulatory focus with the coming into force of the NSCA in 2000 and the enhanced responsibilities associated with hazardous substances.

Over recent years, regulatory action by the CNSC has required effluent treatment system upgrades for selenium and molybdenum at the Key Lake mill. These upgrades were installed and commissioned by the end of 2009. Cameco's environmental monitoring program has demonstrated that selenium and molybdenum surface water concentrations at the near-field and mid-field sampling stations have decreased significantly since 2009. It is expected that surface water quality will continue to improve in the future.

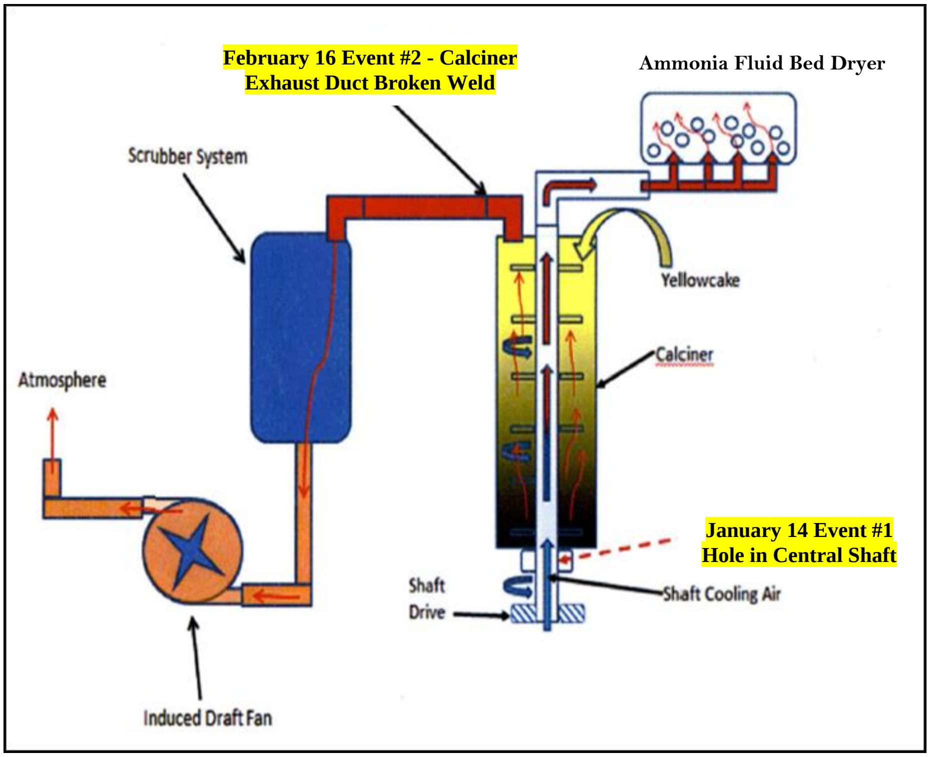
1.5 Key Lake calciner events: unplanned releases of calcined yellowcake in the work environment

Background

Towards the end of the Key Lake milling process, ammonia is used to precipitate uranium as yellowcake (ammonium diuranate- $(NH_4)_2U_2O_7$). The ammonia solution used to precipitate the yellowcake is converted into white ammonium sulphate crystals which are dried in a fluidized bed dryer. The wet yellowcake is sent to a furnace called a calciner where the yellowcake is heated to 850 ^{o}C to produce a dry black product (uranium oxide – U_3O_8) called calcined yellowcake or calcine. As depicted in figure 1-4, the current calciner consists of a propane-fired furnace with a central rotary shaft with attached arms that rake the yellowcake, moving it through the calciner as it is being changed into black 'calcined yellowcake'.

Cameco's Key Lake operation is constructing a new horizontal calciner. Cameco intends to continue to use the old calciner until the new calciner is commissioned. The new calciner will require far less operator maintenance with much lower potential worker exposure to yellowcake.

Figure 1-4: Schematic view of the current Key Lake calciner showing the location of the two events



Events and response

The Key Lake operation reported two events associated with unplanned releases of calcined yellowcake. The releases occurred on January 14, 2015 and February 16, 2015.

The January event was reported by CNSC staff to the Commission at a public Commission meeting on February 4, 2015. Approximately 1 kg of calcined material was discovered in the crystallization circuit by workers. Failure of a sand seal at the base of the calciner allowed calcine material to enter the base enclosure. The rotating shaft was abraded by the calcine creating a hole in the central shaft as shown in figure 1-4. Calcine material then entered the shaft through the hole and was transported by the cooling air to the ammonia fluid bed dryer. The workers reported the material to their supervisor; the area was evacuated and the mill safely shut down. Repairs were conducted and the mill was safely restarted. Five workers received radiation doses that exceeded the weekly action level of 1 mSv, with a maximum individual dose of 1.8 mSv. The dose received by workers was well below the CNSC limit of 50 mSv/year. CNSC staff conducted an inspection following the January event and verified Cameco’s initial assessments of cause. CNSC staff were satisfied with the corrective actions.

On February 16, 2015, there was a second event involving the same calciner. About 2 kg of calcined material was discovered on the building floor below the calciner exhaust duct. The workers reported the material to their supervisor and investigations resulted in the mill being shut down. The initial investigation by Cameco found that the source of the calcine was a broken weld in the calciner exhaust duct. Removal of the insulation and cladding from the duct revealed a total of 12 weld failures of various sizes ranging up to a complete weld failure in one location. Repairs were made and the mill was safely restarted. One worker received a radiation dose of 1.16 mSv, exceeding the weekly action level of 1.0 mSv. CNSC staff conducted an inspection following the February event verifying the initial assessments of cause, corrective actions taken and Cameco's safe start-up plan. CNSC staff were satisfied with the corrective actions.

Subsequent to the two calciner events, CNSC staff issued a request on March 11, 2015, under subsection 12(2) of the *General Nuclear Safety and Control Regulations* to the Cameco- and AREVA-run operations to review:

- the design and operational features that help prevent an unplanned release of yellowcake into the work environment
- the equipment, processes and procedures that help in monitoring and identifying any weakening of containment systems that might lead to the unplanned release of yellowcake into the work environment
- the radiation monitoring equipment and procedures that will quickly identify any unplanned releases of yellowcake into the work environment

The February 16, 2015 event was reported to the Commission as an event initial report at a public Commission meeting on March 25, 2015. The Commission requested that the final report should include causes for the event, health consequences, results of monitoring of the workers, responses to the 12(2) requests and CNSC staff's review, and be presented by CNSC staff as part of the *Regulatory Oversight Report for Uranium Mines and Mills in Canada: 2014.*

CNSC staff reviewed Cameco's root cause analysis report of the two calciner events in May 2015. The report identified the primary cause of both events was mechanical failure. The report also identified opportunities for improvement in the areas of worker awareness, housekeeping, training and additional preventative maintenance for improving the aging calciner operation. CNSC staff accepted the findings in the report and are monitoring the implementation of the improvements.

As previously noted, monitoring confirmed that all radiation doses to workers were well below the regulatory limit of 50 mSv/year. It is also important to note that internal exposure to uranium can also cause a risk to kidneys due to uranium chemical toxicity. In terms of kidney toxicity, there were no health concerns as the uranium kidney deposition was determined to be about 0.3 percent of the recommended uranium chemical toxicity limit in the Oak Ridge National Laboratory standard ORNL/TM-2012/14, *Controlling intake of uranium in the workplace: Applications of biokinetic modelling in occupational monitoring data. Oak Ridge National Laboratory, 2012.*

At the March 25, 2015 public Commission meeting, CNSC staff made a commitment to intensify their review of dryer and calciner operations. CNSC staff conducted a follow-up compliance verification inspection at Key Lake on July 15 and 16, 2015 and confirmed that many of the corrective actions have been implemented, with the remaining to be completed by the end of 2015. CNSC staff are satisfied that the immediate hazards have been corrected, enhanced controls are in place to protect the workers and the environment, and that lessons learned from these events will be transferred to the new Key Lake calciner and operating uranium mills in Saskatchewan. CNSC staff will confirm and verify implementation of all corrective actions.

Key Lake, Rabbit Lake and McClean Lake operations all provided satisfactory responses to the CNSC's requests under subsection 12(2) of the *General Nuclear Safety and Control Regulations*. The licensees' responses did not identify any significant deficiencies. Rather, the review identified opportunities to improve the mitigation measures already in place, such as increasing inspection frequency, improving preventative maintenance, updating documentation and training materials, and increasing workplace monitoring. CNSC staff will continue to verify the implementation of these opportunities for improvement as part of its compliance activities.

1.6 Public information and community engagement

Part of the CNSC's mission is to provide objective scientific and regulatory information to the public concerning nuclear activities. Licensees have an important role to inform the public about their nuclear facilities and activities. To ensure licensees provide open and transparent information to the public, in 2012 the CNSC published new regulatory requirements in RD/GD-99.3, *Public Information and Disclosure*. In 2014, both Cameco and AREVA continued to meet expectations regarding compliance with RD/GD 99.3.

As standard practice, CNSC staff, Cameco and AREVA continued to communicate and engage with communities and their leadership in 2014. For example, CNSC and licensee staff participated 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 Aboriginal. Throughout 2014, licensees also continued to host community meetings to discuss their operations with Aboriginal groups and leadership. CNSC staff attended many of these meetings. The CNSC is committed to keeping interested communities informed of regulatory activities occurring at the mines and mills and will continue to look for ways to enhance the involvement of interested groups.

Figure 1-5: CNSC staff engaging with members of the Environmental Quality Committee in La Ronge

1.7 Mount Polley event – CNSC follow-up

Mount Polley is a copper/gold mine located in British Columbia and is not a CNSC-regulated facility. However, important lessons learned from any mining operation offer continuous improvement opportunities for the uranium mine and mill facilities.

On August 4, 2014 a breach of an operating above-ground tailings facility at the Mount Polley mine released approximately 10 million cubic metres of water and 13.8 million cubic metres of tailings slurry. A comprehensive investigation concluded that the breach occurred when an increased load imposed by the heightening of the tailings dam exceeded the foundation's capacity to sustain it. A silty-clay layer localized in glacial till under the dam breach went undetected and deterioration in the silty-clay layer strength was not recognized. The dam's failure on the silty-clay layer occurred rapidly and without precursors, resulting in dam breach.

The investigation report recommended mines adopt best available practices and technology in construction and operation of above-ground tailings management facilities (AGTMFs). Examples of best available technology include filtered, unsaturated, compacted tailings, and a reduction of the use of water covers in a closure setting.

Of the regulated mine and mill facilities, the Key Lake and Rabbit Lake operations have AGTMFs. Tailings are no longer placed in these AGTMFs as they have been replaced by in-pit tailings management facilities. In both Key Lake and Rabbit Lake AGTMFs, the tailings are filtered, dewatered and compacted, and do not have a water cover, therefore presently aligning with recommendations from the investigation report on best applicable practices and technology. All these factors support a conclusion that the AGTMFs are in a safe and stable condition.

CNSC licences require the Key Lake and Rabbit Lake facilities to complete annual geotechnical inspections of their AGTMFs by qualified engineers. Licensees have confirmed that their AGTMFs are operating as designed, that their safety cases remained valid, and that there were no identified gaps in response to their internal investigations. CNSC staff review the results of these inspections.

As an initial response to the Mount Polley incident, inspections were conducted by CNSC staff of the AGTMFs at the Key Lake and Rabbit Lake facilities in August and September of 2014. No areas of concern were found. Additional inspections of the two AGTMFs were completed by CNSC staff, including geotechnical experts, in May 2015. These inspections further verified the safety case of the tailings dams. CNSC staff will continue to monitor the safety of AGTMF through geotechnical report reviews and inspections. CNSC staff concluded that the AGTMFs remain stable with a very low risk of failure.

Further details of the Mount Polley event follow-up for these facilities will be presented to the Commission in December 2015, within the *Regulatory Oversight Report for Nuclear Waste Facilities in Canada: 2014.*

2 Overview

This report focuses on the uranium mines and mills currently operating in Canada. The facilities listed are located within the Athabasca Basin of northern Saskatchewan and are shown in figure 2-1:

- Cameco Corporation – Cigar Lake operation
- Cameco Corporation – McArthur River operation
- Cameco Corporation – Rabbit Lake operation
- Cameco Corporation – Key Lake operation
- AREVA Resources Canada Inc. – McClean Lake operation

Figure 2-1: Location of uranium mines and mills in Saskatchewan

Other regulatory bodies that conduct inspections at these facilities include Saskatchewan's Ministry of Environment, Saskatchewan's Ministry of Labour Relations and Workplace Safety, and Environment Canada. Staff from the CNSC take the findings from these regulatory bodies into account when assessing licensee performance.

The licensees' requirements to satisfy each safety and control area (SCA) depend on the risks posed by the activities conducted. Appendix A describes the 14 SCAs used by the CNSC in its regulatory evaluations of each facility. A discussion of rating methodologies and definitions can be found in appendix B. Appendix C contains the SCA performance ratings for each facility from 2010 to 2014.

The 2014 SCA performance ratings for the uranium mines and mills facilities are presented in table 2-1. All were rated as "satisfactory" (SA).

Table 2-1: Uranium mines and mills – 2014 SCA performance ratings

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	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

The 2014 uranium production data for the five mine and mill facilities are shown in table 2-2. At Rabbit Lake, the difference in the mine ore grade and the mill feed grade reflects the practice of blending stockpiled material with newly mined ore. At Key Lake, McArthur River ore is blended with stockpiled, lower-grade material to produce a lower-grade mill feed. At McClean Lake, ore from Cigar Lake is blended with stockpiled, lower-grade material to control ore grades for radiation control validation studies.

The Cigar Lake operation began shipping ore slurry to McClean Lake in March 2014. The McClean Lake operation was making mill modifications until September 2014 and then began feeding blended ore to the milling circuit.

Table 2-2: Uranium mines and mills – 2014 production data

Production data	Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClean Lake
Mining – ore tonnage (tonnes/year)	3,318	108,394	328,126	Not applicable	Not applicable
Mining – average ore grade mined (% U expressed as U_3O_8)	7.2	8.73	0.56	Not applicable	Not applicable
Mining – U mined (Mkg* U/year)	0.20	8.02	1.58	Not applicable	Not applicable
Milling – mill ore feed (tonnes/year)	Not applicable	Not applicable	386,970	173,007	7,832
Milling – average mill feed grade (% U expressed as U_3O_8)	Not applicable	Not applicable	0.49	5.03	3.00
Milling – mill recovery (% of U)	Not applicable	Not applicable	97.3	99.4	97.5
Milling – U concentrate produced (Mkg U/year)	Not applicable	Not applicable	1.60	7.37	0.20
Authorized annual production (Mkg U/year)	9.25	8.1	4.25	9.6	5.0

* 1 Mkg = 1,000,000 kg

Licensees are required to develop preliminary decommission plans and associated financial guarantees to ensure the work can be completed satisfactorily. An overview of decommissioning plans and financial guarantees was provided in the *CNSC Staff Report of Uranium Mine and Mill Facilities: 2013*. Decommissioning plans are reviewed by CNSC staff. There were no changes in decommissioning plans or financial guarantees in 2014. Appendix D lists the financial guarantees for the mine and mill facilities, which range from approximately $43 million at the McClean Lake operation to $225 million at the Key Lake operation. Appendix E contains the timeline estimates for the completion of major reclamation and decommissioning activities for each of the five mine and mill facilities, as prepared by the licensees.

2.1 Radiation protection

Uranium mines and mills in Canada are required to implement and maintain a comprehensive radiation protection program in accordance with the *Radiation Protection Regulations*. For 2014, CNSC staff rated the radiation protection SCA at all five uranium mines and mills as “satisfactory”.

Primary sources of radiation exposure at uranium mines and mills include:

- gamma radiation
- long-lived radioactive dust
- radon progeny
- radon gas

Activities conducted by CNSC staff to ensure compliance with radiation protection requirements at uranium mines and mills include regular inspections, as well as reviews of radiation protection programs, compliance reports, monitoring data and radiation dose statistics.

Workers designated as nuclear energy workers (NEWs) are issued optically stimulated luminescence dosimeters (OSLDs), which measure external gamma radiation exposure and resulting dose. Underground workers also wear personal alpha dosimeters (PADs) to measure alpha radiation exposure from radon progeny and long-lived radioactive dust. OSLDs and PADs are issued by a CNSC-licensed dosimetry provider. Where direct monitoring through dosimeters is not practical, or not required, area/group monitoring and time cards are used for worker dose estimates.

The uranium mine and mill facilities have continued to maintain and implement comprehensive radiation protection programs based on the as low as reasonably achievable (ALARA) principle. As a result, facilities set objectives to keep doses well below regulatory limits.

Figure 2-2: McArthur River underground remote scoop tram operation

Uranium mine and mill operations are remote from local populations. Radiological exposures measured at the licensed facility boundaries are maintained near background radiation levels, ensuring the public is protected.

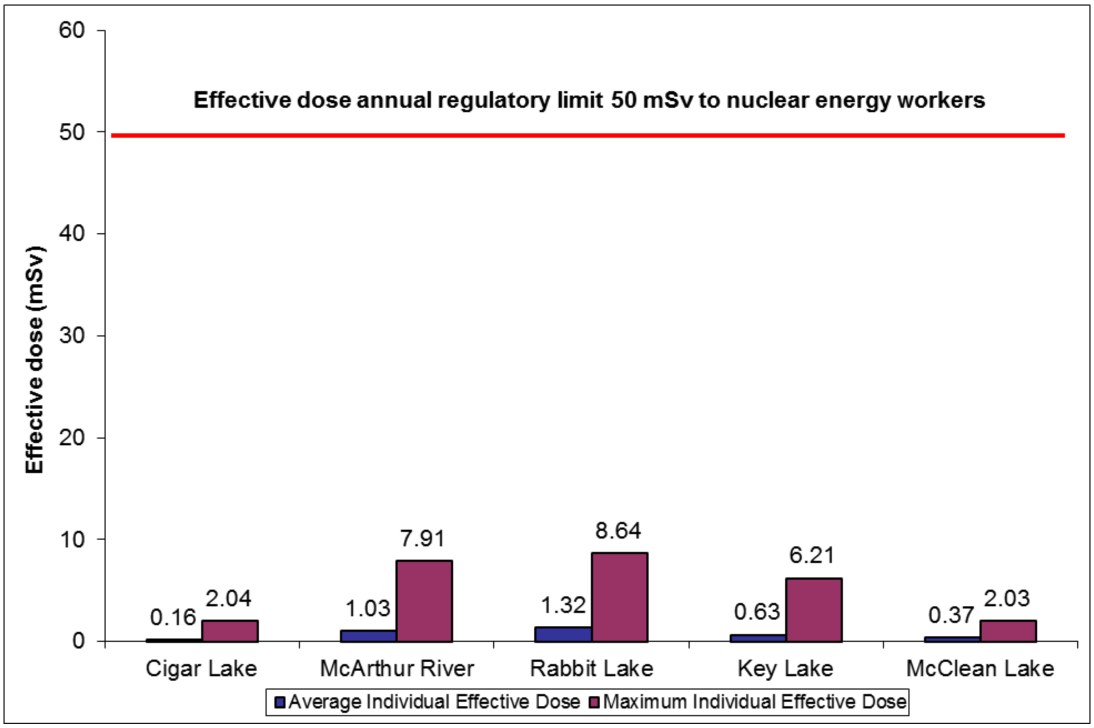
In 2014, no worker at any uranium mine or mill facility exceeded the regulatory individual effective dose limits.

Radiation doses

The individual effective dose limit for a NEW is 50 mSv in a one-year dosimetry period and 100 mSv in a five-year dosimetry period. In addition, action levels have been developed, which, if exceeded, signify a potential loss of control of a portion of the radiation protection program. All five uranium mine and mill facilities listed in this report have the same action levels of 1 mSv/week and 5 mSv/quarter of a year. Appendix F displays the number of NEWs with the corresponding average individual effective dose and maximum individual effective dose for each operating facility from 2010 to 2014. Appendix F also includes the maximum individual dose for the five-year dosimetry period of 41.91 mSv/5 years, well below the regulatory limit of 100 mSv/5 years.

Figure 2-3 compares the average individual effective dose and maximum individual effective dose at each uranium mine and mill during the 2014 reporting period. It shows that the operating uranium mine or mill facilities were well below the regulatory individual effective dose limit of 50 mSv/year.

Figure 2-3: Uranium mines and mills – comparisons of average individual and maximum effective dose of NEWs in 2014



The Cigar Lake operation conducted its first activity in December 2013. Commissioning of the jet boring system mining production of uranium ore continued in 2014 with gradually increasing ore grades. In 2014, worker exposures at the Cigar Lake operation were very low. The average individual effective dose was 0.16 mSv, and the maximum individual effective dose for a full-time Cigar Lake worker was 2.04 mSv.

The maximum individual effective dose in 2014 was 8.64 mSv. The dose was received by a worker at the Rabbit Lake facility. The Rabbit Lake and McArthur River facilities had higher average and maximum individual effective doses when compared to the remaining facilities, since underground mining work activities are conducted closer to the radioactive source than milling operations. The Rabbit Lake operation includes a mine and a mill. The average individual effective dose shown in figure 2-3 therefore includes both mine and mill workers. In 2014, the maximum individual effective dose to a mill worker at Rabbit Lake operation was 5.40 mSv, and the maximum individual effective dose to an underground miner was 8.64 mSv.

The McClean Lake operation conducted construction, maintenance and commissioning operations in 2014. Processing of Cigar Lake ore at McClean Lake began in September 2014.

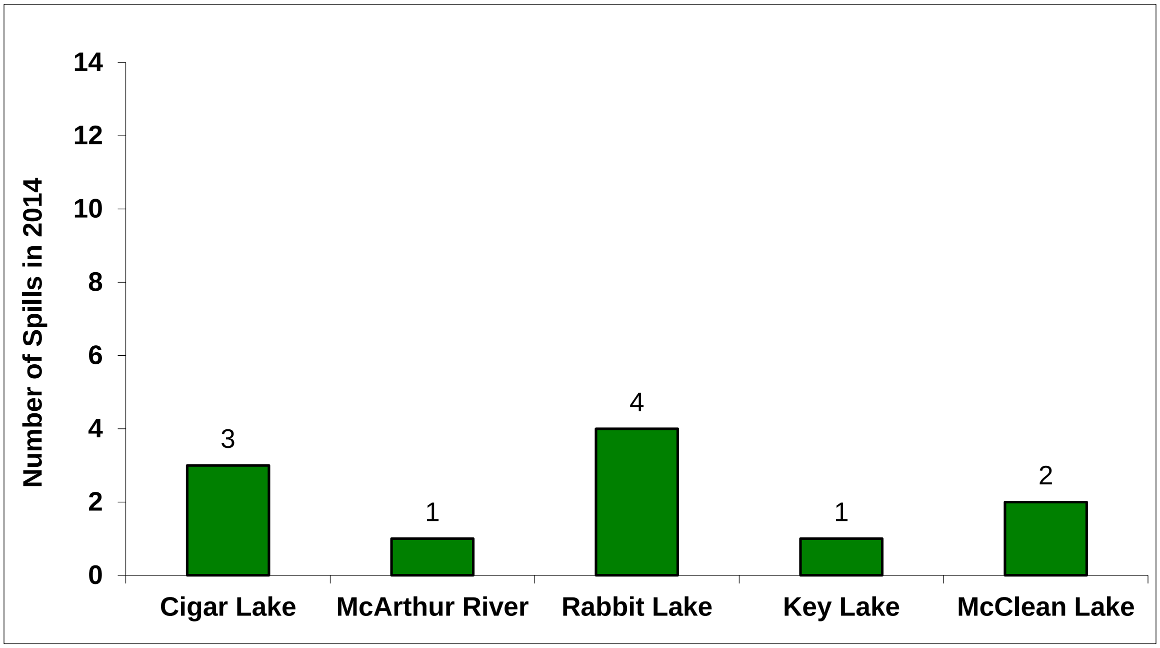
Based on the outcome of inspections and reviews of the radiation protection programs, work practices, monitoring results and effective doses, CNSC staff were satisfied that uranium mine and mill licensees are controlling radiation doses to workers at levels well below the regulatory limits, keeping doses ALARA.

2.2 Environmental protection

CNSC staff rated the 2014 performance of all five uranium mine and mill facilities for the environmental protection SCA as “satisfactory”.

The environmental protection SCA covers programs that identify and monitor releases of nuclear and hazardous substances and their effects on the environment. Licensees are required to develop and implement policies, programs and procedures that comply with applicable federal and provincial regulatory requirements to control the release of nuclear and hazardous substances into the environment. These programs include an environmental management system (EMS) that is integrated into the facilities’ overall management systems. An environmental protection program includes environmental codes of practice that set out licensee administrative levels and action levels for effluent released to the environment. Licensees are required to report to the regulatory authorities, including the CNSC, any unauthorized releases of hazardous or nuclear material to the environment. Figure 2-4 depicts the number of environmental reportable spills for uranium mine and mill facilities in 2014. CNSC staff verified, and were satisfied, that the licensees’ reporting of, and responses to, environmental spills during 2014 was acceptable.

Figure 2-4: Uranium mines and mills – environmental reportable spills, 2014



Appendix G further describes each reportable spill and the corrective actions taken by each licensee in response to the spill. The licensee investigated the causes of spills and implemented corrective actions to remediate the spills and prevent recurrences. CNSC staff reviewed licensee actions to ensure effective remediation and prevention, and were satisfied with actions taken by each licensee. The CNSC rated all 2014 spills as "low significance", as they resulted in no residual impact to the environment. For more information, see table G-2 in appendix G.

Figure 2-5: Downstream from the McArthur River operation

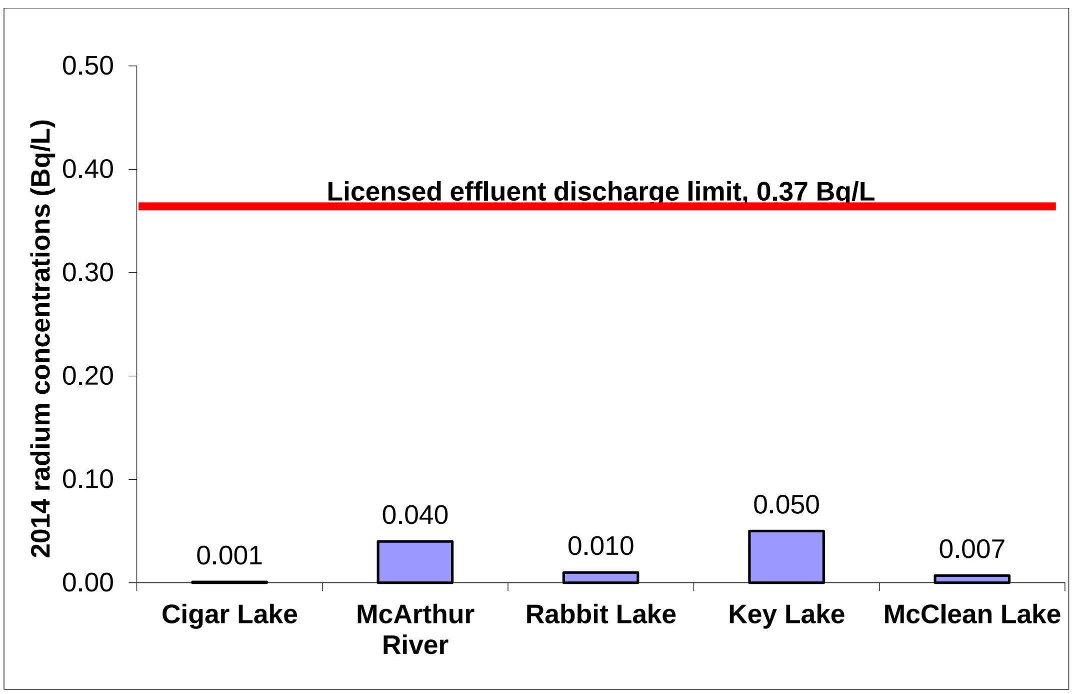
In 2014, all treated effluents released to the environment from licensed mining and milling activities met the effluent discharge limits stipulated in the CNSC operating licences.

Effluent discharge is also measured against the administrative levels and action levels specified in each licensee's environmental code of practice. An exceedance of an administrative level indicates that an operating performance (parameter) is at the upper range of normal operations. Such an event triggers an internal review by the licensee. Exceedance of an action level indicates a potential loss of operational control requiring the licensee take action to correct the problem. Administrative and action levels thus provide an early warning to minimize upsets and prevent an exceedance of a regulatory discharge limit. Facility administrative and/or action levels are determined through the identification and proper operation of available treatment technologies, as well as facility-specific environmental risk studies.

Environmental risk assessments and environmental monitoring data collected prior to 2009 identified releases of molybdenum, selenium and uranium as contaminants of potential concern. As a result, licensees were required to improve engineering controls and treatment technologies to reduce effluent releases of these contaminants. Implemented treatment technologies continued to keep these contaminant concentrations stable and at acceptable levels in 2014.

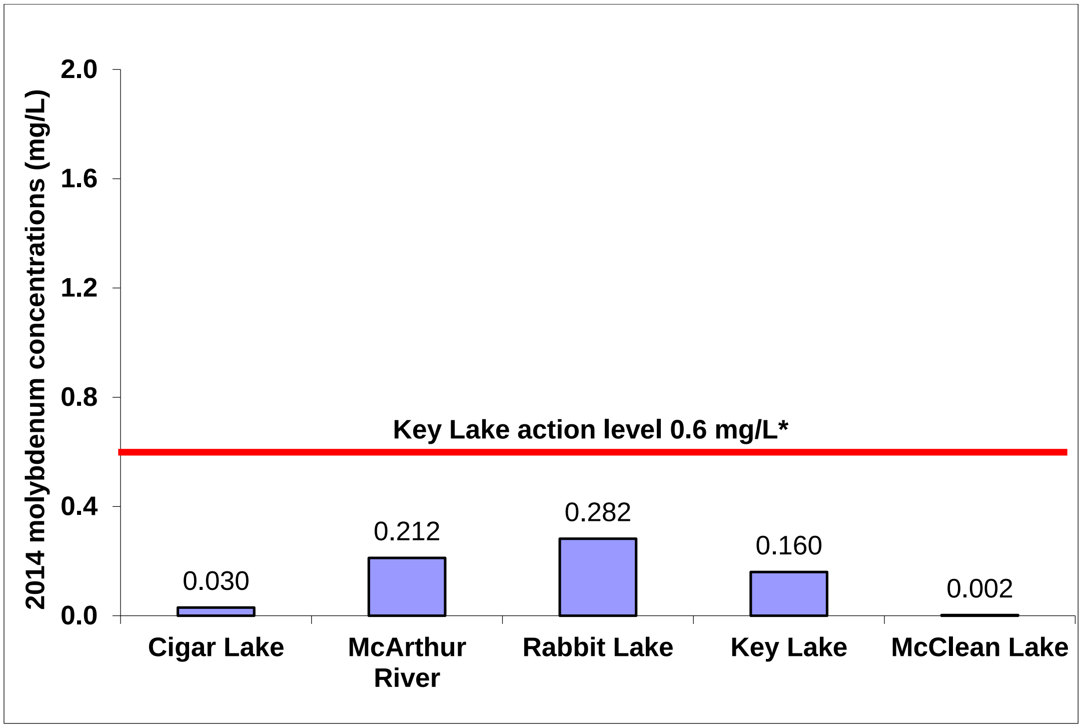
Treated effluent monitoring data provides an overview of the quality of the effluent released from these facilities. Figures 2-6 to 2-9 display the 2014 average annual effluent concentrations for radium-226, molybdenum, selenium and uranium at the five mine and mill facilities.

Figure 2-6: Annual average concentration of radium-226 in effluent released to the environment, 2014



The 2014 radium-226 annual average effluent concentrations for the five facilities were well below the CNSC's licence-authorized effluent discharge limit, as shown in figure 2-6.

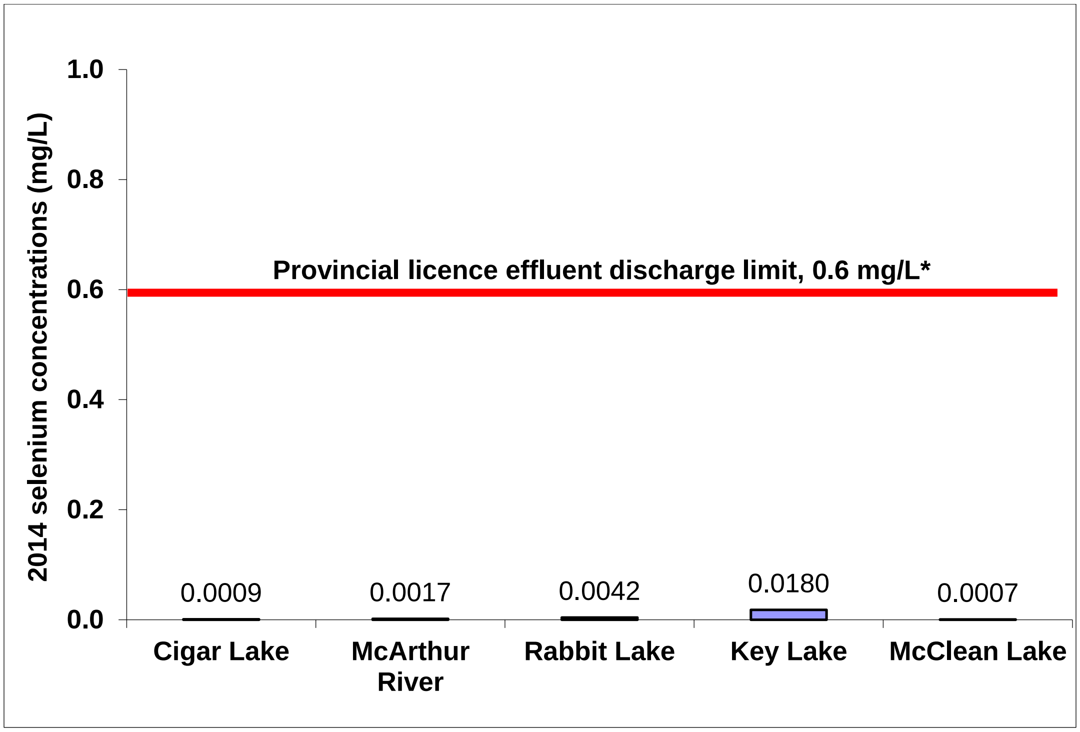
Figure 2-7: Annual average concentration of molybdenum in effluent released to the environment, 2014



* The Key Lake action level for molybdenum is the most stringent of the five operating uranium mines and mills and is shown for reference only.

In the absence of a federal or provincial limit for molybdenum, the CNSC requires licensees to develop facility-specific effluent controls within their individual environmental codes of practice. For molybdenum effluent concentrations, which are shown in figure 2-7, the Key Lake code of practice action level of 0.6 mg/L is shown for reference only and is based on five consecutive ponds. The 2014 molybdenum average effluent concentrations for the five facilities are well below the Key Lake code of practice action level.

Figure 2-8: Annual average concentration of selenium in effluent released to the environment, 2014

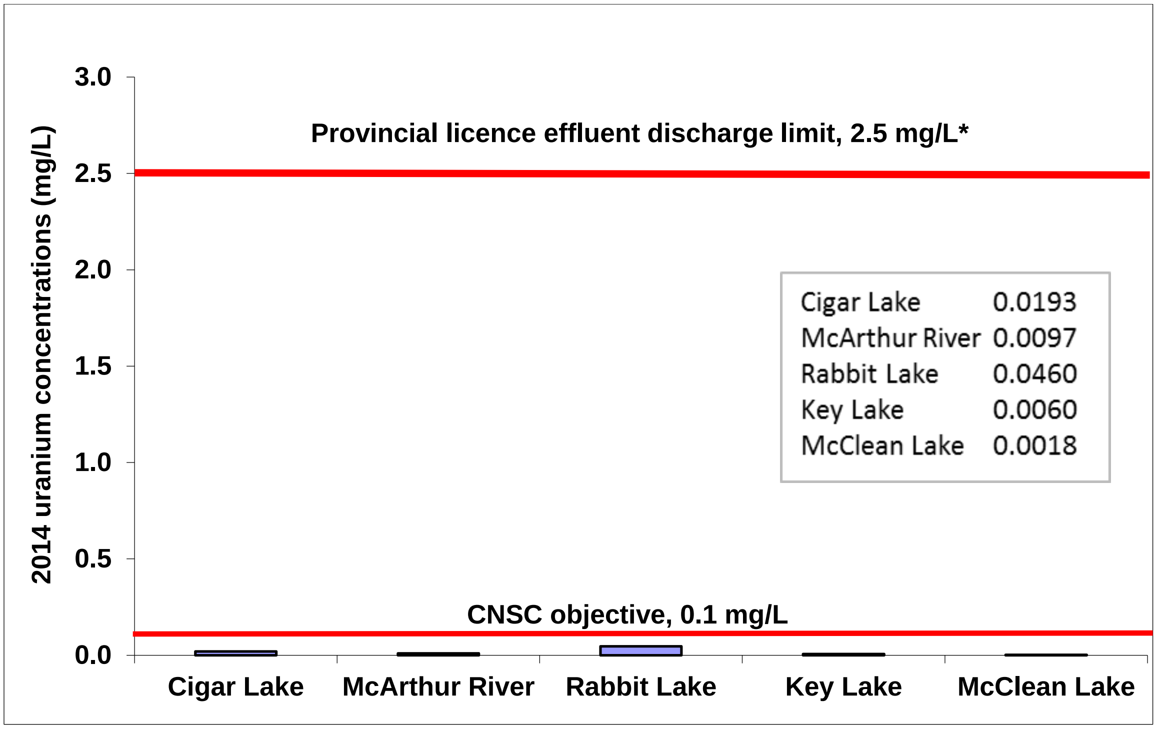


* Saskatchewan’s discharge limit for selenium is shown for reference only.

As no federal limits are currently established, the Province of Saskatchewan’s effluent discharge limits for selenium and uranium are shown in figures 2-8 and 2-9 for reference only. Nevertheless, the CNSC expects performance well below these limits and requires licensees to continually try to reduce effluent contaminant concentrations to be as low as reasonably achievable. Figures 2-8 and 2-9 demonstrate that both selenium and uranium concentrations in treated effluent released to the environment in 2014 remained well below the provincial licence limits.

The Saskatchewan provincial licence limit for uranium is a maximum monthly mean of 2.5 mg/L. However, the *Priority Substances List 2 Assessment* (Environment Canada and Health Canada, 2003) and Rabbit Lake operation environmental investigations indicated that such limits were not adequately protective of the environment in all circumstances. In 2006, a review 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 CNSC is using this value (0.1 mg/L uranium) as an interim objective for uranium mine and mill facilities, which the five facilities met in 2014, as shown in figure 2-9.

Figure 2-9: Annual average concentration of uranium in effluent released to the environment, 2014



* Saskatchewan's discharge limit for uranium is shown for reference only. The CNSC objective is 0.1 mg/L.

Details on effluent release concentrations, with five-year trends for molybdenum, selenium and uranium, are discussed in the facility-specific sections of this report (sections 3 to 7).

In addition to concentration results of radium-226, molybdenum, selenium and uranium in treated effluent released to the environment, the facilities also analyze for concentrations of arsenic, copper, lead, nickel, zinc, total suspended solids (TSS), and for pH. Table 2-3 displays the *Metal Mining Effluent Regulations* (MMER) discharge limits and the annual average parameter concentration values in effluent released in 2014 for these additional parameters. The annual average parameter concentration values for arsenic, copper, lead, nickel, zinc, TSS and pH in effluent released to the environment are meeting MMER discharge limits.

Table 2-3: Annual average parameter concentration values in effluent released to the environment in 2014

Parameters	MMER discharge limits	Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClean Lake
Arsenic (mg/L*)	**0.5**	0.003	0.0013	0.0056	0.007	0.0005
Copper (mg/L)	**0.3**	0.0008	0.0011	0.0040	0.014	0.0048
Lead (mg/L)	**0.2**	0.0001	0.0001	0.0002	<0.01	0.0001
Nickel (mg/L)	**0.5**	0.0019	0.0014	0.0184	0.0049	0.0230
Zinc (mg/L)	**0.5**	0.0271	0.0019	0.0010	0.012	0.0022
TSS (mg/L)	**15**	1.3	1.0	2.0	1.8	1.0
pH	**6.0–9.5**	7.0	7.2	7.3	6.3	7.2

* mg/L – milligram per litre

CNSC staff review the licensees' environmental monitoring results as submitted in monthly, quarterly and annual reports. Each licensee also submits a *Status of the Environment Report* approximately every five years, providing CNSC staff with detailed monitoring information and comparisons to environmental performance expectations.

Environmental programs implemented at uranium mines and mills include monitoring the effects of the operations on the surrounding air and soil. All facilities measure airborne particulate levels using high-volume air samplers and measure the concentration of radon gas in the ambient air around each operation.

A high-volume sampler is used to collect particles from the atmosphere by drawing in large volumes of air using a mechanical pump. This provides concentrations of total suspended particulate (TSP) in the air. The particles are collected on a filter and can later be analyzed for their physical and chemical properties, such as concentrations of metal and radionuclides.

The radon track-etch detector is used to passively measure the radon concentration in air over a determined period of time. The detector consists of a material which is sensitive to alpha particles that are released when radon gas decays. These alpha particles are displayed as tracks on the material that are related to the radon concentration in the air.

The licensee monitors contaminant concentrations in soil and terrestrial vegetation to verify that operational impacts are acceptable. Facilities with milling operations perform stack tests to monitor atmospheric emissions from acid plants, yellowcake dryers, calciner operations, packaging, grinding and ammonium sulphate operations. The applicable Saskatchewan provincial ambient air standards include TSP and sulphur dioxide. Other measured parameters (e.g., ambient radon and stack testing for sulphur dioxide, uranium and heavy metals) verify facility design and evaluate the operations against predictions made in environmental risk assessments.

The operations have demonstrated good performance on mitigating and monitoring the effects of their operations on the surrounding air and soil. The monitoring results indicate negligible impacts from atmospheric releases and that all uranium mines and mills are in compliance with their programs and provincial standards. All facilities conduct regular soil and vegetation monitoring to demonstrate that environmental impacts remain within acceptable levels. 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. Overall, the results indicate that the operations have had a localized effect on vegetation in the areas of activity.

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

Summary

The effluent quality of the uranium mine and mill facilities compares favourably to other mining sectors of base metal, precious metal and iron mines.

Basis for comparison

All metal mines and mills in Canada are subject to the MMER of the federal *Fisheries Act*. The CNSC incorporates the effluent limit requirements of the MMER in uranium mine and mill licences. Compliance with the MMER limits provides a good environmental performance indicator across the metal mining industry.

MMER data from 2013 is used for comparison within this 2014 report since it is the most current sector-specific information available. Effluent quality data for uranium mines and mills is compared to base metal, precious metal and iron mines.

The MMER specifies the maximum concentration limits in effluent for arsenic, copper, lead, nickel, zinc, radium-226, TSS and an allowable pH range. Effluents must also be non-toxic and pass the trout acute-lethality test.

The data used for analysis and comparison is acquired from Environment Canada's annual report, titled *Summary Review of Performance of Metal Mines Subject to the Metal Mining Effluent Regulations*. The mines reporting under the MMER which released effluent in 2013, are grouped into four metal mining sectors based on the primary metal produced. The metal mining sectors are:

- uranium – 5 mines
- base metals (such as copper, nickel, molybdenum or zinc) – 44 mines
- precious metals (such as gold or silver) – 51 mines
- iron – 9 mines

Performance indicators

The environmental performances of the four metal mining sectors are compared using the following performance indicators:

a) Compliance with the effluent concentration limits and pH at all times

A mine is deemed to be “in compliance” if it adheres to all regulated parameters at all times (excluding toxicity tests). This indicator is used to holistically assess if compliance with the parameters of the MMER is a sector-wide concern or if any compliance concern is related to a small portion of mines. The uranium sector maintained 100 percent compliance with the effluent contaminant concentrations and pH limits for 2013.

Table 2-4 illustrates the number of mines out of compliance with MMER effluent standards for at least one parameter in 2013. As noted above, the uranium mines were in full compliance with the provisions of the MMER. In radiological contrast to the uranium sector, two base metal mines had effluent with radium concentrations above the MMER limit for portions of the year.

Table 2-4: Distribution of MMER effluent compliance by mining sector, 2013

Mining sector	Number of mines	Number of mines out of compliance with at least one parameter	Number of mines out of compliance by parameter							
			Total suspended solids	Arsenic	Copper	Lead	Nickel	Zinc	Radium-226	pH range
Uranium	5	0	0	0	0	0	0	0	0	0
Base metal	44	9	1	0	1	0	2	1	2	2
Precious metal	51	8	6	1	2	0	0	0	0	1
Iron	9	5	5	0	0	0	0	0	0	0

b) Annual average effluent concentrations in the metal mining sectors

Table 2-5 presents the 2013 annual average effluent concentrations for parameters in comparison of the metal mine sectors. It is noteworthy that all metal mine sectors met the MMER regulatory limits, as shown in table 2-5. CNSC staff note that the base metal mines effluent concentration for radium-226 is higher than in uranium mines.

Table 2-5: A sector comparison of average effluent parameter concentrations, 2013

Parameters	MMER limit	Uranium	Base metals	Precious metals	Iron
Arsenic (mg/L)	**0.5**	0.004	0.007	0.030	0.0009
Copper (mg/L)	**0.3**	0.003	0.015	0.038	0.006
Lead (mg/L)	**0.2**	0.0002	0.004	0.002	0.001
Nickel (mg/L)	**0.5**	0.023	0.063	0.023	0.062
Zinc (mg/L)	**0.5**	0.006	0.042	0.017	0.036
TSS (mg/L)	**15**	1.1	3.2	4.4	6.3
Radium-226 (Bq/L)*	**0.37**	0.023	0.028	0.009	0.007
pH low	**≥6.0**	6.8	7.6	7.5	7.2
pH high	**≤9.5**	7.2	8.0	7.8	7.5

* Bq/L – Becquerel per litre

c) Toxicity test results

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

Table 2-6 displays the number of pass and fail results of the rainbow trout acute-lethality tests for the metal mining sectors in 2013. The uranium mining metal sector passed all required tests in 2013.

Table 2-6: A sector comparison of pass/fail results of rainbow trout acute-lethality tests in 2013

	MMER limit	Uranium	Base metals	Precious metals	Iron
Rainbow trout acute-lethality test	**Pass**	34	344	446	171
	Fail	0	4	29	0

A mine is considered compliant if, throughout the year, the effluent passes all rainbow trout acute-lethality tests. Table 2-7 summarizes the performance of the metal mining sectors. Uranium mine and mill facilities passed all acute-lethality tests from 2009 to 2013.

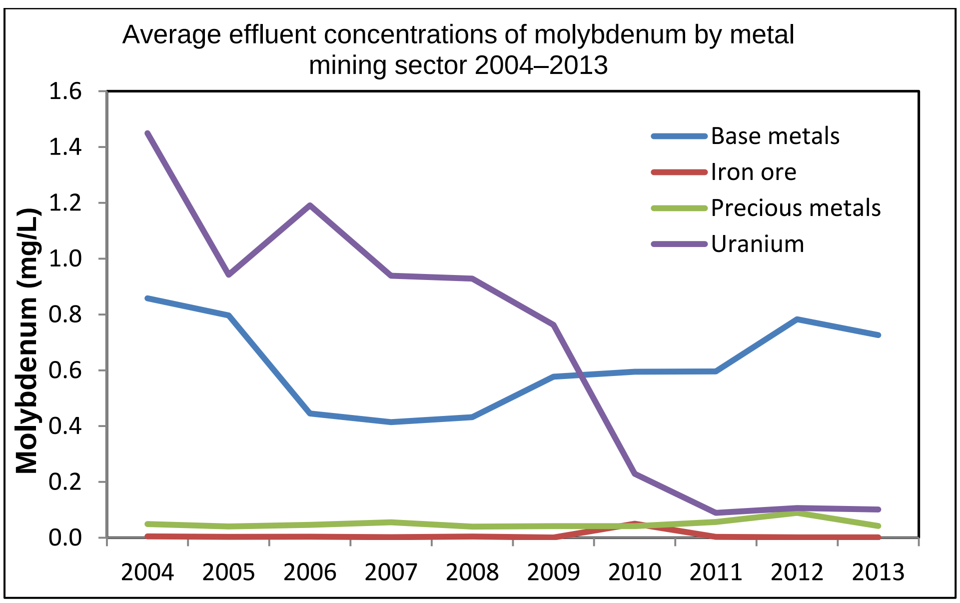
Table 2-7: Percentage of each metal mining sector passing all rainbow trout acute-lethality tests, 2009–2013

Metal mining sector	2009	2010	2011	2012	2013
Uranium	100	100	100	100	100
Base metals	80	90	85	98	93
Precious metals	96	96	96	94	86
Iron	67	80	83	100	100

2.2.2 Comparative performance of molybdenum and selenium by metal mining sector

Under the MMER, molybdenum in treated effluent must be routinely monitored. Figure 2-10 shows continuous improvement by the uranium sector in reducing molybdenum in effluent. In 2013, molybdenum concentrations in uranium mining sector effluent were similar to those measured in the effluents of precious metal and iron mines, and markedly less than in the effluents for base metal mines.

Figure 2-10: Average treated effluent concentration of molybdenum by metal mining sector, 2004–2013



In mid-2012, the MMER added the requirement for monitoring selenium. Table 2-8 summarizes the average selenium concentration in treated effluent from each mining sector using data collected in the last half of 2012 and all of 2013.

Table 2-8: Average selenium concentration in treated effluent by metal mining sector, last half of 2012 and all of 2013

Metal mining sector	Selenium concentration (mg/L)*
Uranium	0.003
Base metals	0.005
Precious metals	0.005
Iron	0.001

* mg/L – milligrams per litre

2.3 Conventional health and safety

The conventional health and safety SCA covers the implementation of a program to manage workplace safety hazards and to protect personnel. 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.

Licensees are expected to identify potential safety hazards, assess the associated risks, and put in place the necessary materials, equipment, programs and procedures to effectively manage, control and minimize these risks. CNSC staff work with Saskatchewan's 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 performing inspections, reviewing health and safety events, and issuing compliance reports.

A key performance measure for conventional health and safety is the number of lost-time incidents (LTIs) that occur per facility. An LTI is a workplace incident that results in the worker being unable to return to work for a period of time. In reviewing LTIs, CNSC staff also consider the incidents' severity and frequency rates. Table 2-9 shows the number of LTIs at the uranium mine and mill facilities along with severity and frequency rates, and the number of full-time equivalent (FTE) workers onsite during 2014.

Table 2-9: Total number of FTE workers, number of LTIs, severity rate and frequency rate, 2014

Total number of FTE workers and LTI statistics	Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClean Lake
Total number of FTE workers[1]	833	692	669	499	739
Number of LTIs[2]	0	0	1	0	3
Severity rate[3]	0	0	11.4	0	4.3
Frequency rate[4]	0	0	0.15	0	0.4

1 **Total number of workers** (employees and contractors) expressed as FTEs. One FTE = total person-hours / 2,000 hours worked per employee per year.
2 **Lost-time incident** – an injury that takes place at work and results in the worker being unable to return to work for a period of time.
3 **Severity rate** – 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.
4 **Frequency rate** – 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.

During 2014, there were three LTIs at the McClean Lake operation, one at the Rabbit Lake operation and none at the other three uranium mine and mill facilities. Appendix H describes the 2014 LTIs and corrective actions taken by each licensee. CNSC staff and personnel from Saskatchewan's Ministry of Labour Relations and Workplace Safety monitor and review each reportable injury to ensure the cause is identified and satisfactory corrective actions are taken. When applicable, incident information is shared among the facilities for lessons learned to improve safety.

CNSC staff confirm that the mine and mill facilities implement effective management of conventional health and safety in their activities. The incident statistics demonstrate satisfactory performance of the uranium mine and mill operations to keep workers safe from occupational injuries. For 2014, CNSC staff rated the conventional health and safety SCA at the uranium mine and mill facilities as "satisfactory".

2.3.1 Lost-time incidents – comparison of uranium mine and mill performance to other mining sectors

The severity rate for uranium mines and mills was reduced from 6.6 in 2013 to 3.1 in 2014, while the number of LTIs and the frequency rate remained constant. The severity rate for all mining sectors may be influenced by carrying over days lost due to an injury that occurred in a previous year.

Table 2-10 compares the various safety statistics of mining sectors within Saskatchewan. Uranium mining and milling activities continue to exhibit good performance compared to other mining sectors.

Table 2-10: Safety statistics of mining sectors in Saskatchewan in 2014

Mining sector	Number of LTIs	Frequency rate (200,000 person-hours)	Severity rate (200,000 person-hours)
Potash (underground)	7	0.1	123.3
Solution (potash)	1	0.2	2.8
Minerals (sodium sulphate, sodium chloride)	1	0.8	69.0
Hardrock (gold, diamond)	5	0.3	13.4
Coal (strip mining)	10	2.0	15.3
Uranium	4	0.1	3.1

Source: Saskatchewan Ministry of Labour and Workplace Safety

3 Cigar Lake Operation

Cameco Corporation operates the Cigar Lake mine located approximately 660 km north of Saskatoon, Saskatchewan. Cigar Lake (see figure 3-1) is the world's second-largest, known high-grade uranium deposit, second to Cameco's McArthur River operation.

The Cigar Lake orebody was discovered in 1981. The first mine shaft was completed in 1990 to support underground exploration and testing of mining methods. A construction licence was granted in late 2004 after the completion of an environmental assessment.

Figure 3-1: View of the Cigar Lake operation

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

In 2014, the Cigar Lake operation continued to mine uranium ore using a jet boring system (JBS). After the ground is frozen, a pilot hole is drilled from the JBS on the 480-metre level up through the orebody. A high-pressure water-jet string inserted into a prepared pilot hole is used to cut the ore. The broken ore and water forms a slurry that is pumped to the run-of-mine storage area and fed to the grinding circuit. The thickened ore slurry is pumped to the surface, loaded into approved containers, and transported by truck to the McClean Lake operation for milling.

Figure 3-2: Ore slurry shipped from Cigar Lake to McClean Lake

The commissioning of the JBS and ore processing continued in 2014. Sixteen cavities were mined. The JBS produced 3,318 tonnes of uranium ore (201,377 kg of uranium) at an average grade of 7.2 percent. The first shipment of ore slurry to the McClean Lake mill was completed in March 2014. Throughout 2014, 402 trucks transported 191,778 kg of uranium to McClean Lake for milling.

Table 3-1: Cigar Lake operation – mining production data, 2010–2014

Mining	2010	2011	2012	2013	2014
Ore tonnage (tonnes/year)	No mining	No mining	No mining	234	3,318
Average ore grade mined (% U_3O_8)	No mining	No mining	No mining	1.40	7.2
U mined (Mkg* U/year)	No mining	No mining	No mining	0.04	0.20
Authorized annual production (Mkg U/year)	No mining	No mining	No mining	9.25	9.25

* 1 Mkg = 1,000,000 kg

Surface construction activities in 2014 included removal of various trailers, completion of the maintenance and HAZMAT buildings, expansion of the freeze plant and continuation of the surface freeze project.

As of December 31, 2014, the proven and probable reserves at the Cigar Lake operation amounted to 90 million kg of uranium.

Figure 3-3: Cigar Lake waste rock pile

3.1 Performance

During 2014, Cameco continued to focus on Cigar Lake mine development including construction and commissioning of the ore processing circuits.

To align with mine operation requirements, Cameco revised its Radiation Protection Program (RPP) and Radiation Code of Practice (RCOP). The RPP describes how the site manages radiation protection risks, meets applicable regulatory requirements and keeps radiation exposures as low as reasonably achievable (ALARA), with social and economic factors considered. The RPP also describes site radiological monitoring and exposure control. The RCOP is an important ALARA tool and is based on correcting potential problems prior to a situation becoming an exposure or dose concern. In 2014, Cameco's RPP and RCOP at the Cigar Lake operation continued to be effective in controlling radiological exposure to workers. CNSC staff assessed that the Cigar Lake operation is adequately controlling radiation doses to workers and keeping levels below the regulatory limits, and conclude the radiation protection SCA rating remains "satisfactory".

It was verified by CNSC staff that Cameco's Cigar Lake operation Occupational Health and Safety Program met regulatory requirements and had no lost-time incidents in 2014. CNSC staff compliance verification activities confirmed that Cameco's performance for the Cigar Lake operation in the conventional health and safety SCA remains "satisfactory".

Cameco updated its Environmental Management Program and Environmental Code of Practice to align with mine operation requirements following the change from construction activities. During 2014, parameter concentrations in treated effluent were low and remained below treated effluent discharge limits. There were no exceedances of Environmental Code of Practice action levels. Cigar Lake operation also maintains a terrestrial and air monitoring program to measure the influence of facility atmospheric releases of metals and radionuclides. Air monitoring shows that impacts to the surrounding terrestrial environment were acceptable in 2014. Cameco reported three environmental spills in 2014 to CNSC staff. Appendix G provides a brief description of each spill and the actions taken by the licensee. The spills were remediated with no residual impacts to the environment, and the resultant corrective actions taken by Cameco were acceptable to CNSC staff.

CNSC staff verified that in 2014 Cameco continued to protect the environment and provided a “satisfactory” rating for the environmental protection SCA.

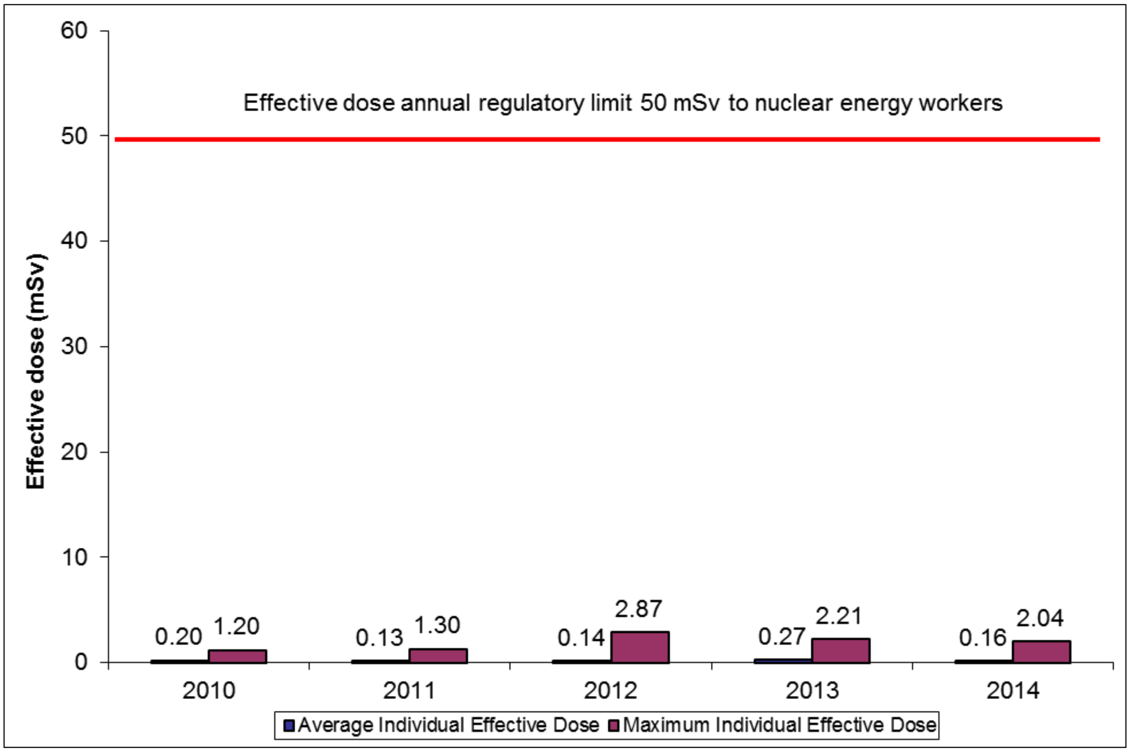
The Cigar Lake SCA ratings for the five-year period from 2010 to 2014 are shown in appendix C. For 2014, CNSC staff rated all 14 SCAs for Cigar Lake as “satisfactory”.

3.2 Radiation protection

The main source of radiological exposure at the Cigar Lake operation is from the mining and processing of high-grade uranium ore. The three primary effective dose contributors for workers are radon progeny, long-lived radioactive dust and gamma radiation. A design criterion for the Cigar Lake operation was established during the early stages of the project to incorporate radiation protection requirements into all process ore-handling areas, as well as ventilation design. The design criterion incorporates best practices and lessons learned from other operating sites (particularly McArthur River). All the process equipment, piping, vessels and ventilation are designed to meet the established criteria.

During the 2014 review period, most of the individual effective doses to workers at Cigar Lake were from exposure to radon progeny. Figure 3-4 displays the average individual effective dose and the maximum individual effective dose for Cigar Lake’s nuclear energy workers (NEWs) from 2010 to 2014. In 2014, the average individual effective dose for workers was 0.16 mSv and the maximum individual effective dose was 2.04 mSv. The annual individual effective dose to workers at the Cigar Lake operation remains well below the 50 mSv/year regulatory limit from 2010 to 2014.

Figure 3-4: Cigar Lake operation – individual effective dose to NEWs, 2010–2014



All five of the uranium mine and mill facilities have the same action levels for worker effective dose: 1 mSv/week and 5 mSv/quarter of a year. There were no effective dose action level exceedances at the Cigar Lake operation in 2014.

During commissioning of the mining system and ore processing circuits, additional administrative controls were implemented:

- Training sessions were conducted emphasizing radiation protection program requirements for workers. Examples included job planning, job hazard analysis, contamination control, access control, ALARA, personal protective equipment requirements and ventilation.
- Additional radiological monitoring was conducted upwind and downwind of the jet boring system for each phase of the cavity development and backfilling.
- Radiation personnel provided additional oversight and monitoring during commissioning.

CNSC staff will continue to monitor the licensee’s performance in keeping worker radiation doses ALARA through site inspections and reviews of compliance reports.

3.3 Environmental protection

In accordance with the Cigar Lake operation’s Environmental Protection Program, Cameco performed effluent and environmental monitoring, site inspections, environmental awareness training and program implementation audits during 2014.

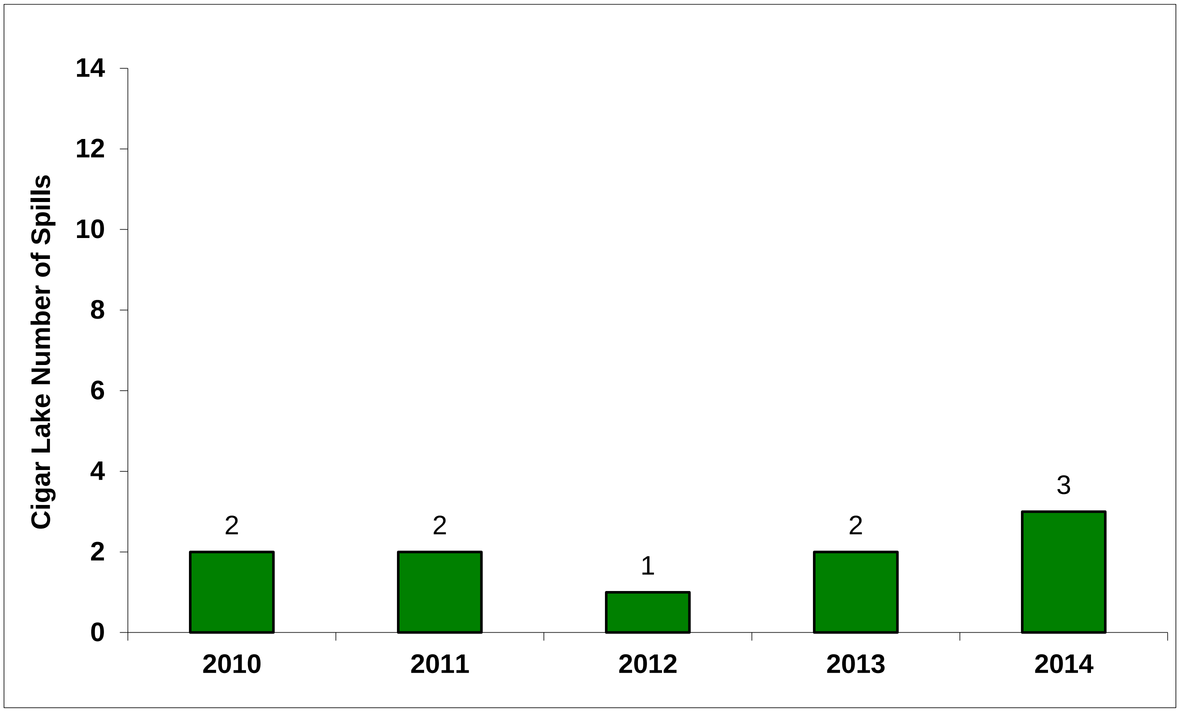
CNSC staff assessed that the Cigar Lake operation's environmental monitoring programs met regulatory requirements during 2014 and treated effluent discharge complied with licence requirements.

In 2014, three events reported to CNSC staff were classified as environmental spills:

- 250 L (0.250 m^3) of filter cake sludge that contained radium-226 reported to the ground from the vacuum truck hose
- 410 L (0.410 m^3) of antifreeze was released when a forklift punctured two drums
- 20 L (0.020 m^3) of lamella sedimentation tank effluent treatment foam reported to the ground

Figure 3-5 displays the number of environmental reportable spills from 2010 to 2014.

Figure 3-5: Cigar Lake operation – environmental reportable spills, 2010–2014



Appendix G contains a brief description of these spills and the corrective actions taken by the licensee. There were no residual impacts to the environment due to timely response and effective corrective actions implemented by the Cigar Lake operation. CNSC staff were satisfied with Cameco's 2014 reporting of spills and the corrective actions taken.

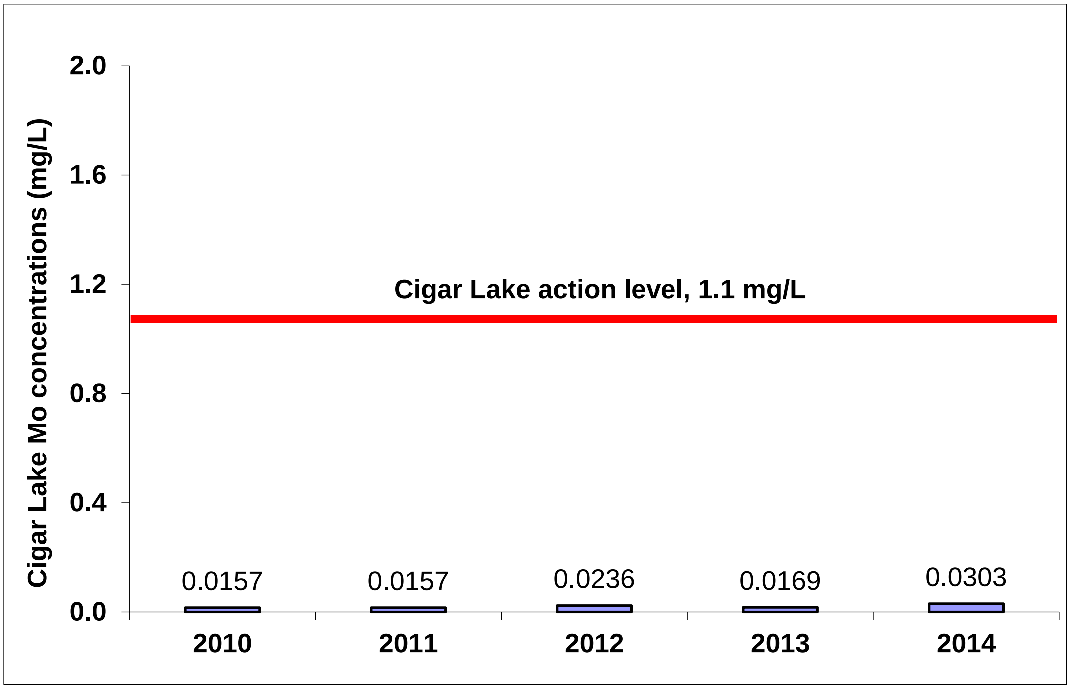
Treated effluent released to the environment

The annual average parameter concentration values of the treated effluent at Cigar Lake were well below the regulatory limits and have been stable over the past five years. There were no treated effluent action level exceedances from 2010 to 2014.

Molybdenum, selenium and uranium in effluent

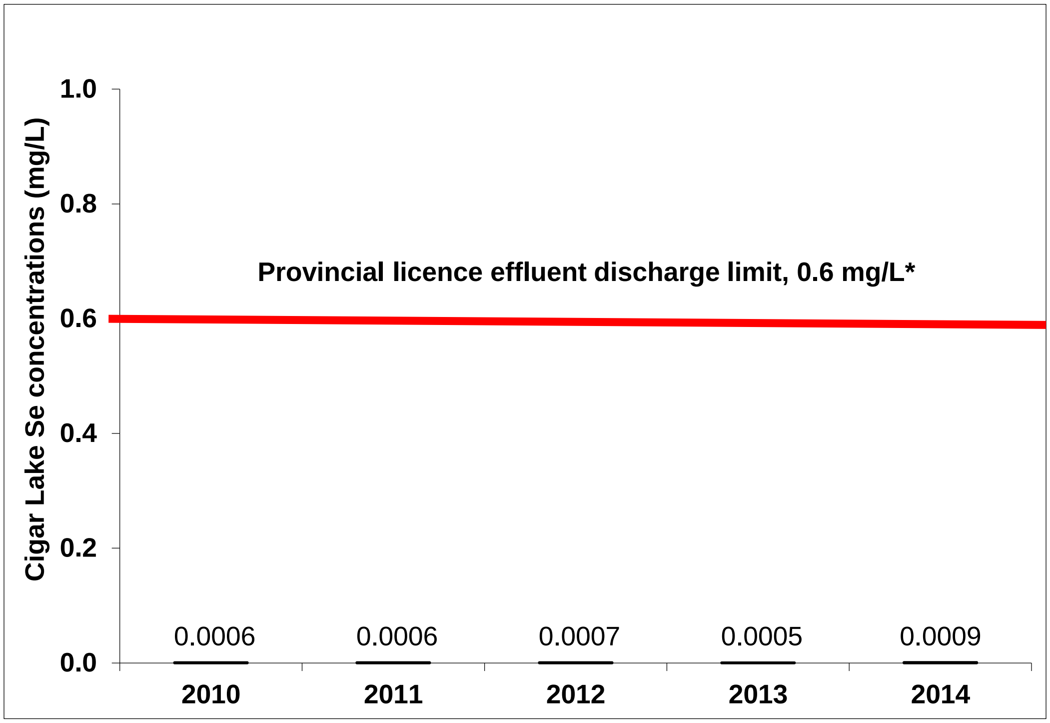
Figures 3-6, 3-7 and 3-8 display concentrations of molybdenum, selenium and uranium in effluent discharged to the environment from 2010 to 2014. Concentrations for these three contaminants remained low in 2014. CNSC staff will continue to review effluent quality results to ensure that the environment is protected. Small increases in concentrations of molybdenum, selenium and uranium in effluent discharged to the environment likely reflect the start-up of mining operations in 2014.

Figure 3-6: Cigar Lake operation – concentrations of molybdenum, 2010–2014



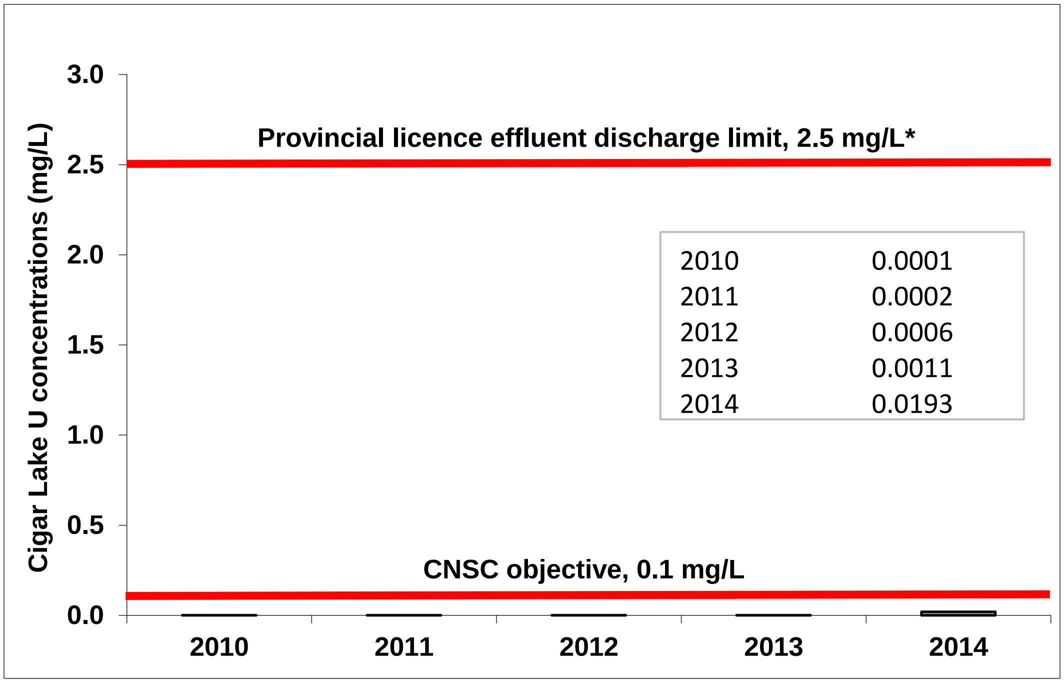
In the absence of a federal or provincial limit for molybdenum, the CNSC requires licensees to develop facility-specific effluent controls within their individual environmental codes of practice. For molybdenum effluent concentrations (such as those described in figure 3-6), the code of practice action level of 1.1 mg/L is based on 10 consecutive ponds.

Figure 3-7: Cigar Lake operation – concentrations of selenium, 2010–2014



* Saskatchewan's discharge limit for selenium is shown for reference only.

Figure 3-8: Cigar Lake operation – concentrations of uranium, 2010–2014

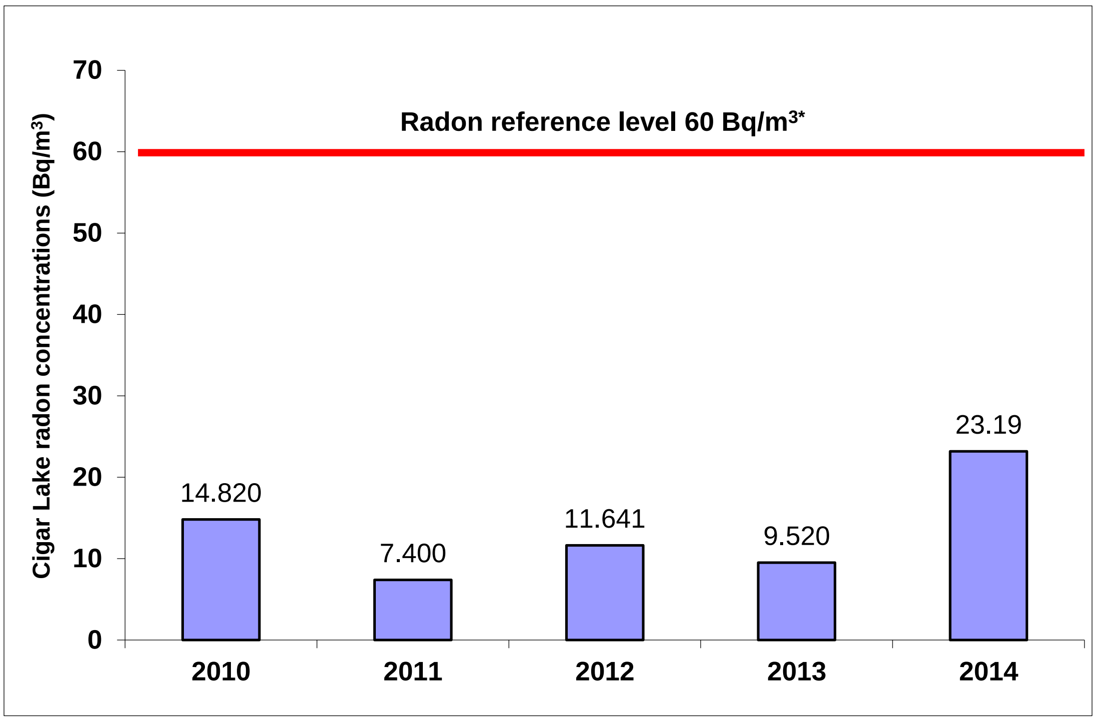


* Saskatchewan's discharge limit for uranium is shown for reference only.

Atmospheric monitoring at the Cigar Lake operation includes ambient radon, total suspended particulate (TSP), soil sampling and lichen sampling to assess the impact of air emissions.

Environmental monitoring for radon concentrations is conducted using the passive method of track-etched cups. Eight monitoring stations are located in four quadrants around the immediate mine site. Figure 3-9 shows that the average concentrations of radon in ambient air for 2010 to 2014 were below the reference level for radon. The radon concentrations were also typical of the northern Saskatchewan regional baseline of < 7.4 Bq/m^3 to 25 Bq/m^3. As Cigar Lake transitioned into operations, an increase was noted in the concentrations of radon in ambient air in 2014, as expected.

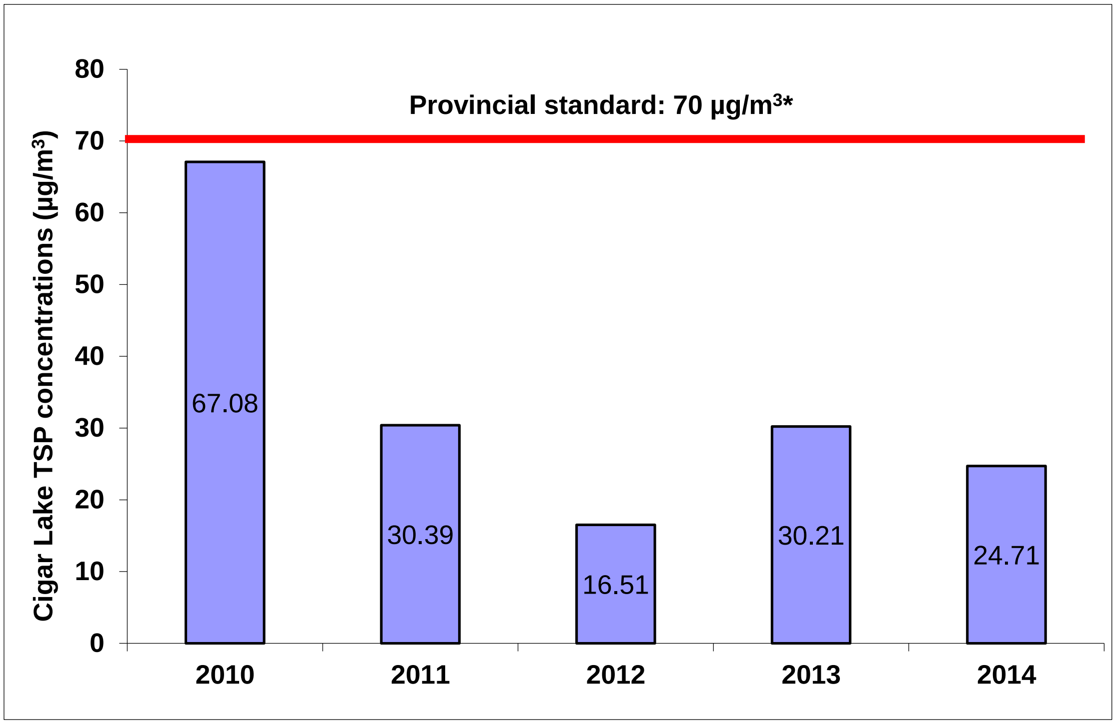
Figure 3-9: Cigar Lake operation – average concentrations of radon in ambient air 2010–2014



* The value of 60 Bq/m^3 has been derived from ICRP-65 as referenced in the *Radiation Protection Regulations* and approximates an annual dose of 1 mSv.
Values are calculated as geometric mean.

A high-volume air sampler (HVAS) is used to collect and measure TSP in air. The HVAS at Cigar Lake is located approximately 150 metres downwind from headframe No.1 and the mine ventilation exhaust. The TSP levels were below Saskatchewan's *The Clean Air Regulations* standard (see figure 3-10). 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 identified in table 3-2.

Figure 3-10: Cigar Lake operation – concentrations of TSP, 2010–2014



* Saskatchewan's standard is shown.
Values are calculated as geometric mean.

Table 3-2: Cigar Lake operation – concentrations of metal and radionuclides in air, 2010–2014

Parameter	Reference annual air quality levels (1)	2010	2011	2012	2013	2014
As (μg/m^3)	**0.06 (2)**	0.00057	0.00038	0.00025	0.00025	0.00025
Mo (μg/m^3)	**23 (2)**	0.00023	0.00021	0.00028	0.00021	0.0001
Ni (μg/m^3)	**0.04 (2)**	0.00165	0.00124	0.00101	0.00104	0.00067
Pb (μg/m^3)	**0.10 (2)**	0.0017	0.0018	0.0016	0.0007	0.0013
Se (μg/m^3)	**1.9 (2)**	0.00010	0.00005	0.00004	0.00003	0.00003
Pb^{210} (Bq/m^3)	**0.021 (3)**	0.000745	0.000333	0.000338	0.000268	0.00025
Po^{210} (Bq/m^3)	**0.028 (3)**	0.000178	0.000106	0.000106	0.000074	0.000086
Ra^{226} (Bq/m^3)	**0.013 (3)**	0.000006	0.000014	0.000005	0.000004	0.000008
Th^{230} (Bq/m$^{3)}$	**0.0085 (3)**	0.000007	0.000008	0.000026	0.000011	0.00001
U (μg/m^3)	**0.06 (2)**	0.00019	0.00012	0.00009	0.00007	0.00008

1 Province of Ontario and International Commission on Radiation Protection reference annual air quality levels are shown for reference only, as no limits have been established federally or in Saskatchewan.
2 Reference annual air quality levels were derived from *Ontario's Ambient Air Quality Criteria*, which were developed by the Ontario Ministry of the Environment in 2012.
3 Reference level from International Commission on Radiation Protection (ICRP 96).

Soil and terrestrial vegetation may be affected by atmospheric deposition of particulate, which includes metals and radionuclides associated with onsite activities. A terrestrial monitoring program is in place to determine if there is influence from aerial deposition. This program includes triennial measurements of metals and radionuclides in lichen and in soil. Lichen and soil samples were collected in 2013, as required by the triennial sampling program and the results reported in last year's CNSC report. The 2013 data displayed that the concentrations of metals and radionuclides in lichen were similar to reference stations and historical data. CNSC staff concluded that the level of airborne particulate contaminants was acceptable and did not pose a risk to the lichen consumers such as caribou. The 2013 soil samples displayed that concentration of metals were below levels described in the *Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health*, 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.

No lichen or soil samples were collected in 2014. The next sampling of lichen and soils is scheduled for 2016.

3.4 Conventional health and safety

CNSC staff monitor 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.

The conventional health and safety SCA is evaluated by CNSC staff through regular compliance activities. These compliance activities include inspections, reviews of incident reports and weekly reports regarding facility activities.

The Cigar Lake operation reported a total of five lost-time incidents (LTIs) from 2010 to 2014 (see table 3-3). There were no LTIs at Cigar Lake in 2014.

Table 3-3: Cigar Lake operation – total number of full-time equivalent (FTE) workers and LTIs, severity rate and frequency rate, 2010–2014

Year	2010	2011	2012	2013	2014
Total number of FTE workers[1]	649	971	1,277	1,570	833
Number of LTIs[2]	0	1	0	4	0
Severity rate[3]	0.0	1.6	0.0	5.6	0
Frequency rate[4]	0.0	0.1	0.0	0.3	0

1 **Total number of workers** (employees and contractors) expressed as FTEs. An FTE = total person-hours / 2,000 hours worked per employee per year.
2 **Lost-time incident** – an injury that takes place at work and results in the worker being unable to return to work for a period of time.
3 **Severity rate** – 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.
4 **Frequency rate** – 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.

Cameco's incident-reporting system includes reporting and investigation of near misses. This helps to reduce future incidents that could cause injury. CNSC staff observed there was also an improved incident-reporting culture.

Figure 3-11: CNSC inspectors' observation of signage at Cigar Lake during June 2014 inspection

4 McArthur River Operation

Cameco Corporation operates the McArthur River mine, located approximately 620 km north of Saskatoon, Saskatchewan. The McArthur River operation is the world's largest high-grade uranium mine (see figure 4-1).

Facilities at the McArthur River operation include an underground uranium mine, primary ore processing, ore slurry loading, waste management facilities, a water treatment plant, surface freeze plants, administration offices and warehouse buildings.

Figure 4-1: View of McArthur River operation

High-grade uranium ore is mined, mixed with water and ground in a ball mill to form a slurry, which is pumped to the surface. The ore slurry is loaded into approved containers and transported to the Key Lake operation for further processing. Low-grade mineralized rock is also transported to Key Lake in covered haul trucks where these materials are blended with high-grade ore slurry to create the mill ore feed.

The McArthur River mine was in operation throughout 2014. Production data for 2010 to 2014 is shown in table 4-1.

Table 4-1: McArthur River operation – mining production data, 2010–2014

Mining	2010	2011	2012	2013	2014
Ore tonnage (tonnes/year)	78,003	80,162	115,107	104,132	108,394
Average ore grade mined (% U_3O_8)	11.25	11.17	7.78	8.83	8.73
U mined (Mkg* U/year)	7.44	7.59	7.60	7.80	8.02
Authorized annual production (Mkg U/year)	8.1	8.1	8.1	8.1	8.1

* 1 Mkg = 1,000,000 kg

As of December 31, 2014, the McArthur River operation's proven and probable ore reserves were 1,053,000 tonnes at a grade of 14.87 percent for a total of approximately 132.8 million kg of uranium.

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

4.1 Performance

In 2014, Cameco's Radiation Protection Program and Radiation Code of Practice at the McArthur River operation continued to be effective in controlling radiological exposure to workers. CNSC staff were satisfied that the McArthur River operation is adequately controlling radiation doses to workers and keeping levels below the regulatory limits, and concluded that the radiation protection safety and control area (SCA) remains "satisfactory".

CNSC staff determined that the McArthur River operation's Environmental Protection Program was effective in protecting the environment, and all treated effluent discharged complied with licence requirements. The McArthur River operation maintains a terrestrial and air monitoring program to measure the influence of atmospheric deposition of metals and radionuclides. Air monitoring interpretation shows that the impacts were at acceptable levels. In 2014, one environmental spill was reported to CNSC staff. It was remediated with no residual impacts to the environment. The McArthur River operation continued to protect the environment and received a "satisfactory" rating in the environmental protection SCA.

CNSC staff determined that McArthur River operation's Occupational Health and Safety Program met regulatory requirements. There were no lost-time incidents (LTIs) at the McArthur River operation in 2014. CNSC staff's compliance verification activities confirmed McArthur River's strong focus on the prevention of accidents. McArthur River operation's performance in the conventional health and safety SCA was rated as "satisfactory".

The McArthur River SCA ratings for the five-year period between 2010 and 2014 are shown in appendix C. For 2014, CNSC staff continue to rate all SCAs as "satisfactory".

4.2 Radiation protection

The source of radiological exposure at the McArthur River operation is from the mining and processing of high-grade uranium ore. The three primary effective dose contributors are gamma radiation, radon progeny and long-lived radioactive dust. The greatest contributor to effective dose is from exposures to radon progeny, which are controlled through the effective use of ventilation, and by the capture and exhaust of high radon sources.

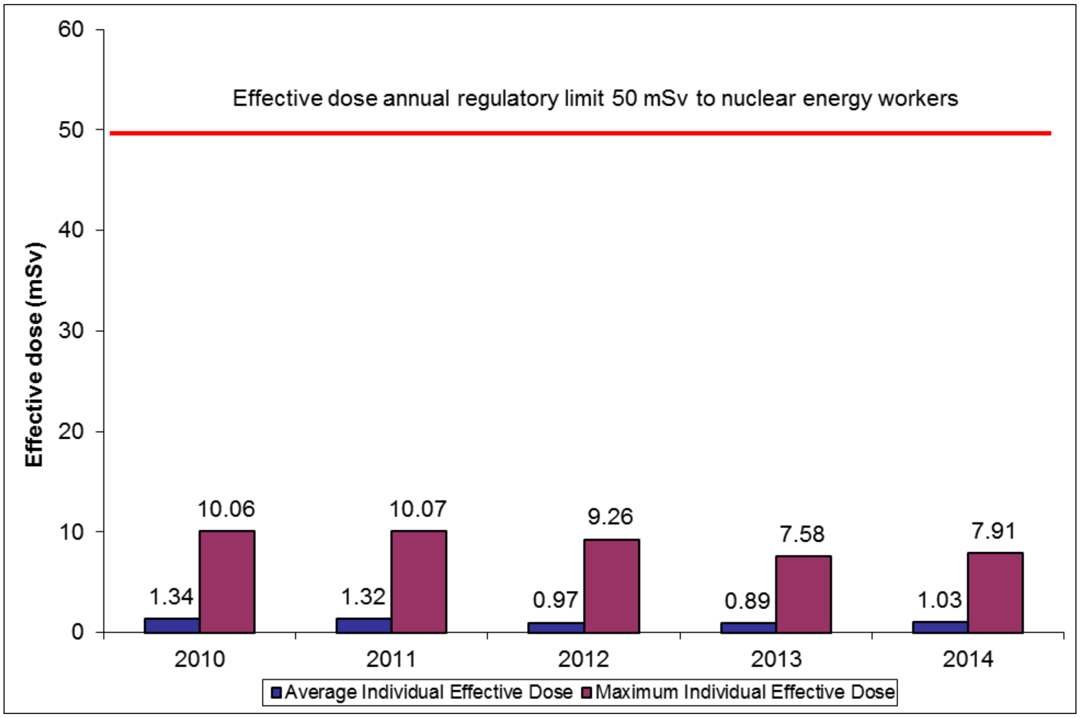
All five of the uranium mine and mill facilities have the same action levels for effective dose of 1 mSv/week and 5 mSv/quarter of a year.

There were no radiological action level exceedances in 2014 at Cameco’s McArthur River operation.

Figure 4-2: Radiation technician performing sampling

In 2014, the average individual effective dose to all nuclear energy workers (NEWs) was 1.03 mSv. Underground miners had the highest average individual effective dose, at 2.20 mSv. The maximum individual effective dose in 2014 was 7.91 mSv. As figure 4-3 shows, the average and maximum individual effective dose levels to NEWs from 2010 to 2014 were well below the annual regulatory limit of 50 mSv.

Figure 4-3: McArthur River operation – individual effective dose to NEWs, 2010–2014



4.3 Environmental protection

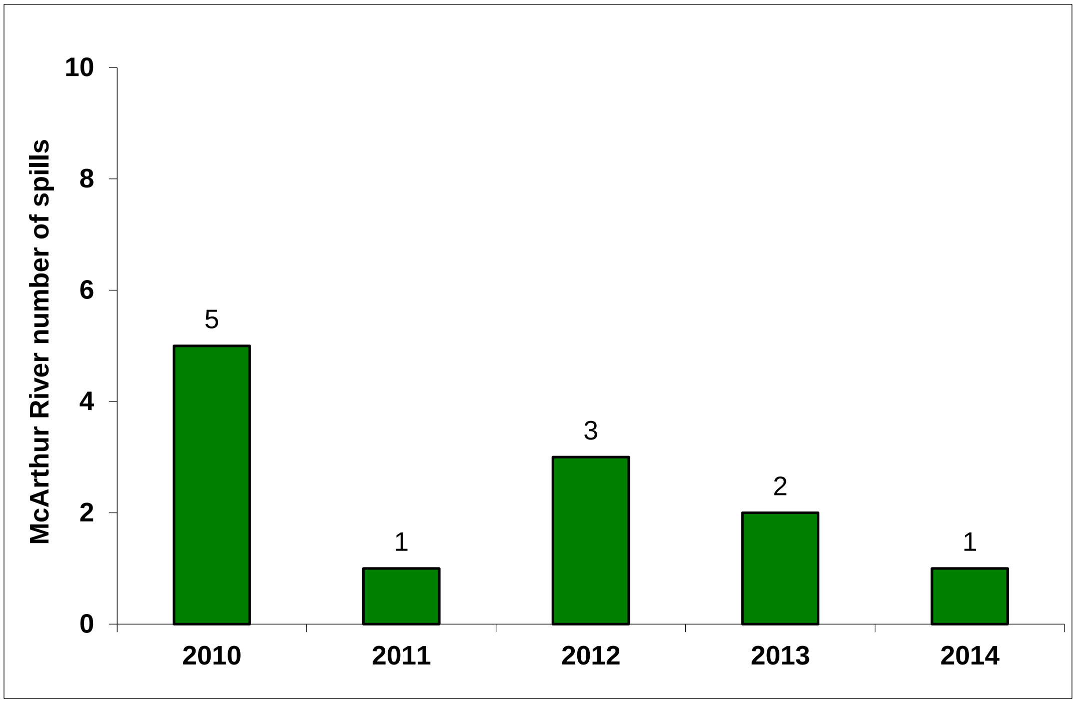
In accordance with the McArthur River operation's Environmental Protection Program, Cameco performed effluent and environmental monitoring, site inspections, environmental awareness training and program implementation audits during 2014.

CNSC staff assessed that the McArthur River operation's Environmental Monitoring Program met all regulatory requirements during 2014, and all effluent discharged complied with licence requirements.

- Figure 4-4 shows the number of reportable spills from the licensed activities at the McArthur River operation from 2010 to 2014. In 2014, one event was classified as an environmental spill:300 L (0.300 m^3) of glycol/water mixture was released to the environment

The spill was immediately cleaned up and there was no residual impact to the environment. The identified corrective actions undertaken by Cameco were acceptable to CNSC staff. A brief description of the spill and the corrective actions implemented are provided in appendix G.

Figure 4-4: McArthur River operation – environmental reportable spills, 2010–2014



Treated effluent released to the environment

In 2014, all effluent released to the environment met regulatory requirements.

Molybdenum, selenium and uranium in effluent

Molybdenum, selenium and uranium were identified as constituents of concern from treated effluent at uranium mines and mills. At the McArthur River operation, molybdenum was the main constituent of concern. In response, Cameco implemented process changes to reduce molybdenum concentrations in treated effluent. In 2013, Cameco instituted a molybdenum concentration action level of 1.0 mg/L for the release of treated effluent. Prior to 2013 Cameco had an internal objective to reduce molybdenum in effluent to below 1.0 mg/L. Molybdenum removal efficiency in treated effluent has improved with decreasing molybdenum concentrations in treated effluent from 0.9110 mg/L in 2010 to 0.2121 mg/L in 2014 (see figure 4-5).

Figure 4-5: McArthur River operation – concentrations of molybdenum, 2010–2014

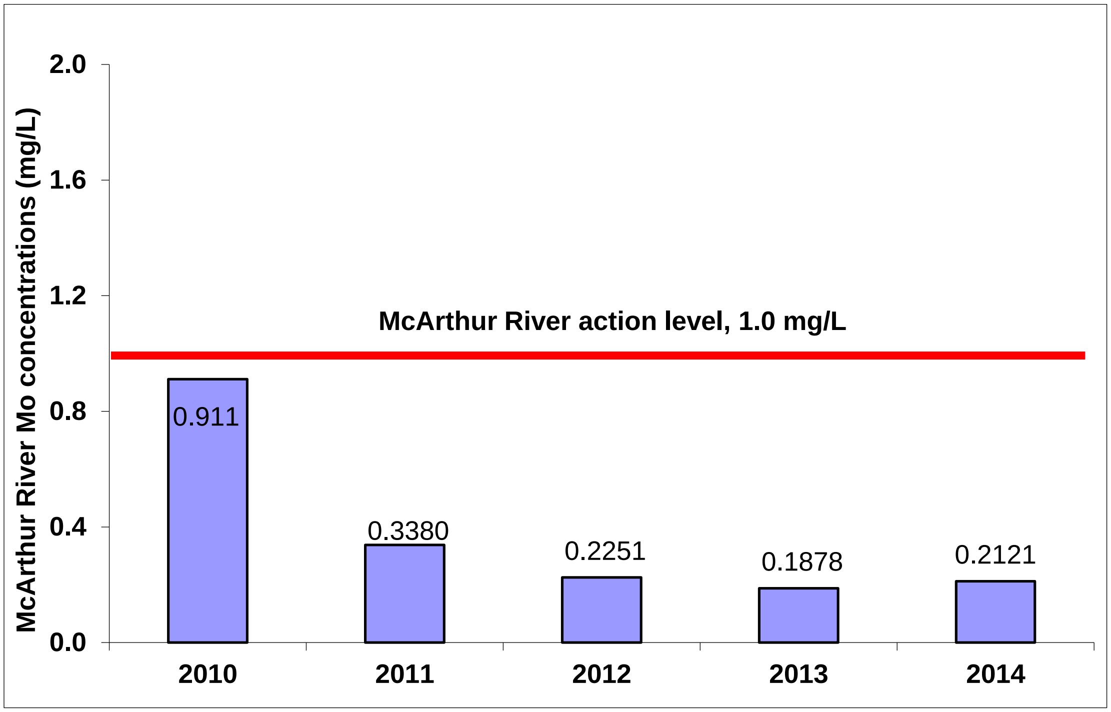
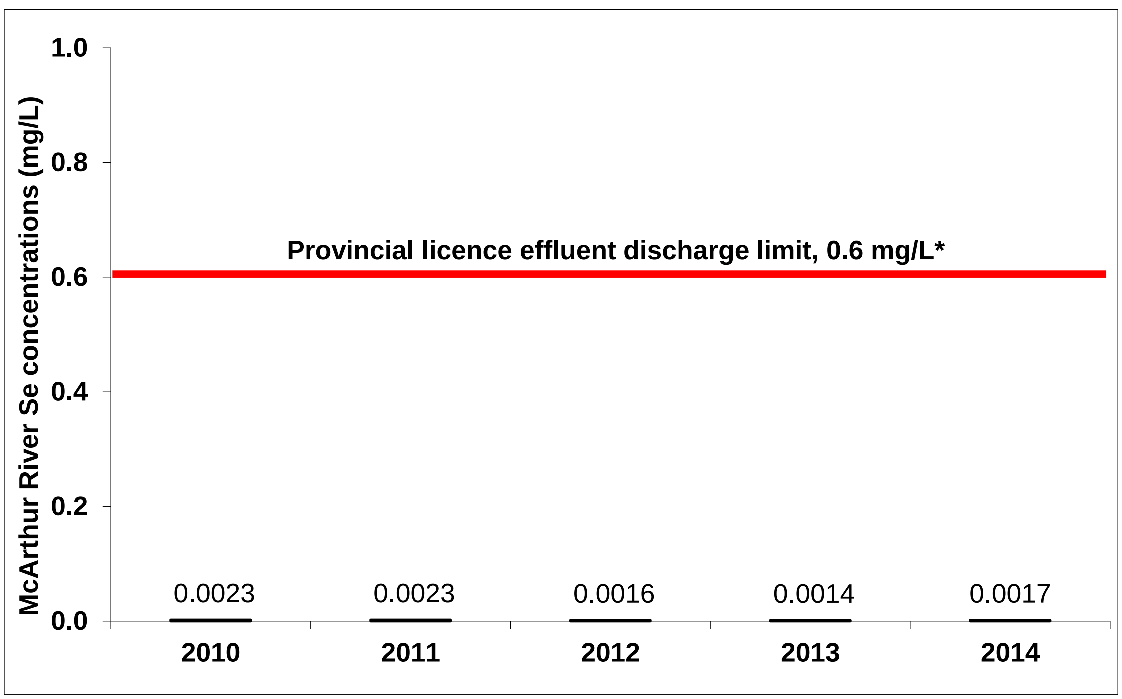


Figure 4-6 shows that the concentrations of selenium in treated effluent remained consistently well below Saskatchewan's licence effluent discharge limit of 0.6 mg/L.

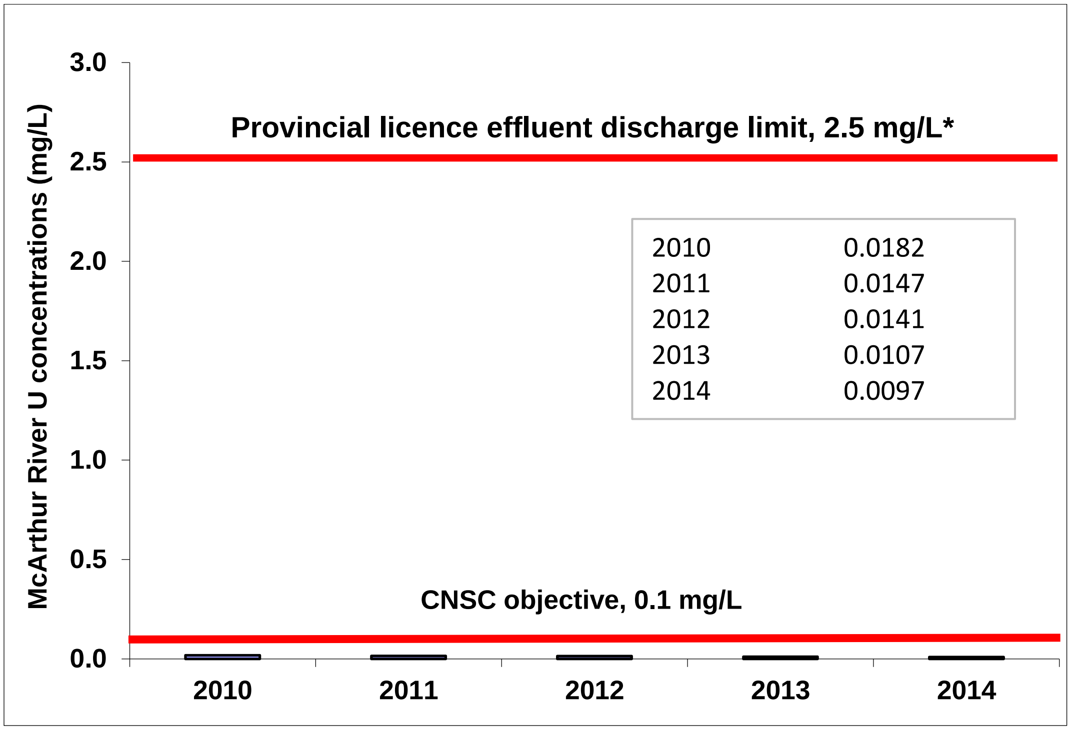
Figure 4-6: McArthur River operation – concentrations of selenium, 2010–2014



* Saskatchewan's discharge limit for selenium is shown for reference only.

Figure 4-7 displays the average annual uranium concentrations in treated effluent from 2010 to 2014. Uranium concentrations remain well below Saskatchewan's regulatory limit of 2.5 mg/L and the CNSC's interim objective of 0.1 mg/L.

Figure 4-7: McArthur River operation – concentrations of uranium, 2010–2014



* Saskatchewan's discharge limit for uranium is shown for reference only.

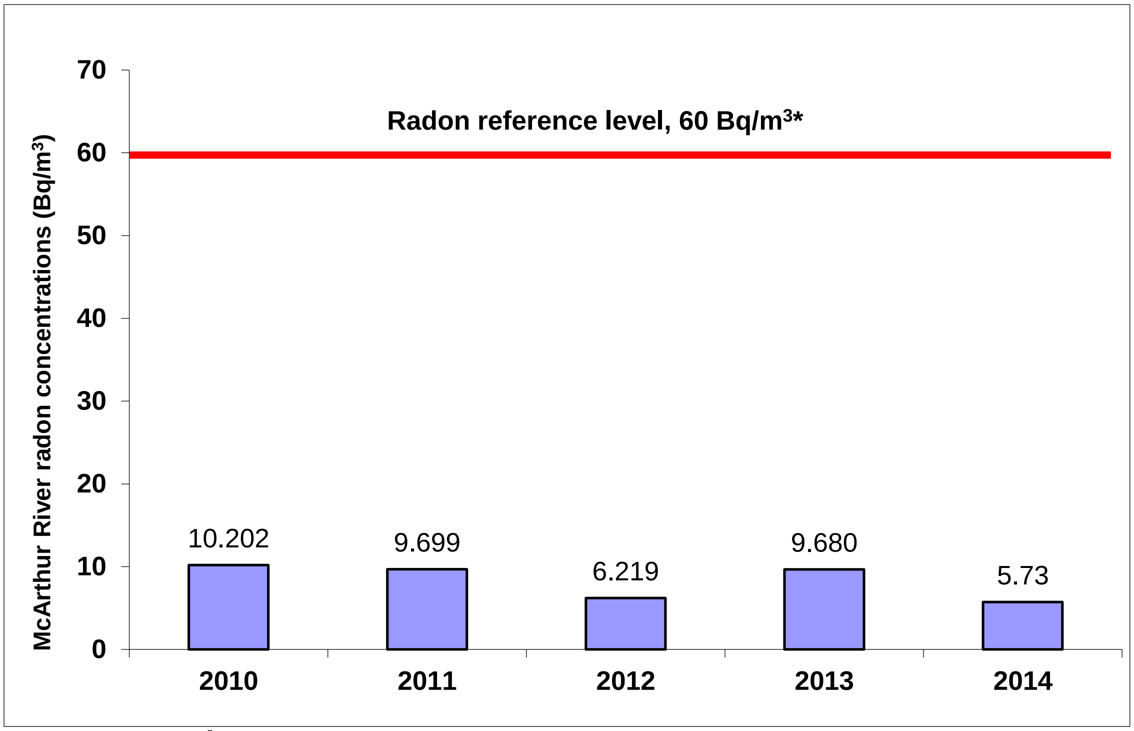
CNSC staff will continue to review the McArthur River operation's treated effluent concentrations at the outflow (see figure 4-8) and in the downstream environment.

Figure 4-8: McArthur River effluent discharge channel

Air quality monitoring at the McArthur River operation consists of high-volume air sampling, radon monitoring, lichen sampling, blueberry twigs and stems sampling, and soil sampling.

A total of 12 monitoring locations are used for the monitoring of ambient radon using passive track-etched cups. Figure 4-9 shows that the average concentrations of radon in ambient air for 2010 to 2014 were below the reference level for radon. In 2014, the radon concentrations were similar to past performance, with all radon concentrations typical of the northern Saskatchewan regional baseline of < 7.4 Bq/m^3 to 25 Bq/m^3.

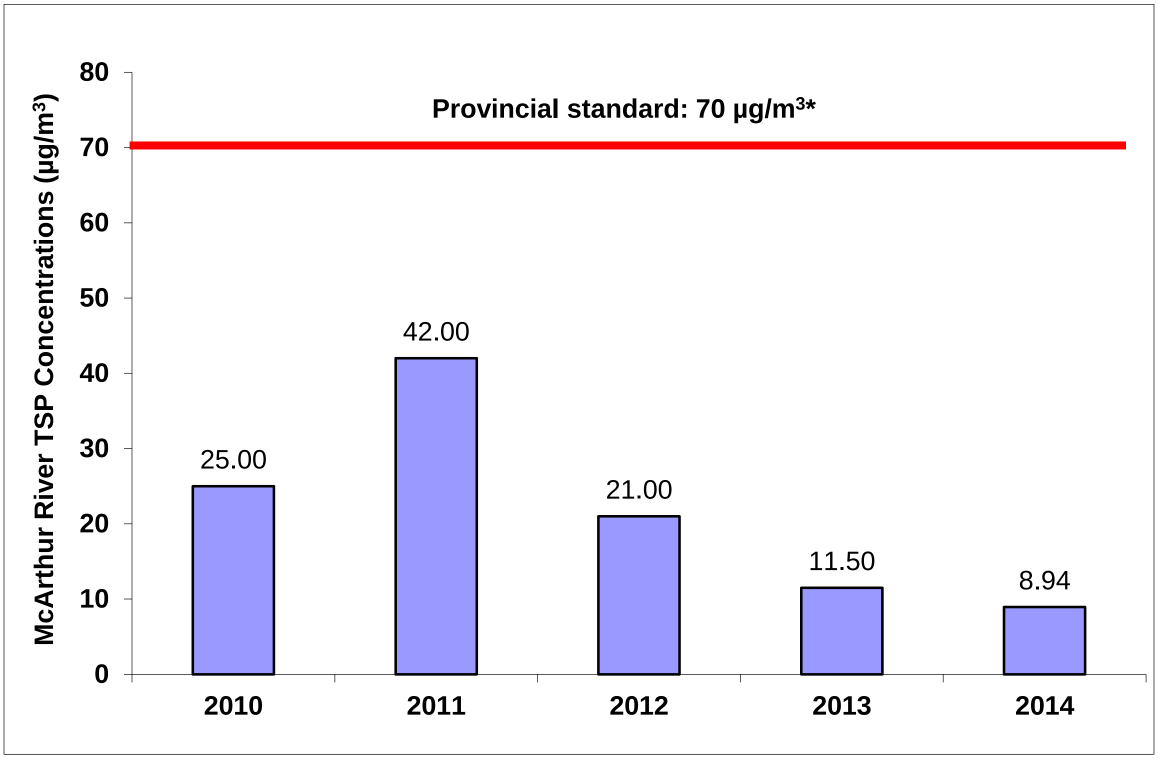
Figure 4-9: McArthur River operation – concentrations of radon in ambient air, 2010–2014



* The value of 60 Bq/m[3] has been derived from the International Commission on Radiological Protection's ICRP-65 document, as referenced in Canada's *Radiation Protection Regulations*. The value approximates an annual dose of 1 mSv.
Values are calculated as geometric mean.

Two high-volume air samplers were used to collect and measure total suspended particulate (TSP) in air. One sampler was located in the vicinity of the main camp residence and the second approximately 250 metres northwest in a location representative of ambient conditions. From the average of the two stations, the TSP levels are less than Saskatchewan's *The Clean Air Regulations* standard (see figure 4-10). TSP samples are also tested 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 4-2.

Figure 4-10: McArthur River operation – concentrations of TSP, 2010–2014



* Saskatchewan's standard is shown.
Values are calculated as geometric mean.

Table 4-2: McArthur River operation – concentrations of metal and radionuclides in air, 2010–2014

Parameter	Reference annual air quality levels (1)	2010	2011	2012	2013	2014
As ($\mu g/m^3$)	0.06 (2)	0.0002	0.0003	0.0003	0.0001	0.0001
Cu ($\mu g/m^3$)	9.6 (2)	0.0075	0.0097	0.0119	0.0067	0.00835
Ni ($\mu g/m^3$)	0.04 (2)	0.0009	0.0016	0.0012	0.0007	0.00085
Pb ($\mu g/m^3$)	0.10 (2)	0.0020	0.0015	0.0018	0.0014	0.0012
Se ($\mu g/m^3$)	1.9 (2)	0.00006	0.00006	0.00005	0.00003	0.0004
Zn ($\mu g/m^3$)	23 (2)	0.0136	0.0247	0.7721	0.01065	0.01225
Pb^{210} (Bq/m^3)	0.021 (3)	0.00036	0.00043	0.00045	0.00034	0.00032
Po^{210} (Bq/m^3)	0.028 (3)	0.00015	0.00013	0.00012	0.0001	0.000095
Ra^{226} (Bq/m^3)	0.013 (3)	0.00007	0.00003	0.00004	0.00001	0.000025
Th^{230} ($Bq/m^{3)}$)	0.0085 (3)	0.00005	0.00002	0.00001	0.00001	0.00001
U ($\mu g/m^3$)	0.06 (2)	0.0040	0.0021	0.0012	0.0005	0.0005

1 Province of Ontario and International Commission on Radiation Protection annual air quality levels are shown for reference only, as no limits have been established federally or in Saskatchewan.
2 Reference annual air quality levels were derived from Ontario *Ambient Air Quality Criteria*, which were developed by the Ontario Ministry of the Environment in 2012.
3 Reference level from International Commission on Radiation Protection (ICRP 96).

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 to determine if there is influence from aerial deposition. This program includes triennial measurements of metals and radionuclides in soil and blueberry samples.

As part of the triennial sampling program, the most recent soil sampling was taken in 2012. The 2012 radionuclide concentrations in soils were low, and near or at background levels and at analytical detection limits. 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.

Blueberry twigs were last collected in 2012 as required by the triennial sampling program. These are monitored to determine if soil-born contaminants (if present) are being absorbed through the roots into the growing plant parts. The concentrations of metals and radionuclides in blueberry twigs have higher than background concentrations for some locations located in the vicinity of onsite waste rock pads. The concentrations decrease within a short distance of the waste rock pads. Compared with historical data, the concentrations are not increasing over time. Blueberry twigs collected near the site boundary are either near or at background levels, and have not been affected by site activities.

4.4 Conventional health and safety

CNSC staff monitor the implementation of the McArthur River operation’s Safety and Health Management Program to ensure protection of workers. To promote continued effective safety performance, Cameco has implemented this program to identify and mitigate risks. The program includes planned internal inspections, a safety permit system, occupational health committees, continued training, and incident investigations.

The conventional health and safety SCA is evaluated by CNSC staff through regular compliance activities, including inspections, and reviews of incidents and health and safety reports. CNSC compliance verification activities confirmed Cameco’s strong focus on the prevention of accidents, and on reducing lost-time incidents (LTIs) and the number of injuries requiring medical treatment.

Cameco’s incident-reporting system includes reporting and investigation of near misses. This originates from recognition that the reporting of incidents offers significant value in reducing future incidents that could cause injury. CNSC staff observed there was also an improved incident-reporting culture.

There were no LTIs reported at the McArthur River operation for 2014 (see table 4-3). In 2010, 2013 and 2014, Cameco was awarded the John T. Ryan trophy for metal mines. The John T. Ryan trophy is an excellence award presented annually to the Canadian metal mine with the lowest accident frequency.

Table 4-3: McArthur River operation – total number of full-time equivalent (FTE) workers and LTIs, severity rate and frequency rate, 2010–2014

Year	2010	2011	2012	2013	2014
Total number of FTE workers[1]	835	966	1,017	914	692
Number of LTIs[2]	1	3	2	0	0
Severity rate[3]	45.1	14.4	8.0	0	0
Frequency rate[4]	0.1	0.3	0.2	0	0

1 **Total number of workers** (employees and contractors) expressed as FTEs. One FTE = total person-hours / 2,000 hours worked per employee per year.

2 **Lost-time incident** – an injury that takes place at work and results in the worker being unable to return to work for a period of time.

3 **Severity rate** – 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.

4 **Frequency rate** – 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.

5 Rabbit Lake Operation

Located 750 km north of Saskatoon, Saskatchewan, the Rabbit Lake operation is owned and operated by Cameco Corporation. The facility consists of an active underground mine (Eagle Point), one mined-out flooded pit, two mined-out pits (now open to Collins Bay in Wollaston Lake), a mill (see figure 5-1), and associated waste rock storage and tailings management facilities.

Figure 5-1: Rabbit Lake mill

Figure 5-2: Rabbit Lake mill with active in-pit tailings management facility in the background

Uranium mine operations first started in 1974. Based on the results of ongoing exploration activities, Cameco expects the Eagle Point mine to operate until at least 2018. Rabbit Lake mining and milling data are provided in tables 5-1 and 5-2.

Table 5-1: Mining production data – Rabbit Lake operation, 2010–2014

Mining	2010	2011	2012	2013	2014
Ore tonnage (tonnes/year)	199,026	197,397	225,282	255,154*	328,126
Average ore grade mined (% U_3O_8)	0.89	0.91	0.84	0.59*	0.56
U mined (Mkg U/year)**	1.49	1.51	1.62	1.28	1.57

* Data corrected
** 1 Mkg = 1,000,000 kg

Table 5-2: Milling production data – Rabbit Lake operation, 2010–2014

Milling	2010	2011	2012	2013	2014
Mill ore feed (tonnes/year)	234,076	209,040	260,299	334,976	386,970
Average annual mill feed grade (% U_3O_8)	0.78	0.83	0.71	0.54	0.49
Percent uranium recovery	96.8	96.8	96.8	97.2	97.3
U concentrate produced (Mkg* U/year)	1.46	1.46	1.48	1.59	1.60
Authorized annual production (Mkg U/year)	4.25	4.25	4.25	4.25	4.25

* 1 Mkg = 1,000,000 kg

For the last several years, ore from the Eagle Point mine has been blended at the Rabbit Lake mill with previously mined, low-grade material to supplement uranium concentrate production. As of December 31, 2014, proven and probable ore reserves remaining at Rabbit Lake were estimated at 5.85 million kg of uranium.

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.

5.1 Performance

Cameco’s radiation protection, environmental protection, and occupational health and safety programs at the Rabbit Lake operation met expectations and performed satisfactorily in 2014.

Based on site inspections, reviews of licensee reports, work practices, monitoring results, and individual effective dose results for 2014, CNSC staff were satisfied that the Rabbit

Lake operation adequately controlled radiation doses to workers. Radiation doses were kept below regulatory limits and as low as reasonably achievable (ALARA). The radiation protection SCA was given a “satisfactory” rating.

Cameco’s Rabbit Lake Environmental Protection Program was effectively implemented and met regulatory requirements during 2014. All effluent discharged complied with licence requirements. Cameco’s effluent treatment system continues to meet performance expectations in reducing the concentrations of previously identified contaminants of concern (i.e., uranium, molybdenum and, to a lesser extent, selenium). The Rabbit Lake operation also maintains a terrestrial and air-monitoring program to monitor emissions and the effects of atmospheric deposition of metals and radionuclides. Air monitoring results indicate negligible impacts. There were four reportable spills at the Rabbit Lake operation in 2014. Appendix G provides a brief description of each spill and the actions taken by the licensee. The spills were remediated, with no residual impacts on the environment. The corrective actions taken by Cameco were acceptable to CNSC staff, who concluded that Cameco continues to protect the environment. Cameco received a “satisfactory” rating in the environmental protection SCA.

CNSC staff verified that the Occupational Health and Safety Program at the Rabbit Lake operation continued to be effective in managing health and safety risks. There was one lost-time-incident (LTI) reported at the Rabbit Lake operation in 2014. The conventional health and safety SCA was rated as “satisfactory”.

The Rabbit Lake ratings for all 14 SCAs during the five-year period of 2010 to 2014 are shown in appendix C. For 2014, CNSC staff rated all 14 SCAs as “satisfactory”.

A previous licence condition required the Rabbit Lake operation to develop and implement a site reclamation plan. Reclamation activities continued as follows:

- Active reclamation of the B-zone waste rock pile was ongoing with the installation of an engineered cover in 2012. The pile was subsequently hydro-seeded. Environmental instrumentation was also installed to monitor reclamation performance. In 2014, CNSC staff observed a stable earthen cover with good vegetation growth on the B-zone pile (see figure 5-3). The flooded B-zone pit remains isolated from Wollaston Lake. CNSC staff will review the reclamation plan for the pit when Cameco submits the plan.
- Progressive, staged reclamation of the above-ground tailings management facility (AGTMF) continued in 2014. The AGTMF operated between 1975 and 1985. A conceptual decommissioning plan was developed in 1993. As part of that plan, a program of consolidating the 6.3 million tonnes of tailings in the AGTMF was initiated. The majority of the ice lenses within the tailings have thawed. The bounding earth dams have been reshaped and armoured for long-term stability. Placement of an interim till cover on the facility was completed in 2013. A portion of the surface has been hydro-seeded to protect the cover integrity and reduce water infiltration, while another portion of the facility continues to be actively used for solid waste disposal. A final cover design will be submitted prior to decommissioning.
- In 2005 and 2010 respectively, the dykes that separated the A-zone and D-zone pits from Wollaston Lake were purposely breached. In 2014, the water quality in the A-zone and D-zone pits continued to be consistent with Wollaston Lake background

values. The vegetation in the remediated areas surrounding the pits is well established.

- The Link Lakes were affected during early operation of the Rabbit Lake mine. Monitoring of the Link Lakes continued in 2014, as a reclamation plan continues to be developed.

Figure 5-3: Contoured, covered and revegetated B-zone waste rock pile

CNSC staff have verified the continuation of reclamation activities through desktop reviews of applications and reports, and onsite inspections. The reclamation plan is updated annually and CNSC staff will monitor and review Cameco's water management practices and reclamation activities to ensure that the environment is protected.

The financial guarantee for the decommissioning of the site was updated to $202.7 million in 2013 and remained at that value in 2014.

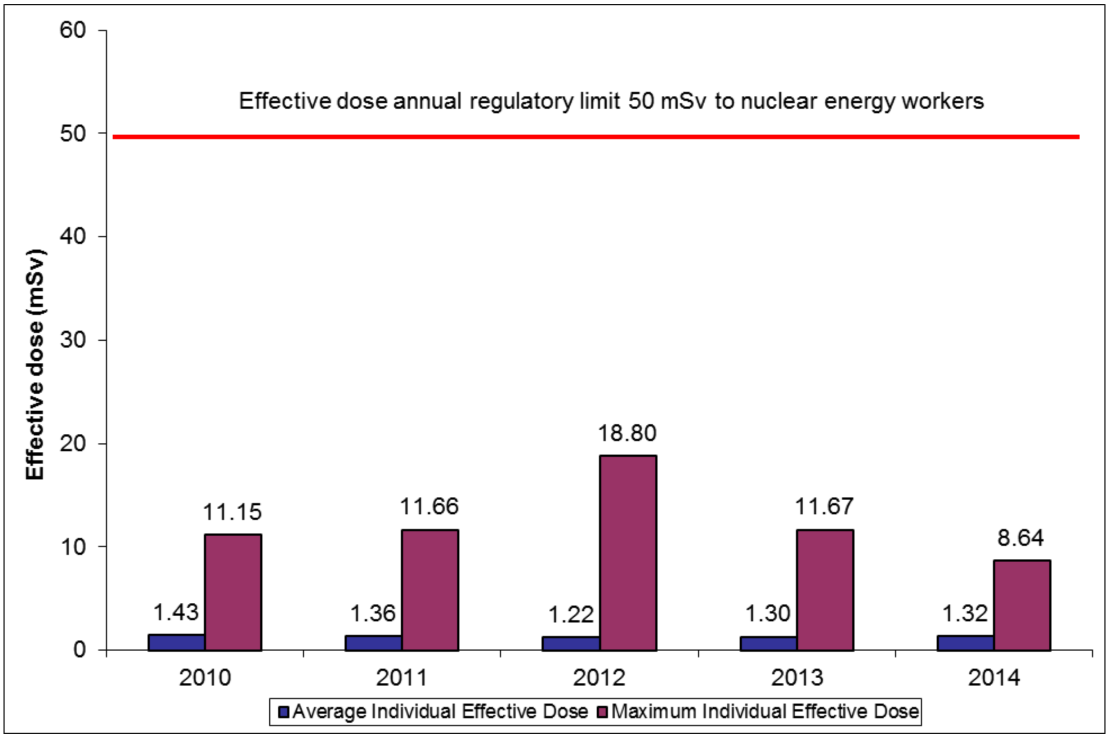
5.2 Radiation protection

The source of radiological exposure at the Rabbit Lake operation is from mining at the Eagle Point underground mine and from uranium ore milling at the Rabbit Lake mill. The three primary effective dose contributors are gamma radiation, radon progeny and long-lived radioactive dust (LLRD).

The effective dose to nuclear energy workers (NEWs) from exposures to radon progeny and LLRD is controlled through the effective use of ventilation, and by the capture and exhaust of high sources. Gamma radiation exposure is controlled through the application of time, distance and shielding. Radon progeny contributes approximately 50 percent of the total effective dose.

Figure 5-4 displays the average annual individual effective dose for Rabbit Lake workers as relatively consistent over the five years from 2010 to 2014. The maximum individual effective dose in 2014 decreased to 8.64 mSv. This value represents the lowest maximum individual effective dose recorded since the Eagle Point mine reopened in 2002. Doses to workers continued to be below the annual regulatory dose limit of 50 mSv.

Figure 5-4: Rabbit Lake operation – individual effective dose to NEWs, 2010–2014



Notes:

1 In 2012, the maximum individual effective doses for 2010 and 2011 were modified from the previous *CNSC Staff Report on the Performance of Canadian Uranium Fuel Cycle and Processing Facilities: 2011*. These changes occurred as a result of dose changes approved through the National Dose Registry. The new values resulted from previously rejected personal alpha dosimeter results, which were accepted later in early 2012 (2010 changed from 10.7 mSv to 11.15 mSv; 2011 changed from 11.4 mSv to 11.66 mSv).

2 In 2013, the 2012 maximum individual effective dose was modified from 14.37 to 18.8 mSv (as stated in the *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.

The average individual effective dose for the mill workers in 2014 was 1.4 mSv, consistent with values measured since 2010. The average individual effective dose in 2014 for underground miners was 3.2 mSv, similar to 3.1 mSv in 2013.

All five uranium mine and mill facilities have the same effective dose action levels for workers of 1 mSv/week and 5 mSv/quarter of a year. There were no action level exceedances reported at the Rabbit Lake operation in 2014.

Figure 5-5: Rabbit Lake operation – underground worker wearing personal alpha dosimeter

Improvements in radiation protection

Continual improvements to the Rabbit Lake operation's Radiation Protection Program were made in accordance with subsection 4(*a*) of the *Radiation Protection Regulations* and CNSC guide document G-129, *Keeping Radiation Exposure and Doses "As Low as Reasonably Achievable"*.

Through compliance activities in 2014, CNSC staff observed improvements in the area of radiation protection consistent with the application of ALARA. For example:

- The Radiation Work Permit program was reviewed by Cameco with the objective to keep doses ALARA. Cameco reported that the changes have had a positive effect on dose control.
- Improvements to the radon gas dosimetry program were undertaken.

5.3 Environmental protection

CNSC staff assessed that Rabbit Lake's environmental monitoring programs met all regulatory requirements during 2014 and were effective in environmental performance. All treated effluent discharged to the environment complied with licence requirements.

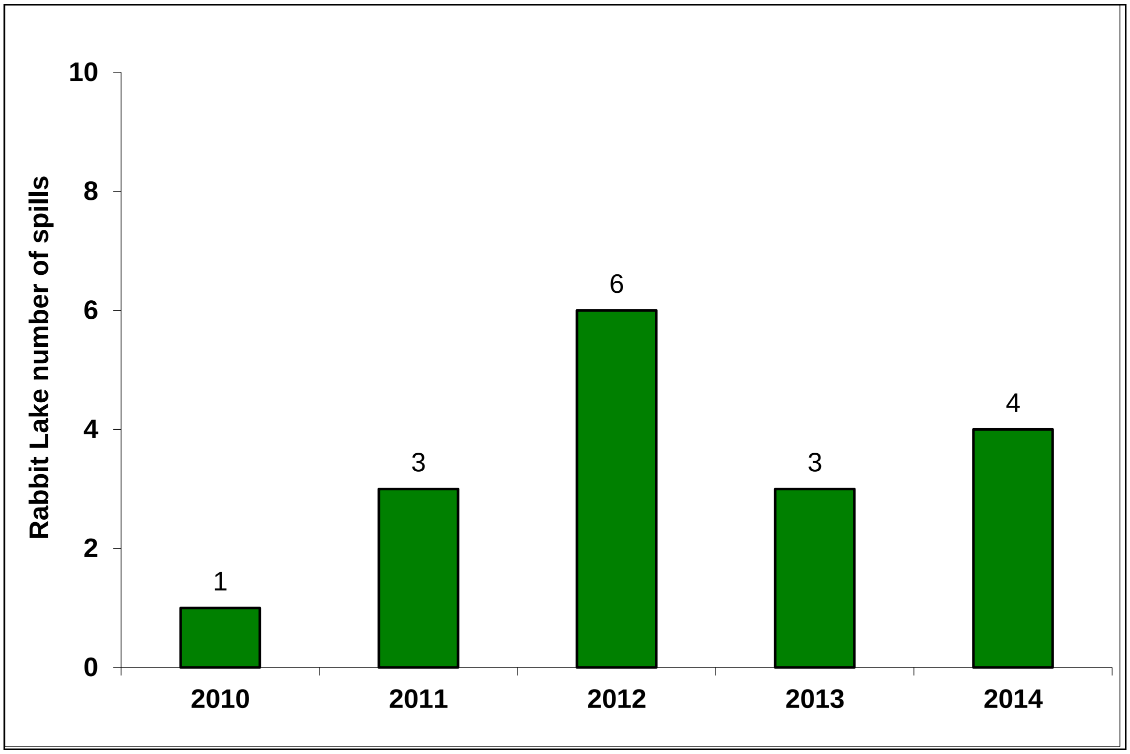
There were four events classified as spills in 2014:

- 5 L (0.005 m^3) of contaminated mine water was released from a pipeline
- 10,000 L (10 m^3) of contaminated water was released from a leak in the pipeline to the Rabbit Lake In-Pit Tailings Management Facility (RLITMF)
- 20 L (0.020 m^3) of water being transferred from the AGTMF to the water treatment plant leaked from a weld break in the pipeline

- 50 L (0.050 m^3) of contaminated raise water from the RLITMF released from a leak in the pipeline

Appendix G further describes the 2014 reportable spills and the corrective actions taken by the licensee. The licensee continues to report environmental spills in a timely manner and applies a lessons-learned approach to reduce such spills in the future. CNSC staff were satisfied with the remedial actions taken by the licensee, and concluded that there were no residual environmental impacts from these spills.

Figure 5-6: Rabbit Lake operation – environmental reportable spills, 2010–2014



In 2014, tailings were deposited into the RLITMF under a water cover. This subaqueous method of tailings placement will prevent the development of a new ice lens in the tailings mass and will reduce the release of radon and dust. The active thaw program in the RLITMF is currently planned to resume after the tailings disposition is completed.

Treated effluent released to the environment

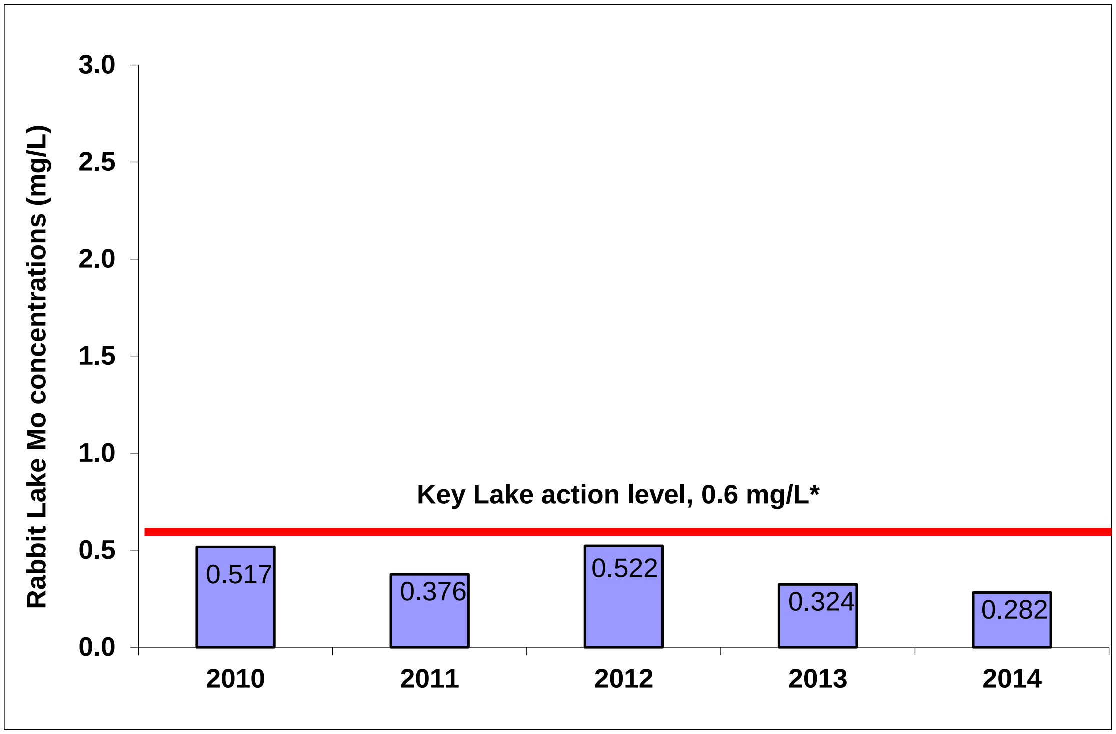
Effluent from the Rabbit Lake operation met regulatory requirements throughout 2014. The CNSC approved modifications to the effluent treatment system that permanently bypassed the final stage of sand filters, after a year-long field demonstration that the final effluent quality would not be affected. This change also enabled the establishment of gravity flow between the final settling ponds without the requirement for pumping. This represented a substantial reduction in energy requirements and an improved reliability without any detrimental effect on effluent quality.

Figure 5-7: Rabbit Lake final effluent treatment

Molybdenum, selenium and uranium in effluent

Molybdenum, selenium and uranium have been identified as constituents of concern from treated effluent at uranium mines and mills. Uranium and molybdenum were the main constituents of concern at the Rabbit Lake operation. Substantial water treatment modifications have been completed at Rabbit Lake since 2007 to improve the quality of the treated effluent released to the environment. The licensee installed additional chemical treatment processes to reduce molybdenum (see figure 5-8), selenium (see figure 5-9) and uranium (see figure 5-10) concentrations. Molybdenum concentrations display continued reductions since additional effluent treatment processes were installed. Selenium concentrations have been stable.

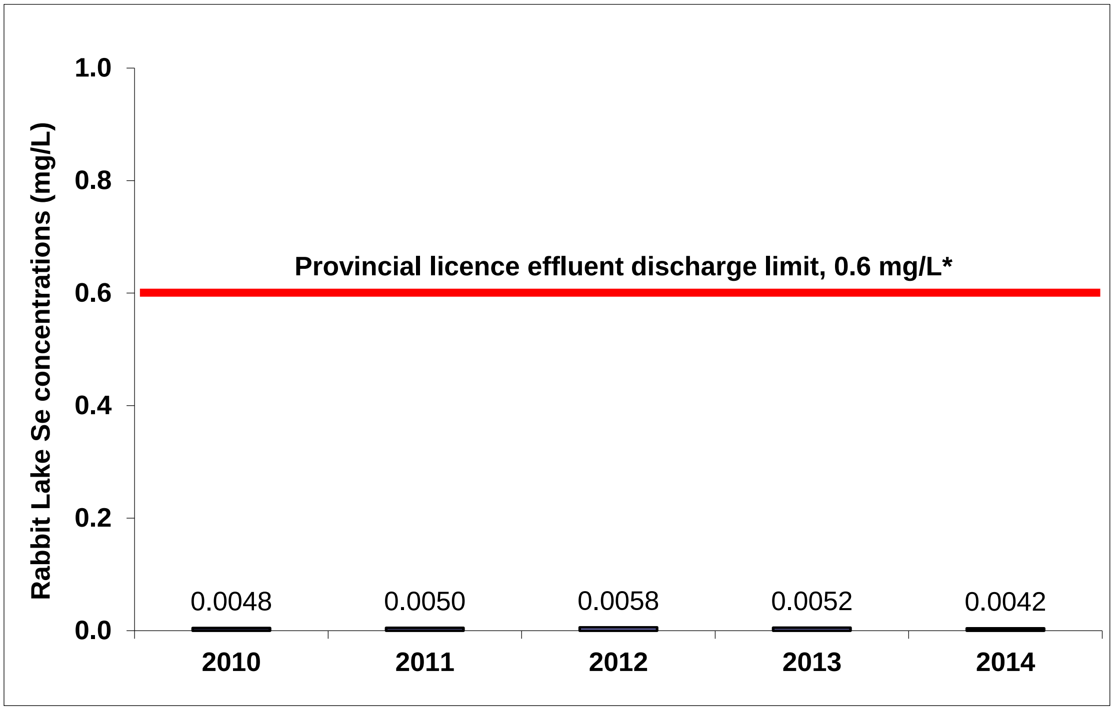
Figure 5-8: Rabbit Lake operation – concentrations of molybdenum, 2010–2014



* The Key Lake action level for molybdenum is the most stringent of the five operating uranium mines and mills and is shown for reference only.

In the absence of a federal or provincial limit for molybdenum, the CNSC requires licensees to develop facility-specific effluent controls within their individual environmental codes of practice. For molybdenum effluent concentrations (see figure 5-8), the Key Lake code of practice action level of 0.6 mg/L is shown for reference only.

Figure 5-9: Rabbit Lake operation – concentrations of selenium, 2010–2014

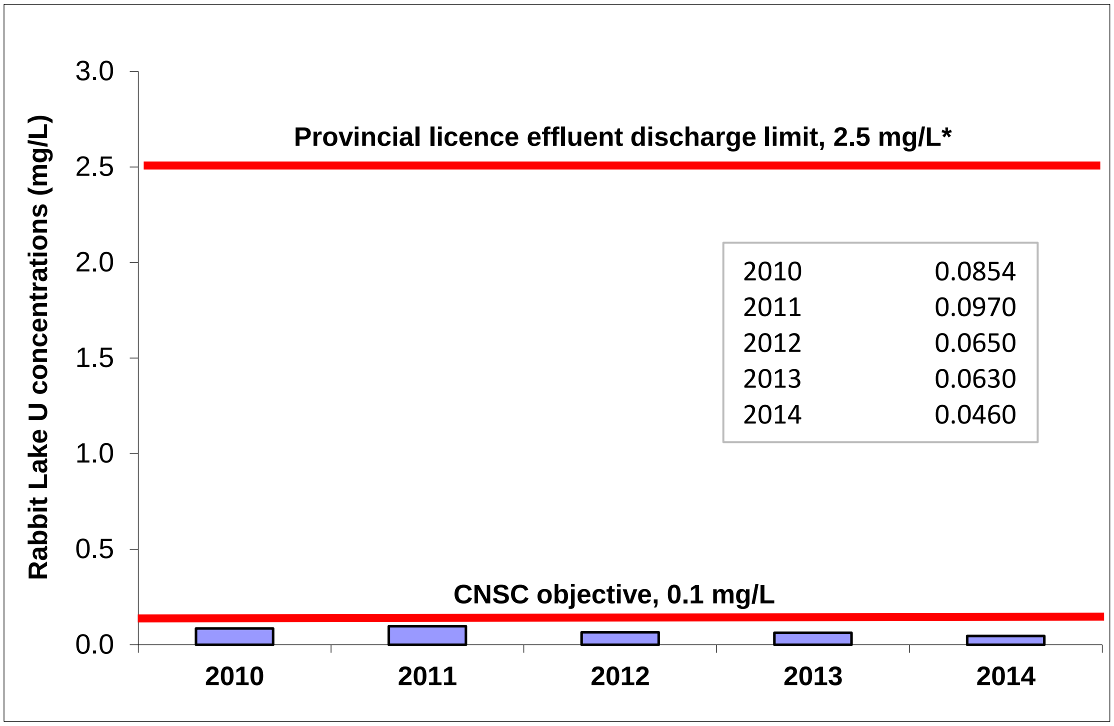


* Saskatchewan's discharge limit for selenium is shown for reference only.

The Saskatchewan provincial licence limit for uranium is a maximum monthly mean of 2.5 mg/L. However, the 2003 edition of the *Priority Substances List 2 Assessment*, which is maintained jointly by Environment Canada and Health Canada, and the Rabbit Lake operation environmental investigations indicated that such limits were not adequately protective of the environment in all circumstances. In 2006, a review identified a concentration of uranium in effluent of 0.1 mg/L as a potential treatment design objective that could be achieved and would be protective of the environment. The CNSC is using this value (0.1 mg/L uranium) as an interim objective for uranium mine and mill facilities.

In 2007, the Rabbit Lake operation implemented improvements resulting in an 86 percent reduction of uranium in treated effluent. The treatment circuit modifications have been successful in meeting the uranium target objective of 0.1 mg/L as shown in figure 5-10.

Figure 5-10: Rabbit Lake operation – concentrations of uranium, 2010–2014



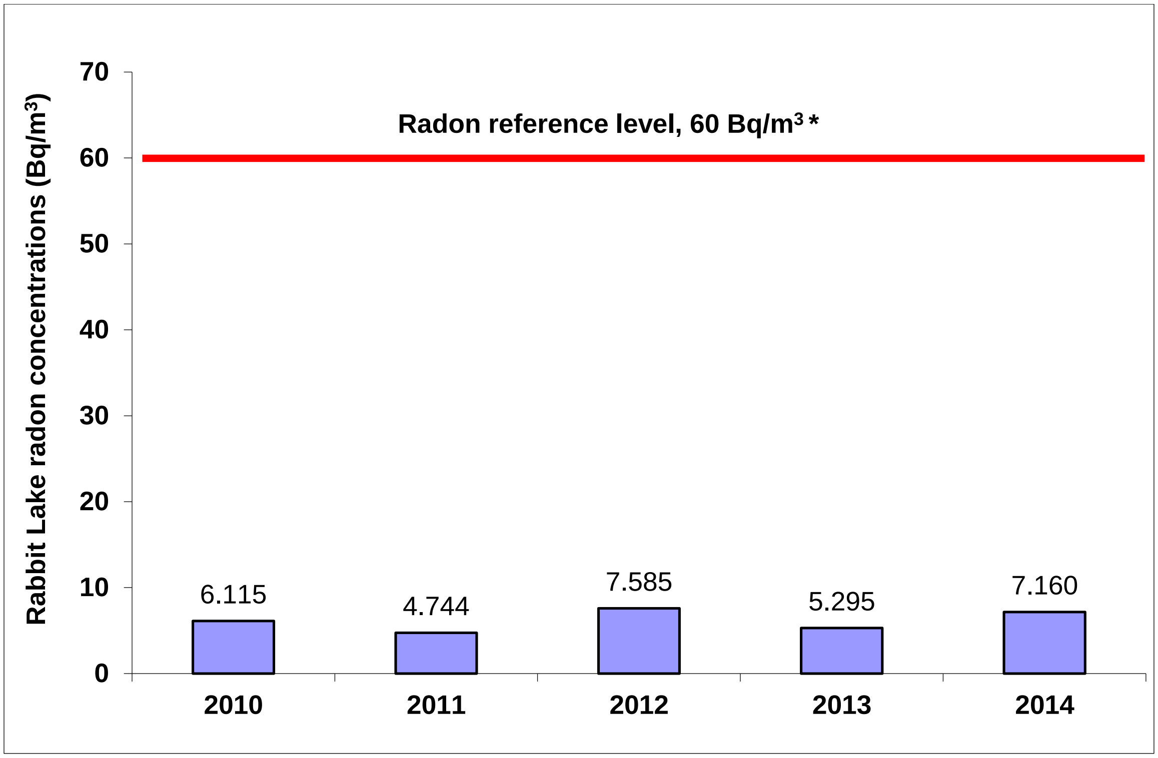
* Saskatchewan's discharge limit for uranium is shown for reference only.

Air quality at the Rabbit 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.

The atmospheric monitoring program at the Rabbit Lake operation includes ambient monitoring for sulphur dioxide, radon and total suspended particulate (TSP).

Twenty monitoring locations are used for the monitoring of ambient radon, using passive track-etched cups. Figure 5-11 shows that the average concentrations of radon in ambient air for 2010 to 2014 were below the reference level for radon. The radon concentrations were also typical of the northern Saskatchewan regional baseline of < 7.4 Bq/m^3 to 25 Bq/m^3.

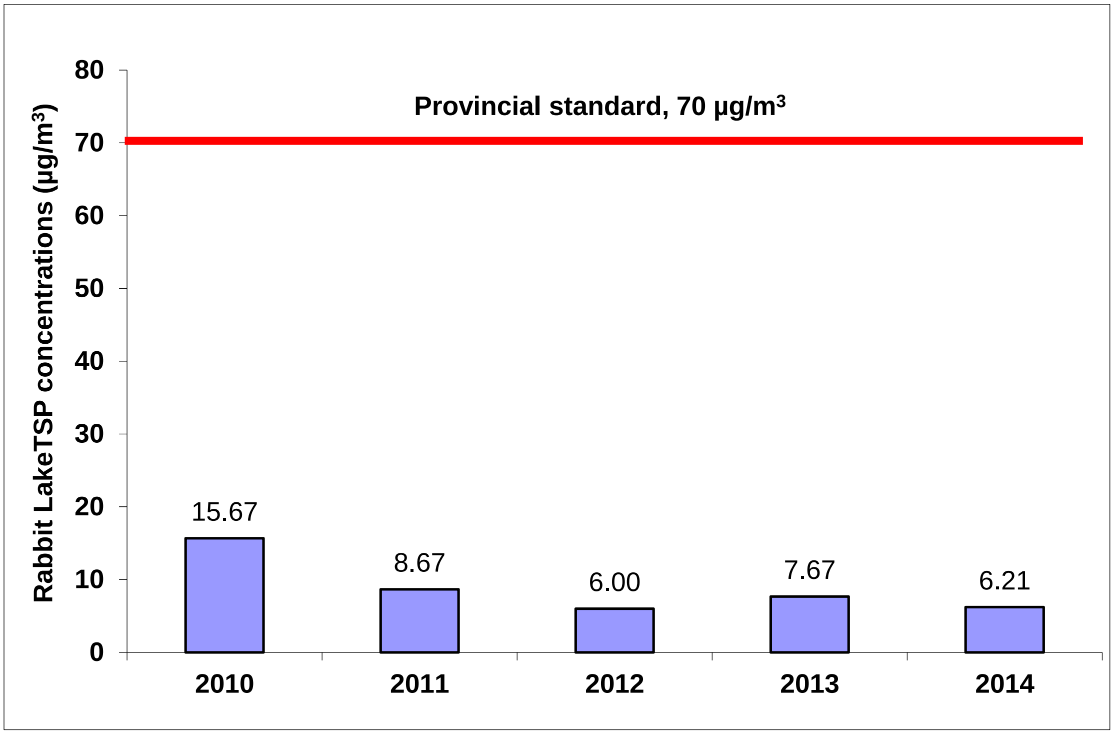
Figure 5-11: Rabbit Lake operation – concentrations of radon in ambient air, 2010–2014



* The value of 60 Bq/m^3 has been derived from the International Commission on Radiological Protection's ICRP-65 document, as referenced in Canada's *Radiation Protection Regulations*. The value approximates an annual dose of 1 mSv.
Values are calculated as geometric mean.

Three high-volume air samplers (HVAS) were used to collect and measure total suspended particulate (TSP) in air. The HVAS units are located in the vicinity of the mill, at the B-zone ore pad and the Eagle Point mine. The TSP levels, from the average of the three stations, are below Saskatchewan's *The Clean Air Regulations* standard (see figure 5-12). TSP samples were also analyzed for concentrations of metals and radionuclides. The mean concentrations of metals and radionuclides adsorbed to TSP are low and remain below the reference annual air quality levels identified in table 5-3.

Figure 5-12: Rabbit Lake operation – concentrations of TSP, 2010–2014



* Saskatchewan's standard is shown.
Values are calculated as geometric mean.

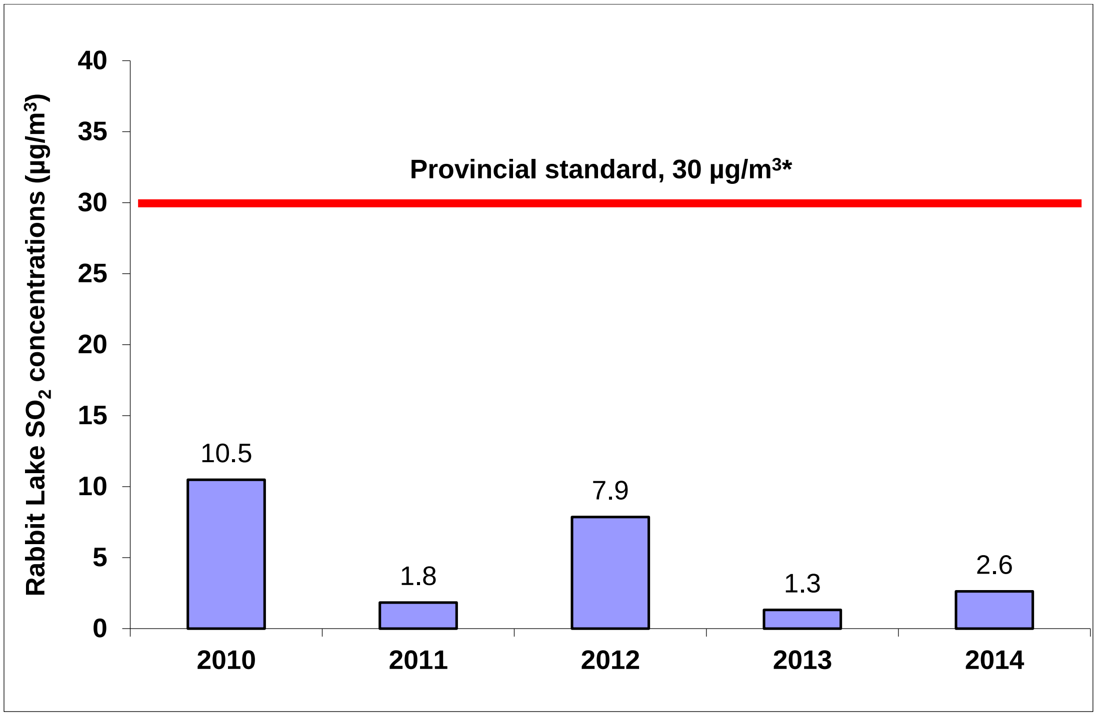
Table 5-3: Rabbit Lake operation – concentrations of metal and radionuclides in air, 2010–2014

Parameter	Reference annual air quality levels (1)	2010	2011	2012	2013	2014
As (µg/m^3)	0.06 (2)	0.000533	0.000483	0.000233	0.000175	0.000217
Ni (µg/m^3)	0.04 (2)	0.000850	0.000800	0.000033	0.000007	0.000138
Pb^{210} (Bq/m^3)	0.021 (3)	0.000012	0.000017	0.000012	0.000010	0.000013
Ra^{226} (Bq/m^3)	0.013 (3)	0.000004	0.000002	0.000000	0.000002	0.000002
Th^{230} (Bq/m$^{3)}$	0.0085 (3)	0.000039	0.000003	0.000001	0.000001	0.000002
U (µg/m^3)	0.06 (2)	0.001800	0.001500	0.000917	0.001033	0.001960

1 Province of Ontario and International Commission on Radiation Protection reference annual air quality levels are shown for reference only, as no limits have been established federally or in Saskatchewan.
2 Reference annual air quality levels were derived from Ontario's *Ambient Air Quality Criteria*, which were developed by the Ontario Ministry of the Environment in 2012.
3 Reference level from International Commission on Radiation Protection (ICRP 96).

A sulphur dioxide sampler monitors ambient sulphur dioxide associated with mill operations. It is located approximately 450 metres southwest of the acid plant. Sulphur dioxide monitoring results (see figure 5-13) show no exceedances of the annual standard of 30 µg/m^3. The operations at Rabbit Lake do not have an adverse effect on ambient sulphur dioxide levels at the site.

Figure 5-13: Rabbit Lake operation – concentrations of ambient sulphur dioxide, 2010–2014



***** Saskatchewan's standard is shown.

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 to determine if there is influence from aerial deposition. This program includes measurements of metals and radionuclides in soil and on lichen.

The triennial lichen sampling program was last undertaken in 2013. Lichen samples were therefore not collected in 2014. Lichen samples are analyzed to determine the level of airborne particulate contaminants deposited on the surface of the lichen as a means of ensuring that a significant level of contamination is not entering lichen consumers, such as caribou. The lichen sampling sites are located to detect both near-field and far-field influences, with a control station providing information for comparison. The 2013 concentrations of metals and radionuclides in lichen were similar to historical data. Most lichen results were consistent with the control station, with near-field stations showing slightly elevated results, as expected. CNSC staff concluded that the level of airborne particulate contaminants produced by the Rabbit Lake operation is acceptable and does not pose a risk to lichen consumers such as caribou.

The most recent soil samples collected were in 2008 as part of the *2005–2009 Integrated Environmental Risk Assessment and State of the Environment Report*. The next report is expected in 2015. The 2008 soil sample results showed radionuclide concentrations in soils 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 Rabbit Lake operation is acceptable and does not pose a risk to the environment.

Monitoring of stack emissions from the Rabbit Lake yellowcake dryer, yellowcake packaging and the yellowcake area dust collector stacks are completed triennially, most recently in 2013. Overall, the stack emissions show results consistent with or better than past performance and verify that the air quality emission controls are operating as designed.

5.4 Conventional health and safety

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 to ensure the protection of workers.

Figure 5-14: Rabbit Lake operation – full-scale emergency response training exercise

The conventional health and safety SCA is evaluated by CNSC staff through regular compliance activities, including inspections and reviews of incidents. Rabbit Lake's safety objectives for 2014 included adherence to routine requirements, increased safety awareness and incident reduction. CNSC compliance verification activities confirmed the Rabbit Lake operation's strong focus on the prevention of accidents and injuries.

In 2014, there was one lost-time incident (LTI) at the Rabbit Lake operation. The Rabbit Lake LTI performance for 2010 to 2014 is shown in table 5-4.

Table 5-4: Rabbit Lake operation – total number of full-time equivalent (FTE) workers and LTIs, severity rate and frequency rate, 2010–2014

Year	2010	2011	2012	2013	2014
Total number of FTE workers[1]	524	551	719	744	669
Number of LTIs[2]	0	2	1	0	1
Severity rate[3]	27.6	10.9	22.6	25.8	11.4
Frequency rate[4]	0.0	0.4	0.1	0.0	0.15

1 **Total number of workers** (employees and contractors) expressed as FTEs. An FTE = total person-hours / 2,000 hours worked per employee per year.
2 **Lost-time incident** – an injury that takes place at work and results in the worker being unable to return to work for a period of time.
3 **Severity rate** – 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.
4 **Frequency rate** – 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.

It should be noted that the "days lost" value used in the calculation of severity rates is recorded from the year in which they occur. Therefore, although the year 2010 had no LTIs, it shows a severity rate of 27.6 as a result of an LTI that occurred in 2009. An LTI also occurred in 2012, resulting in days lost in 2013; therefore, although no LTIs took place in 2013, the severity rate for the entire year was 25.8.

The 2014 Rabbit Lake LTI occurred when an underground worker who was working in a muck pile twisted an ankle and sustained a bone fracture while trying to retrieve a hose. Corrective actions arising from this event were improvements to housekeeping to prevent entraining equipment, and reminding employees how to safely undertake such tasks when they are necessary. CNSC staff were satisfied with the follow-up actions taken by the Rabbit Lake operation.

There was also a noteworthy near-miss incident at the Eagle Point mine in 2014. On August 13, 2014 about two tons of rock fell while workers were using a scissor lift to rock bolt in the Eagle Point underground mine. One miner received a glancing blow from the falling rock, which resulted in lacerations to the head and a fractured bone in the wrist. The injured miner returned to work on modified duty for the next 67 work days. Corrective actions arising from this event included using mechanical bolters for high hazard work areas, reinforcing to the miners the importance of scaling (i.e., the removal of loose rock), implementing additional safety measures for scissor deck bolting, and providing coaching to the miners involved in the incident. CNSC staff were satisfied with the follow-up actions taken by the Rabbit Lake operation.

Figure 5-15: Rock bolting and screening observed at Eagle Point work area

Cameco's incident-reporting system includes reporting and investigation of near misses. This originates from a facility-wide recognition that the reporting of incidents offers significant value in reducing future incidents that could cause injury. CNSC staff also observed promotion of an incident-reporting culture.

6 Key Lake Operation

Located approximately 570 km north of Saskatoon, Saskatchewan, the Key Lake operation is owned and operated by Cameco Corporation. The Key Lake operation began with two open-pit mines and a mill complex. The Gaertner open pit was mined from 1983 to 1987, followed by mining of the Deilmann open pit until 1997. Milling of the Deilmann ore continued until 1999, when the McArthur River operation began supplying ore slurry to the Key Lake mill (see figure 6-1). The Key Lake operation continues today as a mill operation processing McArthur River ore slurry.

Figure 6-1: Key Lake operation

Figure 6-2: Ore slurry being transported from McArthur River operation to the Key Lake operation mill

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. Mill tailings continue to be deposited into this facility today.

Table 6-1 provides the Key Lake milling production data from 2010 to 2014.

Table 6-1: Key Lake operation – milling production data, 2010–2014

Milling	2010	2011	2012	2013	2014
Mill ore feed (tonnes/year)	196,180	189,821	193,511	184,099	173,007
Average annual mill feed grade (% U_3O_8)	4.68	4.85	4.61	5.03	5.03
Percentage of uranium recovery	98.4	98.7	98.9	99.3	99.4
U concentrate produced (Mkg* U/year)	7.66	7.69	7.52	7.75	7.37
Authorized annual production (Mkg U/year)	7.85	7.85	7.85	7.85	9.60

* 1 Mkg = 1,000,000 kg

In October 2013, the Commission issued a 10-year licence following a public hearing in La Ronge, Saskatchewan. Cameco’s licence for the Key Lake operation includes a licence conditions handbook, which provides the licensing basis and authorized activities. In 2014, the Commission approved the Key Lake Extension Project Environmental Assessment. In December 2014, the licence conditions handbook was revised to include references from the environmental assessment, and an increase in annual production from 7.85 million kg of uranium to 9.6 million kg.

6.1 Performance

In 2014, CNSC staff were satisfied that the Key Lake operation was adequately controlling radiation doses to workers at levels below regulatory limits based on the outcome of inspections, reviews of the radiation protection program, work practices, monitoring results and effective doses. CNSC staff concluded that the effective implementation of the radiation protection program maintained worker doses as low as reasonably achievable, and the radiation protection safety and control area (SCA) was rated as “satisfactory”.

CNSC staff concluded that the Key Lake operation’s environmental program met regulatory requirements during 2014. CNSC staff verified that treated mill effluent discharged to Wolf Lake in 2014 displayed stabilized concentrations of molybdenum and selenium and complied with licence requirements. In 2014, there was one reportable spill at the Key Lake operation. It was defined by CNSC staff as being of low safety significance. The environmental protection SCA was rated as “satisfactory”.

CNSC staff concluded that the Health and Safety Program at the Key Lake operation continues to be effective. CNSC staff verified that Cameco is committed to accident prevention, safety awareness and an increased focus on safety culture. There were no lost-time incidents (LTIs) reported for the Key Lake operation in 2014. By the end of 2014, contractors had achieved more than seven years with no LTIs. The conventional health and safety SCA was rated as “satisfactory”.

The Key Lake SCA ratings for the 14 SCAs for the period of 2010 to 2014 are shown in appendix C. For 2014, CNSC staff continue to rate all SCAs as “satisfactory”.

6.2 Radiation protection

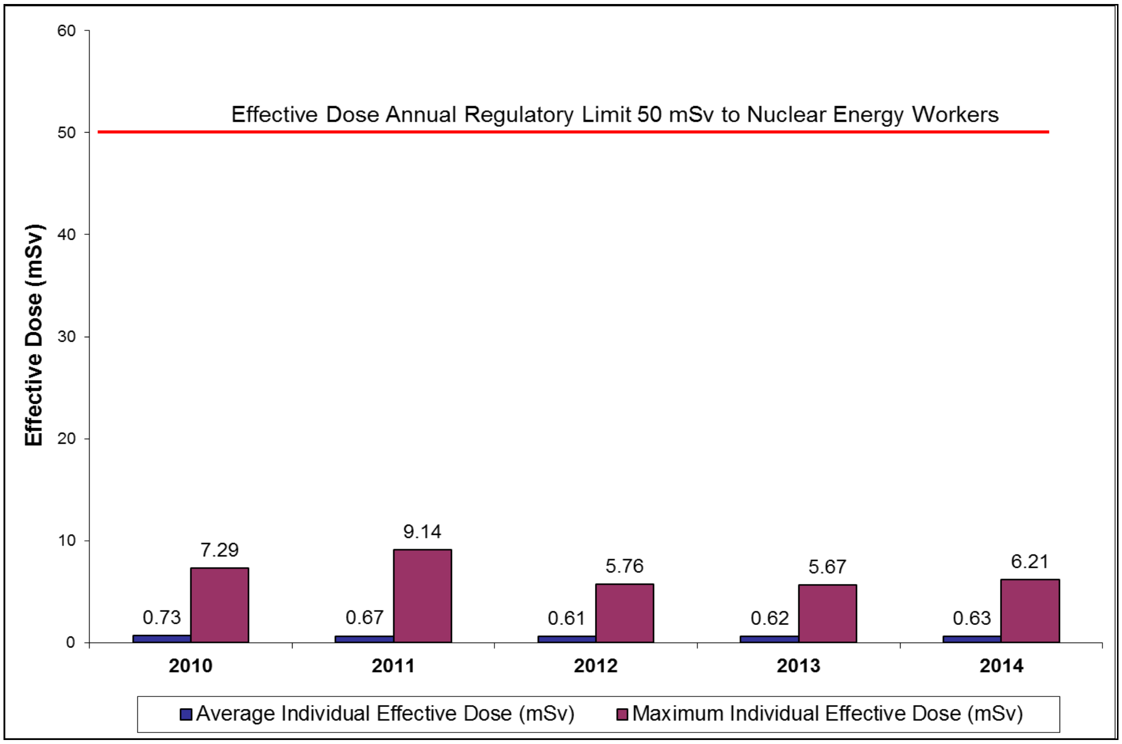
The source of radiological exposure at the Key Lake operation is the milling of uranium ore received from the McArthur River mine. The three primary effective dose contributors are gamma radiation, radon progeny and long-lived radioactive dust (LLRD).

During the 2014 review period, the average individual effective dose for nuclear energy workers (NEWs) at the Key Lake mill was primarily from gamma radiation (39 percent) and LLRD (39.5 percent). Gamma radiation is controlled through the effective use of time, distance and shielding, while LLRD is controlled through ventilation, contamination control and personal protective equipment, including Tyvek suits and powered air-purifying respirators.

The maximum individual effective dose at the Key Lake operation over the last few years, including 2014, has been a result of LLRD exposures from maintenance in the calciner operations. In 2015, there were two calciner mechanical failure incidents that resulted in LLRD individual dose action level exceedances. These two calciner incidents are discussed in greater detail in section 1.5. The Key Lake operation is currently installing a new calciner to replace the aging calciner which will minimize these types of incidents. The new calciner is expected to be commissioned by the end of 2015.

As seen in figure 6-3, the effective doses to workers remain well below the annual regulatory limit of 50 mSv, and have been consistently low from year to year. In 2014, the average individual effective dose was 0.63 mSv, while the maximum individual effective dose received was 6.21 mSv.

Figure 6-3: Key Lake operation – individual effective dose to NEWs, 2010–2014



All five of the uranium mine and mill facilities have the same action levels for worker effective dose of 1 mSv/week and 5 mSv/quarter of a year. There were no radiation action level exceedances reported at the Key Lake operation in 2014.

Improvements in radiation protection

The new calciner construction is ongoing, and is expected to be commissioned by the end of 2015. It is anticipated that the new horizontal rotary calciner will lower maintenance requirements and minimize exposure risks.

Continual improvements to the Key Lake operation's Radiation Protection Program were made in accordance with subsection 4(*a*) of the *Radiation Protection Regulations* and CNSC guide document G-129, *Keeping Radiation Exposure and Doses "As Low as Reasonably Achievable".*

Through desktop reviews and inspections, CNSC staff concluded that an effective radiation protection program exists at the Key Lake operation.

6.3 Environmental protection

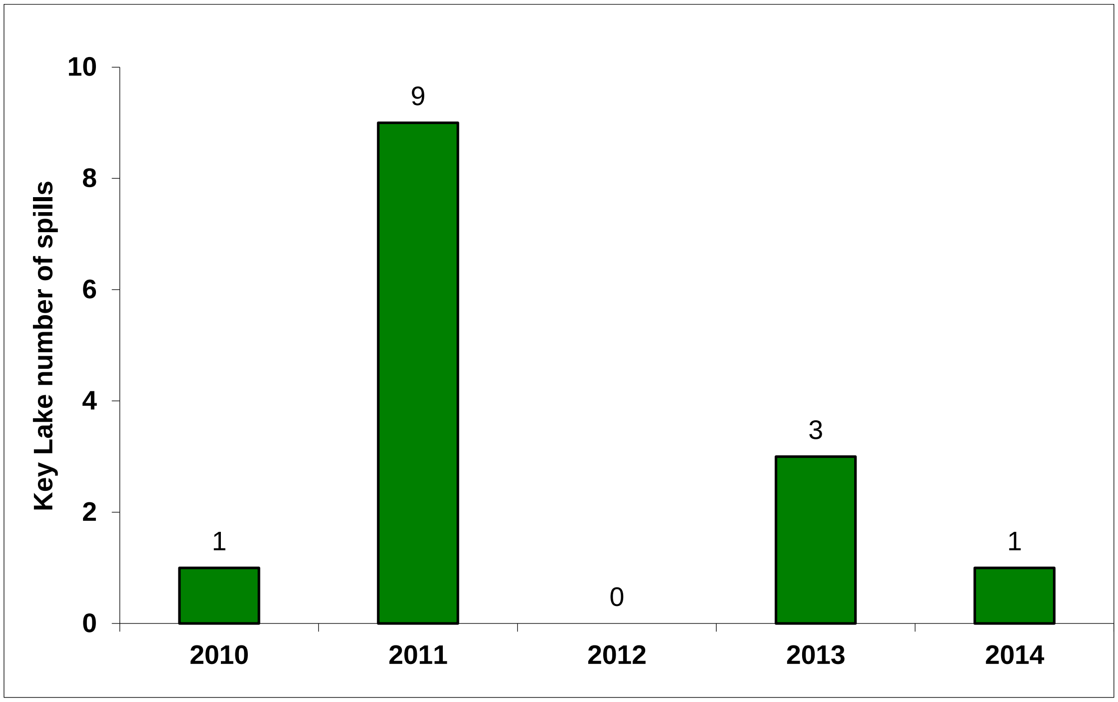
In accordance with the Key Lake operation's Environmental Protection Program, Cameco performed effluent and environmental monitoring, site inspections, environmental awareness training and program implementation audits during 2014.

Figure 6-4 shows the number of reportable spills from the licensed activities at the Key Lake operation from 2010 to 2014. In 2014, one event was classified as an environmental spill by CNSC staff:

- 200 L (0.200 m^3) spill of propylene glycol was released to the ground

The spill was immediately cleaned up and there was no residual impact to the environment. The identified corrective actions taken by Cameco were acceptable to CNSC staff. A brief description of the spill and corrective actions implemented is provided in appendix G. CNSC staff concluded that the Key Lake operation's Environmental Protection Program met regulatory requirements during 2014.

Figure 6-4: Key Lake operation – environmental reportable spills, 2010–2014



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 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, and monitoring has verified that this effluent poses no environmental concern. The Key Lake treated effluent quality further discussed in this report refers only to the mill effluent as released to the David Creek system.

Molybdenum, selenium and uranium in effluent

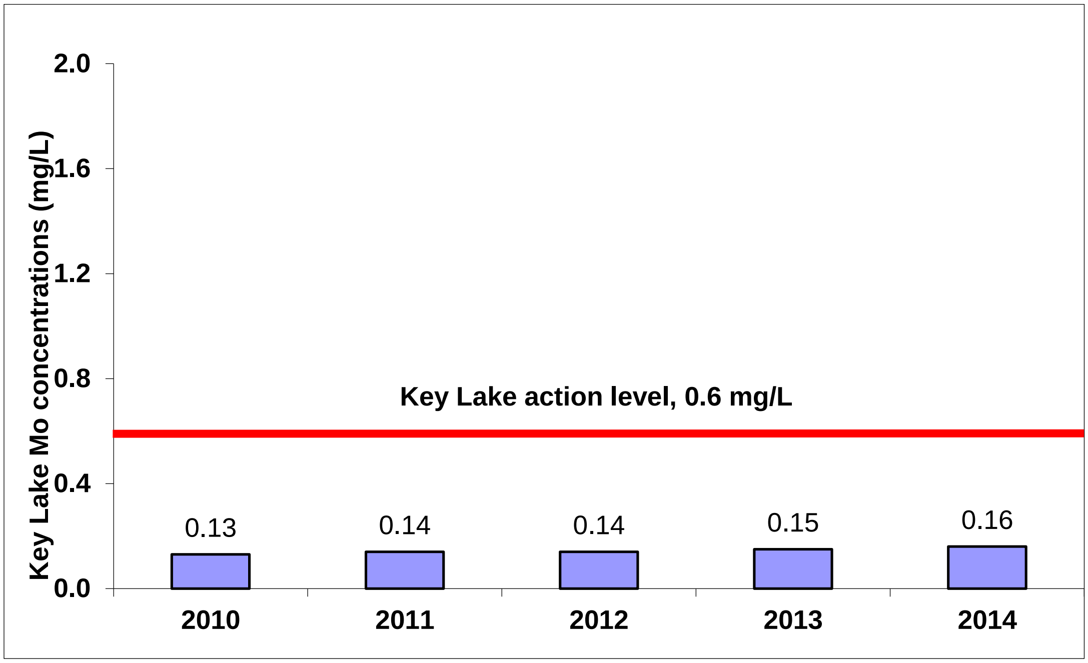
In 2014, the licensed parameter concentration values in the treated mill effluent were well below the regulatory limits. There were also no exceedances of environmental action levels at the Key Lake operation.

Molybdenum, selenium and uranium have been identified as contaminants of concern from treated effluent at uranium mines and mills. Molybdenum and selenium concentrations were the primary concerns at Key Lake. Cameco has targeted process changes to reduce concentrations in treated effluent.

Figure 6-5: Key Lake operation – effluent water treatment plant

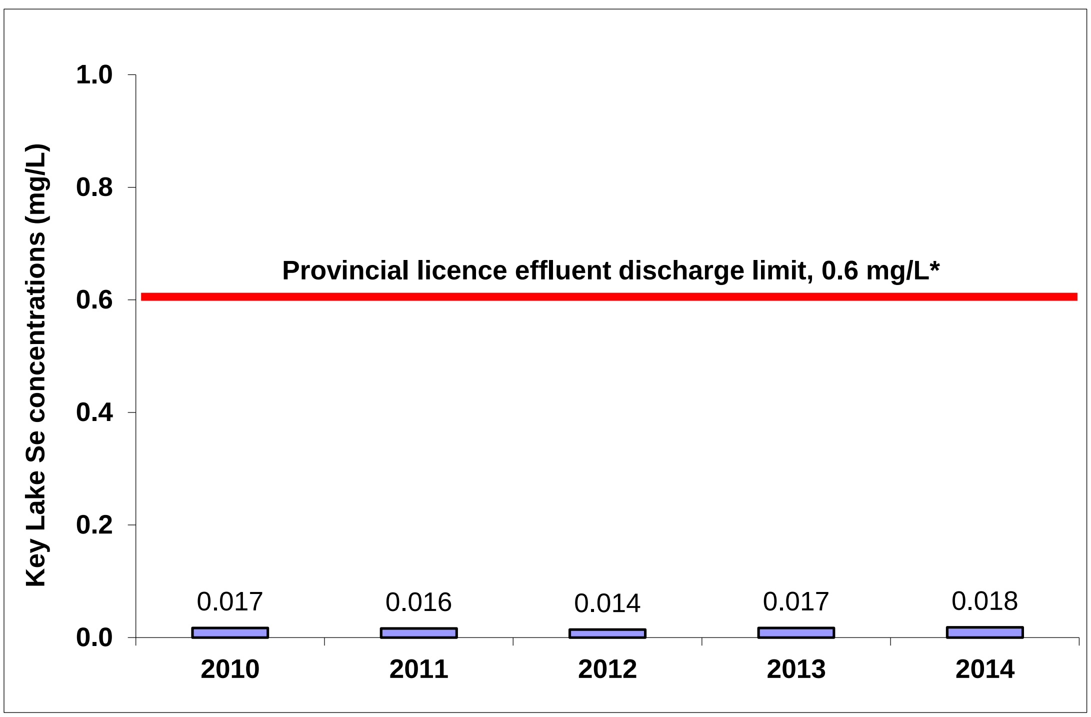
Significant reductions of molybdenum and selenium occurred from 2008 to 2009 when additional treatment components were installed and optimized. Figures 6-6 and 6-7 show that stable reduced concentrations of molybdenum and selenium concentrations in treated effluent have occurred from 2010 to 2014. CNSC staff also note that the stable reduced concentrations occurred during a period of increased uranium production. Due to the improved treated effluent results, continued monitoring of molybdenum and selenium in the receiving environment is expected to demonstrate stabilization and/or improvements over the coming years.

Figure 6-6: Key Lake operation – concentrations of molybdenum, 2010–2014



In the absence of federal or provincial limits for molybdenum, the CNSC requires licensees to develop facility-specific effluent controls within their individual environmental codes of practice. For molybdenum effluent concentrations (see figure 6-6), the Key Lake code of practice action level of 0.6 mg/L is based on five consecutive ponds.

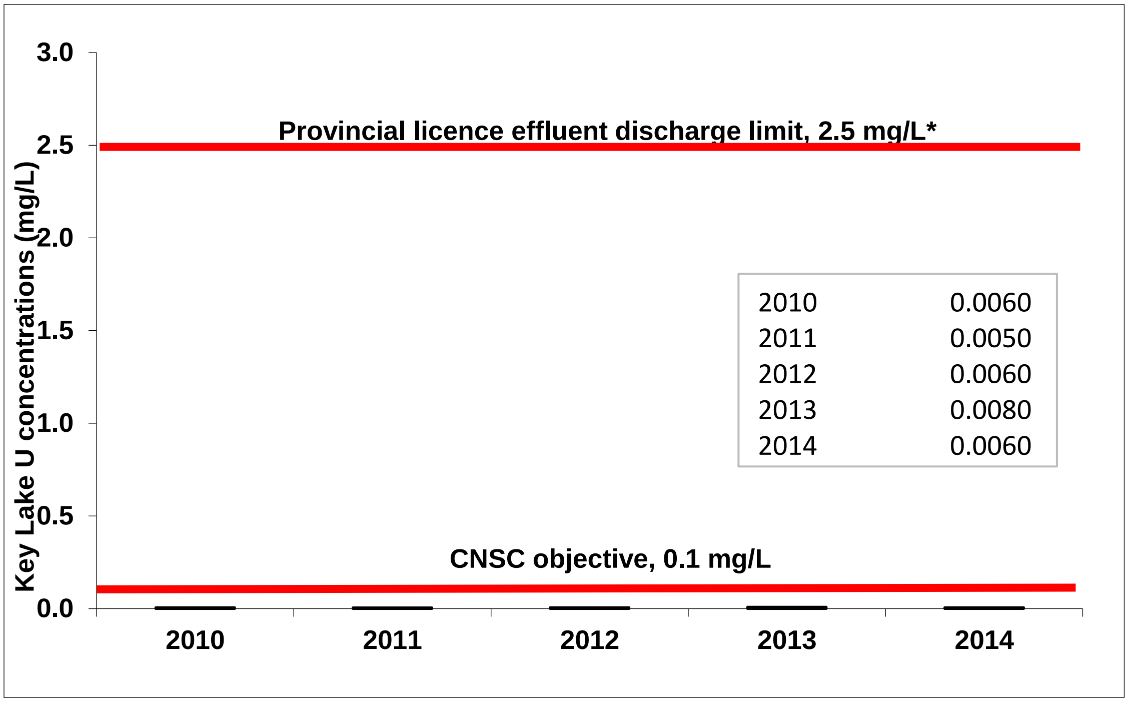
Figure 6-7: Key Lake operation – concentrations of selenium, 2010–2014



* Saskatchewan's discharge limit for selenium is shown for reference only.

Figure 6-8 indicates that uranium concentrations in treated effluent released from the Key Lake mill remain low and are effectively controlled.

Figure 6-8: Key Lake operation – concentrations of uranium, 2010–2014

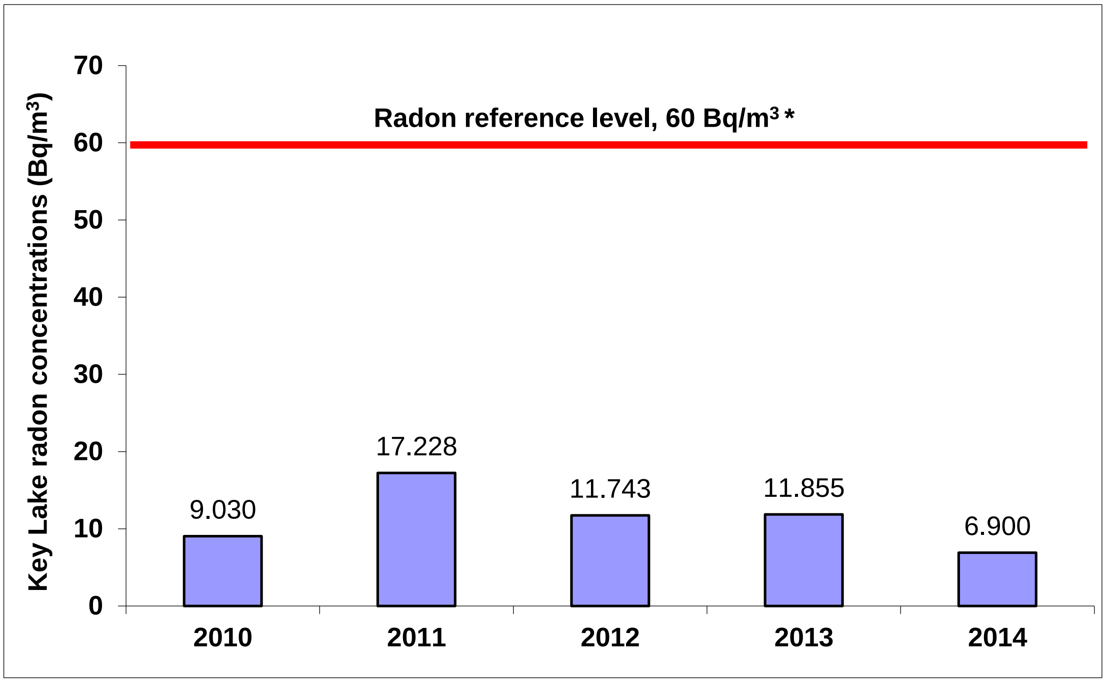


* Saskatchewan's discharge limit for uranium is shown for reference only.

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

Five boundary monitoring locations and one boundary reference station are used for the monitoring of ambient radon using passive track-etched cups. Figure 6-9 shows that the average concentrations of radon in ambient air for 2010 to 2014 are below the reference level for radon. The radon concentrations were also typical of the northern Saskatchewan regional baseline of < 7.4 Bq/m^3 to 25 Bq/m^3.

Figure 6-9: Key Lake operation – concentrations of radon in ambient air, 2010–2014

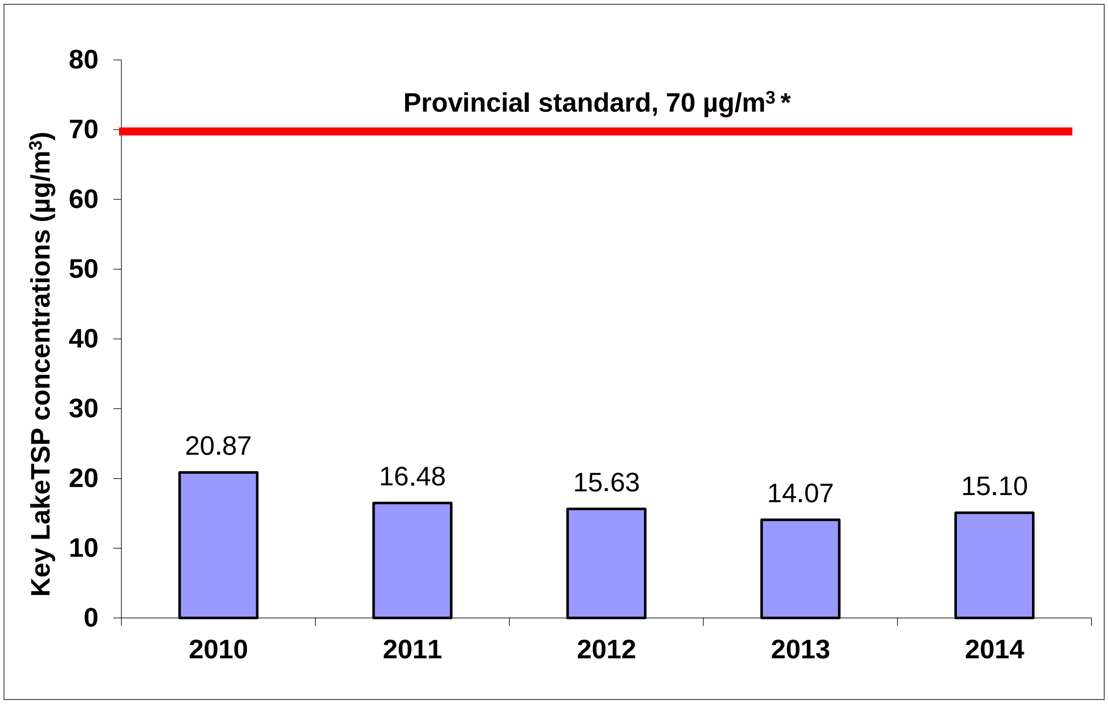


* The value of 60 Bq/m^3 has been derived from the International Commission on Radiological Protection's ICRP-65 document, as referenced in Canada's *Radiation Protection Regulations*. The value approximates an annual dose of 1 mSv.
Values are calculated as geometric mean.

Five high-volume air samplers (HVAS) were used to collect and measure TSP in air. The HVAS units are located downwind of the milling facility, downwind of the crusher, east and west of the Above Ground Tailings Management Facility, and in the vicinity of the main camp residence. The TSP levels are below Saskatchewan's *The Clean Air Regulations* standard (see figure 6-10). 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 identified in table 6-2.

A sulphur dioxide monitor is used to continuously measure the ambient sulphur dioxide associated with mill emissions. It is located approximately 300 metres downwind of the mill facility. The measured sulphur dioxide monitoring data (see figure 6-11) shows no exceedances of the annual standard of 30 $\mu g/m^3$.

Figure 6-10: Key Lake operation – concentrations of TSP, 2010–2014



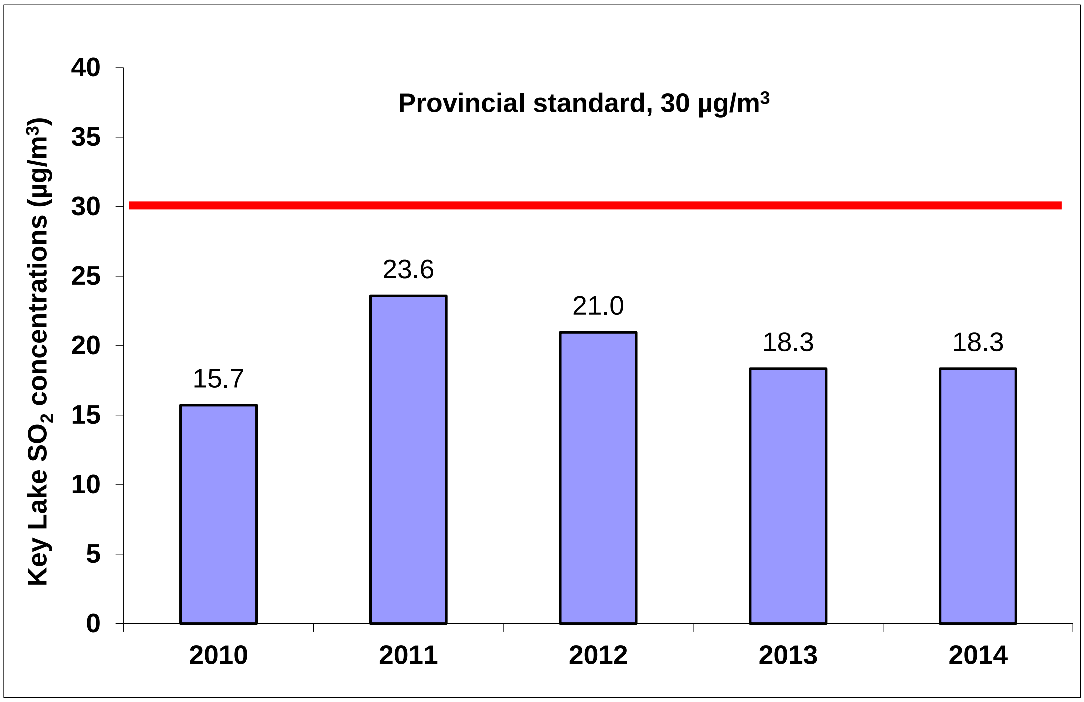
* Saskatchewan's standard is shown.
Values are calculated as geometric mean.

Table 6-2: Key Lake operation – concentrations of metal and radionuclides in air, 2010–2014

Parameter	Reference annual air quality levels (1)	2010	2011	2012	2013	2014
As ($\mu g/m^3$)	0.06 (2)	0.00150	0.00222	0.00266	0.00166	0.00444
Ni ($\mu g/m^3$)	0.04 (2)	0.00092	0.00186	0.00222	0.00118	0.00340
Pb^{210} (Bq/m^3)	0.021 (3)	0.00048	0.00038	0.00034	0.00032	0.00044
Ra^{226} (Bq/m^3)	0.013 (3)	0.00010	0.00010	0.00010	0.00010	0.00022
Th^{230} ($Bq/m^{3)}$)	0.0085 (3)	0.00010	0.00014	0.00028	0.00010	0.00022
U ($\mu g/m^3$)	0.06 (2)	0.0046	0.01286	0.0074	0.00646	0.00794

1 Province of Ontario and International Commission on Radiation Protection reference annual air quality levels are shown for reference only, as no limits have been established federally or in Saskatchewan.
2 Reference annual air quality levels are derived from Ontario's *Ambient Air Quality Criteria*, which were developed by the Ontario Ministry of the Environment in 2012.
3 Reference level from International Commission on Radiation Protection (ICRP 96).

Figure 6-11: Key Lake operation – concentrations of ambient sulphur dioxide, 2010–2014



* Saskatchewan's standard is shown.

In addition to ambient air monitoring for sulphur dioxide, sulfate levels have been monitored in four lakes selected to measure the effects of sulphur dioxide emissions from the operation. The results of the 2014 lake sampling program continue to show that sulfate concentrations remain relatively unchanged, compared to historical data. The operations at Key Lake, and 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. A terrestrial monitoring program is in place to determine if there is facility emission influence by aerial deposition. This program includes measurements of metals and radionuclides in soil and lichen.

Lichen samples were collected in 2013, with the next sampling scheduled for 2016, as required by the triennial sampling program. A total of five sites, chosen to detect both near-field and far-field influences, including a control station, were sampled. Lichen samples were analyzed to determine the level of airborne particulate contaminants deposited on the surface of the lichen as a means of ensuring that a significant level of contamination is not entering lichen consumers, such as caribou. The concentrations of metals and radionuclides in lichen samples collected from exposure stations were similar to reference stations and historical data. 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 lichen consumers such as caribou.

The most recent soil samples were collected in 2013, with the next sampling scheduled for 2016. Soil samples were taken in the immediate vicinity of the mine. The soil metal parameter concentrations were below the *Canadian Environmental Quality Guidelines* for industrial and residential/parkland land use. Radionuclide concentrations in soils 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 Key Lake operation, based on soil sampling results, is acceptable and does not pose a risk to the environment.

Monitoring of the Key Lake calciner stack is conducted annually. Overall, the stack emissions show results consistent with, or better than, past performance and verify that operational controls are working as designed. A new calciner is currently under construction and expected to be commissioned in 2015. This will further improve stack emissions.

Sulphur dioxide concentrations from the acid plant stack are monitored on a daily basis. In 2012, a new acid plant was commissioned, resulting in a reduction in sulphur dioxide emissions of more than 90 percent. The new acid plant is operating as designed, with stack emissions continuing to provide the improved performance.

6.4 Conventional health and safety

CNSC staff monitor the implementation of the Key Lake operation's Occupational Health and Safety Program to ensure protection of workers. The Key Lake operation has implemented a health and safety management program to identify and control risks. CNSC staff observed that the health and safety program at the Key Lake operation continues to provide education, training, tools and support to workers. The Key Lake operation's approach is that safety is the responsibility of all individuals; this is promoted by management, supervisors and workers. Key Lake operation's management stresses the importance of conventional health and safety through regular communication, management oversight, and continual improvement of safety systems.

There were seven lost-time incidents (LTIs) at the Key Lake operation between 2010 and 2014 (see table 6-3). There were none in 2014.

Table 6-3: Key Lake operation – total number of full-time equivalent (FTE) workers and LTIs, severity rate and frequency rate, 2010–2014

Year	2010	2011	2012	2013	2014
Total number of FTE workers[1]	786	886	736	679	499
Number of LTIs[2]	3	3	1	0	0
Severity rate[3]	26.0	13.1	21.6	8.5	0
Frequency rate[4]	0.4	0.3	0.1	0.0	0

1 **Total number of workers** (employees and contractors) expressed as FTEs. An FTE = total person-hours / 2,000 hours worked per employee per year.
2 **Lost-time incident** – an injury that takes place at work and results in the worker being unable to return to work for a period of time.
3 **Severity rate** – 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.
4 **Frequency rate** – 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.

Contractor safety risks continue to be effectively managed. At the end of 2014, the site reported that contractors had no LTIs over the past seven years.

Cameco’s incident-reporting system records health and safety-related events and utilizes several layers of review in investigations. Corrective measures are tracked and assessed for effectiveness prior to closure. Key Lake continued its planned health and safety inspection program in 2014. Any items of concern found during these inspections are included in Cameco’s incident-reporting system.

7 McClean Lake Operation

The McClean Lake operation is located about 750 km north of Saskatoon, Saskatchewan and is operated by AREVA Resources Canada Inc. Construction of the McClean Lake operation began in 1994. 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. Also, no ore was mined in 2014 through the Surface Access Borehole Resource Extraction (SABRE) project. The CNSC was informed during the first quarter of 2014 that the SABRE project had been placed into care and maintenance for the foreseeable future.

Figure 7-1: McClean Lake operation

Mill tailings resulting from the processing of ore from the open pit operations were deposited within the McClean Lake operation's Tailings Management Facility which was constructed in the mined-out JEB open pit.

The McClean Lake mill stopped producing uranium concentrate from July 2010 to September 2014. Testing of Cigar Lake ore samples in 2012 and 2013 identified the release of higher-than-expected concentrations of hydrogen gas during the acid leaching process. As a result, modifications were made to the leaching circuit to ensure hydrogen gas concentrations are kept at safe levels. Modifications included:

- control of slurry level in leach tanks to ensure head space volume is maintained
- minimization of the volume of high-point dead spaces, where hydrogen could accumulate
- addition of sufficient air sweep with back-up to remove hydrogen as it evolves
- addition of a continuous gas monitoring system
- addition of a contingency nitrogen purge system to create a safe headspace independent of hydrogen gas build-up

The hydrogen mitigation system was successfully commissioned and has demonstrated safe operating conditions over a range of ore grades. CNSC staff concluded that workers and the environment would continue to be protected following implementation of these modifications.

Ore slurry shipments from the Cigar Lake operation began in March 2014. A delay in the McClean Lake mill restart occurred as a result of the modifications being made to the leaching circuit. This created a need for additional short-term ore slurry storage. Modifications were made to the JEB ore pad to facilitate temporary storage of ore slurry. Mill start-up activities began in the third quarter of 2014, using blended ore consisting of Sue B low grade with Cigar Lake ore slurry.

Figure 7-2 McClean Lake workers

Tables 7-1 and 7-2 display the production data for mining and milling from 2010 to 2014.

Table 7-1: McClean Lake operation – mining production data, 2010–2014

Mining[1]	2010	2011	2012	2013	2014
Ore tonnage (tonnes/year)	360	No mining	1,022	No mining	No mining
Average ore grade mined (% U_3O_8)	3.96	No mining	4.76	No mining	No mining
U mined (Mkg* U/year)	0.02	No mining	0.04	No mining	No mining

1 The last ore from the Sue E pit was mined on March 15, 2008, and Sue B pit's last ore was mined on November 26, 2008. Mine production since then is from the SABRE project.

* 1 Mkg = 1,000,000 kg

Table 7-2: McClean Lake operation – milling production data, 2010–2014

Milling	2010	2011	2012	2013	2014
Mill ore feed (tonnes/year)	97,167*	No milling[1]	No milling[1]	No milling[1]	7,832
Average annual mill feed grade (% U_3O_8)	0.80	No milling[1]	No milling[1]	No milling[1]	3.00
Percentage of uranium recovery	95.7	No milling[1]	No milling[1]	No milling[1]	97.5
Uranium concentrate produced (Mkg U)**	0.67*	No milling[1]	No milling[1]	No milling[1]	0.200
Authorized annual production (Mkg U/year)	3.08	3.08	5.00	5.00	5.00

1 The McClean Lake operation mill temporarily stopped producing uranium concentrate during July 2010.
* Ore that had been mined before the end of 2008 and ore extracted during the SABRE project were processed by the McClean Lake operation mill during 2009 and 2010.
** 1 Mkg = 1,000,000 kg

The McClean Lake licence was issued in July 2009, amended on December 19, 2012 and expires June 30, 2017. The amended licence (which includes the licence conditions handbook) authorizes:

- the operation of the ore slurry receiving circuit and high-grade milling circuits in the McClean Lake mill
- the processing of ore slurry from approved sources, including the Cigar Lake operation and the McArthur River operation at the McClean Lake mill
- an increase of the maximum annual uranium concentrate production from 3.6 million kg to 5.9 million kg U_3O_8 (3.08 million kg to 5.00 million kg U)

Changes were made to the licence conditions handbook in April 2014 to reference the Commissioning Management Plan for the Mill Upgrade Project as well as the ore slurry storage on the JEB ore pad, and to reflect various administrative edits to licensing documents. Changes to the licence conditions handbook are reflected in appendix J.

7.1 Performance

Milling of Cigar Lake ore began at AREVA's McClean Lake mill in September 2014. Three major ongoing AREVA projects during 2014 were the following:

1) The JEB Tailings Management Facility (TMF) Optimization Project focused on repairing erosion issues that occurred during the spring run-off at the JEB TMF. This work involved re-establishing drainage culverts and adding rip-rap and diversion works to better manage spring runoff. A drainage management plan was developed to assist staff with inspection locations, maintenance of surface drainage and erosion control of the JEB TMF and waste rock pile.
2) The Sue Water Treatment Plant optimization including:
    - high pH treatment for nickel
    - enhanced radium polishing by increasing retention time

- sludge clean-out from sedimentation ponds to reduce solids carry-over
- improved control of contaminated runoff from ore stockpiles by diversion and collection to the Sue C and Sue A ponds

3) The McClean Lake Mill Upgrade Project includes modifications, alterations and additions to some of the mill uranium production circuits, mill utilities and supporting facilities. This upgrade project is scheduled to be completed in 2016, which will enable the mill to produce 24 million pounds of uranium concentrate per year. Commissioning and start-up activities to the new and modified circuits were ongoing. Production ramp-up was coordinated with the Cigar Lake mine plan and ore slurry delivery schedule.

CNSC staff verified that AREVA is adequately controlling radiation doses to workers at the McClean Lake operation to levels below the regulatory limits. CNSC staff conclude that the effective implementation of the radiation protection program maintained worker doses as low as reasonably achievable, and the radiation protection safety and control area (SCA) was rated as “satisfactory”.

CNSC staff concluded that the McClean Lake operation’s Environmental Protection Program met regulatory requirements during 2014. All treated mill effluent discharged to the environment was well below regulatory limits. There were two reportable spills at the McClean Lake operation in 2014, which were remediated with no residual impacts to the environment. Corrective actions taken on the spills by the McClean Lake operation were acceptable to CNSC staff. The environmental protection SCA was rated as “satisfactory”.

AREVA continues to improve performance and maintain health and safety programs at the McClean Lake operation to minimize occupational health and safety risks. AREVA has an effective Occupational Health and Safety Committee and completes regular reviews of its safety program. There were three lost-time incidents at the McClean Lake operation in 2014. CNSC staff verified that the health and safety programs at McClean Lake continue to be effective. The conventional health and safety SCA was rated as “satisfactory”.

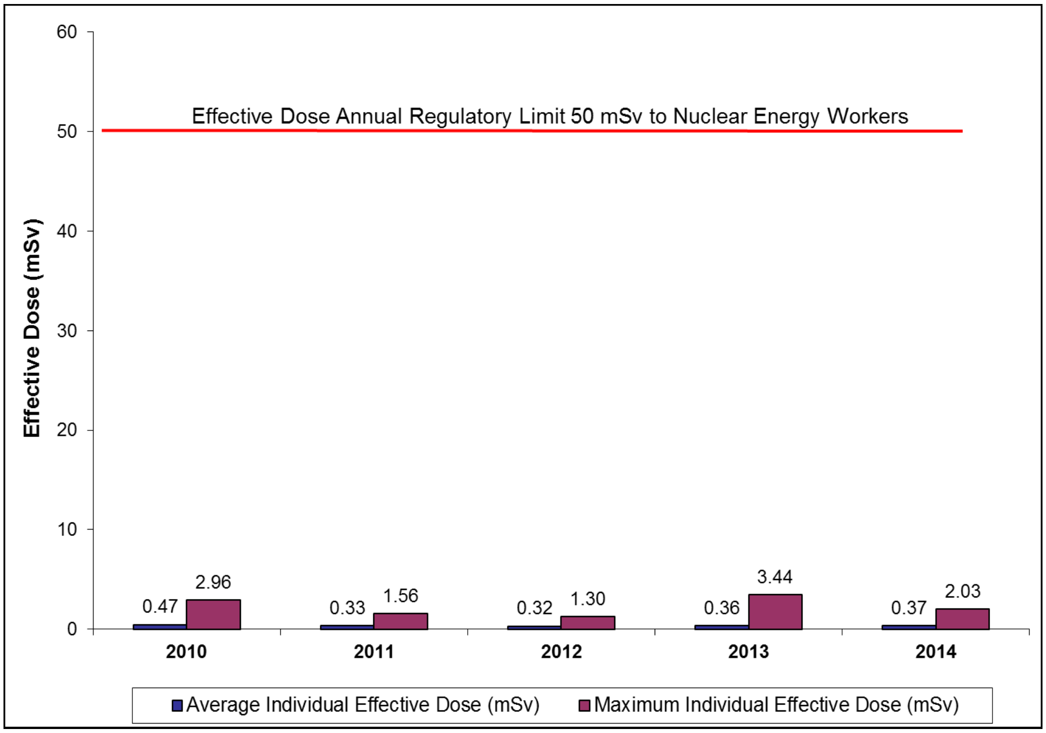
The McClean Lake rating for all 14 SCAs for the five-year period, 2010 to 2014, are shown in appendix C. For 2014, CNSC staff rate all 14 SCAs as “satisfactory”.

7.2 Radiation protection

The source of radiological exposure at the McClean Lake operation comes from the milling of uranium ore. The three primary contributors to worker effective dose are gamma radiation, radon progeny and long-lived radioactive dust.

Figure 7-3 displays the average individual effective dose and the maximum individual effective doses for 2010 to 2014. The cessation of mining in 2008, and the temporary shutdown of milling operations in 2010, resulted in average and maximum individual effective doses remaining low. In the first three quarters of 2014, construction and maintenance were the main activities taking place at the mill, with mill start-up beginning in September 2014. The average individual effective dose for nuclear energy workers (NEWs) in 2014 was 0.37 mSv, while the maximum individual effective dose received was 2.03 mSv. Annual effective doses to all workers at the McClean Lake operation from 2010 to 2014 remained well below the annual regulatory dose limit of 50 mSv.

Figure 7-3: McClean Lake operation – individual effective dose to NEWs, 2010–2014



The action levels for effective dose are 1 mSv/week and 5 mSv/quarter of a year. There were no exceedances of either action level during 2014.

Improvements in radiation protection

Continual improvements to AREVA's Radiation Protection Program at the McClean Lake operation were made in accordance with subsection 4(*a*) of the *Radiation Protection Regulations* and CNSC guide document G-129, *Keeping Radiation Exposure and Doses "As Low as Reasonably Achievable".*

CNSC staff noted the following improvements to worker radiation protection in 2014:

- reduction of sump pit volumes to reduce the deposition of high grade ore slurry
- implementation of Bluetooth-compatible direct reading dosimeters which allow the workers to review a graph of gamma dose rates over the course of their shift
- installation of a new yellowcake packaging system designed to minimize drum contamination and worker exposure to long-lived radioactive dust

7.3 Environmental protection

In accordance with the McClean Lake operation's Environmental Protection Program, effluent and environmental monitoring, site inspections, environmental awareness training and program implementation audits were carried out by AREVA or third-party consultants during 2014.

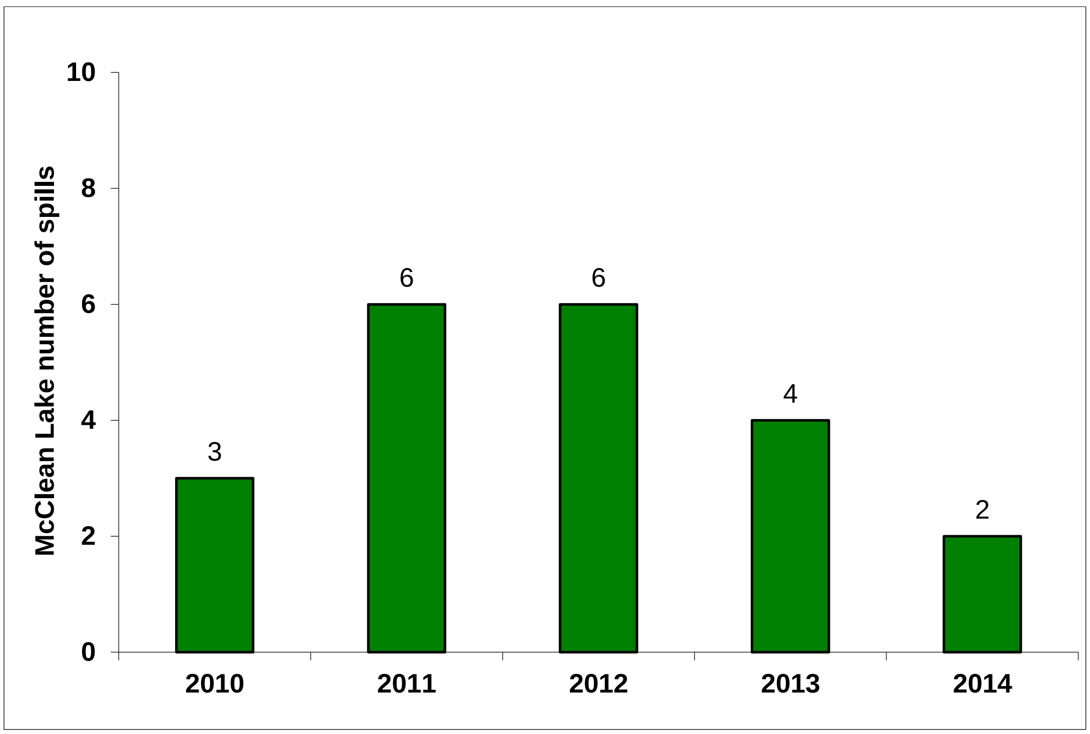
CNSC staff verified that the McClean Lake operation's environmental monitoring programs met regulatory requirements during 2014 and treated effluent discharged to the environment complied with licence requirements.

CNSC staff were satisfied with AREVA on its reporting of spills in a timely manner and the corrective actions taken. In 2014, CNSC staff classified two events as environmental spills (see figure 7-4):

- 10 to 20 L (0.010 m^3 to 0.020 m^3) of dilute radioactive tailings
- 40 L (0.040 m^3) of radioactive slurry at grinding circuit

The spills were investigated by AREVA and resulted in preventative and corrective measures being implemented. Appendix G further describes the spills and corrective actions taken. There were no residual impacts on the environment by the spills due to the timely response and effective actions applied by the McClean Lake operation. CNSC staff were satisfied with the corrective actions taken.

Figure 7-4: McClean Lake operation – environmental reportable spills, 2010–2014



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, and treated water released to the Sink Lake Reservoir in the McClean Lake system.
- Effluent from the mined-out open pits to maintain hydraulic containment of ground water is treated in the Sue Water Treatment Plant using a chemical precipitation and settling pond clarification process before being released to the Sink Lake Reservoir in the McClean Lake system.

The blended treated effluent is released in a controlled manner and monitoring has verified that this effluent poses no environmental concern. The McClean Lake treated effluent quality further discussed in this report refers only to the JEB mill effluent.

Figure 7-5: McClean Lake operation – JEB tailings management facility

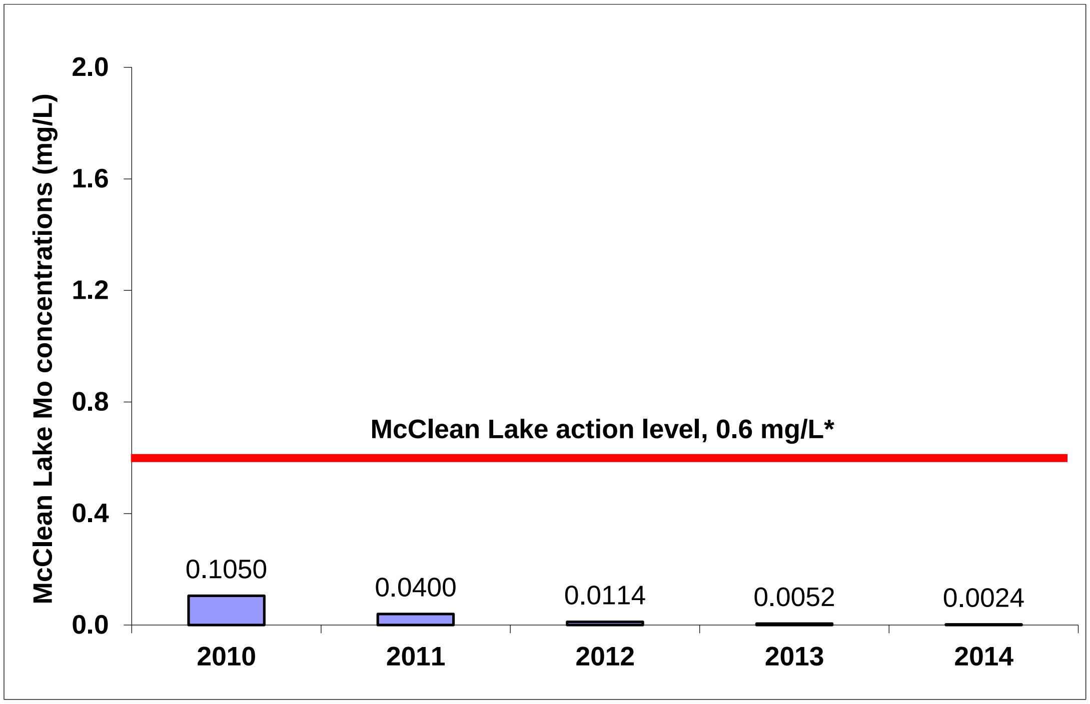
Treated effluent released to the environment

Contaminated waste water from the McClean Lake operation's JEB mill is treated in the JEB water treatment plant to remove dissolved metals and suspended solids. The quality of the final treated effluent is monitored, and if acceptable, discharged to the environment through the Sink/Vulture Treated Effluent Management System. There were no treated effluent regulatory limit discharge exceedances during 2014.

Molybdenum, selenium and uranium in effluent

The McClean Lake operation temporarily ceased milling operations in July 2010. It restarted in September 2014 using Cigar Lake ore. However, effluent treatment of the JEB tailings management facility pond water continued while the mill was not in operation. The concentrations of molybdenum, selenium and uranium in treated effluent decreased during those years and remained low (see figures 7-6, 7-7 and 7-8).

Figure 7-6: McClean Lake operation – concentrations of molybdenum from JEB water treatment plant, 2010–2014

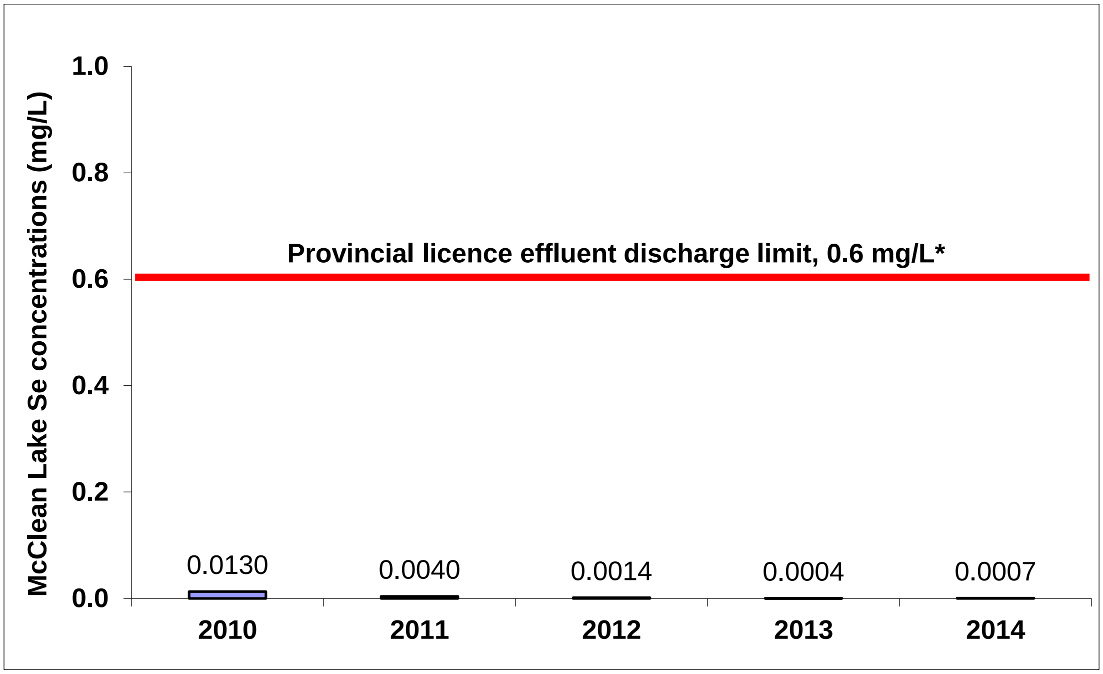


* The McClean Lake action level for molybdenum is the most stringent of the five operating uranium mines and mills and is shown for reference only.

In the absence of a federal or provincial limit for molybdenum, the CNSC requires licensees to develop facility-specific effluent controls within their individual environmental codes of practice. For molybdenum effluent concentrations (see figure 7-6), the Key Lake code of practice action level of 0.6 mg/L is shown for reference only.

Figure 7-7 shows that selenium concentrations in treated effluent are well below the Saskatchewan Ministry of Environment's licensed limit of 0.6 mg/L.

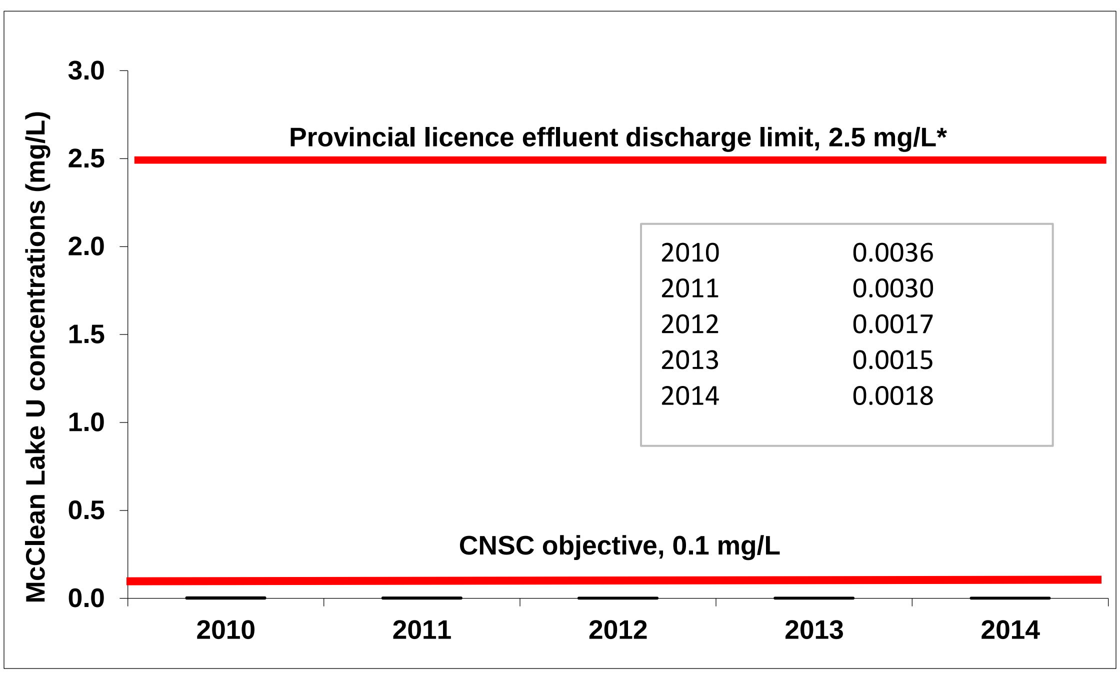
Figure 7-7: McClean Lake operation – concentrations of selenium from JEB water treatment plant, 2010–2014



* Saskatchewan's selenium discharge limit is shown for reference only.

Figure 7-8 shows that reduced concentrations of uranium in treated effluent from 2010 to 2014 are well below the Saskatchewan Ministry of Environment's licensed limit of 2.5 mg/L and the CNSC's interim objective of 0.1 mg/L.

Figure 7-8: McClean Lake operation – concentrations of uranium from JEB water treatment plant, 2010–2014

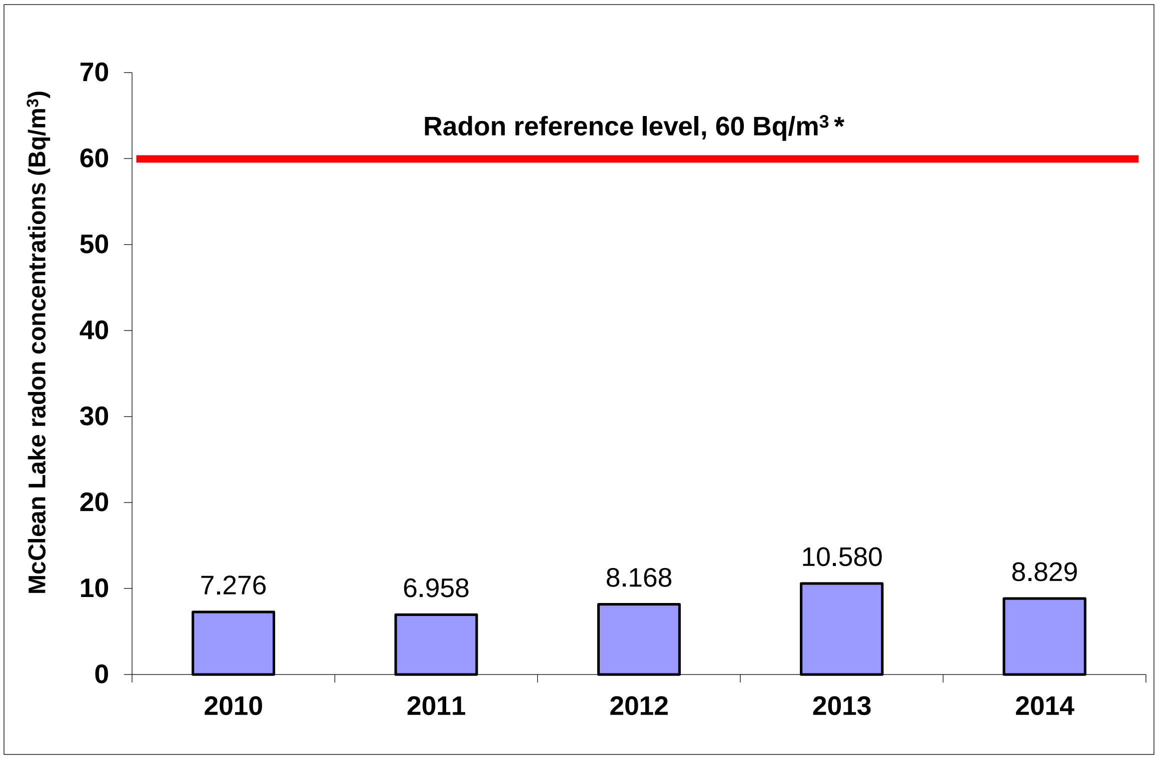


* Saskatchewan's uranium discharge limit is shown for reference only.

Air quality monitoring at the McClean Lake operation includes programs for ambient radon, total suspended particulate (TSP), sulphur dioxide and exhaust stack monitoring. Ambient sulphur dioxide and exhaust stack monitoring restarted in September 2014 with the mill restart and commissioning activities.

Environmental monitoring for radon concentrations is conducted using the passive method of track-etched cups. Twenty-three monitoring stations are located in various locations around the site-lease boundary. Figure 7-9 shows that the average concentrations of radon in ambient air for 2010 to 2014 were below the reference level for radon. The radon concentrations were also typical of the northern Saskatchewan regional baseline of < 7.4 Bq/m^3 to 25 Bq/m^3.

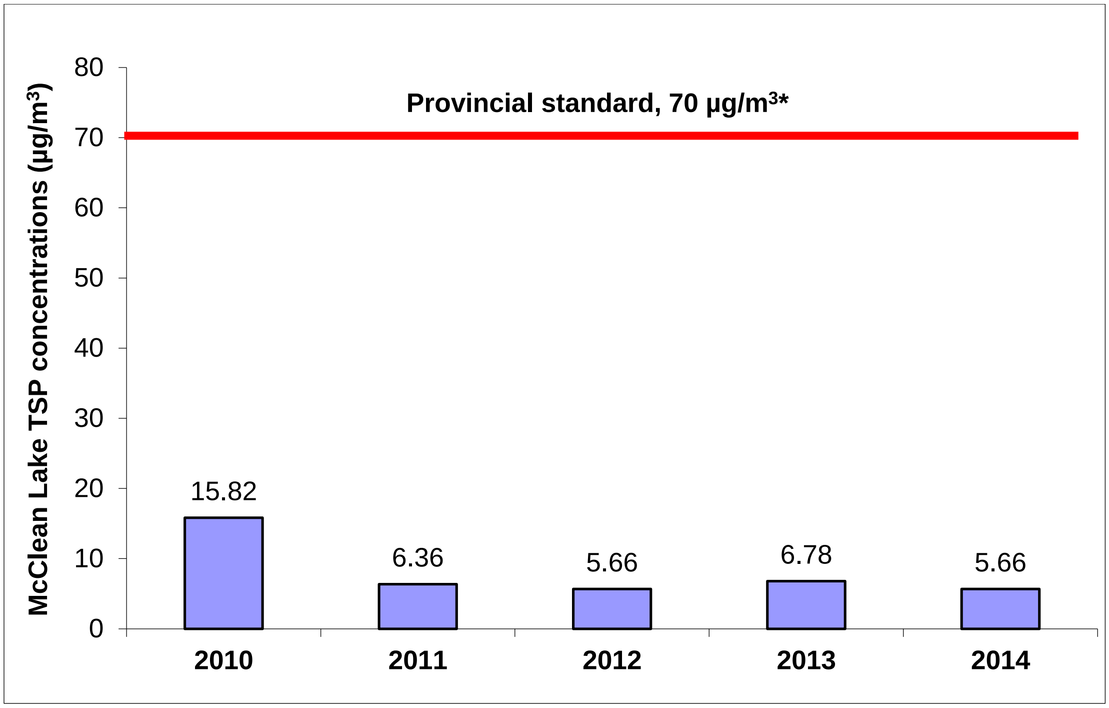
Figure 7-9: McClean Lake operation – concentrations of radon in ambient air 2010–2014



* The value of 60 Bq/m^3 has been derived from the International Commission on Radiological Protection's ICRP-65 document, as referenced in Canada's *Radiation Protection Regulations*. The value approximates an annual dose of 1 mSv.
Values are calculated as geometric mean.

Five high-volume sampling units, which are used to collect and measure TSP in air, are located at various locations around the site. The sampling units are located downwind of the milling facility away from operational activity. TSP values remained low in 2014 and well below the provincial standard of 70 µg/m^3 as shown in figure 7-10. 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 7-3.

Figure 7-10: McClean Lake operation – concentrations of total suspended particulate, 2010–2014



* Saskatchewan's standard is shown.
Values are calculated as geometric mean.

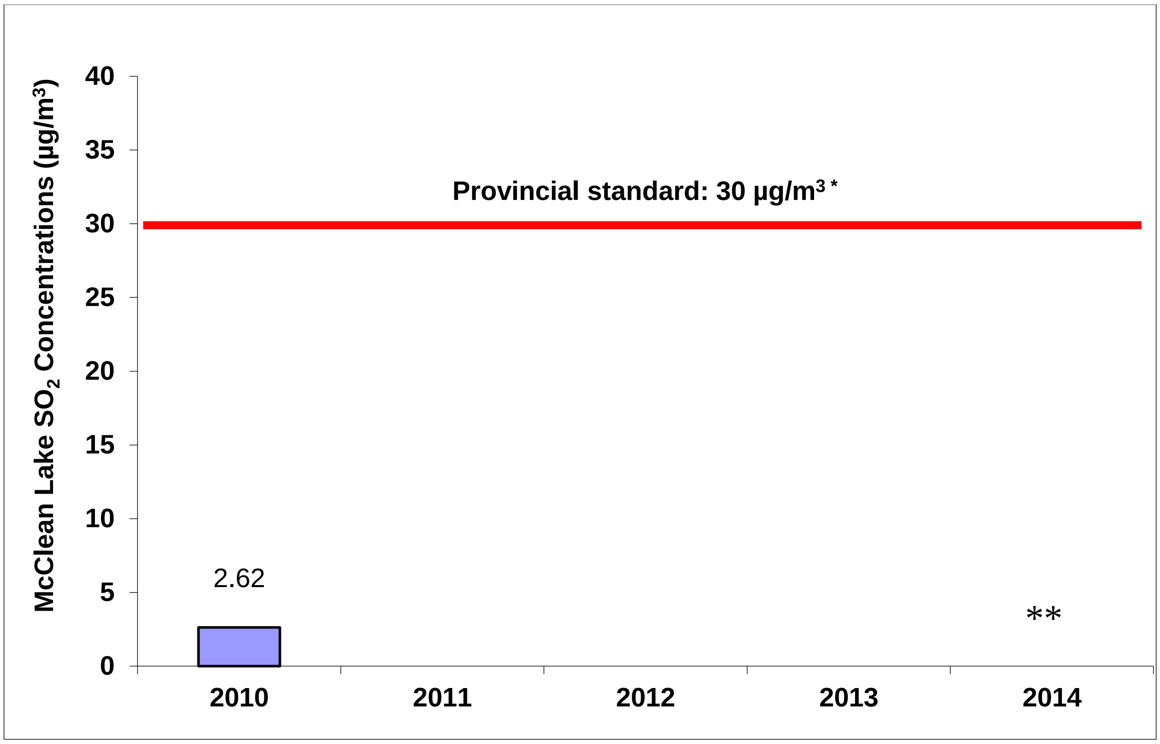
Table 7-3: McClean Lake operation – concentrations of metal and radionuclides in air, 2010–2014

Parameter	Reference annual air quality levels (1)	2010	2011	2012	2013	2014
As ($\mu g/m^3$)	0.06 (2)	0.001343	0.000565	0.000350	0.000226	0.000420
Cu ($\mu g/m^3$)	9.6 (2)	0.000036	0.000025	0.016789	0.036192	0.013888
Mo ($\mu g/m^3$)	23 (2)	0.000000	0.000000	0.000061	0.000657	0.000721
Ni ($\mu g/m^3$)	0.04 (2)	0.000001	0.000000	0.000259	0.000258	0.000420
Pb ($\mu g/m^3$)	0.10 (2)	0.000001	0.000001	0.000453	0.000422	0.000501
Zn ($\mu g/m^3$)	23 (2)	0.000008	0.000002	0.006790	0.005896	0.005939
Pb^{210} (Bq/m^3)	0.021 (3)	0.000521	0.000588	0.000388	0.000763	0.000277
Po^{210} (Bq/m^3)	0.028 (3)	0.000185	0.000194	0.000130	0.000159	0.000088
Ra^{226} (Bq/m^3)	0.013 (3)	0.000008	0.000010	0.000008	0.000013	0.000010
Th^{230} (Bq/m^3)	0.0085 (3)	0.000006	0.000003	0.000004	0.000000	0.000005
U ($\mu g/m^3$)	0.06 (2)	0.003183	0.000657	0.000444	0.000328	0.000576

1 Province of Ontario and International Commission on Radiation Protection reference annual air quality levels are shown for reference only, as no limits have been established federally or in Saskatchewan.
2 Reference annual air quality levels have been derived from Ontario's *Ambient Air Quality Criteria*, which were developed by the Ontario Ministry of the Environment in 2012.
3 Reference level from International Commission on Radiation Protection (ICRP 96).

A sulphur dioxide (SO_2) monitor is used to continuously measure ambient SO_2 concentrations associated with mill emissions during operations. The monitor is located approximately 200 metres downwind of the sulphuric acid plant stack.

Figure 7-11: McClean Lake operation – concentrations of ambient sulphur dioxide 2010–2014



* Province of Saskatchewan's standard is shown.

** Ambient 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. Measurement of ambient SO_2 concentrations began again on December 29, 2014 when the acid plant restarted. Sulphur dioxide concentration data will be representative and available for the 2015 report.

The sulphuric acid plant at McClean Lake was not operating from July 2010 until the end of December 2014 due to the temporary shutdown of the mill. During start-up of the acid plant on December 29, 2014, the operator noticed that elevated sulphur dioxide (SO_2) was being released from the plant stack. It was determined that a process monitoring control, a stack SO_2 analyzer, was providing incorrect monitoring data. The improper operation resulted in increased SO_2 being released through the acid plant stack. The elevated SO_2 released during start-up exceeded the hourly provincial standard for the initial few hours. It should be noted that the plant does not run efficiently until it reaches optimum temperatures and, therefore, it is normal to have slightly elevated SO_2 concentrations during start-up. Once corrections were made, process conditions and stack emissions of SO_2 returned to acceptable operating concentrations. This incident was reported to the CNSC as an environmental code of practice action level exceedance. The McClean Lake operation will ensure proper functioning of the operation prior to any future start-ups. CNSC staff reviewed the incident and were satisfied with the corrective actions.

AREVA's terrestrial monitoring program determines if there is influence on the environment from aerial deposition, as soil and terrestrial vegetation may be affected by 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.

The most recent soil samples collected were reported in the *Status of the Environment Report* (submitted in June 2009), which covered the assessment period of 2006–2008. Results from soil samples collected in 2011 and 2015 will be presented in the next *Status of the Environment Report* due in 2016. In 2008, the soil metal parameter concentrations were below the *Canadian Environmental Quality Guidelines* for industrial and residential/parkland land use. Three metal parameters (arsenic, nickel and uranium) measured in soil samples at the McClean Lake operation are below levels described in the *Soil Quality Guidelines* presented by the Canadian Council of Ministers of the Environment. Radionuclide concentrations in soils were also low, and 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 last completed in 2008 and shows most parameters are within the range of concentrations previously measured in lichen, Labrador tea and blueberry twig samples. Blueberry twigs are monitored to determine if soil-born contaminants (if present) are being absorbed through the roots into the growing plant parts. Lichen samples are analyzed to determine the level of airborne particulate contaminants deposited on the surface of the lichen as a means of ensuring that a significant level of contamination is not entering lichen consumers, such as caribou. 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 indicate that the McClean Lake operation has had a localized effect on vegetation in areas of activity. 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 lichen consumers.

7.4 Conventional health and safety

CNSC staff monitor the implementation of the McClean Lake operation's Occupational Health and Safety Program to ensure protection of workers. The McClean Lake operation has implemented a health and safety program to identify and control risks. CNSC staff observed that the health and safety program at the McClean Lake operation continues to provide education, training, tools and support to ensure protection of workers. AREVA has an active Occupational Health Committee and completes regular reviews of its safety program. Through inspections, review of incidents and discussions with McClean Lake staff, CNSC staff verified that the McClean Lake operation is committed to accident prevention and safety awareness.

Table 7-4 shows that AREVA reported five lost-time incidents (LTIs) at the McClean Lake operation between 2010 and 2014. Three of those occurred in 2014.

Table 7-4: McClean Lake operation – total number of full-time equivalent (FTE) workers, LTIs, severity rate and frequency rate, 2010–2014

Year	2010	2011	2012	2013	2014
Total number of FTE workers[1]	225	163	249	348	739
Number of LTIs[2]	1	0	1	0	3
Severity rate[3]	13.3	0.0	1.2	0.0	4.3
Frequency rate[4]	0.4	0.0	0.4	0.0	0.4

1 **Total number of workers** (employees and contractors) expressed as FTEs. An FTE = total person-hours / 2,000 hours worked per employee per year.
2 **Lost-time incident** – an injury that takes place at work and results in the worker being unable to return to work for a period of time.
3 **Severity rate** – 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.
4 **Frequency rate** – 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.

AREVA investigates safety concerns and incidents, including near-miss events. In 2014, 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 why it happened and determine the best solutions to correct the root causes.

Corrective actions are 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. Employees are encouraged and trained to continuously identify and assess risks, and propose solutions.

Figure 7-12: McClean Lake operation – emergency response vehicles

Glossary

Commission

A corporate body of not more than seven members, established under the *Nuclear Safety and Control Act* and appointed by the Governor in Council, to perform the following functions:

- regulate the development, production and use of nuclear energy and the production, possession, use and transport of nuclear substances
- regulate the production, possession and use of prescribed equipment and prescribed information
- implement measures respecting international control of the development, production, transport and use of nuclear energy and nuclear substances, including those respecting the non-proliferation of nuclear weapons and nuclear explosive devices
- disseminate scientific, technical and regulatory information concerning the activities of the CNSC and the effects on the environment and on the health and safety of persons, of the development, production, possession, transport and uses referred to above

Commission member document (CMD)

A document prepared for Commission hearings and meetings by CNSC staff, proponents and interveners. Each CMD is assigned a specific identification number.

derived release limit (DRL)

A limit imposed by the CNSC on the release of a radioactive substance from a licensed nuclear facility, such that compliance with the derived release limit gives reasonable assurance that the regulatory dose limit is not exceeded.

effective dose

The sum of the products, in sieverts, obtained by multiplying the equivalent dose of radiation received by and committed to each organ or tissue set out in column one of an item of schedule one of the *Radiation Protection Regulations*, by the weighting factor set out in column two of that item.

equivalent dose

The product, in sieverts, obtained by multiplying the absorbed dose of radiation of the type set out in column one of an item of schedule two of the *Radiation Protection Regulations*, by the weighting factor set out in column two of that item.

frequency rate

The accident frequency rate measuring the number of lost-time incidents (LTIs) for every 200,000 person-hours worked at the site. The frequency rate is calculated as follows:
Frequency = [(# of injuries in last 12 months) / # of hours worked in last 12 months)] x 200,000.

full-time equivalent (FTE)

Total person-hours divided by 2,000 hours worked per employee per year.

geometric mean

An average that indicates the central tendency or typical value of a set of numbers according to the product of their values (as opposed to the arithmetic mean, which uses their sum);

The geometric mean of a data set (a_1, a_2, … a_n) is given by:

$$\left(\prod_{i=1}^{n} a_i\right)^{1/n} = \sqrt[n]{a_1 a_2 \cdots a_n}.$$

The geometric mean is a useful summary when we expect that changes in the data occur in a relative fashion. An example is when filters trap dusts in an amount relative to the amount of air flowing through the filters.

International Atomic Energy Agency (IAEA)

An independent international organization related to the United Nations (UN) system. The IAEA, located in Vienna, works with its member states and multiple partners worldwide to promote safe, secure and peaceful nuclear technologies. The IAEA reports annually to the UN General Assembly and, when appropriate, to the Security Council regarding non-compliance by states with their safeguards obligations, as well as on matters relating to international peace and security.

lost-time incident (LTI)

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

root-cause analysis

An objective, structured, systematic and comprehensive analysis designed to determine the underlying reason(s) for a situation or event, which is conducted with a level of effort consistent with the safety significance of the event.

severity rate

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

total number of workers

A measure of all workers at a site, including employees and contractors, expressed as full-time equivalents (FTE).

triennial

Recurring every three years.

uranium concentrate (yellowcake)

Commonly referred to as U_3O_8, the product of mined and milled uranium ore.

Appendix A: Safety and Control Area Framework for Uranium Mines and Mills

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 according to their functional area as management, facility and equipment, or core control processes.

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 ▪ 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
Facility and equipment	**Safety analysis**	Covers maintenance of the safety analysis that supports the overall safety case for the facility. Safety analysis is a systematic evaluation of the potential hazards associated with the conduct of a proposed activity or facility and considers the effectiveness of preventative measures and strategies in reducing the effects of such hazards.	▪ Deterministic safety analysis ▪ Hazard analysis ▪ Probabilistic safety analysis ▪ Criticality safety ▪ Severe accident analysis ▪ Environmental risk assessment ▪ 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

Safety and control area framework			
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
	Emergency management and fire protection	Covers emergency plans and emergency preparedness programs that exist for emergencies and for non-routine conditions. This area also includes any results of participation in exercises.	▪ Conventional emergency preparedness and response ▪ Nuclear emergency preparedness and response ▪ Fire emergency preparedness and response
	Waste management	Covers internal waste-related programs that form part of the facility's operations up to the point where the waste is removed from the facility to a separate waste management facility. This area also covers the planning for decommissioning.	▪ Waste characterization ▪ Waste minimization ▪ Waste management practices ▪ Decommissioning plans
	Security	Covers 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 for 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

Safety and control area framework			
Functional area	**Safety and control area**	**Definition**	**Specific areas**
Other matters of regulatory interest			
▪ Environmental assessment ▪ CNSC consultation – Aboriginal ▪ CNSC consultation – other ▪ Cost recovery ▪ Financial guarantees ▪ Improvement plans and significant future activities ▪ Licensee public information program ▪ Nuclear liability insurance			

Appendix B: Rating Methodology and Definitions

Performance ratings used in this report are defined as follows:

Fully satisfactory (FS)

Safety and control measures implemented by the licensee are highly effective. In addition, compliance with regulatory requirements is fully satisfactory, and compliance within the safety and control area (SCA) 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 SCA 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 SCA 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 SCA 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.

Appendix C: Trends in Safety and Control Area Ratings

Table C-1: Cigar Lake operation – safety and control area summary

Safety and control areas	2010 rating	2011 rating	2012 rating	2013 rating	2014 rating
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	FS	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 C-2: McArthur River operation – safety and control area summary

Safety and control areas	2010 rating	2011 rating	2012 rating	2013 rating	2014 rating
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 C-3: Rabbit Lake operation – safety and control area summary

Safety and control areas	2010 rating	2011 rating	2012 rating	2013 rating	2014 rating
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 C-4: Key Lake operation – safety and control area summary

Safety and control areas	2010 rating	2011 rating	2012 rating	2013 rating	2014 rating
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 C-5: McClean Lake operation – safety and control area summary

Safety and control areas	2010 rating	2011 rating	2012 rating	2013 rating	2014 rating
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

Appendix D: Financial Guarantees

The following table outlines the financial guarantees as of December 31, 2014 for the five uranium mines and mills facilities.

Table D-1: Uranium mines and mills – financial guarantees

Facility	Financial guarantee (Canadian dollars)
Cigar Lake operation	$49,200,000
McArthur River operation	$48,400,000
Rabbit Lake operation	$202,700,000
Key Lake operation	$225,100,000
McClean Lake operation	$43,074,800
Total	$568,474,800

Appendix E: Decommissioning and Reclamation Activities

Decommissioning and reclamation discussion of the Cigar Lake operation

The goal of reclamation and decommissioning efforts at the Cigar Lake operation is to decommission and reclaim the site to an ecological and radiological condition as similar to the surrounding environment as reasonably achievable. The Cigar Lake operation employs a strategy intended to actively reclaim inactive areas during the course of regular operations where economically and operationally feasible.

Current progressive decommissioning and reclamation activities at the Cigar Lake operation include:

- campaign haulage of problematic waste rock from Cigar Lake to the mined-out Sue C pit at the AREVA Resources Inc. McClean Lake operation, as approved in the 2001 environmental impact statement
- contour and revegetation of the very few inactive areas of the site

Decommissioning and reclamation of Cigar Lake, in their entirety, are reflected in the Cigar Lake *Preliminary Decommissioning Plan* (PDP) and *Preliminary Decommissioning Cost Estimate* (PDCE). These documents are based on a hypothetical "decommission tomorrow" scenario and provide the current preferred methodology and schedule for decommissioning and reclamation of the entire operation. The PDCE forms the basis for the financial guarantee. Cameco currently maintains the financial guarantee for the Cigar Lake operation in the form of irrevocable standby letters of credit. The most recent updates to the Cigar Lake PDP and PDCE were completed in support of the operating licence renewal in 2013.

The decommissioning schedule provided is based on current planned progressive decommissioning and reclamation activities coupled with the current preferred methodologies and assumed timelines from the PDP. The timelines provided are assumptions based on relevant industry and Cameco-specific experience. The timelines are subject to ongoing revisions and updates resulting from changes in the facility operation strategy or preferred decommissioning and reclamation methodology, including potential changes in mineral reserves at the Cigar Lake operation.

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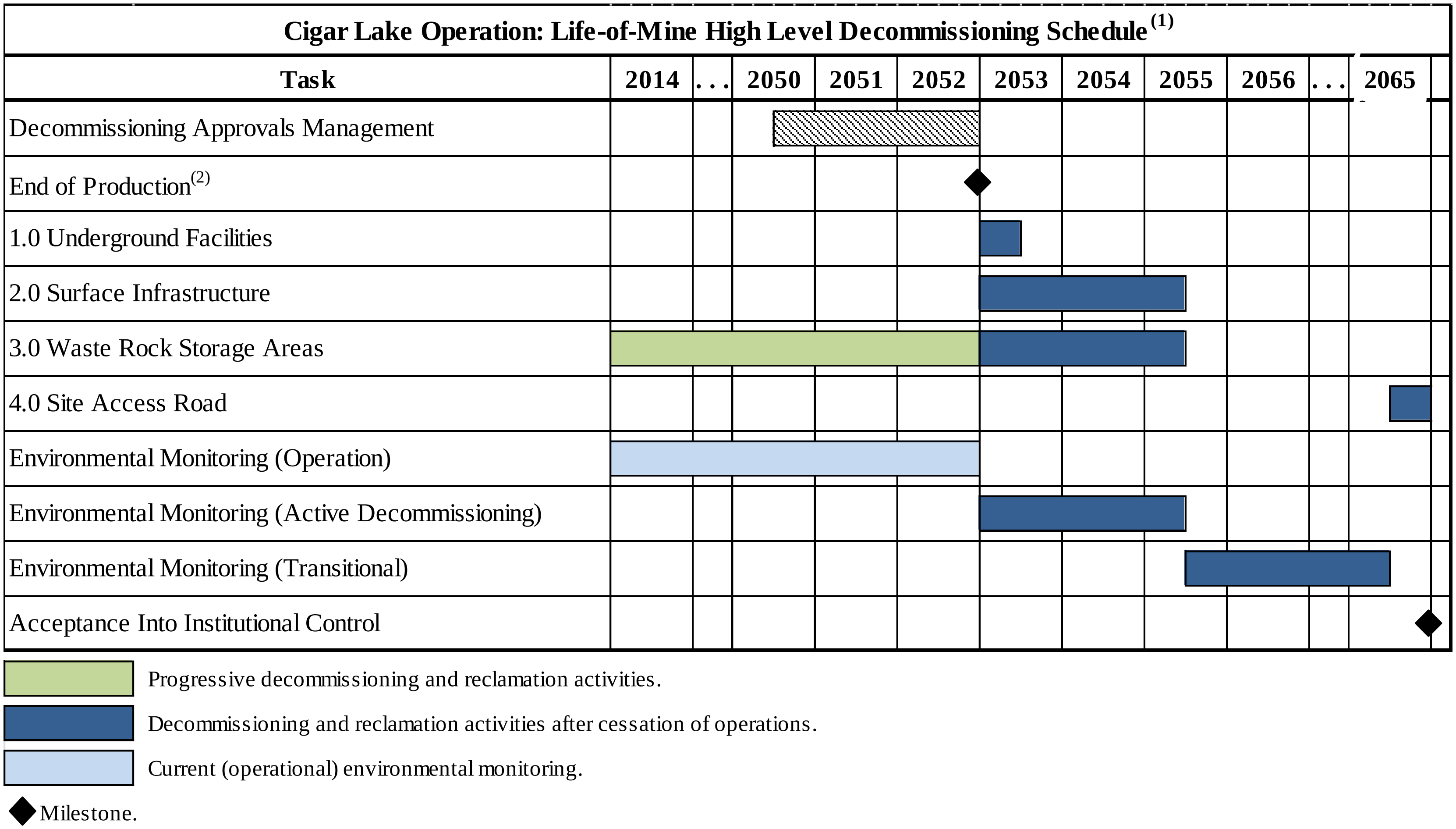


[1] Timelines are preliminary estimates based on the current PDP.

[2] Based on current mineral reserves and resources.

Decommissioning and reclamation discussion of the McArthur River operation

The goal of reclamation and decommissioning efforts at the McArthur River operation is to decommission and reclaim the site to an ecological and radiological condition as similar to the surrounding environment as reasonably achievable. The McArthur River operation employs a progressive decommissioning and reclamation strategy intended to actively reclaim inactive areas during the course of regular operations where economically and operationally feasible.

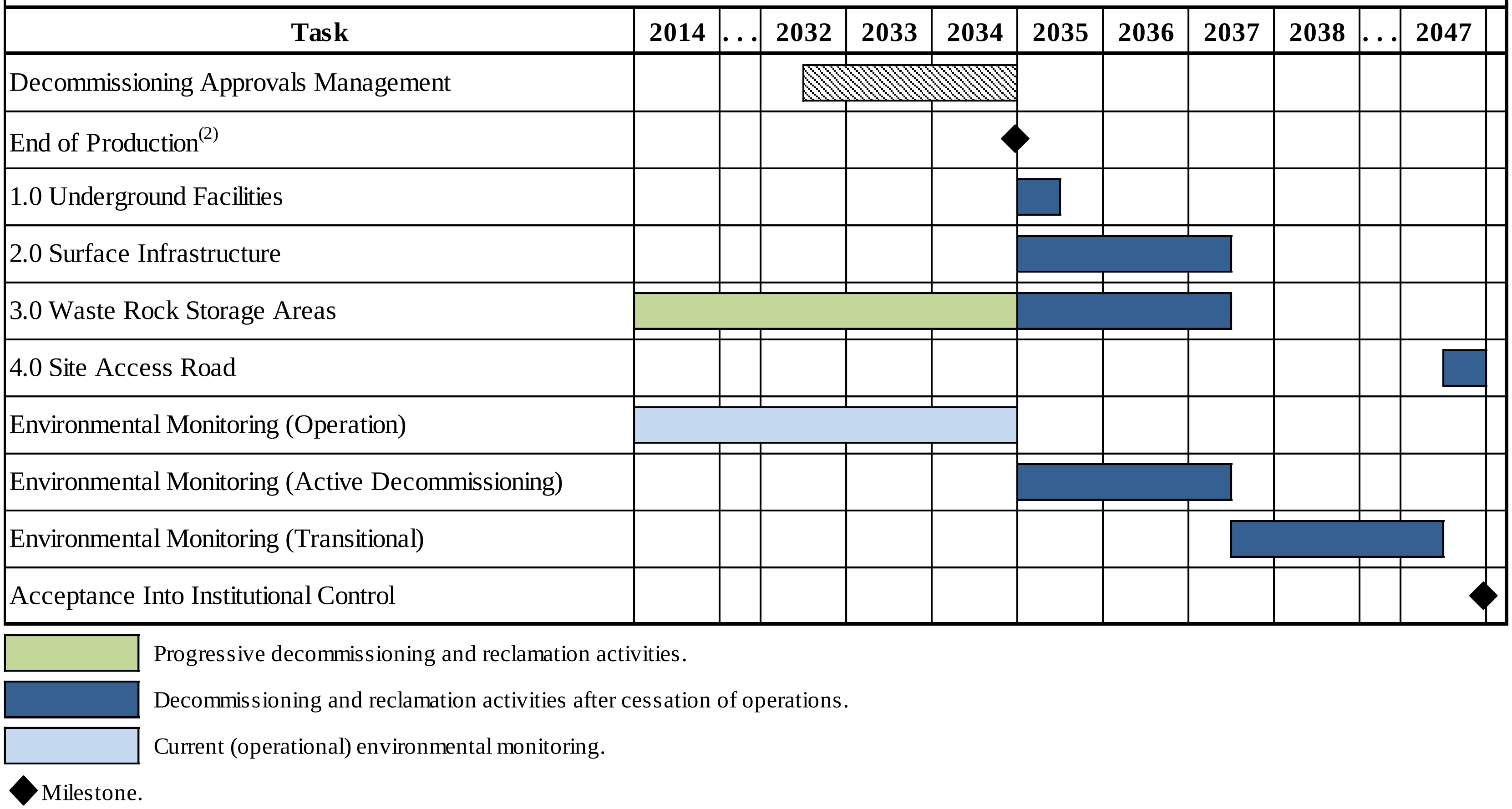
Current progressive decommissioning and reclamation activities at the McArthur River operation include:

- transporting mineralized waste rock to Key Lake to be added to the milling process
- contouring and revegetation of the very few inactive areas of the site

Decommissioning and reclamation of McArthur River, in their entirety, are reflected in the McArthur River *Preliminary Decommissioning Plan* (PDP) and *Preliminary Decommissioning Cost Estimate* (PDCE). These documents are based on a hypothetical “decommission tomorrow” scenario and provide the current preferred methodology and schedule for decommissioning and reclamation of the entire operation. The PDCE forms the basis for the financial guarantee; Cameco currently maintains the financial guarantee for the McArthur River operation in the form of irrevocable standby letters of credit. The most recent updates to the McArthur River PDP and PDCE were completed in support of the operating licence renewal in 2013.

The decommissioning schedule provided is based on current planned progressive decommissioning and reclamation activities coupled with the current preferred methodologies and assumed timelines from the PDP. The timelines provided are assumptions based on relevant industry and Cameco-specific experience. The timelines are subject to ongoing revisions and updates resulting from changes in the facility operation strategy or preferred decommissioning and reclamation methodology, including potential changes in mineral reserves at the McArthur River operation.

McArthur River Operation: Life-of-Mine High Level Decommissioning Schedule [1]



[1] Timelines are preliminary estimates based on the current PDP.

[2] Based on current mineral reserves.

Decommissioning and reclamation discussion of the Rabbit Lake operation

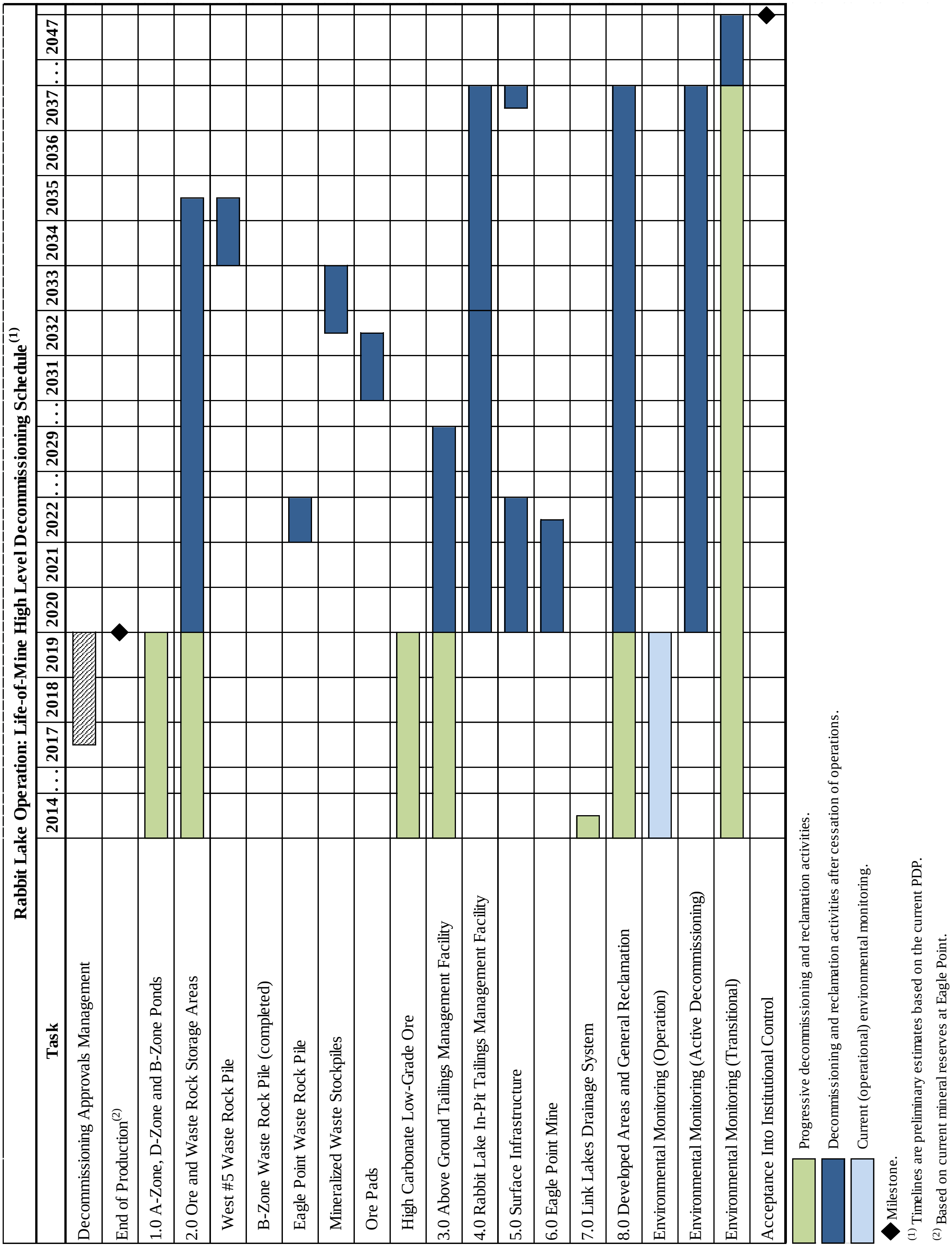
The goal of reclamation and decommissioning efforts at the Rabbit Lake is to decommission and reclaim the site to an ecological and radiological condition as similar to the surrounding environment as is reasonably achievable. The Rabbit Lake operation employs a progressive decommissioning and reclamation strategy intended to actively reclaim inactive areas of the operation during the course of regular operations where economically and operationally feasible. Detailed information on the progressive decommissioning and reclamation strategy and plans are submitted in the *Rabbit Lake Site Wide Reclamation Plan*.

Current decommissioning and reclamation activities at the Rabbit Lake operation include:

- monitoring of the B-zone pond to support application for dyke breaching
- placing a cover and beginning revegetation of the above-ground tailings management facility (AGTMF), while continuing studies to support further reclamation activities
- transitional monitoring of the B-zone waste rock pile (active decommissioning and reclamation was completed in 2013)
- continued milling of the high-carbonate low-grade ore stockpile
- assessing the Link Lakes drainage system (completed in 2014) and ongoing monitoring of natural recovery of the system

Decommissioning and reclamation of Rabbit Lake, in their entirety, are reflected in the Rabbit Lake *Preliminary Decommissioning Plan* (PDP) and *Preliminary Decommissioning Cost Estimate* (PDCE). These documents are based on a hypothetical “decommission tomorrow” scenario and provide the current preferred methodology and schedule for decommissioning and reclamation of the entire operation. The PDCE forms the basis for the financial guarantee; Cameco currently maintains the financial guarantee for the Rabbit Lake operation in the form of irrevocable standby letters of credit. The Rabbit Lake PDP and PDCE were most recently updated in support of the operating licence renewal in 2013.

The decommissioning schedule provided is based on current planned progressive decommissioning and reclamation activities coupled with the current preferred methodologies and assumed timelines from the PDP. The timelines provided are based on relevant industry and Cameco-specific experience. The timelines are subject to ongoing revisions and updates resulting from changes in the facility operation strategy or preferred decommissioning and reclamation methodology, including potential changes in mineral reserves at the Rabbit Lake operation.


Rabbit Lake Operation: Life-of-Mine High Level Decommissioning Schedule(1)
Task
2014 . . . 2017 2018 2019 2020 2021 2022 . . . 2029 . . . 2031 2032 2033 2034 2035 2036 2037 . . . 2047
Decommissioning Approvals Management
End of Production(2)
1.0 A-Zone, D-Zone and B-Zone Ponds
2.0 Ore and Waste Rock Storage Areas
West #5 Waste Rock Pile
B-Zone Waste Rock Pile (completed)
Eagle Point Waste Rock Pile
Mineralized Waste Stockpiles
Ore Pads
High Carbonate Low-Grade Ore
3.0 Above Ground Tailings Management Facility
4.0 Rabbit Lake In-Pit Tailings Management Facility
5.0 Surface Infrastructure
6.0 Eagle Point Mine
7.0 Link Lakes Drainage System
8.0 Developed Areas and General Reclamation
Environmental Monitoring (Operation)
Environmental Monitoring (Active Decommissioning)
Environmental Monitoring (Transitional)
Acceptance Into Institutional Control
Progressive decommissioning and reclamation activities.
Decommissioning and reclamation activities after cessation of operations.
Current (operational) environmental monitoring.
Milestone.
(1) Timelines are preliminary estimates based on the current PDP.
(2) Based on current mineral reserves at Eagle Point.

Decommissioning and reclamation discussion of the Key Lake operation

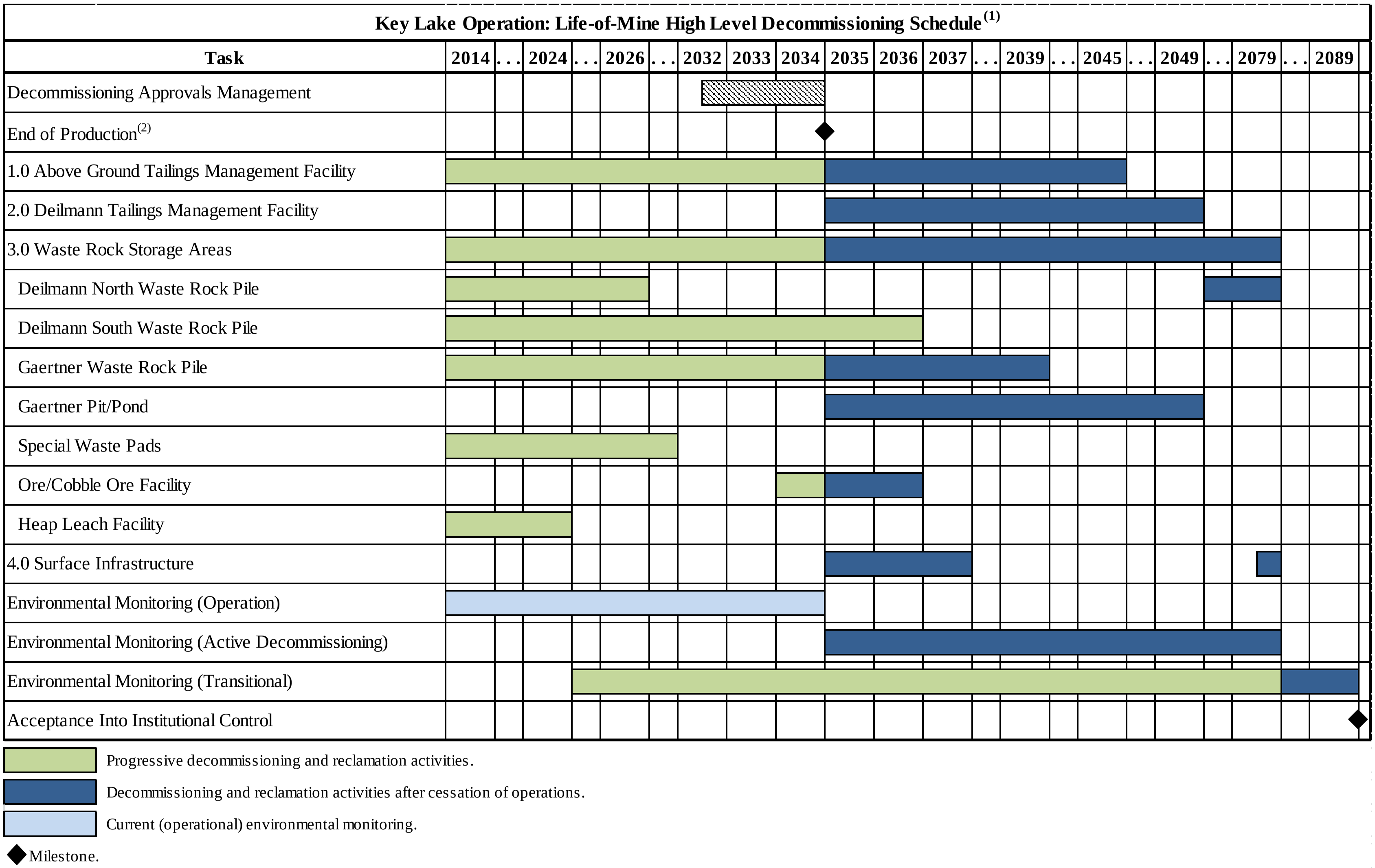
The goal of reclamation and decommissioning efforts at the Key Lake operation is to return the site to a maintenance-free state in which natural, self-sustaining native vegetation develops to a state similar to that which existed before mining began. Cameco's preferred approach is to plan and undertake reclamation and decommissioning activities during the operating life of the facility (i.e., incremental/progressive decommissioning), where such an approach makes economic and operational sense. Additional information on progressive decommissioning and reclamation is available in the *Key Lake Site Wide Reclamation Plan*.

Current decommissioning and reclamation activities at Key Lake operation include:

- monitoring test-cover performance on the Deilmann North waste rock pile
- monitoring and maintaining vegetation plots and revegetated areas on the Gaertner waste rock pile
- consuming Deilmann and Gaertner special waste as needed for blending
- decommissioning and reclamation of the heap leach facility
- placing sand on side-slopes of the Deilmann South waste rock pile
- strategically placing waste and evaluating thaw characteristics for the above-ground tailings management facility

Decommissioning and reclamation of Key Lake, in their entirety, are reflected in the Key Lake *Preliminary Decommissioning Plan* (PDP) and *Preliminary Decommissioning Cost Estimate* (PDCE). These documents are based on a hypothetical "decommission tomorrow" scenario and provide the current preferred methodology and schedule for decommissioning and reclamation of the entire operation. The PDCE forms the basis for the financial guarantee; Cameco currently maintains the financial guarantee for the Key Lake operation in the form of irrevocable standby letters of credit. The Key Lake PDP and PDCE were updated in support of the Key Lake operating licence renewal in 2013.

The decommissioning schedule provided is based on current planned progressive decommissioning and reclamation activities coupled with the current preferred methodologies and assumed timelines from the PDP. The timelines provided are assumptions based on relevant industry and Cameco-specific experience. The timelines are subject to ongoing revision and update as a result of changes in preferred decommissioning and reclamation methodology or facility operation strategy including potential changes in mineral reserves at McArthur River.



(1) Timelines are preliminary estimates based on the current PDP.

(2) Based on current mineral reserves at McArthur River.

Decommissioning and reclamation discussion of the McClean Lake operation

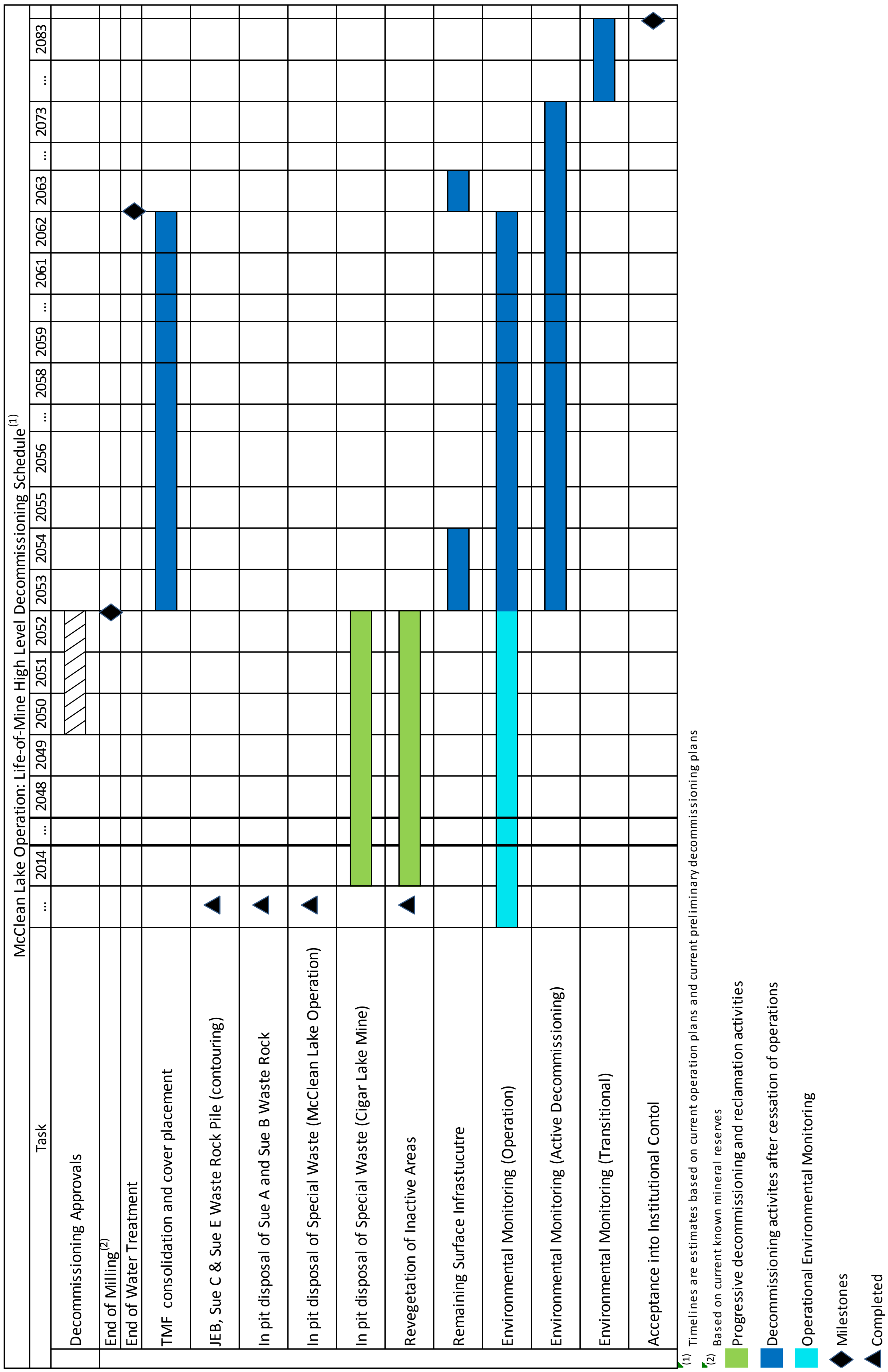
AREVA Resources Inc.'s (AREVA's) key decommissioning objective is to remove, minimize, and control potential contaminant sources and thereby minimize the potential for adverse environmental effects associated with the decommissioned property. The decommissioning plan is designed to achieve an end-state of the properties that will be safe for human and non-human biota, be chemically and physically stable, allow utilization for traditional purposes, and that minimizes potential constraints on future land use planning decisions. AREVA believes that by progressively reclaiming the site as various mining areas are completed, and by addressing any environmental issues that arise within those areas during the operational phase, that the site can achieve a state of passive, perpetual care and long-term institutional control measures can be minimized.

Examples of progressive reclamation and decommissioning activities at the McClean Lake operation include:

- contouring of the JEB, Sue C and Sue E clean waste rock piles (completed)
- in-pit disposing of Sue A and Sue B clean waste rock (completed)
- in-pit disposing of special waste rock generated during mining at the McClean Lake operation (completed)
- in-pit disposing of special waste rock generated at the Cigar Lake mine (campaign haulage will occur over the life of the Cigar Lake mine)
- ongoing revegetation of inactive areas (numerous areas completed, others will continue during the life of the operation).

Decommissioning and reclamation of the McClean Lake operation are described in the McClean Lake operation *Preliminary Decommissioning Plan* (PDP) and *Financial Assurance* (FA). This plan assumes a "closure tomorrow" scenario, where AREVA would no longer be able to fulfill its obligation to decommission the site and the Saskatchewan provincial government would assume that role. The most recent updates to the McClean Lake operation PDP and FA were completed in 2010, following the 2009 McClean Lake operation CNSC licence renewal process.

The decommissioning schedule provided is based on currently proposed decommissioning and reclamation activities, as well as current preferred methodologies and timelines provided in the PDP. The timelines provided are assumptions based on relevant industry and AREVA-specific experience, and are subject to ongoing revision, as a result of changes in methodology or best management practices.


McClean Lake Operation: Life-of-Mine High Level Decommissioning Schedule(1)
Task
… 2014 … 2048 2049 2050 2051 2052 2053 2054 2055 2056 … 2058 2059 … 2061 2062 2063 … 2073 … 2083
Decommissioning Approvals
End of Milling(2)
End of Water Treatment
TMF consolidation and cover placement
JEB, Sue C & Sue E Waste Rock Pile (contouring)
In pit disposal of Sue A and Sue B Waste Rock
In pit disposal of Special Waste (McClean Lake Operation)
In pit disposal of Special Waste (Cigar Lake Mine)
Revegetation of Inactive Areas
Remaining Surface Infrastucutre
Environmental Monitoring (Operation)
Environmental Monitoring (Active Decommissioning)
Environmental Monitoring (Transitional)
Acceptance into Institutional Contol
(1) Timelines are estimates based on current operation plans and current preliminary decommissioning plans
(2) Based on current known mineral reserves
Progressive decommissioning and reclamation activities
Decommissioning activites after cessation of operations
Operational Environmental Monitoring
Milestones
Completed

Appendix F: Worker Dose Data

Table F-1 shows the total number of nuclear energy workers (NEWs) monitored at each of the five operating mines for 2014. An individual worker who is required to work with a nuclear substance or in a nuclear industry is designated as a NEW if there is a reasonable probability of receiving an individual effective dose greater than the prescribed effective dose limit for a member of the public (1 mSv in a calendar year).

Table F-1: Total number of NEWs at each of the five operating facilities, 2014

	Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClean Lake
Total NEWs	1,458	1,149	964	1,170	894

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

Table F-2: Radiation dose data to nuclear energy workers at uranium mines and mills, 2014

Facility	Average individual effective dose (mSv/yr)	Maximum individual effective dose (mSv/yr)	Regulatory limit
Cigar Lake operation	0.16	2.04	**50 mSv/yr**
McArthur River operation	1.03	7.91	
Rabbit Lake operation	1.32	8.64	
Key Lake operation	0.63	6.21	
McClean Lake operation	0.37	2.03	

The following tables provide a five-year trend (2010 to 2014) of the average and maximum effective annual doses received at the various operating uranium mines and mills.

Each table also identifies the maximum five-year dose for a worker at each operating uranium mine and mill. In 2014, no radiation dose at any operating uranium mine or mill exceeded a regulatory effective dose limit.

Table F-3: Cigar Lake operation – worker effective dose

Dose data	2010	2011	2012	2013	2014	Regulatory limit
Total nuclear energy workers (NEWs)	1,266	1,932	2,420	3,039	1,458	**N/A**
Average individual effective dose (mSv)	0.20	0.13	0.14	0.27	0.16	**50 mSv/yr**
Maximum individual effective dose (mSv)	1.20	1.30	2.87	2.21	2.04	**50 mSv/yr**
Maximum five-year dose for an individual (mSv) 2011–2015	13.03					**100 mSv/5 yrs**

Table F-4: McArthur River operation – worker effective dose

Dose data	2010	2011	2012	2013	2014	Regulatory limit
Total nuclear energy workers (NEWs)	1,189	1,253	1,276	1,302	1,149	**N/A**
Average individual effective dose (mSv)	1.34	1.32	0.97	0.89	1.03	**50 mSv/yr**
Maximum individual effective dose (mSv)	10.06	10.07	9.26	7.58	7.91	**50 mSv/yr**
Maximum five-year dose for an individual (mSv) 2011–2015	27.58					**100 mSv/5 yrs**

Table F-5: Rabbit Lake operation – worker effective dose

Dose data	2010	2011	2012*	2013**	2014	Regulatory limit
Total nuclear energy workers (NEWs)	968	1,066	1,257	1,178	964	**N/A**
Average individual effective dose (mSv)	1.43	1.36	1.22	1.30	1.32	**50 mSv/yr**
Maximum individual effective dose (mSv)	11.15*	11.66*	18.8**	11.67	8.64	**50 mSv/yr**
Maximum five-year dose for an individual (mSv) 2011–2015	41.91					**100 mSv/5 yrs**

* In 2012, the maximum individual effective doses for 2010 and 2011 were modified from the previous *CNSC Staff Report on the Performance of Canadian Uranium Fuel Cycle and Processing Facilities: 2011*. These changes occurred as a result of dose changes approved through the National Dose Registry. The new values resulted from previously rejected personal alpha dosimeter results, which were accepted later, in early 2012 (2010 changed from 10.7 mSv to 11.15 mSv; 2011 changed from 11.4 mSv to 11.66 mSv).

** 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.)

Table F-6: Key Lake operation – worker effective dose

Dose data	2010	2011	2012	2013	2014	Regulatory limit
Total nuclear energy workers (NEWs)	1,232	1,314	1,345	1,380	1,170	**N/A**
Average individual effective dose (mSv)	0.73	0.67	0.61	0.62	0.63	**50 mSv/yr**
Maximum individual effective dose (mSv)	7.29	9.14	5.76	5.67	6.21	**50 mSv/yr**
Maximum five-year dose for an individual (mSv) 2011–2015	18.80					**100 mSv/5 yrs**

Table F-7: McClean Lake operation – worker effective dose

Dose data	2010	2011	2012	2013	2014	Regulatory limit
Total nuclear energy workers (NEWs)	219	120	174	308	894	**N/A**
Average individual effective dose (mSv)	0.47	0.33	0.32	0.36	0.37	**50 mSv/yr**
Maximum individual effective dose (mSv)	2.96	1.56	1.30	3.44	2.03	**50 mSv/yr**
Maximum five-year dose for an individual (mSv) 2011–2015	3.44					**100 mSv/5 yrs**

Appendix G: Environmental Reportable Spills in 2014 and CNSC Spill Rating Definitions

CNSC staff were satisfied with the remedial actions taken by the licensees for each spill described in table G-1, and concluded that these spills resulted in no residual impacts to the environment.

Table G-1: Uranium mines and mills – environmental reportable spills

Facility	Spill details	Corrective actions	CNSC rating (table G-2)
Cigar Lake operation	On April 22, 2014, approximately 250 L of filter cake sludge containing radium-226 was spilled during unloading at Slimes Pond No. 3. Factors included a worn hose used to unload the vacuum truck and deviations from the operating procedures.	Site services crews underwent a vacuum truck refresher course and review of the contaminated material work instruction.	Low
Cigar Lake operation	On November 19, 2014, a forklift punctured two drums, resulting in a spill of approximately 410 L of antifreeze.	A review of this event was made with both crews for discussion on controls to prevent similar events.	Low
Cigar Lake operation	On December 11, 2014, 20 L of foam from the top of the lamella clarifier was drawn through the ventilation fan and discharged outside the building to the ground.	Corrective actions included modifying the ventilation system to prevent reoccurrence.	Low
McArthur River operation	On November 6, 2014, a fitting failure caused 300 L of heat transfer fluid (50/50 mixture of water/ethylene glycol) to be spilled to the compacted sand basement floor.	Spilled material was cleaned up satisfactorily.	Low
Rabbit Lake operation	On March 7, 2014, during a routine line patrol inspection, 5 L of untreated mine water was noticed dripping from a pipeline. Frozen conditions caused the water to freeze, preventing movement outside the immediate area.	Frozen ground conditions allowed for full recovery of released water in the form of ice and snow. Ice and snow in the immediate spill area was removed and disposed of in the B-zone Sedimentation Pond. A gamma grid survey of the affected area was completed.	Low
Rabbit Lake operation	On May 19, 2014, during a routine inspection of the Rabbit Lake In-Pit Tailings Management Facility, a crack in a pipeline was observed that resulted in 10,000 L of contaminated raise water spilled.	The mill control room was contacted and flow to the line stopped. All released water was captured.	Low

Facility	Spill details	Corrective actions	CNSC rating (table G-2)
Rabbit Lake operation	On August 4, 2014, approximately 20 L of contaminated water spilled from a surface water line through a failed weld.	Upon discovery, flow to the line was stopped and the line immediately drained. Impacted soil was recovered and disposed of at the approved contaminated landfill.	Low
Rabbit Lake operation	On August 18, 2014, during flushing of a pipeline with process-water, a small leak at a fusion weld was discovered. Approximately 50 L of process water was spilled. The ditch prevented release to the surrounding environment.	Upon discovery, the spilled material and saturated soil was removed by the hydrovac truck.	Low
Key Lake operation	On October 12, 2014, a forklift punctured a drum resulting in approximately 200 L of propylene glycol spilled.	Spill pads were used and contaminated soil was collected and placed in the Above Ground Tailings Management Facility.	Low
McClean Lake operation	On May 25, 2014, mill operations were investigating a blockage of a tailings line. A flange was opened and 10 to 20 L of dilute tailings leaked.	The spilled tailings were cleaned up and placed in the contaminated landfill. Work instructions were updated. Area operators were instructed to visually confirm that lines are clear before being brought into service.	Low
McClean Lake operation	On November 21, 2014, a spill of approximately 40 L of radioactive slurry occurred. A slurry line had a valve partially open allowing slurry to leak.	Spilled material was cleaned up and disposed of in the grinding circuit. The partially open valve has been locked out. McClean Lake is reviewing other measures such as improving containment.	Low

Table G-2: CNSC spill rating definitions

Functional area	Radiation protection		Environmental protection	
SCA/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. Example: ▪ NEW exceeding 20 mSv/year or 100 mSv/5 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 impacts or extensive future remediation. Example: 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 limited area.	Incident that results in, or has reasonable potential to exceed, an action level. Example: Dose to workers of ▪ 1 mSv/week ▪ 5 mSv/quarter	Nuclear or hazardous substances being released to the environment exceeding action levels (including public exposure) or that results in impact to the environment outside the licensing basis.	Incident that results in, or has reasonable potential to have a minor impact or requiring some future remediation Example: ▪ 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 negligible impact Example: ▪ effluent administrative level exceedance ▪ spills to environment (including atmosphere) with no future impacts

Appendix H: Lost-time Incidents in 2014

Table H-1: Uranium mines and mills – lost-time incidents

Facility	Lost-time incidents (LTIs)	Corrective action
Cigar Lake operation	There were no LTIs at Cigar Lake in 2014.	Not applicable
McArthur River operation	There were no LTIs at McArthur River in 2014.	Not applicable
Rabbit Lake operation	On April 22, 2014, a worker got his foot wedged while attempting to retrieve a hose buried in a pile of rock. The worker fell, twisting their ankle resulting in a fractured foot.	Corrective actions were taken to improve housekeeping and to remind employees to use caution when performing unusual tasks. CNSC staff were satisfied with the corrective actions taken.
Key Lake operation	There were no LTIs at Key Lake in 2014.	Not applicable
McClean Lake operation	On March 30, 2014, an AREVA employee was using a crowbar to remove a pin from a piece of equipment. When the pin was released, the equipment moved causing the crowbar to strike the employee's leg. The employee was taken to the onsite medical center and then sent off-site for further medical evaluation. The employee remained off work for the remainder of the work shift.	AREVA reviewed and ensured the existing quick attachment preventative maintenance schedules were adequate and reviewed with operators the importance of reporting damage and deficiencies. CNSC staff were satisfied with the corrective actions taken.
McClean Lake operation	On November 16, 2014, a worker was proceeding up the ramp towards a door carrying a pry bar and slipped on ice. The worker suffered an injury to the middle and ring fingers of the right hand. The worker was wearing gloves at the time. The worker reported the incident to their supervisor and was treated by the nurse.	The ramp was coated with sand following the incident. Corrective actions included: use of stock issue ice cleats for outside slippery conditions; additional coaching of the use of the 5 point safety card (check entrance and travel ways); modification of operational controls to reduce splashing and build-up of ice in the area, and establishment of a preventive maintenance schedule for all overheard doors. CNSC staff were satisfied with the corrective actions taken.
McClean Lake operation	On December 20, 2014, during start-up of the acid plant, winds blew sulphur dioxide (SO_2) released into the atmosphere back into the mill, creating a localized high SO_2 environment where a mill operator inhaled the SO_2. The employee experienced respiratory issues which resulted in an LTI.	Corrective actions included, fixing the SO_2 monitors in the mill ventilation system; implementing staff alerts for planned start-ups of the sulphuric acid plant; modification of the sulphuric acid plant start-up procedures to check for prevailing wind direction and; to delay sulphur feed until favourable wind conditions exist. CNSC staff were satisfied with the corrective actions.

Appendix I: Links to Provincial and Licensee Websites

Cameco Corporation – Cigar Lake operation

Cameco Corporation – McArthur River/Key Lake operation

Cameco Corporation – Rabbit Lake operation

AREVA Resources Canada Inc. – McClean Lake operation

Province of Saskatchewan – Eastern Athabasca Regional Monitoring Program

Appendix J: Changes to Licence Conditions Handbooks, 2014

Record of issuance of licence conditions handbooks			
Licensee/licence #	**Licence conditions handbook revision**	**Summary of changes**	**Effective date**
AREVA Resources Canada McClean Lake Operation Uranium Mine Operating Licence UMOL-MINEMILL-McCLEAN.01/2017	2	Added reference to the Commissioning Management Plan and ore slurry storage on the JEB ore pad, update to the table of radiation devices. Update to licensing basis documents. Other minor editorial changes.	April 24, 2014
Cameco Corporation Cigar Lake Operation Uranium Mine Licence UML-MINE-CIGAR.00/2021	1	Update to the table of radiation devices. Update to licensing basis documents. Other minor editorial changes.	January 23, 2014
Cameco Corporation McArthur River Operation Uranium Mine Licence UMOL-MINE-McARTHUR.00/2023	1	Modified document for an increase in annual production. The new production limit is 8.1 million kg of uranium per year. Update to the table of radiation devices. Update to licensing basis documents. Other minor editorial changes.	April 24, 2014
Cameco Corporation Key Lake Operation Uranium Mill Licence UMLOL-MILL-KEY.00/2023	1	Modified document for an increase in annual production. The new production limit is 9.6 million kg of uranium per year. Update to licensing basis documents. Other minor editorial changes.	December 15, 2014

Appendix K: Acronyms

AGTMF	above-ground tailings management facility
ALARA	as low as reasonably achievable
AREVA	AREVA Resources Canada Inc.
Bq/LCMD	becquerel per litreCommission Member Document
CNSC	Canadian Nuclear Safety Commission
CSA	Canadian Standards Association
EARMP	Eastern Athabasca Regional Monitoring Program
EC	Environment Canada
ERA	environmental risk assessment
FTE	full-time equivalent
HVAS	high-volume air sampler
GNSCR	*General Nuclear Safety and Control Regulations*
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
JBS	jet boring system
LCH	licence conditions handbook
LLRD	long-lived radioactive dust
LTIMAC	lost-time incident
mg/L	Maximum allowable concentration milligram per litre
mSv	millisievert
MMER	*Metal Mining Effluent Regulations*
NEW	nuclear energy worker
NSCA	*Nuclear Safety and Control Act*
OMOE	Ontario Ministry of Environment
OSLD	optically stimulated luminescence dosimeters
PAD	personal alpha dosimeter
PDCE	preliminary decommissioning cost estimate
PDP	preliminary decommissioning plan
RCOP	radiation code of practice
RPP	radiation protection program
RWP	radiation work permit
SABRE	Surface Access Borehole Resource Extraction

SCA	safety and control area
TMF	tailings management facility
TSP	total suspended particulate
TSS	total suspended solids
WQGAL	*Water Quality Guidelines for the Protection of Aquatic Life*