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Annual Program Report

Regulatory Oversight Report for Uranium and Nuclear Substance Processing Facilities in Canada: 2019

Rapport annuel sur les programmes

Rapport de surveillance réglementaire des installations de traitement de l'uranium et des substances nucléaires au Canada: 2019

Public Meeting

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Canada

Summary

This Commission member document (CMD) pertains to the *Regulatory Oversight Report for Uranium and Nuclear Substance Processing Facilities in Canada: 2019*.

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

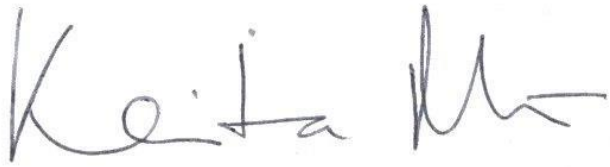
Résumé

Ce document à l'intention des commissaires (CMD) porte sur le *Rapport de surveillance réglementaire des installations de traitement de l'uranium et des substances nucléaires au Canada : 2019*.

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

Signed/signé le

2 October 2020



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EXECUTIVE SUMMARY

The *Regulatory Oversight Report for Uranium and Nuclear Substance Processing Facilities in Canada: 2019* presents the regulatory efforts of Canadian Nuclear Safety Commission (CNSC) staff in relation to such facilities for the 2019 calendar year. This report also provides an update on CNSC staff regulatory activities pertaining to public information, community engagement, and aspects of the CNSC's Independent Environmental Monitoring Program that relate to uranium and nuclear substance processing facilities. Where possible, trends are shown and information is compared to previous years.

CNSC staff use 14 safety and control areas (SCAs) to evaluate the performance of each licensee. The resulting performance ratings for all 14 SCAs are set out in this report. Particular focus is placed on the three SCAs – radiation protection, environmental protection, and conventional health and safety – that contain the majority of the key performance indicators for these facilities.

The SCA ratings in this report were derived from the results of compliance activities conducted by CNSC staff. These activities included onsite inspections, technical assessments, reviews of reports submitted by licensees, reviews of events and incidents, and ongoing exchanges of information with licensees. For the 2019 reporting year, CNSC staff rated all SCAs as "satisfactory" for all uranium and nuclear substance processing facilities, and confirmed that all such facilities in Canada were operating safely.

In 2019, CNSC staff's efforts supported their ongoing commitment to meeting consultation and accommodation obligations and continuing to build relationships with Indigenous peoples with interests in Canada's uranium and nuclear substance processing facilities.

CNSC staff concluded that the licensees for the regulated facilities covered in this report made adequate provision for the health and safety of workers, the protection of the public and the environment, and the fulfillment of Canada's international obligations.

This report is available on the CNSC website, and the documents referenced in it are available to the public upon request by contacting:

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1 INTRODUCTION

Through the application of the *Nuclear Safety and Control Act* (NSCA) [1], and its associated Regulations, the Canadian Nuclear Safety Commission (CNSC) regulates Canada's nuclear industry to protect the health and safety of persons and the environment and to implement Canada's international commitments on the peaceful use of nuclear energy. The CNSC also disseminates objective scientific, technical and regulatory information to the public. Licensees are responsible for operating their facilities safely, and are required to implement programs that make adequate provision for meeting legislative and regulatory requirements.

This Regulatory Oversight Report (ROR) provides an overview of CNSC regulatory efforts related to uranium and nuclear substance processing facilities in Canada for the 2019 calendar year.

The sites covered by this report are:

- Uranium processing facilities*
  - Cameco Corporation Blind River Refinery (BRR) in Blind River (FFOL-3632.00/2022)
  - Cameco Corporation Port Hope Conversion Facility (PHCF) in Port Hope (FFOL-3631.00/2027)
  - Cameco Fuel Manufacturing Inc. (CFM) in Port Hope (FFOL-3641.00/2022)
  - BWXT Nuclear Energy Canada Inc. (formerly GE Hitachi Nuclear Energy Canada Inc.) in Toronto (BWXT Toronto) (FFOL-3620.01/2020)
  - BWXT Nuclear Energy Canada Inc. (formerly GE Hitachi Nuclear Energy Canada Inc.) in Peterborough (BWXT Peterborough) (FFOL-3620.01/2020)
- Nuclear substance processing facilities*
  - SRB Technologies (Canada) Inc. (SRBT) in Pembroke (NSPFOL-13.00/2022)
  - Nordion (Canada) Inc. (Nordion) in Ottawa (NSPFOL-11A.01/2025)
  - Best Theratronics Ltd. (BTL) in Ottawa (NSPFOL-14.00/2029)

*Each alpha-numeric expression refers to the licence held by the licensee.

The three Safety and Control Areas (SCAs) focused on in this report – radiation protection, environmental protection, and conventional health and safety – include key metrics to demonstrate a licensee's performance, such as the radiation dose to workers and the public, releases to the environment and the number of lost-time injuries (LTIs). The report also includes information on the licensees' public information programs, engagement with Indigenous groups and communities, and reportable events. Appendix A provides a list to the licensees' websites.

2 URANIUM PROCESSING FACILITIES

Uranium processing facilities are part of the nuclear fuel cycle that includes refining, conversion and fuel manufacturing. The fuel produced is used in nuclear power plants for the generation of electricity.

2.1 Cameco Blind River Refinery

Cameco Corporation owns and operates the Blind River Refinery (BRR) in Blind River, Ontario. The facility is located about 5 km west of the town of Blind River, Ontario.

The BRR facility refines uranium concentrates (yellowcake) received from uranium mines worldwide to produce uranium trioxide (UO_3), an intermediate product of the nuclear fuel cycle. The primary recipient of the UO_3 product is Cameco's Port Hope Conversion Facility (PHCF). For more general information please visit:

http://www.nuclearsafety.gc.ca/eng/uranium/processing/nuclear-facilities/blind-river/index.cfm

2.2 Cameco Port Hope Conversion Facility

Cameco Corporation owns and operates PHCF, which is located in Port Hope, Ontario, situated on the north shore of Lake Ontario, approximately 100 km east of Toronto.

PHCF converts UO_3 powder produced by Cameco's BRR into uranium dioxide (UO_2) and uranium hexafluoride (UF_6). UO_2 is used in the manufacture of Canada Deuterium Uranium (CANDU) reactor fuel, while UF_6 is exported for further processing before being converted into fuel for light-water reactors. For more general information please visit:

http://www.nuclearsafety.gc.ca/eng/uranium/processing/nuclear-facilities/port-hope-uranium-conversion/index.cfm

Vision in Motion

Vision in Motion (VIM) is Cameco's project to clean up and renew the site. The project is being carried out under Cameco's operating licence for the facility. Licence condition 16.1 requires that "The licensee shall implement and maintain a program to carry out clean-up, decontamination and remediation work." In 2019, Cameco carried out work that included:

- Preparation and transfer of stored wastes to the Canadian Nuclear Laboratories (CNL) Port Hope Area Initiative's (PHAI) Long-Term Waste Management Facility (LTWMF) from the PHCF main site, Dorset Street site, and the completion of transfers from the Centre Pier site
- Building demolition was completed at the Centre Pier and the demolition waste was transferred to the LTWMF

- At Building 27 (former UF_6 plant) asbestos abatement and process hazard removal was completed, interior equipment removal began and demolition of the tote bin and emergency generator rooms was completed
- Infrastructure work in the corridor between building 2 and 6, 7, 12 and 12 A was substantially completed
- Installation of infrastructure for storm water management and the new hydrogen station began at the south end of the facility
- Demolition of the former water works plant (garage building demolition pending) and remediation of Low Level Radioactive Waste (LLRW)

During relicensing in 2016, the Commission approved the removal of Centre Pier as a licensed area once Cameco completed building demolition and ceased operational activities. Cameco submitted documentation following the demolition of all Centre Pier buildings, the removal of all demolition and stored waste to convey their intent to terminate all operational activities at Centre Pier. After verifying Cameco's actions via an onsite inspection in June 2019, Centre Pier was officially removed from the PHCF licensed area drawing, a document referenced in the PHCF Licence Conditions Handbook (LCH). At present, Centre Pier is under the care and control of CNL. It will undergo further remediation of historically contaminated soils and will also be used to support Port Hope Harbour remedial activities.

2.3 Cameco Fuel Manufacturing Inc.

Cameco Fuel Manufacturing Inc. (CFM) is a wholly owned subsidiary of Cameco Corporation. CFM operates two facilities: a nuclear fuel fabricating facility licensed by the CNSC in Port Hope, Ontario; and a metals manufacturing facility in Cobourg, Ontario, which manufactures fuel bundle and reactor components (non-nuclear activities). This latter facility is not licensed by the CNSC and is not discussed further in this report.

The CFM facility manufactures fuel pellets from natural uranium dioxide (UO_2) powder and assembles nuclear reactor fuel bundles. The finished fuel bundles are primarily shipped to Canadian nuclear power reactors. For more general information please visit:

http://www.nuclearsafety.gc.ca/eng/uranium/processing/nuclear-facilities/port-hope-nuclear-fuel/index.cfm

2.4 BWXT Nuclear Energy Canada Inc.

BWXT Nuclear Energy Canada Inc. (BWXT) (formerly known as GE-Hitachi Nuclear Energy Canada Inc.) produces nuclear fuel and fuel bundles used by Ontario Power Generation's (OPG) Pickering and Darlington nuclear generating stations. BWXT has licensed operations in two locations: Toronto and Peterborough, Ontario.

The Toronto site produces uranium dioxide (UO_2) fuel pellets, and the Peterborough site manufactures the fuel bundles, using the pellets from Toronto and zircaloy tubes manufactured in-house. The Peterborough site also runs a fuel

services business involved with the manufacturing and maintenance of equipment for use in nuclear power plants. For more general information please visit:

http://www.nuclearsafety.gc.ca/eng/uranium/processing/nuclear-facilities/bwxt-nuclear-energy-canada-inc-toronto/index.cfm

http://www.nuclearsafety.gc.ca/eng/uranium/processing/nuclear-facilities/bwxt-nuclear-energy-canada-inc-peterborough/index.cfm

In November 2018, BWXT submitted a licence renewal application requesting to renew its operating licence for a ten-year period. The Commission conducted an oral public renewal hearing in March 2020 in Toronto, Ontario and Peterborough, Ontario. In April 2020 the Commission announced a Continuation of Hearing and directed CNSC staff to collect additional soil samples of beryllium of properties adjacent to BWXT's Peterborough facility. Once the Commission receives CNSC staff's submission, the Commission will deliberate on BWXT's licence renewal request. The resampling results and the supplementary submission will be publically available. For more information on the Continuation of Hearing please visit:

http://www.nuclearsafety.gc.ca/eng/the-commission/pdf/NoticeRev1-Continuation-BWXT-20-H2-e.pdf

To date the Commission has not yet made a decision on the BWXT licence renewal application.

3 NUCLEAR SUBSTANCE PROCESSING FACILITIES

Nuclear substance processing facilities process nuclear substances for a variety of end uses in industrial or medical applications. The nuclear substances can be used for lighting self-luminous emergency and exit signs, sterilizing items for sanitary reasons such as surgical gloves, and providing cancer diagnosis and treatment.

3.1 SRB Technologies (Canada) Inc.

SRB Technologies (Canada) Inc. (SRBT) operates a Class IB facility that manufactures gaseous tritium light source (GTLS) on the outskirts of Pembroke, Ontario, located approximately 150 km northwest of Ottawa.

The SRBT facility processes tritium gas (HT) to produce sealed glass capsules coated with phosphorescent powder and filled with HT to generate continuous light. Examples of such GTLS include signs, markers and tactical devices. SRBT distributes its products in Canada and internationally. For more general information please visit:

http://www.nuclearsafety.gc.ca/eng/nuclear-substances/nuclear-facilities/srb-technologies/index.cfm

3.2 Nordion (Canada) Inc.

Nordion (Canada) Inc. is located adjacent to industrial and residential property in Ottawa, Ontario, and is licensed to operate a Class IB nuclear substance processing facility.

At this facility, Nordion processes unsealed radioisotopes (such as yttrium-90 (Y-90)) for health and life sciences applications, and manufactures sealed radiation sources (cobalt-60 (Co-60)) for industrial and medical applications. The facility is composed of two major production operations, one involving the processing of radioisotopes used in nuclear medicine (medical isotopes) and the other involving sealed sources used in cancer therapy and irradiation technologies (gamma technologies).

In April 2018 BWX Technologies Ltd. (BWXT) announced an agreement to acquire Nordion's medical isotope business. The acquisition was completed in August 2018. CNSC staff assessed the information provided by Nordion on the acquisition, including the proposed management system, and determined that the proposed change would have a neutral impact on safety and was within the licensing basis. No licence amendment or Commission approval was required for the acquisition to proceed as Nordion will continue to operate the medical isotope facility until such time as BWXT obtains a separate Class IB nuclear substance processing facility operating licence (NSPFOL). For more general information please visit:

http://www.nuclearsafety.gc.ca/eng/nuclear-substances/nuclear-facilities/nordion/index.cfm

3.3 Best Theratronics Ltd.

Best Theratronics Ltd. (BTL) owns and operates a manufacturing facility in Ottawa, Ontario.

BTL manufactures cyclotrons and medical equipment, including cobalt-60 radiation therapy units and cesium-137 blood irradiators. BTL is licensed by the CNSC for the development and testing of Co-60 teletherapy devices, the manufacturing of self-shielded irradiators, the storage of nuclear substances, and construction and testing of particle accelerators (cyclotrons). For more general information please visit:

http://www.nuclearsafety.gc.ca/eng/nuclear-substances/nuclear-facilities/best-theratronics/index.cfm

In September 2018, BTL submitted a licence renewal application requesting to renew its operating licence for a ten-year period. The Commission conducted an oral public renewal hearing in May 2019. The Commission renewed BTL's Class IB licence for a ten-year period in June 2019.

4 CNSC REGULATORY OVERSIGHT

The CNSC performs regulatory oversight of licensed facilities to verify compliance with the requirements of the NSCA and associated Regulations made under the NSCA, each site's licence and licence conditions, and any other applicable standards and regulatory documents.

CNSC staff use the Safety and Control Area (SCA) framework to assess, evaluate, review, verify and report on licensee performance. The SCA framework includes 14 SCAs, which are subdivided into specific areas that define its key components. Further information on the CNSC's SCA framework can be found on the CNSC's website at:

http://www.nuclearsafety.gc.ca/eng/resources/publications/reports/powerindustry/safety-and-control-areas.cfm.

4.1 Regulatory activities

CNSC staff conducted risk-informed regulatory oversight activities at Canada's uranium and nuclear substance processing facilities in 2019. Table 4-1 presents the licensing and compliance verification efforts from CNSC staff for these facilities throughout 2019. Of note is the high numbers for BWXT and BTL licensing activities. This is due to activities associated with licence renewal efforts for both facilities.

Table 4-1: CNSC regulatory oversight licensing and compliance verification activities, uranium and nuclear substance processing facilities, 2019

Facility	Number of onsite inspections	Person-days for compliance verification activities	Person-days for licensing activities	Number of safeguards inspections led by IAEA*
BRR	4	157	11	3
PHCF	4	275	7	6
CFM	3	200	17	4
BWXT	3	232	302	6
SRBT	2	110	2	0
Nordion	4	91	20	0
BTL	1	66	225	0

*International Atomic Energy Agency

Compliance Verification

The CNSC ensures licensee compliance through verification, enforcement and reporting activities. CNSC staff implement compliance plans for each site by conducting regulatory activities including on-site inspections, desktop reviews and technical assessments of licensee programs, processes and reports.

Appendix B contains a list of CNSC inspections carried out at each uranium and nuclear substance processing facility in 2019. All findings in these inspections were considered low-risk and did not have an impact on safety at the facilities.

Licensing

CNSC staff activities for licensing include drafting new licences, preparing Commission Member Documents, and drafting or revising LCHs.

As CNSC regulatory documents are published, CNSC staff update the LCHs as applicable for each site, taking into consideration the licensee's implementation plans. Appendix C provides a list of changes to uranium and nuclear substance processing facility licences and LCHs. CNSC staff verify the implementation as part of ongoing compliance verification activities. Appendix D provides a list of CNSC regulatory documents implemented at uranium and nuclear substance processing facilities and used by CNSC staff for compliance verification. Appendix E presents the financial guarantee amounts for each facility.

IAEA Safeguards Activities

Under the terms of the Canada-IAEA safeguards agreements, the IAEA has the right to perform independent verification activities at various types of sites in Canada. IAEA activities are not CNSC compliance inspections, but CNSC staff accompany the IAEA in approximately 75% of their activities.

4.2 Performance ratings 2019

Performance ratings result from regulatory oversight activities. Table 4-2 presents CNSC staff's rating for each licensee's performance for each SCA in 2019.

Table 4-2: SCA Performance ratings, 2019

SCA	BRR	PHCF	CFM	BWXT	SRBT	Nordion	BTL
Management system	SA	SA	SA	SA	SA	SA	SA
Human performance management	SA	SA	SA	SA	SA	SA	SA
Operating performance	SA	SA	SA	SA	SA	SA	SA
Safety analysis	SA	SA	SA	SA	SA	SA	SA
Physical design	SA	SA	SA	SA	SA	SA	SA
Fitness for service	SA	SA	SA	SA	SA	SA	SA
Radiation protection	SA	SA	SA	SA	SA	SA	SA
Conventional health and safety	SA	SA	SA	SA	SA	SA	SA
Environmental protection	SA	SA	SA	SA	SA	SA	SA
Emergency management and fire protection	SA	SA	SA	SA	SA	SA	SA
Waste management	SA	SA	SA	SA	SA	SA	SA
Security	SA	SA	SA	SA	SA	SA	SA
Safeguards and non-proliferation	SA	SA	SA	SA	N/A*	SA	SA
Packaging and transport	SA	SA	SA	SA	SA	SA	SA

*There are no safeguard verification activities associated with this facility.

Appendix F provides SCA ratings for each licensee from 2015 to 2019.

Please note that in order to prioritize work in the context of the COVID pandemic, facility performance assessment used a binary approach for the 2019 ROR. That is, licensees were only rated as “Satisfactory (SA)” or “Below Expectation (BE)”, and the “Fully Satisfactory (FS)” rating was not used. It is important to recognize that a facility that received an SCA rating of FS in the 2018 ROR and now has a rating of SA, does not necessarily indicate a reduction in performance. The binary

rating approach considerably reduced the effort that is often needed to reach a consensus on a final rating.

5 THE CNSC'S ASSESSMENT OF SAFETY AT URANIUM AND NUCLEAR SUBSTANCE PROCESSING FACILITIES

The CNSC regulates all aspects of safety at nuclear sites in Canada, including risks to workers, the public and the environment. Information related to the SCAs of radiation protection, environmental protection and conventional health and safety are most representative of overall safety performance. In particular, the SCAs of radiation protection and conventional health and safety are a good measure of the safety of workers at uranium and nuclear substance processing facilities, while the SCA of environmental protection is a good measure of the safety of the public and the environment.

For both the radiation protection and environmental protection SCAs, action levels are used. Action levels are a tool used to ensure that licensees are operating their facility appropriately and in accordance with their approved radiation and environmental protection programs, and within the design and operational parameters of their wastewater treatment and air pollution control systems. Action levels serve as an early warning system to ensure that licensees are carefully monitoring their operation and performance, to ensure radiation dose limits and release limits are not exceeded. Action level exceedances are reportable to the CNSC.

5.1 Environmental protection

Protection of the environment and the public are linked in the SCA of environmental protection. This SCA covers programs that identify, control and monitor all releases of radioactive and hazardous substances, and the effects on the environment from facilities or as a result of licensed activities.

Currently, all licensees covered by this ROR have acceptable environmental protection programs in place to ensure the protection of the public and the environment. For 2019, CNSC staff rated the environmental protection SCA at all uranium and nuclear substance processing facilities as "satisfactory".

Appendix G provides the total annual releases of radionuclides for each uranium and nuclear substance processing facility from 2015 to 2019. Appendix H contains data on dose to the public from 2015 to 2019. Appendix I contains supplemental environmental data for all licensees.

Effluent and emissions control (releases)

All uranium and nuclear substance processing facilities implement effluent and environmental monitoring programs commensurate with the risks of their operations. Airborne and waterborne releases of radioactive and hazardous substances at all uranium and nuclear substance processing facilities remained below regulatory limits in 2019.

Action levels

The following environmental action level exceedances were reported to the CNSC in 2019:

- On July 1 2019, Cameco PHCF reported a fluoride measurement of 266 g HF/h which exceeds the action level of 230 g HF/h. The action level was exceeded due to an electrolytic cell gland failure in the UF_6 plant cell room. Cameco isolated the cell which resulted in fluoride concentrations returning to normal. This did not pose a risk to people or the environment. As a corrective action from Cameco's investigation, they revised their procedure on how to troubleshoot a cell failure and how to adequately implement isolation and purging techniques.
- During the second and third quarters of 2019, Cameco PHCF reported 18 instances where the daily action level of 100 µg U/L was exceeded for uranium discharges to the sanitary sewer. This was attributed to the unusually high Lake Ontario water elevations and associated groundwater infiltration to the sanitary sewer system due to significant precipitation events. Cameco completed the implementation of its corrective actions which has helped reduce the number of action level exceedances in 2020. Cameco is continuing to repair sections of the sanitary sewer network and is upgrading it as part of the Vison in Motion (VIM) project. The discharges remained below the monthly mean release limit of 275 µg U/L.

CNSC staff have assessed that there was no impact to workers, the public or the environment as a result of these exceedances. CNSC staff reviewed the licensees' corrective actions in relation to the action level exceedances and are satisfied with the licensee's responses.

Environmental management system

The CNSC requires each licensee to develop and maintain an environmental management system (EMS) that provides a framework for integrated activities related to environmental protection. EMS are described in environmental management programs and include activities such as the establishment of annual environmental objectives, goals and targets. Licensees conduct internal audits of their programs at least once a year. As part of regular compliance verification, CNSC staff review and assess these objectives, goals and targets. CNSC staff determined that, in 2019, the uranium and nuclear substance processing facility licensees established and implemented their EMS in compliance with the CNSC regulatory requirements.

Assessment and monitoring

CNSC staff verify that each uranium and nuclear substance processing facility licensee has environmental monitoring programs commensurate with the risks of the operations at each of its facilities. The environmental monitoring programs are designed to monitor releases of radioactive and hazardous substances, and to characterize the quality of the environment associated with the licensed facility.

Environmental risk assessment

Licensees develop environmental risk assessments (ERAs) to analyze the risks associated with contaminants in the environment as a result of licensed activities. ERAs provide the basis for the scope and complexity of environmental monitoring programs at the uranium and nuclear substance processing facilities.

CNSC staff use CSA standard N288.6-12, *Environmental Risk Assessments at Class I Nuclear Facilities and Uranium Mines and Mills* [2], to help determine whether licensees are in compliance with regulatory requirements for protection of the environment and human health. CSA N288.6-12 specifically states: "Facility ERAs should be reviewed on a five-year cycle or more frequently if major facility changes are proposed that would trigger a predictive assessment" [2]. CNSC staff expect licensees to periodically review ERAs for their facilities, as appropriate.

Protection of the public

The CNSC requires licensees to demonstrate that the health and safety of the public are protected from exposures to hazardous (non-radiological) substances released from their facilities. Licensees use effluent and environmental monitoring programs to verify that releases of hazardous substances do not result in environmental concentrations that may affect public health. CNSC staff receive reports of discharges to the environment in accordance with reporting requirements outlined in the licence and the LCH. Based on assessments of the programs at the uranium and nuclear substance processing facilities, CNSC staff concluded that the public continues to be protected from facility emissions of hazardous substances.

Estimated dose to the public

The maximum dose to the public from licensed activities is calculated by considering monitoring results from air emissions, liquid effluent releases and gamma radiation. The CNSC's requirement for following the as low as reasonably achievable, taking into account social and economic factors (ALARA) principle, means that licensees must monitor their facilities and keep doses to the public below the annual public dose limit of 1 millisievert (mSv)/year prescribed in the *Radiation Protection Regulations* [3].

Table H-1 of Appendix H compares estimated public doses from 2015 to 2019 for the uranium and nuclear processing facility licensees. Estimated doses to the public from all these facilities continued to be well below the regulatory annual public dose limit of 1 mSv/year.

Conclusion on environmental protection

CNSC staff concluded that the uranium and nuclear substance processing facility licensees implemented their environmental protection programs satisfactorily during 2019. The licensees' programs are effective in protecting the health and safety of the public and the environment.

5.2 Radiation protection

The radiation protection SCA covers the implementation of a radiation protection program in accordance with the *Radiation Protection Regulations* [3]. The program must ensure that contamination levels and radiation doses received by individuals are monitored, controlled and maintained ALARA.

For 2019, CNSC staff rated the radiation protection SCA at all uranium and nuclear substance processing facilities as "satisfactory".

Appendix J contains data on dose to workers for each uranium and nuclear substance processing facility from 2015 to 2019.

Application of ALARA

CNSC staff confirmed that in 2019 all uranium and nuclear substance processing facility licensees continued to implement radiation protection measures to keep radiation exposures and doses to persons ALARA. The CNSC requirement for licensees to apply the ALARA principle has consistently resulted in these doses staying well below regulatory dose limits.

Worker dose control

The design of radiation protection programs includes the dosimetry methods and the determination of workers who are identified as nuclear energy workers (NEWs). These designs vary, depending on the radiological hazards present and the expected magnitude of doses received by workers. The dose statistics provided in this report are primarily for NEWs, with the inherent differences in the design of radiation protection programs among licensees taken into consideration. Additional information on the total number of monitored persons, including workers, contractors and visitors, is provided in the facility-specific sections.

CNSC staff confirmed that in 2019 all uranium and nuclear substance processing facility licensees monitored and controlled the radiation exposures and doses received by all persons present at their licensed facilities, including workers, contractors and visitors. Direct comparison of doses received by NEWs among facilities does not necessarily provide an appropriate measure of a licensee's effectiveness in implementing its radiation protection program, since radiological hazards differ across these facilities due to complex and varying work environments.

Radiation protection program performance

CNSC staff conducted regulatory oversight activities at all uranium and nuclear substance processing facilities in 2019 to verify that the licensees' radiation protection programs complied with regulatory requirements. These oversight activities included onsite inspections, desktop reviews, and compliance verification activities specific to radiation protection. Through these activities, CNSC staff confirmed that all these licensees have effectively implemented their radiation protection programs, to control occupational exposures to workers and keep doses ALARA.

Action levels

Action levels for radiological exposures are established as part of the licensees' radiation protection programs. Each licensee is responsible for identifying the parameters of its own program(s) to represent timely indicators of potential losses of control of the program(s). These licensee-specific action levels may also change over time, depending on operational and radiological conditions.

If an action level is reached, it triggers the licensee to determine the cause, notify the CNSC and, if applicable, take corrective action to restore the effectiveness of the radiation protection program. It is important to note that occasional action level exceedances indicate that the action level chosen is likely an adequately sensitive indicator of a potential loss of control of the program.

It is possible that action levels which are never exceeded have not been established low enough to detect the emergence of a potential loss of control. For this reason, licensee performance is not evaluated solely on the number of action level exceedances in a given period, but rather on how the licensee responds and implements corrective actions to enhance program performance and prevent reoccurrence. Licensees are also required to periodically review their action levels to validate their effectiveness.

The following radiation protection action level exceedances were reported to the CNSC in 2019:

- At BRR, a worker's dosimeter recorded whole body and skin doses of 0.72 mSv and 13.62 mSv respectively during the wearing period for the second quarter of 2019. These doses exceeded the action levels for quarterly whole body dose (0.70 mSv) and quarterly skin dose (6 mSv). Following Cameco's investigation into the action level exceedances, it was determined that the exposures were mostly non-personal in nature. The dosimeter had been lost in a processing area for a period of time, where it was exposed to radiation. When the dosimeter was found, it was returned to the dosimeter storage rack where it was collected and returned to the dosimetry service provider for processing. The dose recorded on the dosimeter was assigned to the worker in the National Dose Registry (NDR). Cameco reviewed the worker's work practices during the quarter, and developed a more reasonable dose estimate. Cameco subsequently pursued a dose change with the NDR, and also established corrective actions around communicating to workers expectations when dosimeters are lost.
- CFM's extremity dose action level of 55 mSv/quarter was reached when a worker's extremity dose for the third quarter was determined to be 73.7 mSv. Cameco's investigation into the exceedance did not identify a clear cause, and determined the dose was not possible given the job tasks assigned to the worker, consideration of the worker's past extremity doses, and comparisons with other workers' extremity doses. CFM confirmed that the dose is not personal. CFM will be pursuing a change to the worker's dose record with the NDR.

CNSC staff reviewed the action level exceedances and are satisfied with the licensee's responses.

Radiological hazard control

CNSC staff verified that, in 2019, all uranium and nuclear substance processing facility licensees continued to implement adequate measures to monitor and control radiological hazards in their facilities. These measures included delineation of zones for contamination control purposes and in-plant air-monitoring systems. Licensees demonstrated that they have implemented workplace monitoring programs to protect workers. The licensees have also demonstrated that levels of radioactive contamination were controlled within their facilities throughout the year.

Conclusion on radiation protection

CNSC staff concluded that throughout 2019 the uranium and nuclear substance processing facility licensees effectively implemented and maintained their radiation protection programs, to ensure the health and safety of persons working in their facilities.

5.3 Conventional health and safety

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

Based on regulatory oversight activities, CNSC staff rated the performance of all uranium and nuclear substance processing facilities for the conventional health and safety SCA as "satisfactory" in 2019.

Appendix K contains health and safety information for each uranium and nuclear substance processing facility from 2015 to 2019.

Performance

Employment and Social Development Canada (ESDC) and the CNSC regulate conventional health and safety programs at uranium and nuclear substance processing facilities. Licensees submit hazardous-occurrence investigation reports to both ESDC and the CNSC, in accordance with their respective reporting requirements. CNSC staff monitor compliance with regulatory reporting requirements and, when a concern is identified, consult with ESDC staff.

Licensees are required to report to the CNSC as directed by section 29 of the *General Nuclear Safety and Control Regulations* [4]. These reports include serious illnesses or injuries incurred or possibly incurred as a result of a licensed activity.

A key performance measure for the conventional health and safety SCA is the number of lost-time injuries (LTIs) that occur per year. An LTI is an injury that takes place at work and results in the worker being unable to return to work to carry out their duties for a period of time.

In 2019, there were 2 LTIs at Nordion and 2 at BTL.

Practices

Licensees are responsible for developing and implementing conventional health and safety programs for the protection of their workers. These programs must comply with Part II of the *Canada Labour Code* [5].

CNSC staff conducted desktop reviews and onsite inspections at all uranium and nuclear substance processing facilities during 2019 to verify compliance of the licensees' conventional health and safety programs with regulatory requirements. CNSC staff determined, based on these regulatory oversight activities, that these licensees met all regulatory requirements for this specific area.

Awareness

Licensees are responsible for ensuring that workers have the knowledge to identify workplace hazards and take the necessary precautions to protect against these hazards. This is accomplished through training and ongoing internal communications with workers.

During onsite inspections, CNSC staff verify that workers are trained to identify hazards at the facilities. CNSC staff confirmed that the uranium and nuclear substance processing facilities have effectively implemented their conventional health and safety programs to keep workers safe.

Conclusion on conventional health and safety

CNSC staff concluded that the uranium and nuclear substance processing facility licensees implemented their conventional health and safety programs satisfactorily throughout 2019. The programs are effective in protecting the health and safety of persons working in these facilities.

6 EVENTS AND OTHER MATTERS OF REGULATORY INTEREST

6.1 Reportable events

Detailed requirements for reporting unplanned situations or events at uranium and nuclear substance processing facilities to the CNSC are included in the applicable LCH. CNSC Regulatory Document 3.1.2 *Reporting Requirements for Non-Power Reactor Class I Facilities and Uranium Mines and Mills* [6] came into force for uranium and nuclear substance processing facility licensees in January 2019. Over the period covered by this report, licensees complied with the requirements for submission of these reports.

For reportable events which occurred in 2019, all were of low safety significance and CNSC staff are satisfied with the licensees' corrective actions.

BRR

- In March 2019, Cameco received four drums with missing drum ring bolts that are necessary under Type IP-1 packaging requirements. Cameco identified the deficiency and secured each drum ring prior to offloading the

drums. There was no loss of material or contamination and no impacts to the health and safety of workers as a result of this reportable event.

PHCF

- Cameco reported a total of thirteen (13) reportable events in 2019. As summarized below, the licensee effectively reported all of these events in accordance with its regulatory reporting requirements. Cameco also reported all airborne and liquid releases to the government of Ontario's Spills Action Centre. In all cases there were no impacts to the environment, the health and safety of workers or the public.
  - On March 28, Cameco reported that a purge meter that caught fire at the UF_6 facility. The fire was immediately extinguished and work resumed within the hour. There were no injuries and no further damage to the facility reported due to this event.
  - Cameco reported a total of five (5) releases to Port Hope Harbour. Releases reported in May 8 and June 21 were discharges of steam condensate. The June 18 release was a sanitary sewer spill due to the failure of an underground sanitary sewer pipe connection, which led to surface pooling onsite. Cleanup up and repairs were immediately carried out to minimize the release and prevent reoccurrence. The June 27 and November 26 events were releases of potable municipal water during the flushing of a condensate line used in VIM activities and due to a broken water main, respectively. Cameco reported these releases to the government of Ontario's Spills Action Centre. In all cases there were no impacts to the environment or to the health and safety of the public.
  - Cameco reported a total of three (3) transportation-related events. On January 5 a minor transportation accident was reported involving a vehicle transporting a UF6 cylinder. No injuries were reported and there was no damage to the cylinder or to the tractor trailer. On April 9 contamination (loose dirt) was discovered on the outside of a transport vehicle carrying drums to the Canadian Nuclear Laboratories (CNL) Port Hope Long Term Waste Management Facility (LTWMF). The area in question was cleaned up, and additional measures were put in place to verify for loose dirt on all remaining shipments. On July 18 Cameco reported a loose stem on a uranium cylinder. The cylinder was found to have an incorrect torque applied on the stem which was rectified upon discovery. No loose contamination was observed and that the cylinder pressure was deemed unaffected by this occurrence.
  - On July 19, Cameco reported the receipt of a flexible pressurized house of suspect quality. Upon further investigation it was determined that the hose's flange was not fully welded and that quality control was lacking. Cameco's internal quality control steps identified this issue before usage.

- Cameco reported a total of three (3) Emergency Response Team (ERT) activation events. On July 17, the ERT was activated to respond to an onsite building that reported floodwaters entering and egressing the building. The ERT response and immediate clean-up ensured that there were no impacts to the environment as a result of this event. On October 4 the ERT was activated due to the detection of fluorine in the UF_6 cell room. The release was due to a gasket failure. The affected area was isolated and repaired before being returned to service. Two personnel who were working in the area in question were monitored for fluorine exposure, and found to not have elevated fluorine results due to this incident. Based on action taken there were no impacts to site personnel or to the environment. On October 24 the ERT was activated to respond to an individual experiencing shortness of breath unrelated to work activities. The employee was later taken to the hospital for observation and released the same day.

CFM

- In January 2019, Cameco detected a leak of nitrogen gas from a valve on exterior equipment at CFM. Following its discovery, the faulty valve was quickly replaced. The release was estimated to be approximately 136 m^3 of nitrogen gas. Cameco reported this event to the Government of Ontario's Spills Action Centre and also posted details of this event on its website. There were no impacts to the environment or to the health and safety of the public as a result of this event.

BWXT

- In March 2019, BWXT reported that one personal air sample of an operator was above the occupational exposure limit for beryllium. Subsequent investigations by the licensee showed that the local ventilation equipment needed adjustment and was upgraded to increase the capture efficiency. This improvement was found to be effective and continues to be monitored. BWXT-NEC submitted an event report that detailed root causes and corrective actions.
- On March 2019, BWXT reported a transport truck carrying a consignment of uranium dioxide (UO_2) powder contained within Type IP-1 steel drums from Cameco in Port Hope was involved in a minor motor vehicle accident. There was minor damage to the truck, but no damage to the contents and there was no release of material. There were no effects on the environment, the health and safety of persons, or national or international security as a result of this event.

SRBT

- On January 2019, a significant fire at an industrial lumber facility near the SRBT facility occurred. The fire resulted in the loss of power for much of the city of Pembroke, including the SRBT facility. For the duration of the loss of power, there was an employee present in the facility as per the requirements of the SRBT Security Program. Power returned to the facility the next morning.

There were no effects on the health and safety of persons or on the environment due to loss of power to the SRBT facility.

- On January 2019, SRBT accepted three (3) aircraft signs containing 279.72 GBq of tritium gas from a customer in the European Union. The three signs were sold and exported by SRBT in accordance with an export licence issue by the CNSC. The customer sent the three signs back as it did not meet their design requirements, and the shipment was mistakenly accepted upon arrival, prior to being authorized by SRBT. SRBT reinforced with the customer that the returns process had not been followed, and that SRBT expects that this process shall be followed in the future in all cases where products may need to be returned to Canada. The shipments took place without any incident and there was no impact to the public or the environment as a result of this event.

Nordion

- Nordion reported three events related to packaging and transport in 2019. In all three cases, the events were low-risk, involving damage to Type A packages sustained during handling by shippers or carriers, with no impact to the radioactive contents of the packages.
- In July 2019, Nordion reported an event related to the discovery of a potentially leaking cobalt-60 (Co-60) source received from CNL's Chalk River Laboratories, which had slightly elevated contamination levels as a result of an abnormal weld. There were no corrective actions by Nordion as this was the second last shipment of Co-60 from CNL before CNL ceased production.

BTL

- On February 2019, BTL reported that a fire alarm was activated due to an electrical short in the fire safety system by a water leak. Emergency fire personnel responded to the alarm and confirmed the false alarm. The electrical short was caused by water entering the building in an area that was to undergo roof repair at a later date.
- On February 2019, BTL reported of a non-compliant Pre-shipment Notification to an incorrect importing authority. The correct importing authority was advised, corrective action issued, and procedure retraining was administered.

CNSC staff are satisfied that uranium and nuclear substance processing facility licensees responded appropriately to the events and implemented appropriate corrective actions in response to each event.

6.2 Public engagement

The area of public engagement has two aspects, those of activities carried out directly by CNSC staff, and of activities carried out by licensees.

6.2.1 CNSC

The NSCA mandates the CNSC to disseminate objective scientific, technical and regulatory information to the public concerning its activities and the activities it regulates. CNSC staff fulfill this mandate in a variety of ways, including the publishing of RORs and through 'Meet the Regulator' sessions. CNSC staff also seek out other opportunities to engage with the public and Indigenous groups, often participating in meetings or events in communities with interest in nuclear sites. These allow CNSC staff to answer questions about the CNSC's mandate and role in regulating the nuclear industry, including the uranium and nuclear substance processing facilities. For the facilities covered in this ROR, CNSC staff participated in the following events:

- BWXT annual summer barbecues – Toronto and Peterborough
- Port Hope Fall Fair

6.2.2 Uranium and nuclear substance processing facilities

All uranium and nuclear processing facility licensees are required to maintain and implement public information and disclosure programs, in accordance with regulatory document REGDOC-3.2.1, *Public Information and Disclosure* [7]. These programs are supported by disclosure protocols that outline the type of facility information to be shared with the public as well as details on how that information is to be shared. This ensures that timely information about the health, safety and security of persons and the environment, and other issues associated with the lifecycle of nuclear facilities, is effectively communicated to the public.

In 2019, CNSC staff evaluated licensees' implementation of their public information and disclosure programs by reviewing the communications activities they conducted. CNSC staff determined that all uranium and nuclear substance processing facility licensees were in compliance with requirements and that they issued information in accordance with their public disclosure protocols.

6.3 Indigenous consultation and engagement

As an agent of the Crown and as Canada's nuclear regulator, the CNSC recognizes and understands the importance of consulting and building relationships with Indigenous peoples in Canada. CNSC staff are committed to building long-term relationships with Indigenous groups who have interest in CNSC-regulated facilities within their traditional and/or treaty territories. By pursuing informative and collaborative ongoing interactions, the CNSC's goal is to build relationships and trust. The CNSC's Indigenous engagement practices, which include information sharing and funding support (through the CNSC's Participant Funding Program (PFP)) to assist Indigenous peoples in meaningfully participating in Commission proceedings and ongoing regulatory activities, are consistent with the principles of upholding the honour of the Crown and reconciliation.

6.3.1 CNSC staff engagement

The uranium and nuclear substance processing facilities in Canada fall within the traditional and/or treaty territories of many Indigenous communities (see Appendix L). CNSC staff efforts in 2019 supported the CNSC's ongoing commitment to meet its consultation obligations and build relationships with Indigenous peoples with interests in Canada's nuclear processing facilities. CNSC staff continued to work with Indigenous communities and organizations to identify opportunities for formalized and regular engagement, including meetings and workshops, throughout the lifecycle of these facilities. Through this engagement, CNSC staff welcomed the opportunity to discuss and address topics of interest and concern related to CNSC-regulated activities to interested Indigenous communities.

In addition, to ensure that interested Indigenous communities were made aware of this 2019 regulatory oversight report, CNSC staff provided them with a notice of the PFP opportunity to review and comment on it, as well as the opportunity to submit a written intervention and/or appear before the Commission as part of the Commission meeting. CNSC staff also sent copies of this report to all Indigenous communities and organizations who had requested that they be kept informed of activities at the facilities covered in the report.

6.3.2 Licensee engagement activities

In 2019, CNSC staff continued to monitor the engagement work conducted by the uranium and nuclear substance processing facility licensees (Cameco, BWXT, SRBT, Nordion and BTL) to ensure that they actively engage and communicate with Indigenous groups who have interest in their facilities.

CNSC staff confirm that the licensees have Indigenous engagement and outreach programs. Throughout 2019, the licensees met and shared information with interested Indigenous communities and organizations. These efforts have included emails, letters, meetings, site visits and tours, as well as community visits, upon request. The CNSC encourages licensees to continue to develop relationships and engage with Indigenous groups who have expressed an interest in the licensee's activities.

6.4 CNSC Independent Environmental Monitoring Program

As a standard licence condition, the licensee of each nuclear facility shall develop, implement and maintain an environmental monitoring program to demonstrate that the public and the environment are protected from emissions resulting from the licensee's licensed activities. The licensees submit the results of these monitoring programs to the CNSC to ensure compliance with applicable requirements, as set out in the applicable regulations.

The CNSC implements its Independent Environmental Monitoring Program (IEMP) to independently verify that the public and the environment around licensed nuclear facilities are protected. The IEMP is separate from, but complementary to the CNSC's ongoing compliance verification program. Under

the IEMP, samples are taken from public areas around licensed facilities. The amounts of radioactive and hazardous substances in those samples are measured and analyzed, and the results are compared against relevant guidelines, limits and objectives.

In 2019, CNSC staff conducted independent environmental monitoring at BWXT Toronto and BWXT Peterborough. The 2019 IEMP results, which are posted on the CNSC's IEMP web page, demonstrate that the public and the environment around these facilities are protected, and that no adverse environmental or health effects are expected as a result of these facility operations. In addition, these results are consistent with the results submitted by the licensees and demonstrate that the licensees' environmental protection programs continue to protect the health and safety of people and the environment.

However, in March 2020 during the BWXT licence renewal hearing, several interventions expressed concerns over the levels of beryllium in soil near the Peterborough facility observed during the CNSC's IEMP sampling campaigns in 2014, 2018 and 2019. In response to public concerns, CNSC staff were directed by the Commission to carry out expedited soil resampling for beryllium of properties adjacent to BWXT's Peterborough facility, with a special focus on the property where the Prince of Wales Public School is located. The Commission also directed CNSC staff to carry out an analysis of the results and to clarify the risk that the beryllium levels may present to the health and safety of the public and the environment. CNSC staff completed the additional sampling in July 2020. Once the sampled have been analyzed, the information will be made available.

6.5 Follow-up from previous Commission meeting

On December 11, 2019, during the presentation of the *Regulatory Oversight Report for Uranium and Nuclear Substance Processing Facilities in Canada: 2018* [8], the Commission requested two follow-up actions from CNSC staff:

- The Commission requested licensees to provide a direct point of contact to CNSC staff so that it can then be made publicly available to assist intervenors.
    - Status: Licensees provided the requested information and this action is CLOSED.
- CNSC staff were requested to provide a summary of the basis behind Derived Release Limits (DRLs)
    - Status: Please see the Fact Sheet for Licence Limits for Releases to the Environment attached in Appendix M.

6.6 Update on CNSC COVID-19 response and nuclear fuel cycle facility oversight

On March 15, 2020, the CNSC activated the Business Continuity Plan (BCP) in response to the COVID-19 pandemic. Effective March 16, all CNSC staff in Ottawa and at regional and site offices were directed to work from home. CNSC management immediately suspended all regular nuclear fuel cycle facility

compliance activities and identified activities that were considered critical in order to support continued safe operation of licensed facilities and delivery of the CNSC mission and mandate. For example, files scheduled to be presented to the Commission and the associated timelines for submission to the Secretariat were reviewed to confirm any impact and plan any mitigation measures.

The majority of nuclear fuel cycle program licensees (such as Canadian Nuclear Laboratories, Cameco, Orano, and Ontario Power Generation's waste management facilities) shut down their operations at the start of the pandemic. All licensees activated Business Continuity Plans and most stopped operations with non-essential staff working remotely. For licensees with operations deemed to be essential services (e.g., medical isotope production, global healthcare service providers), operations were not interrupted and public health guidelines were followed with additional safety protocols. As well, all licensees maintained all appropriate security measures at their sites. In all other cases, on-site licensees reduced the number of staff to the minimum required to maintain safety of the facility or site while in shut down state.

In April 2020, CNSC staff reviewed all planned on-site compliance activities on a risk-informed basis to determine an appropriate path forward. CNSC staff identified planned compliance activities well suited to be delivered by other means (e.g., remote verification methods, desktop review of documents and submission of licensee records or other supporting evidence) and adjusted planned activities as appropriate. Licensee changes drove many changes to CNSC oversight, particularly in cases where no regulatory oversight was needed due to a licensee cancelling a particular activity.

The CNSC developed a pandemic-related Pre-Job Brief as additional instructions to be delivered by CNSC directors to inspectors prior to performing on-site oversight activities. The CNSC provided personal protective equipment (PPE) to inspectors prior to any on-site activity. The Pre-Job Brief clearly outlines the rights of individual employees to not attend an in-person inspection if they do not feel safe to do so.

Compliance activities of nuclear fuel cycle facilities continued remotely and on-site oversight activities have since resumed on a risk-informed basis in observance of relevant COVID-19 health protocols. CNSC staff continue to conduct oversight activities during the COVID-19 pandemic to ensure the protection of the environment, and the health and safety of people. Oversight activities completed in 2020 during the pandemic will be further described in the 2020 regulatory oversight report.

7 OVERALL CONCLUSIONS

CNSC staff concluded that uranium and nuclear substance processing facilities in Canada operated safely during the 2019 calendar year. This assessment is based on CNSC staff's verification of licensee activities, including onsite inspections, reviews of reports submitted by licensees, and reviews of events and incidents, supported by follow-up and general communication with the licensees.

In 2019, the performance ratings in all 14 SCAs for the facilities were rated as "satisfactory".

CNSC staff's compliance verification activities confirmed that:

- radiation protection programs at all facilities were effective and adequately controlled radiation exposures, keeping doses ALARA
- environmental protection programs at all facilities were effective in protecting people and the environment
- conventional health and safety programs at all facilities continued to protect workers

CNSC staff concluded that, in 2019, the licensees discussed in this report made adequate provision for the health and safety of workers, as well as for the protection of the public and the environment, and for meeting Canada's international obligations on the peaceful use of nuclear energy.

CNSC staff continue to provide regulatory compliance oversight to all licensed facilities.

REFERENCES

[1] *Nuclear Safety and Control Act*, S.C. 1997, c. 9.

[2] CSA Group, CSA N288.6-12, *Environmental Risk Assessments at Class I Nuclear Facilities and Uranium Mines and Mills*, 2012.

[3] *Radiation Protection Regulations* (2000), SOR/2000-203.

[4] *General Nuclear Safety and Control Regulations* (2000), SOR/2000-202.

[5] *Canada Labour Code*, R.S.C., 1985, c. L-2.

[6] CNSC, REGDOC-3.1.2: *Reporting Requirements for Non-Power Reactor Class I Nuclear Facilities and Uranium Mines and Mills*, Ottawa, Canada, 2018.

[7] CNSC, REGDOC-3.2.1, *Public Information and Disclosure*, Ottawa, Canada, 2018.

[8] CNSC, *Regulatory Oversight Report for Uranium and Nuclear Substance Processing Facilities in Canada: 2018*, Ottawa, Canada, 2019.

[9] CNSC, REGDOC-3.6, *Glossary of CNSC Terminology*, Ottawa, Canada, 2019.

[10] CSA Group, CSA N288.1-14, *Guidelines for calculating derived release limits for radioactive materials in airborne and liquid effluents for normal operation of nuclear facilities*, 2019 [10].

[11] Ministry of the Environment, Conservation and Parks. 2019. Ontario's Ambient Air Quality Criteria.

[12] Health Canada, *Guidelines for Canadian Drinking Water Quality*, 2017.

[13] Canadian Council of Ministers of the Environment, *Canadian Water Quality Guidelines for the Protection of Aquatic Life*, 1999.

[14] Canadian Council of Ministers of the Environment, *Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health*, 1999.

[15] CSA Group, CSA N288.7 *Groundwater protection programs at Class I nuclear facilities and uranium mines and mills*, 2015.

ACRONYMS AND ABBREVIATIONS

AANTC	Algonquin Anishinabeg Nation Tribal Council
ALARA	as low as reasonably achievable, taking into account social and economic factors
AFN	Alderville First Nation
AOO	Algonquins of Ontario
APFN	Algonquins of Pikwàkanagàn First Nation
BE	below expectations
Bq	becquerel
BRR	Blind River Refinery
BTL	Best Theratronics Ltd.
BWXT	BWXT Nuclear Energy Canada Inc.
CAD	Canadian dollar
Cameco	Cameco Corporation
CANDU	Canada Deuterium Uranium
CBFN	Chippewas of Beausoleil First Nation
CCME	Canadian Council of Ministers of the Environment
CFM	Cameco Fuel Manufacturing Inc.
CGIFN	Chippewas of Georgina Island First Nation
CLFN	Curve Lake First Nation
cm	centimetre
CMD	Commission Member Document
CNL	Canadian Nuclear Laboratories
CNSC	Canadian Nuclear Safety Commission
Co-60	cobalt-60
CRFN	Chippewas of Rama First Nation
CSA	Canadian Standards Association (now CSA Group)
DRL	derived release limit
EMS	environmental management system
ERA	environmental risk assessment
ERT	Emergency Response Team
ESDC	Employment and Social Development Canada
FFOL	fuel facility operating licence
FS	fully satisfactory

g	gram
GBq	gigabecquerel
GCDWQ	Guidelines for Canadian Drinking Water Quality
GEH-C	GE Hitachi Nuclear Energy Canada Inc.
GTLS	gaseous tritium light source
h	hour
HF	hydrogen fluoride
HFN	Hiawatha First Nation
HT	tritium gas
HTO	hydrogenated tritium oxide or tritiated water
HNO_3	nitric acid
IAEA	International Atomic Energy Agency
IEMP	Independent Environmental Monitoring Program
kg	kilogram
Km	kilometre
L	litre
LCH	licence conditions handbook
LTI	lost-time injury
m^3	cubic metres
MBq	megabecquerel
MeV	megaelectronvolt
mg	milligram
mg/L	milligram per litre
MBQ	Mohawks of the Bay of Quinte
MCFN	Mississaugas of the Credit First Nation
MFN	Mississauga First Nation
MECP	Ontario Ministry of the Environment, Conversation and Parks
MNO	Métis Nation of Ontario
MSIFN	Mississaugas of Scugog Island First Nation
mSv	millisievert
N	nitrogen
NEW	nuclear energy worker
NOx	nitrogen oxides
NO_2	nitrogen dioxide

Nordion	Nordion (Canada) Inc.
NSCA	*Nuclear Safety and Control Act*
NSPFOL	nuclear substance processing facility operating licence
OPG	Ontario Power Generation
PFP	Participant Funding Program
PHCF	Port Hope Conversion Facility
PPE	Personal protective equipment
ppm	parts per million
ROR	regulatory oversight report
RP	radiation protection
SA	satisfactory
SAN	Sagamok Anishnawbek Nation
SCA	safety and control area
SRBT	SRB Technologies (Canada) Inc.
SRFN	Serpent River First Nation
T_2	tritiated gas
TBq	terabecquerel
TFN	Thessalon First Nation
UA	unacceptable
µg	microgram
µSv	microsievert
UF_6	uranium hexafluoride
UO_2	uranium dioxide
UO_3	uranium trioxide
VIM	Vision in Motion
WSC	Workplace Safety Committee
WTFN	Williams Treaties First Nations

GLOSSARY

For definitions of terms used in this document, see REGDOC-3.6, *Glossary of CNSC Terminology* [9], which includes terms and definitions used in the *Nuclear Safety and Control Act* [1] and the regulations made under it, and in CNSC regulatory documents and other publications. REGDOC-3.6 is provided for reference and information.

A. Links to licensee websites

Licensee	Website	2019 Annual Compliance Reports
Cameco BRR	camecofuel.com/business/blind-river-refinery	2019 Annual Compliance Report
Cameco PHCF	camecofuel.com/business/port-hope-conversion-facility	2019 Annual Compliance Report
Cameco CFM	camecofuel.com/business/cameco-fuel-manufacturing	2019 Annual Compliance Report
BWXT Toronto and Peterborough	nec.bwxt.com	2019 Annual Compliance Report
SRBT	srbt.com	2019 Annual Compliance Report
Nordion	nordion.com	2019 Annual Compliance Report
BTL	theratronics.ca	2019 Annual Compliance Report

B. CNSC inspections

Table B-1: Inspections, BRR, 2019

Inspection title	Safety and control areas covered	Inspection report sent date
CAMECO-BRR-2019-01	Management system, fitness for service, operating performance, radiation protection, conventional health and safety, human performance management	May 31, 2019
CAMECO-BRR-2019-02	Emergency management and fire protection	December 6, 2019
CAMECO-BRR-2019-03	Packaging and transport	January 21, 2020
CAMECO-BRR-2019-04	Fitness for service	March 4, 2020

Table B-2: Inspections, PHCF, 2019

Inspection Title	Safety and control areas covered	Inspection report sent date
CAMECO-PHCF-2019-01	Security	PROTECTED
CAMECO-PHCF-2019-02	Management system, human performance management, fitness for service, radiation protection, conventional health and safety, environmental protection	June 13, 2019
CAMECO-PHCF-2019-03	Emergency management and fire protection	October 1, 2019
CAMECO-PHCF-2019-04	Management system, fitness for service, operating performance, radiation protection, conventional health and safety	November 1, 2019

Table B-3: Inspections, CFM, 2019

Inspection title	Safety and control areas covered	Inspection report sent date
CAMECO-CFM-2019-01	Management System	June 21, 2019
CAMECO-CFM-2019-02	Operating performance, fitness for service, conventional health and safety, radiation protection	September 19, 2019
CAMECO-CFM-2019-03	Emergency management and fire protection	January 8, 2020

Table B-4: Inspections, BWXT Toronto and Peterborough, 2019

Inspection title	Safety and control areas covered	Inspection report sent date
BWXT-2019-01	Management system	July 31, 2019
BWXT-2019-02	Operating performance, physical design, fitness for service, radiation protection, conventional health and safety, environmental protection, emergency management and fire protection	June 3, 2019
BWXT-2019-03	Radiation protection	January 21, 2020

Table B-5: Inspections, SRBT, 2019

Inspection title	Safety and control areas covered	Inspection report sent date
SRBT-2019-01	Operating performance, fitness for service, radiation protection, conventional health and safety, environmental protection, waste management	May 6, 2019
SRBT-2019-02	Environmental protection	November 1, 2019

Note: Security inspection reports contain sensitive information and will not be made public.

Table B-6: Inspections, Nordion, 2019

Inspection title	Safety and control areas covered	Inspection report sent date
NORDION-2019-01	Security	PROTECTED
NORDION-2019-02	Packaging and transport	June 3, 2019
NORDION-2019-03	Emergency management and fire protection	September 18, 2019
NORDION-2019-04	Packaging and transport	November 18, 2019

Table B-7: Inspections, BTL, 2019

Inspection title	Safety and control areas covered	Inspection report sent date
BT-2019-01	Waste management, radiation protection, environmental protection, operating performance, conventional health and safety	July 16, 2019

C. Significant changes to licence and licence conditions handbook

Table C-1: Changes to the licence

Licensee	Date	Facility licence	Summary of changes
Nordion	February 26, 2019	NSPFOL-14.01/2025	Nordion requested a transfer of its operating licence to a new corporate identity with the same name but with a new corporate number, to reflect the amalgamation of Nordion with its direct parent company and two other non-licensee-affiliated companies. There are no changes to the existing licensed operations as a result of the licence transfer.
BTL	July 1, 2019	NSPFL-14.00/2029	On May 2019, the Commission held a hearing in Ottawa regarding the renewal of BTL's operating licence. The Commission issued BTL's licence on July 1, 2019

Table C-1: Changes to the LCH

Licensee	Date	Facility licence	Summary of changes
Nordion	January 25, 2019	NSPFOL-14.00/2025	**LCH Revision 1:** • Updated formatting • Removed transition descriptions for: o CSA N286-12 (Management System) o REGDOC-2.2.2, Personnel Training (Human Performance Management) o CSA N393 (Fire Protection) o CSA N288.4 (Environmental Protection) o REGDOC 2.10.1 (Emergency Response) o REGDOC 2.12.3 (Security, sealed sources)

			• Updated Release Limits table to reflect implementation of CSA N288 series documents
			• Added guidance for
			  ○ CSA N288.7 and N288.8 (Environmental Protection)
			  ○ CSA B-51 (Physical Design)
			  ○ CSA N292.1 and IAEA NS-R-5 (Safety Analysis)
			  ○ CSA N292.0 (Waste Management)
			• Included REGDOC-2.13.1 as compliance verification criteria for Safeguards and Non-Proliferation, and removed RD-336.
			• Included REGDOC-3.1.2 as compliance verification criteria for Reporting
			• Revised action level reporting dates from 60 days to 21 days, in line with REGDOC-3.1.2
			• Included REGDOC-2.11.1 as guidance for Waste Management, and removed G-320 and P-290
			• Added REGDOC 3.2.1 as Guidance for Public Information and Disclosure

Nordion	February 26, 2019	NSPFOL-14.01/2025	**LCH Revision 2:** • Updated licence number from NSPFOL-11A.00/2025 to NSPFOL-11A.01/2025 • Updated Nordion corporate number from 891613-6 to 1115250-5 to reflect licence transfer • Updated licence period from "November 1, 2015 to October 31, 2025" to February 26, 2019 to October 31, 2025, to reflect licence transfer
BTL	July 1, 2019	NSPFL-14.00/2029	First release of BTL's LCH after the May 2019 relicensing hearing held in Ottawa. The Commission issued BTL's licence on July 1, 2019

D. Regulatory document implementation

Regulatory document	Version	PHCF	BRR	CFM	BWXT
REGDOC-2.10.1, *Nuclear Emergency Preparedness and Response*	February 2016	Implemented	Implemented	Implemented	Implemented
REGDOC-2.2.2, *Personnel Training*	December 2016	Implemented	Implemented	Implemented	Implemented
REGDOC-2.9.1, *Environmental Protection: Environmental Principles, Assessments and Protection Measures*	April 2017	Implementation plans expected in 2020	Implementation plans expected in 2020	Implementation plans expected in 2020	Implementation plans expected in 2020
REGDOC-3.1.2, *Reporting Requirements, Volume I: Non-Power Reactor Class I Nuclear Facilities and Uranium Mines and Mills*	January 2018	Implemented	Implemented	Implemented	Implemented
REGDOC-2.13.1, *Safeguards and Nuclear Material Accountancy*	February 2018	Implemented	Implemented	Implemented	Implementation expected by January 2019
REGDOC-2.1.2, *Safety Culture*	April 2018	Implementation expected by June 2022	Implementation expected by June 2022	Implementation expected by June 2022	Implemented
REGDOC-3.2.1, *Public Information and Disclosure*	May 2018	Implementation plans expected in 2020	Implementation plans expected in 2020	Implementation plans expected in 2020	Implementation plans expected in 2020

Regulatory document	Version	SRBT	Nordion	BTL
REGDOC-2.10.1, *Nuclear Emergency Preparedness and Response*	February 2016	Implemented	Implemented	Implemented
REGDOC-2.2.2, *Personnel Training*	December 2016	Implemented	Implemented	Implemented
REGDOC-2.9.1, *Environmental Protection: Environmental Principles, Assessments and Protection Measures*	April 2017	Implementation plans expected in 2020	Implementation plans expected in 2020	Implementation expected by December 2020
REGDOC-3.1.2, *Reporting Requirements, Volume I: Non-Power Reactor Class I Nuclear Facilities and Uranium Mines and Mills*	January 2018	Implemented	Implemented	Implemented
REGDOC-2.13.1, *Safeguards and Nuclear Material Accountancy*	February 2018	N/A	Implemented	Implemented
REGDOC-2.1.2, *Safety Culture*	April 2018	Implemented	Implemented	Implementation expected by December 2020
REGDOC-3.2.1, *Public Information and Disclosure*	May 2018	Implementation plans expected in 2020	Implementation plans expected in 2020	Implementation expected by December 2020

E. Financial guarantees

Table E-1: Financial guarantees, uranium processing facilities

Facility	Amount Canadian dollar (CAD)
BRR	$48,000,000
PHCF	$128,600,000
CFM	$21,000,000
BWXT Toronto	$45,568,100
BWXT Peterborough	$6,803,500

Table E-2: Financial guarantees, nuclear substance processing facilities

Facility	Amount (CAD)
SRBT	$727,327
Nordion	$45,124,748
BTL	$1,800,000

F. Safety and control area ratings

Please note that in order to prioritize work in the context of the COVID pandemic, facility performance assessment used a binary approach for the 2019 ROR. For 2019, that is, licensees were only rated as "Satisfactory (SA)" or "Below Expectation (BE)", and the "Fully Satisfactory (FS)" rating was not used. It is important to recognize that a facility that received an SCA rating of FS in the 2018 ROR and now has a rating of SA, does not necessarily indicate a reduction in performance. The binary rating approach considerably reduced the effort that is often needed to reach a consensus on a final rating.

Table F-1: SCA ratings, BRR facility, 2015–19

SCAs	2015 rating	2016 rating	2017 rating	2018 rating	2019 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	FS	FS	FS	FS	SA
Environmental protection	SA	SA	SA	SA	SA
Emergency management and fire protection	SA	SA	SA	SA	SA
Waste management	SA	SA	SA	SA	SA
Security	SA	SA	SA	SA	SA
Safeguards and non-proliferation	SA	SA	SA	SA	SA
Packaging and transport	SA	SA	SA	SA	SA

FS = fully satisfactory; SA = satisfactory

Table F-2: SCA ratings, PHCF, 2015–19

SCAs	2015 rating	2016 rating	2017 rating	2018 rating	2019 rating
Management system	SA	SA	BE	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

BE = below expectations; SA = satisfactory

Table F-3: SCA ratings, CFM, 2015–19

SCAs	2015 rating	2016 rating	2017 rating	2018 rating	2019 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

SA = satisfactory

Table F-4: SCA ratings, BWXT Toronto and Peterborough, 2015–19

SCAs	2015 rating	2016 rating	2017 rating	2018 rating	2019 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

SA = satisfactory

Table F-5: SCA ratings, SRBT, 2015–19

SCAs	2015 rating	2016 rating	2017 rating	2018 rating	2019 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	FS	FS	FS	FS	SA
Radiation protection	SA	SA	SA	SA	SA
Conventional health and safety	FS	FS	SA	FS	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*	N/A	N/A	N/A	N/A	N/A
Packaging and transport	SA	SA	SA	SA	SA

FS = fully satisfactory; N/A = not applicable; SA = satisfactory
*There are no safeguard verification activities associated with this facility.

Table F-6: SCA ratings, Nordion, 2015–19

SCAs	2015 rating	2016 rating	2017 rating	2018 rating	2019 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	FS	FS	FS	FS	SA
Emergency management and fire protection	SA	SA	SA	SA	SA
Waste management	SA	SA	SA	SA	SA
Security	FS	FS	FS	FS	SA
Safeguards and non-proliferation	SA	SA	SA	SA	SA
Packaging and transport	SA	SA	SA	SA	SA

FS = fully satisfactory; SA = satisfactory

Table F-7: SCA ratings, BTL, 2015–19

SCAs	2015 rating	2016 rating	2017 rating	2018 rating	2019 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	BE	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

BE = below expectations; SA = satisfactory

G. Total annual releases of radionuclides directly to the environment

The CNSC is making radionuclide release data more readily accessible to the public as part of its commitment to Open Government and its mandate to disseminate this information to the public; this appendix reflects the continued commitment to provide data, within the regulatory oversight reports, on the total annual release of radionuclides.

CNSC staff have commenced publishing annual releases of radionuclides to the environment from nuclear facilities on the CNSC Open Government Portal: https://open.canada.ca/data/en/dataset/6ed50cd9-0d8c-471b-a5f6-26088298870e.

Uranium processing facilities

Direct releases of radionuclides to the environment from uranium fuel refinery, manufacturing and conversion facilities are primarily limited to uranium released to the atmosphere. As uranium is more chemically toxic than radiologically toxic, releases are monitored as total uranium. As a result, the annual load is reported in kilograms. Of these facilities, only Cameco's Blind River Refinery has direct releases to surface water; the relevant radionuclides are uranium and radium-226.

Table G-1: Total annual load of relevant radionuclides released to atmosphere or surface waters for uranium processing facilities, 2015–19

Facility and year	Annual uranium release to air (kg)	Annual uranium released in liquid effluent to surface waters (kg)	Total radium-226 released in liquid effluent to surface waters (MBq)
Blind River Refinery			
2015	1.3	2.6	1.06
2016	1.0	1.2	0.92
2017	0.8	1.9	1.04
2018	1.2	1.9	1.05
2019	2.0	2.7	2.10
Port Hope Conversion Facility			
2015	38.7	N/A	N/A
2016	34.3	N/A	N/A
2017	31.5	N/A	N/A
2018	34.1	N/A	N/A
2019	48.5	N/A	N/A
Cameco Fuel Manufacturing			
2015	0.46	N/A	N/A
2016	0.73	N/A	N/A
2017	0.58	N/A	N/A
2018	1.26	N/A	N/A
2019	1.09	N/A	N/A
BWXT Toronto			
2015	0.0108	N/A	N/A
2016	0.0108	N/A	N/A
2017	0.0074	N/A	N/A
2018	0.0063	N/A	N/A
2019	0.0071	N/A	N/A
BWXT Peterborough			
2015	0.000003	N/A	N/A
2016	0.000004	N/A	N/A
2017	0.000002	N/A	N/A
2018	0.000002	N/A	N/A
2019	0.000004	N/A	N/A

MBq = megabecquerel; N/A = not applicable

Nuclear substance processing facilities

SRBT

Direct releases to the environment for SRBT are limited to atmospheric releases of tritium. There are no direct releases to surface waters.

Table G-2: Total annual load of relevant radionuclides released to atmosphere, SRBT, 2015–19

Year	Tritium	
	Tritiated water or HTO (GBq)	Elemental tritium or T_2 (GBq)
2015	1.15E+04	4.47E+04
2016	6.29E+03	2.27E+04
2017	7.20E+03	1.76E+04
2018	1.07E+04	2.24E+04
2019	1.19E+04	1.99E+04

GBq = gigabecquerel; HTO = hydrogenated tritium oxide; HT = tritium gas

Nordion

Direct radionuclide releases to the environment at Nordion are limited to atmospheric releases.

Table G-3: Total annual load of relevant radionuclides released to the atmosphere, Nordion, 2015–19

Year	Cobalt-60 (GBq)	Iodine-125 (GBq)	Iodine-131 (GBq)	Xenon-133 (GBq)	Xenon-135 (GBq)	Xenon-135m (GBq)
2015	0.005	0.12	0.15	11,916	8,237	10,758
2016	0.006	0.21	0.35	7,277	4,299	5,421
2017	0.0034	0.0012	0.0008	0	0	0
2018	0.002	0	0.006	0	0	0
2019	0.00002	0	0	0	0	0

GBq = gigabecquerel

BTL

BTL does not have any airborne or liquid radiological releases.

H. Public dose data

This appendix contains information on the estimated dose to the public around uranium and nuclear substance processing facilities. Regulatory release limits known as derived release limits or DRLs are site-specific calculated releases that could, if exceeded, expose a member of the public of the most highly exposed group to a committed dose equal to the regulatory annual dose limit of 1 mSv/year, pursuant to subsection 1(3) of the *Radiation Protection Regulations* [3]. DRLs are calculated using CSA standard N288.1-14, *Guidelines for calculating derived release limits for radioactive materials in airborne and liquid effluents for normal operation of nuclear facilities* [10].

Considering the fact that the radiological releases from all the sites covered by this ROR have remained small fractions of the DRLs applicable to those sites, the contribution to the dose to the public from these releases remains a very small fraction of the prescribed limit for the general public.

Table H-1: Public dose comparison table (mSv), uranium and nuclear substance processing facilities, 2015–19

Facility	Year					Regulatory limit
	2015	2016	2017	2018	2019	
BRR	0.005	0.005	0.005	0.005	0.005	**1 mSv/year**
PHCF	0.006	0.020	0.153*	0.173	0.127	
CFM	0.025	0.023	0.022	0.030	0.027	
BWXT Toronto	0.010	0.0007	0.0175	0.0004	0.023	
BWXT Peterborough	<0.001	<0.001	<0.001	<0.001	0.0115	
SRBT	0.0068	0.0046	0.0033	0.0038	0.0021	
Nordion	0.0057	0.0021	0.000052	0.000067	0.00087	
BTL	N/A	N/A	N/A	N/A	N/A	

N/A = not available (No activities occur inside the BTL facility that result in the release of radioactive material to the environment); mSv = millisievert

*In 2016, PHCF updated the dose calculations related to releases to water and the fenceline gamma locations used for reporting the dose to the public. The amounts in 2017 and 2018 look higher than in previous years, but there has not been an actual increase in emissions/dose from the facility. The results actually represent a much more conservative estimate of dose to the public, as the gamma monitoring location at the facility fenceline is now closer to the operating facility than the previous location, resulting in the increase shown in the table. For this reason, the results beginning in 2017 cannot be compared with previous years' results.

I. Environmental data

This appendix provides environmental data for each uranium and nuclear substance processing facility.

Blind River Refinery

Atmospheric emissions

Cameco monitors uranium, nitrogen oxides (NO_x), nitric acid (HNO_3) and particulates released from the facility stacks. The monitoring data in Table I-1 demonstrates that atmospheric emissions from the facility continued to be effectively controlled as annual averages were consistently well below their respective licence limits between 2015 and 2019.

Table I-1: Air emission monitoring results (annual averages), BRR, 2015–19

Parameter	2015	2016	2017	2018	2019	Licence limit
Dust collection and exhaust ventilation stack: uranium (kg/h)	0.00005	0.00005	0.00004	0.00005	0.00005	**0.1**
Absorber stack: uranium (kg/h)	0.00001	0.00001	0.00001	0.00001	0.00001	**0.1**
Incinerator stack: uranium (kg/h)	0.00001	<0.00001	<0.00001	<0.00001	<0.00001	**0.01**
NO_X + HNO_3 (kg NO_2/h)	2.5	1.6	1.8	2.3	3.3	**56.0**
Particulate (kg/h)	0.006	0.006	0.008	0.010	0.012	**11.0**

HNO_3 = nitric acid; kg/h = kilogram per hour; NO_2 = nitrogen dioxide; NO_x = nitrogen oxides
Note: Results less than detection limit are denoted as "<".

Liquid Effluent

There are three sources of allowable liquid effluent from the BRR facility: plant effluent, storm water runoff and sewage treatment plant effluent. These effluents are collected in lagoons and treated, as required, prior to discharge into Lake Huron. Cameco monitors uranium, radium-226, nitrates and pH in liquid effluents to demonstrate compliance with their respective licence limits. In addition to licence limits, BRR has action levels that are used to provide assurance that the licence release limits will not be exceeded. No action levels for liquid effluents were exceeded at any time in 2019.

Table I-2 summarizes the average monitoring results from 2015 to 2019. For 2019, the liquid discharges from the facility continued to be within their respective licensed limits.

Table I-2: Liquid effluent monitoring results (annual averages), BRR, 2015–19

Parameter	2015	2016	2017	2018	2019	Licence limit
Uranium (mg/L)	0.02	0.01	0.01	0.01	0.01	**2**
Nitrates (mg/L)	13	11	14	20	21	**1,000**
Radium-226 (Bq/L)	<0.01	0.01	0.01	0.01	0.01	**1**
pH (min)	7.2	7.3	7.3	7.3	7.2	**Min 6.0**
pH (max)	8.4	8.6	8.2	8.5	8.4	**Max 9.5**

Bq/L = Becquerel per litre; mg/L = milligram per litre
Note: Results less than detection limit are denoted as "<".

Uranium in ambient air

The concentrations of uranium in the ambient air, as monitored by Cameco's sampling network around BRR, continued to be consistently low. In 2019, the highest annual average concentration (among the sampling stations) of uranium in ambient air measured was 0.004 µg/m^3, which is well below the Ministry of the Environment, Conservation and Parks (MECP) Ambient Air Quality Criteria (AAQC) for uranium of 0.03 µg/m^3 [11].

Groundwater monitoring

Cameco has an extensive groundwater monitoring program in place around the facility with 35 monitoring wells: 14 wells located inside the perimeter fence and 21 outside the fenceline. Though not used as a potable water source, uranium concentrations from all the groundwater monitoring wells in 2019 were below Health Canada's *Guidelines for Canadian Drinking Water Quality* (GCDWQ) for uranium [12]. Table I-3 below provides groundwater monitoring results.

Table I-3: Annual groundwater monitoring results, 2015–19

Parameter	2015	2016	2017	2018	2019	GCDWQ*
Average uranium concentration (µg/L)	1.7	1.3	1.2	2.3	2.0	**20**
Maximum uranium concentration (µg/L)	18.5	14.0	11.0	27.0	14.0	**20**

GCDWQ = *Guidelines for Canadian Drinking Water Quality* [12]; µg/L = microgram per litre
*None of the groundwater wells monitored are used for drinking water.

Surface water monitoring

Cameco continues to monitor surface water for uranium, nitrate, radium-226 and pH at the location of BRR's outfall diffuser in Lake Huron. The concentrations of uranium, nitrate, radium-226 and the pH levels in the lake remained well below the CCME guidelines. Table I-4 below provides surface water monitoring results.

Table I-4: Surface water annual average results at outfall diffuser in Lake Huron, 2015–19

Parameter		2015	2016	2017	2018	2019	CCME guidelines*
Uranium (µg/L)	**Average**	0.2	<0.8	<0.8	<0.7	<0.7	**15**
	Maximum	0.4	<0.8	<0.8	<0.7	<0.7	
Nitrate (mg/L as N)	**Average**	0.2	0.2	0.2	0.2	0.1	**13**
	Maximum	0.2	0.2	0.2	0.2	0.2	
Radium-226 (Bq/L)	**Average**	<0.005	<0.005	<0.005	0.008	<0.005	**N/A**
	Maximum	<0.005	<0.005	<0.005	0.008	<0.005	
pH	**Average**	7.3	8.0	7.3	8.0	8.1	**6.5–9.0**
	Maximum	7.9	8.2	7.7	8.3	8.2	

Bq/l = Becquerel per litre; CCME = Canadian Council of Ministers of the Environment; mg/L = milligrams per litre; µg/L = microgram per litre

Note: Results below the detection limit are denoted as "<".

*****CCME, *Canadian Water Quality Guidelines for the Protection of Aquatic Life* [13]

Soil monitoring

Cameco collects soil samples at the 0 to 5 cm depth each year and at the 5 to 15 cm depth every five years, in order to monitor uranium concentrations in surface soil for long-term effects of air emissions on soil quality due to deposition of airborne uranium on soil in the vicinity of the BRR facility. The 2019 soil monitoring results remained consistent with the respective concentrations detected in previous years as shown in table I-5; that is, that uranium soil concentrations did not appear to increase in the area surrounding the facility. The maximum uranium soil concentrations measured near the facility were

slightly above Ontario's natural background levels (up to 2.5 µg/g) and well below 23 µg/g, which is the most restrictive soil quality guideline set by the CCME for uranium (for residential and parkland land use) [14]. This data demonstrates that the current BRR operations do not contribute to accumulation of uranium in surrounding soil, and that no adverse consequences to relevant human and environmental receptors are expected.

Table I-5: Soil monitoring results (0-5 cm depth), 2015–19

Parameter	2015	2016	2017	2018	2019	CCME guidelines*
Average uranium concentration (µg/g) within 1,000 m	3.8	1.5	1.6	2.0	2.1	**23**
Average uranium concentration (µg/g) outside 1,000 m	1.4	0.5	0.6	0.7	1.0	
Maximum uranium concentration (µg/g)	9.7	2.9	2.8	3.7	3.8	

cm = centimetre; CCME = Canadian Council of Ministers of the Environment; µg/g = microgram per gram
*CCME, *Soil Quality Guidelines for the Protection of Environmental and Human Health* [14] (for residential/parkland land use)

Gamma monitoring

A portion of radiological public dose from BRR operations is due to gamma radiation sources. Consequently, monitoring of gamma radiation effective dose rates at the fenceline of the BRR main site and the nearby golf course (the critical receptor location) is essential to ensuring that levels of potential gamma radiation exposure are maintained ALARA. The land immediately outside the perimeter fence continues to be owned and controlled by Cameco. Therefore, Cameco sets an action level for gamma dose rates of 1.0 µSv/h at the north fence only, because the critical receptor location for the gamma component of dose to the public is the neighbouring golf course north of the BRR site. Cameco uses environmental dosimeters which are replaced monthly to measure the effective dose rates for gamma radiation. In 2019, the maximum monthly fenceline gamma measurements at the BRR site was 0.50 µSv/h (east), 0.30 µSv/h (north), 0.51 µSv/h (south) and 1.01 µSv/h (west). All north fenceline results in 2019 were below the action level. These measurements indicate that gamma dose rates are controlled and that the public is protected.

Port Hope Conversion Facility

Atmospheric emissions

Cameco monitors uranium, fluorides and ammonia released from stacks at PHCF. The monitoring data in Table I-6 demonstrates that the atmospheric emissions from the facility continued to be effectively controlled, as annual averages remained consistently below their respective licence limits from 2015 to 2019.

Table I-6: Air emission monitoring results (annual daily average), PHCF, 2015–19

Location	Parameter	2015	2016	2017	2018	2019	Licence limit
UF_6 plant	Uranium (kg/h)	0.0017	0.0012	0.0011	0.0014	0.0027	**0.280**
	Fluorides (kg/h)	0.0170	0.0100	0.021	0.030	0.018	**0.650**
UO_2 plant	Uranium (kg/h)	0.0012	0.0010	0.0005	0.0007	0.0008	**0.240**
	Ammonia (kg/h)	2.4	1.7	1.4	1.7	2.1	**58**

UO_2 = uranium dioxide; UF_6 = uranium hexafluoride

The annual daily average uranium emission in 2019 at the UF_6 has increased when compared to levels within the five year period, as a result of increased production days and volumes.

Liquid effluent

Cameco's operating licence does not allow the discharge of any process waste water effluent from PHCF. In 2019, there were no process liquid discharges from PHCF. Cameco continues to collect and evaporate rather than discharge process liquid effluent.

Cameco does discharge non-process liquid effluent, such as cooling water and sanitary sewer discharges, from PHCF. Cameco monitors these releases in compliance with the requirements of other regulators that have jurisdiction. In 2016 and early 2017, as part of the licence renewal process, a daily sanitary sewage discharge action level of 100 µg uranium per litre (U/L) and a monthly mean release limit of 275 µg U/L were developed and accepted. The sanitary sewage action level was exceeded on multiple occasions in 2017, 2018, and 2019. This was attributed to the unusually high Lake Ontario water elevations and associated groundwater infiltration to the sanitary sewer system due to significant precipitation events.

As a result of these exceedances, Cameco implemented a number of corrective actions between 2017 and 2019. In fall 2019, Cameco completed the implementation of these corrective actions which has helped reduce the number of action level exceedances in 2020.

Cameco is continuing to repair sections of the sanitary sewer network and is upgrading it as part of the Vison in Motion (VIM) project. CNSC staff concluded that in 2019,

Cameco met its licence requirement not to discharge process wastewater effluent and to keep the sanitary sewer discharges below their respective release limits.

Groundwater monitoring

Cameco samples groundwater quality at the PHCF in the following monitoring wells:

- 12 active pumping wells on a monthly basis
- 55 monitoring wells in the overburden (soil) on a quarterly basis
- 15 monitoring wells in the bedrock on an annual basis

The pump-and-treat wells have been performing as expected. They continue to reduce the mass of groundwater contaminants before discharging water into the harbour, at rates similar to previous years, as shown in table I-7 below.

CNSC staff review Cameco's annual groundwater monitoring reports and noted that in 2019 there were increasing trends of nitrite concentrations in South Plume groundwater monitoring wells, Radium-226 concentrations in East Plume monitoring wells, and ammonia concentrations in the original UF_6 plant area. The elevated concentrations do not impose an adverse impact to surface water in the harbour, however, CNSC staff are in communications with Cameco to ensure that the legacy onsite groundwater contamination is under control and Cameco's current operation is not causing an adverse impact to the groundwater environment.

Table I-7: Mass (kg) of contaminants removed by pumping wells, 2015–19

Parameter	2015	2016	2017	2018	2019
Uranium	25.3	22.8	34.0	27.0	27.0
Fluoride	48.3	36.9	61.0	57.0	47.0
Ammonia	63.7	73.6	70.0	66.0	39.0
Nitrate	44.0	42.6	56.0	124.0	69.0
Arsenic	2.6	1.9	3.0	1.0	0.5

kg = kilogram

Surface water monitoring

The surface water quality in the harbour near the PHCF site has been monitored since 1977 through the analysis of samples collected from the south cooling water intake near the mouth of the Ganaraska River. The trend of surface water quality over time shows improvement since 1977 and very low uranium levels.

Surface water in the harbour is sampled at 13 locations on a quarterly basis. This activity includes the collection of samples at depths slightly below the water surface and slightly above the harbour sediment layer at each location. These sampling locations were restricted beginning in 2018 due to CNL's remedial harbour activities; however, PHCF

has continued to conduct ongoing monitoring of the cooling water intake located in the Port Hope harbour near the mouth of the Ganaraska River. Given its proximity to the harbor outlet, the cooling water intake provides a good indication of the overall water quality in the Port Hope harbour under routine/baseline conditions. Unusual and non-routine circumstances such as the 2018 west turning basin wall failure, CNL harbour isolation works and CNL harbour remedial activities have influenced the Port Hope Harbour water quality. Table I-8 below provides annual average and maximum concentrations of uranium, fluoride, nitrate and ammonia monitored in the harbour water from 2015 to 2019.

The maximum uranium concentration was elevated compared to previous years due to CNL's inner harbour remedial work and associated sediment disturbances in 2019. Uranium concentrations in the cooling water intake have been trending downward in 2020.

Table I-8: Harbour water quality, 2015–19

Parameter	Value	2015	2016	2017	2018	2019	CCME* guidelines
Uranium (µg/L)	Average	2.9	2.6	3.3	5.2	5.1	**15**
	Maximum	6.6	10	8.8	31	46	
Fluoride (mg/L)	Average	0.13	0.15	0.19	0.16	0.092	**0.12**
	Maximum	0.17	0.22	0.29	0.36	0.18	
Nitrate (mg/L)	Average	0.89	0.85	1.0	1.0	0.95	**13**
	Maximum	1.7	1.6	2.2	1.8	1.6	
Ammonia + ammonium (mg/L)	Average	0.20	0.16	0.18	0.13	0.031	**0.3**
	Maximum	0.66	0.58	0.40	0.47	0.21	

CCME = Canadian Council of Ministers of the Environment; mg/L = milligrams per litre; µg/g = microgram per gram
*****CCME, *Canadian Water Quality Guidelines for the Protection of Aquatic Life*

Soil monitoring

Cameco's soil monitoring program consists of five monitoring locations beyond the facility's fenceline in Port Hope. Three of these locations are within a 0 to 500 m radius zone from the facility, while the remaining two monitoring locations are within the 500 to 1,000 m and 1,000 to 1,500 m radius zones. This includes one location (waterworks side yard) remediated with clean soil to avoid interference from historical uranium soil contamination. Cameco takes samples annually at various depths within the soil profile to determine whether the concentration of uranium has changed as compared with previous sample results.

The measured average uranium-in-soil concentrations in 2019 have remained similar to those of past years. This suggests that uranium emissions from current PHCF operations do not contribute to accumulation of uranium in soil. Table I-9 below provides soil sampling results for the waterworks side yard location from 2015-2019. The results have been well below the most restrictive CCME *Soil Quality Guidelines for the Protection of Environmental and Human Health* [14] for residential and parkland land use (23 µg/g) and within the range of the natural background levels for Ontario (up to 2.5 µg/g).

Cameco has made a commitment to maintain the existing five soil monitoring locations and to report the results to the CNSC each year. Reclamation activities, as part of the Port Hope Area Initiative, will provide an opportunity for Cameco to review the locations of its soil monitoring stations throughout the Port Hope community.

Table I-9: Uranium concentrations at waterworks side yard remediated with clean soil (µg/g), 2015–19

Soil depth (cm)	2015	2016	2017	2018	2019	CCME guidelines*
0–5	1.0	1.2	0.8	0.91	0.82	**23**
5–10	1.0	1.1	0.8	0.85	0.74	
10–15	1.2	1.0	0.9	0.98	0.80	

CCME = Canadian Council of Ministers of the Environment; cm = centimetre; µg/g = microgram per gram
*CCME, *Soil Quality Guidelines for the Protection of Environmental and Human Health* [14] (for residential/parkland land use)

Fluoride monitoring

The impact of fluoride emissions from PHCF on the environment is determined each growing season. At that time, samples of fluoride-sensitive vegetation are collected and then analyzed for fluoride content. The vegetation sampling program was modified in 2017, when sampling locations were standardized to Manitoba maple locations where clusters of trees were sampled as composite samples versus single location sampling. The results in 2019 as shown in table I-10 below continued to be well below the MECP's Upper Limit of Normal Guideline of 35 parts per million.

Table I-10: Fluoride concentration in local vegetation, 2015–19

Parameter	2015	2016	2017	2018	2019	MECP guidelines*
Fluoride in vegetation (ppm)	3.2	3.0	11.0	5.0	5.0	**35**

MECP = Ontario Ministry of the Environment, Conservation and Parks; ppm = parts per million
*****MECP's Upper Limit of Normal Guidelines

Gamma monitoring

A portion of radiological public dose from PHCF operations is due to gamma radiation sources. Consequently, monitoring gamma radiation effective dose rates at the fenceline of the two PHCF sites is essential to ensuring that levels of potential gamma radiation exposure are maintained ALARA. The gamma radiation effective dose rates for both sites are measured with environmental dosimeters supplied by a licensed dosimetry service. Per the 2016 Operating Release Level (ORL), the dose to the public is calculated for both Sites 1 (PHCF main site) and 2 (Dorset Street) using specific gamma fenceline monitoring locations. The modifications to the ORL in 2016 came into effect in 2017 and represent a much more conservative estimate of dose to the public. Due to these significant changes, the results beginning in 2017 cannot be compared with those of previous years. Refer to the "Radiation protection" section above on "Estimated dose to the public" for further information about the updates made to the ORL.

The 2015 and 2016 annual average of doses for gamma are shown in table I-11 below. The 2017, 2018 and 2019 maximum monthly doses for gamma are shown in table I-12. For 2017-2019, the specific gamma fenceline monitoring locations used for Site 1 included results from monitoring stations 2, 10 and 13; for Site 2, they included results from stations 2 and 21. The results at stations 2 and 13 are used for Site 1 public dose calculations prior to July 1, 2019 and stations 2 and 10 are used for Site 1 public dose calculations after July 1, 2019 due to the removal of station 13 at Centre Pier.

In 2019, the maximum monthly gamma measurements were all below the respective licensed limits for Cameco:

- Station 2 results measured 0.20 µSv/h; the licensed limit is 0.57 µSv/h.
- Station 13 results measured 0.00 µSv/h; the licensed limit is 0.40 µSv/h.
- Station 10 results measured 0.05 µSv/h; the licensed limit is 0.61 µSv/h.
- Station 21 results measured 0.06 µSv/h; the licensed limit is 0.26 µSv/h.

These measurements indicate that gamma dose rates are controlled and the public is protected.

Table I-11: Gamma monitoring results, annual average, 2015–16

Parameter	2015	2016	Licence limit
Site 1 (µSv/h)	0.007	0.005	**0.14**
Site 2 (Dorset Street)) (µSv/h)	0.044	0.054	**0.40**

µSv/h = microsievert per hour

Table I-12: Gamma monitoring results, maximum monthly, 2017–19

Station number and site	2017	2018	2019	Licence limit
Station 2 - Sites 1 and 2 (µSv/h)	0.25	0.26	0.20	**0.57**
Station 13/10* - Site 1 (µSv/h)	0.03	0.07	0.00/0.05*	**0.40/0.61***
Station 21 - Site 2 (µSv/h)	0.08	0.07	0.06	**0.26**

µSv/h = microsievert per hour
*Denotes values for station 10. The results at stations 2 and 13 are used for Site 1 public dose calculations prior to July 1, 2019 and stations 2 and 10 are used for Site 1 public dose calculations after July 1, 2019 due to the removal of station 13 at Centre Pier.

Cameco Fuel Manufacturing Inc.

Atmospheric emissions

Cameco continued to monitor uranium released as atmospheric emissions from the facility. The monitoring data in Table I-13 demonstrates that stack and building exhaust ventilation emissions from the facility continued to be effectively controlled as annual averages remained consistently well below their licence limits between 2015 and 2019.

Table I-13: Air emission monitoring results, CFM, 2015–19

Parameter	2015	2016	2017	2018	2019	Licence limit
Total uranium discharge through stacks (kg/year)	0.01	0.03	0.01	0.01	0.004	**14**
Total uranium discharge through building exhaust ventilation (kg/year)	0.45	0.70	0.57	1.25	1.09	

kg = kilogram

In 2018 and 2019, the annual uranium discharge through building exhaust ventilation was calculated by using a summation of the daily release values with a total sum provided for the year. This capability was built into the CFM facility's new environmental monitoring software and is a better reflection of day-to-day operations compared to using an average result. Previously, the annual value was calculated by adding the quarterly results (2016 and 2017) and using the annual average (2015). This caused the 2018 and 2019 annual result to be higher when compared with those of previous years due to the number of days used in the annual calculation compared to the number of days used in the quarterly

calculation. The summation of the daily values is more representative of the actual building ventilation emissions.

In addition to the licence limits, Cameco uses action levels to provide assurance that licence release limits will not be exceeded. No action levels for atmospheric emissions were exceeded at any time in 2019.

Liquid effluent

After liquid effluent generated from the production process is collected, an evaporator process is used to remove the majority of the uranium. The condensed liquid is sampled and analyzed prior to a controlled release to the sanitary sewer line. Cameco continues to monitor uranium released as liquid effluent from the facility. The monitoring data in Table I-14 demonstrates that liquid effluent from the facility in 2019 remained consistently well below the licence limit and continued to be effectively controlled.

Table I-14: Liquid effluent monitoring results, CFM, 2015–19

Parameter	2015	2016	2017	2018	2019	Licence limit
Total uranium discharge to sewer (kg/year)	1.24	0.85	0.64	0.84	0.39	**475**

kg = kilogram

In 2019, there was a reduction in the amount of uranium discharged to the sanitary sewer. The decrease is attributed to the installation and commissioning of the automated pellet grinding equipment in 2018. The pellet wash water on the automated lines is processed in the waste treatment circuit and not released to the sanitary sewer. This has resulted in a reduction of uranium discharged to the sewers.

In addition to the licence limits, Cameco uses action levels to provide assurance that licence release limits will not be exceeded. No action levels for liquid effluent were exceeded at any time in 2019.

Uranium in ambient air

Cameco operates high-volume air samplers to measure the airborne concentrations of uranium at points of impingement of stack plumes. The samplers are located on the east, north, southwest and northwest sides of the facility. In 2019, the results from these samplers showed that the highest annual average concentration of uranium in ambient air (among the sampling stations) was 0.0016 μg/m^3. This is well below MECP's Ambient Air Quality Criteria (AAQC) for uranium of 0.03 μg/m3 [11].

Due to the benefits offered by ICP-MS (inductively coupled plasma – mass spectrometry), CFM ceased alpha counting and exclusively used ICP-MS beginning in 2018 to analyze filters. The ICP-MS method allows results to be reported directly through the Cameco database system.

Groundwater monitoring

Groundwater has been monitored at the site twice a year since 1999 with a network of 70 monitoring wells, including 43 overburden, 23 shallow bedrock and 4 deep bedrock wells. The groundwater monitoring results confirmed that current operations are not contributing to the concentrations of uranium in groundwater on the licensed property.

Surface water monitoring

In 2019, Cameco collected surface water samples at nine locations in April, June, and October. The sample locations were on and adjacent to the facility, and were analyzed for uranium.

Uranium concentrations in all surface water samples collected in 2019 met the applicable CCME *Water Quality Guidelines for the Protection of Aquatic Life* [13].

All surface water samples satisfied the CCME guidelines for long-term exposure (15 µg/L) in the Gages Creek tributary. There were a few exceedances of the CCME guidelines for short-term exposure (33 µg/L) at the intermittent drainage locations SW-4 (93 µg/L in 2019-04 and 78 µg/L in 2019-06) and SW-9 (51 µg/L in 2019-06) that were attributed to groundwater infiltration within the upstream storm sewer works.

CNSC staff will continue to oversee Cameco's monitoring at locations around the vicinity of CFM to confirm that uranium concentrations remain at safe levels in surface water.

Soil monitoring

Every three years, Cameco collects soil samples from 23 locations surrounding the CFM facility. Soil samples were last collected in 2019 and analyzed for uranium content. The soil monitoring results are shown in table I-15 below. The 2019 average uranium concentration in soil near the CFM facility is within the Ontario natural background level of up to 2.5 µg/g. The maximum concentrations detected are attributable to historical contamination in Port Hope, which has long been recognized and continues to be the focus of environmental studies and cleanup activities. The results for all samples were below the CCME *Soil Quality Guidelines for the Protection of Environmental and Human Health* [14] of 23 µg/g. This is the most restrictive guideline; therefore, no adverse consequences to human and environmental receptors are expected. The next soil samples will be collected in 2022.

Table I-15: Soil monitoring results*

Parameter	2009	2010	2013	2016	2019	CCME guidelines**
Average uranium concentration (µg/g)	6.8	5.6	4.8	3.1	3.0	**23**
Maximum uranium concentration (µg/g)	17.0	21.1	17.4	10.2	7.6	

µg/g = microgram per gram
***** CFM reverted to a three-year soil monitoring program and did not monitor soil in 2011, 2012, 2014, 2015, 2017 and 2018.
** CCME, *Soil Quality Guidelines for the Protection of Environmental and Human Health* [14] (for residential and parkland land use)

Gamma monitoring

For the CFM facility, a portion of radiological public dose is due to gamma radiation sources. Consequently, monitoring of gamma radiation effective dose rates at the fenceline of the CFM site is essential to ensuring that levels of potential gamma radiation exposure are maintained ALARA. The gamma radiation effective dose rates for the site are measured with environmental dosimeters supplied by a licensed dosimetry service. In 2019, the annual average of fenceline gamma measurements at the CFM site was 0.051 µSv/h. CFM has a licensed limit for fenceline gamma dose rates of 0.35 µSv/h at the monitoring station corresponding to the critical receptor and 1.18 µSv/h at all other monitoring locations. No licence limits were exceeded in 2019.

In addition to licence limits, CFM has action levels for the critical receptor and other locations. There were no exceedances of the action levels in 2019.

BWXT Toronto

Atmospheric emissions

To ensure compliance with licence limits, air from the BWXT facilities is filtered and sampled prior to its release into the atmosphere. Table I-16 provides BWXT Toronto's annual maximum uranium emissions from 2015 to 2019. Table I-17 provides BWXT Peterborough's annual maximum uranium and beryllium emissions from 2015 to 2019. The annual emissions remained well below the licence limits for both facilities. The results demonstrate that air emissions of uranium and beryllium were being controlled effectively.

Table I-16: Air emission monitoring results (annual maximum concentrations), BWXT Toronto, 2015–19

Parameter	Stack	2015	2016	2017	2018	2019	Licence limit
Uranium (µg/m^3)	Rotoclone	0.197	0.355	0.180	0.464	0.077	65
	6H-68	0.375	0.145	0.160	0.118	0.111	47
	4H-48	0.217	0.500	0.130	0.086	0.037	97
	Furnace #1	NA[1]	0.105	0.440	0.112	0.081	437
	Furnace #2/4	NA[1]	0.809	0.150	0.092	0.103	55
	Furnace #5/6	NA[1]	0.132	0.230	0.467	0.245	52

[1]*Continuous sampling and reporting of uranium emissions from the three furnace stacks was not implemented until 2016*

Table I-17: Air emission monitoring results (annual maximum concentrations), BWXT Peterborough, 2015–19

Parameter	Stack	2015	2016	2017	2018	2019	Licence limit
Uranium (µg/m^3)	R2 Decan	0.016	0.012	0.003	0.006	0.014	410
Beryllium (µg/m^3)	North	0.002	0.001	0.001	0.001	0.001	2.6
	South	0.002	0.001	0.001	0.001	0.001	
	Acid	0.009	0.002	0.001	0.000	0.000	

In addition to licence limits, the two facilities have action levels that are used to provide assurance that licence release limits will not be exceeded. No action levels for atmospheric emissions were exceeded at any time in 2019.

Liquid effluent

To ensure compliance with licence limits, wastewater from the BWXT Toronto and Peterborough facilities is collected, filtered and sampled prior to its release into sanitary sewers. Table I-18 provides BWXT's annual maximum concentrations of uranium and beryllium released to the sanitary sewers from 2015 to 2019. In 2019, the releases

continued to be well below the licence limits. The results demonstrate that liquid effluent releases were being controlled effectively.

Table I-18: Liquid effluent monitoring results (annual maximum concentrations), mg/L, 2015–19

Facility	Parameter	2015	2016	2017	2018	2019	Licence limit
BWXT Toronto	Uranium	2.44	2.80	2.56	2.95	2.58	1000
BWXT Peterborough	Uranium	0.09	0.48	0.09	0.03	0.07	2500
	Beryllium	0.0655	0.0025	0.0054	0.0025	0.0018	26

Uranium in ambient air

BWXT Toronto operates five high-volume air samplers to measure the airborne concentrations of uranium at points of impingement of stack plumes. The results from these samplers show that the annual average concentration of uranium (among the sampling stations) in ambient air measured around the facility in 2019 was below the minimum detection limit. This demonstrates that the results are well below MECP's Ambient Air Quality Criteria (AAQC) for uranium of 0.03 µg/m^3 [11]. Table I-19 provides air monitoring results for BWXT Toronto.

BWXT Peterborough does not monitor uranium in ambient air because the atmospheric emissions discharged from the facility already meet the MECP standard of 0.03 µg/m^3 at the point of release, thus eliminating the need for additional ambient monitoring.

Table I-19: Uranium in boundary air monitoring results, BWXT Toronto, 2015–19

Parameter	2015	2016	2017	2018	2019
Average concentration (µg/m^3)	0.001	0.001	0.000	0.000	0.000

µg = microgram
Note: Ontario standard for uranium in ambient air is 0.03 µg/m^3.

Soil monitoring

BWXT conducts soil sampling at its Toronto facility as part of its environmental program. In 2019, soil samples were taken from 49 locations and analyzed for uranium content. The samples were collected on the BWXT site, on commercial lands located along the south border of the site and in the nearby residential neighbourhood. In 2019, the measured soil concentrations of uranium ranged from <1.1 µg/g at a residential location to 2.8 µg/g on commercial lands. These concentrations are comparable to Ontario's background concentrations of up to 2.5 µg/g and well below the applicable

CCME *Soil Quality Guidelines for the Protection of Environmental and Human Health* [14] for uranium for industrial, commercial and residential/parkland land use.

Tables I-20, I-21 and I-22 below provide soil sampling results. The data demonstrates that current BWXT operations do not contribute to the accumulation of uranium in surrounding soil, and that no adverse consequences to relevant human and environmental receptors are expected.

Table I-20: Uranium in soil monitoring results, BWXT Toronto property, 2015–19

Parameter	Industrial lands				
	2015	2016	2017	2018	2019
Number of samples	1	1	1	1	1
Uranium concentration (µg/g)	1.4	1.2	1.7	1.3	1.2
CCME guideline (µg/g)*	**300**				

CCME = Canadian Council of Ministers of the Environment; µg/g = microgram per gram
*CCME, *Soil Quality Guidelines for the Protection of Environmental and Human Health* [14]

Table I-21: Uranium in soil monitoring results, commercial lands, BWXT Toronto, 2015–19

Parameter	Commercial lands				
	2015	2016	2017	2018	2019
Number of samples	30	34	34	34	34
Average uranium concentration (µg/g)	2.9	2.7	3.0	2.3	1.5
Maximum uranium concentration (µg/g)	8.7	13.6	20.6	11.9	2.8
CCME guideline (µg/g)*	**33**				

CCME = Canadian Council of Ministers of the Environment; µg/g = microgram per gram
*CCME, *Soil Quality Guidelines for the Protection of Environmental and Human Health* [14]

Table I-22: Uranium in soil monitoring results, residential locations, BWXT Toronto, 2015–19

Parameter	Residential locations				
	2015	2016	2017	2018	2019
Number of samples	18	14	14	14	14
Average uranium concentration (µg/g)	0.7	0.5	1.0	< 1.0	1.1
Maximum uranium concentration (µg/g)	2.1	0.7	1.6	< 1.0	1.7
CCME guidelines (µg/g)*	**23**				

CCME = Canadian Council of Ministers of the Environment; µg/g = microgram per gram
*CCME, *Soil Quality Guidelines for the Protection of Environmental and Human Health* [14]

Gamma monitoring

A portion of public radiological dose from both the BWXT Toronto and Peterborough facilities is due to gamma radiation sources. Consequently, it is necessary to monitor gamma radiation effective dose rates at the fenceline of the Toronto site and at the Peterborough plant boundary to ensure that levels of potential gamma radiation exposure are maintained ALARA.

Since 2014, BWXT has used environmental dosimeters to measure the effective dose rates for gamma radiation for the Toronto site. The estimated effective dose as a result of gamma radiation during 2019 was 23 µSv, for a total estimated critical receptor dose of 23.5 µSv when combined with the contribution from air emissions (0.5 µSv). This is well below the regulatory dose limit of 1 mSv (1000 µSv) per year to a member of the public.

Since 2016, the gamma radiation effective dose rate for the BWXT Peterborough plant has also been measured with environmental dosimeters. The estimated effective dose as a result of gamma radiation during 2019 was 11.5 µSv, for a total estimated critical receptor dose of 11.5 µSv when combined with the contribution from air emissions (0.0 µSv). This is well below the regulatory dose limit of 1 mSv (1000 µSv) per year to a member of the public.

These estimates indicate that gamma dose rates from both BWXT facilities are controlled and that the public is protected.

SRB Technologies (Canada) Inc.

Atmospheric emissions

SRBT monitors tritium releases from the facility stacks and reports them on an annual basis. The monitoring data for 2015 through 2019, provided in table I-23, demonstrate that atmospheric emissions from the facility remained below their regulatory limits.

Table I-23: Atmospheric emissions monitoring results, 2015–19

Parameter	2015	2016	2017	2018	2019	Licence limit (TBq/year)
Tritium as tritium oxide (HTO) (TBq/year)	11.55	6.29	7.19	10.74	11.86	**67.2**
Total tritium as HTO + HT (TBq/year)	56.24	28.95	24.82	33.18	31.77	**448**

TBq = terabecquerel; HTO = hydrogenated tritium oxide; HT = tritium gas

Liquid effluent

SRBT continues to control and monitor tritium released as liquid effluent from the facility. The monitoring data for 2015 through 2019, provided in table I-24 below, demonstrate that liquid effluent from the facility remained below their regulatory limits.

Table I-24: Liquid effluent monitoring results for release to sewer, 2015–19

Parameter	2015	2016	2017	2018	2019	Licence limit (TBq/year)
Tritium-water soluble (TBq/year)	0.007	0.005	0.007	0.010	0.014	**0.200**

TBq = terabecquerel

Tritium in ambient air

SRBT has 40 passive air samplers located within a 2-kilometre radius of the facility. These samplers represent tritium exposure pathways for inhalation and skin absorption, and are used in the calculations to determine public dose. The 2019 air monitoring results from these samplers demonstrated that tritium levels in ambient air near SRBT remain low.

Groundwater monitoring

In 2019, groundwater was sampled from 29 SRBT-installed monitoring wells at their facility plus an additional eight wells at surrounding residential and business properties. From the 2019 sampling results, the highest average tritium concentration was reported for monitoring well MW06-10 (34,592Bq/L, with a minimum of 23,900 Bq/L and maximum of 52,321 Bq/L). This well is located directly beneath the area where the active ventilation stacks are located. This well is a dedicated, engineered groundwater monitoring well very near to the facility within a secured area, and is not available to be

used as a source of water consumption. Throughout the year of 2019, no other wells exceeded the *Ontario Drinking Water Standard* for tritium of 7,000 Bq/L. Figure I-1 below shows annual average tritium concentrations in select groundwater wells around the SRBT facility.

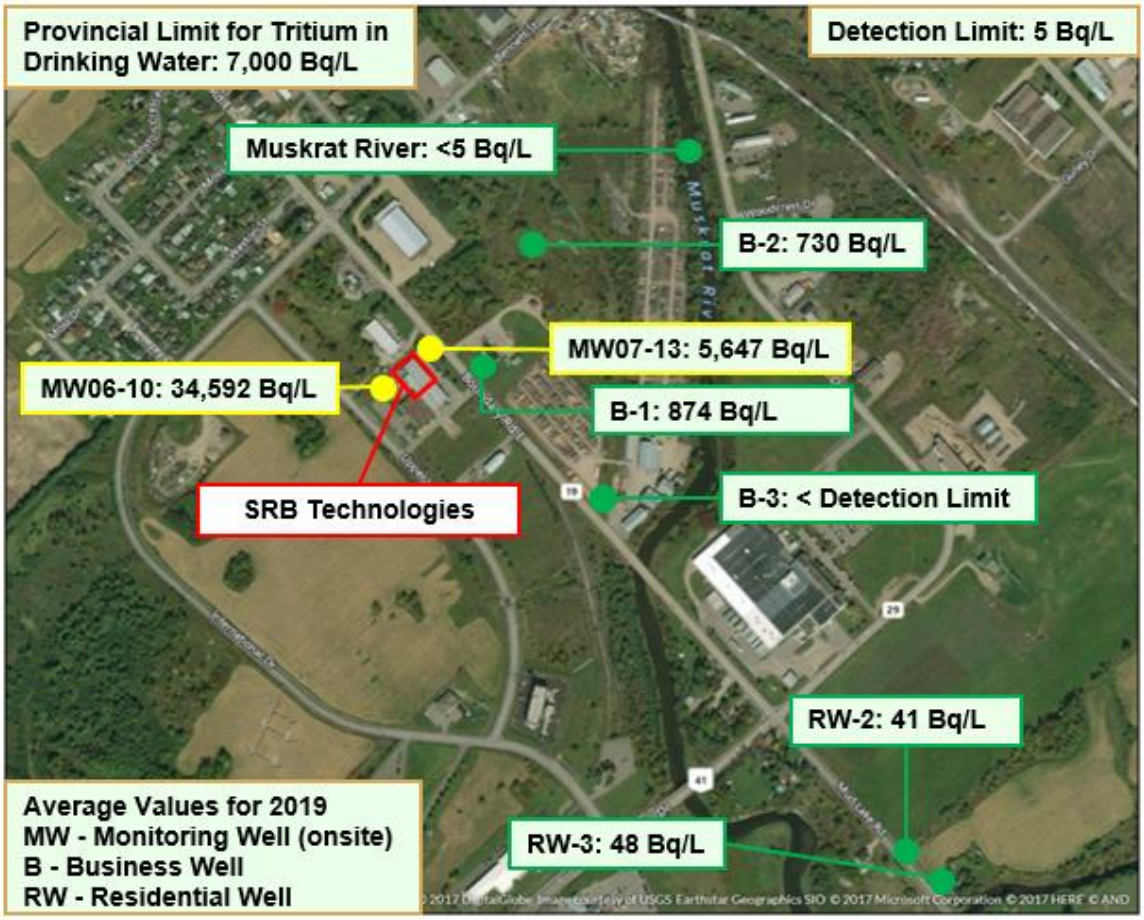
Tritium concentrations decrease significantly at locations farther away from SRBT. In 2019, the highest concentration of tritium sampled from the three business wells was 916 Bq/L and the highest in the five sampled residential wells was 58 Bq/l. These results are far below Ontario's drinking quality standard of 7,000 Bq/L. All of residential wells are over 1 km away from SRBT and are not in the groundwater flow pathway.

Tritium concentrations in Muskrat River (the receiving surface water environment about 420 meters from the SRB property) in 2019 fell below the minimum detectable activity (MDA) (between 5 - 6 Bq/L), as they were in 2018.

Overall, CNSC staff concluded that the tritium inventory in the groundwater system around the facility has been trending downward since 2006. This trend is due to SRBT's initiative to reduce emissions, including the commissioning of improved tritium trap valves and remote display units, the real-time monitoring of gaseous effluent, and a reduction in the amount of failed leak tests of manufactured light sources. Along with the reduced emissions, the concentration of tritium in the groundwater is decreasing due to the natural decay of tritium and the flushing of historical tritium emissions through the groundwater system.

Since 2016 SRBT has been in compliance with CSA N288.7-15, *Groundwater protection programs at Class I nuclear facilities and uranium mines and mills* [15].

Figure I-1: Annual average tritium concentrations in groundwater and the Muskrat River, SRBT, 2019



Other monitoring

SRBT also samples and analyzes runoff water from its facility, and engages a qualified third party to perform monitoring and analysis of precipitation, surface water, produce, milk and wine. The 2019 monitoring data for these items are low and consistent with previous years. This monitoring complements the principal monitoring activities, which focus on air and groundwater.

Nordion (Canada) Inc.

Atmospheric emissions

Nordion continues to control and monitor the releases of radioactive materials from its facility to prevent unnecessary releases of radioisotopes to the atmosphere. Table I-25 below shows Nordion's radioactive air emissions monitoring results from 2015 to 2019. The monitoring data demonstrate that the radioactive air emissions from the facility in 2019 remained below the regulatory limits. In November 2016, Nordion ceased the production of molybdenum-99, iodine-125, iodine-131 and xenon-133.

Table I-25: Air emissions monitoring results, 2015–19

Parameter	2015	2016	2017	2018	2019	Licence limit (DRL) (GBq/year)
Cobalt-60	0.005	0.006	0.0034	0.002	0.00002	250
Iodine-125	0.12	0.21	0.0012	0	0	952
Iodine-131	0.15	0.35	0.0008	0.006	0	686
Xenon-133	11,916	7,277	0	0	0	677,000,000
Xenon-135	8,237	4,299	0	0	0	102,000,000
Xenon-135m	10,758	5,421	0	0	0	69,000,000

DRL = derived release limit; GBq = gigabecquerel

Liquid effluent

Nordion continues to collect, sample and analyze all liquid effluent releases before discharge into the municipal sewer system. Table I-26 below shows Nordion's monitoring results for radioactive liquid emissions from 2015 to 2019.

The monitoring data demonstrate that the authorized radioactive liquid effluent releases from the facility in 2019 remained below the regulatory limits.

In 2019, Nordion reported two environmental reportable limit exceedances involving non-radiological releases to the sanitary sewer and one halocarbon release. CNSC staff acknowledge that these few reportable short term exceedances do not pose undue risk to the environment or human health due to conservatisms built in to the reportable limits used, but do expect Nordion to continue to investigate non-radiological sanitary sewer and halocarbon releases and identify ways to minimize or remove the source of such releases.

Table I-26: Liquid effluent monitoring results for release to sewer, 2015–19

Parameter	2015	2016	2017	2018	2019	Licence limit (DRL) (GBq/year)
β < 1 MeV	0.191	0.222	0.212	0.243	0.162	763
β > 1 MeV	0.044	0.051	0.048	0.055	0.038	35,000
Iodine-125	0.111	0.144	0.145	0.146	0.063	1,190
Iodine-131	0.006	0.006	0.006	0.007	0.004	389
Molybdenum-99	0.060	0.052	0.049	0.055	0.036	10,200
Cobalt-60	0.019	0.026	0.022	0.027	0.020	35.4
Niobium-95	0.0010	0.0010	0.0010	0.0010	0.002	3,250
Zirconium-95	0.0010	0.0015	0.0020	0.0017	0.0019	2,060
Cesium-137	0.0004	0.0007	0.0007	0.0007	0.0007	24.8

β < 1 MeV = beta particles less than 1 megaelectronvolt; DRL = derived release limit; GBq = gigabecquerel

Groundwater monitoring

There are currently nine groundwater monitoring wells on the Nordion site. Since 2005, Nordion has been monitoring groundwater at least once a year for non-radioactive contaminants in four monitoring wells. The monitoring results from 2014 to 2019 demonstrate that there were no significant changes in the groundwater in 2019 compared to previous years.

Since 2014, Nordion has been monitoring groundwater at least once a year for radioactive contaminants in five monitoring wells. The results since then have detected only naturally occurring radionuclides that are not processed at the Nordion facility. These results, which are either below detection limits or at natural background levels, indicate that releases of radioactive and hazardous substances from Nordion's facility have had no measurable impact on groundwater quality.

Nordion has completed a gap analysis against the requirements of CSA N288.7-15, *Groundwater protection programs at Class I nuclear facilities and uranium mines and mills* [15] and is continuing to update internal procedures and programs to meet these requirements and fill gaps identified.

Soil sampling

Nordion performed soil sampling in 2019, and no radionuclides attributable to licensed activities were detected in the soil samples.

Environmental thermoluminescent dosimeters program

Nordion monitors environmental gamma radiation with the use of thermoluminescent dosimeters (TLDs). The dosimeters are deployed at locations to generally cover the points of a compass and preferentially to the east of the facility, which receives the prevailing west winds. Dosimeters are also placed in residences of Nordion employees located near the facility. The annual monitoring results for 2019 showed that the levels of gamma radiation at offsite monitoring locations are in the range of natural background levels. These results indicate that Nordion's operations is not contributing to the public's exposure to gamma radiation at, and beyond, the perimeter of the facility.

Best Theratronics Ltd.

Effluent and emissions control (releases)

BTL has determined that there are no radiological releases (liquid or airborne) at the BTL facility that require controls or monitoring. BTL's operation uses radioactive sealed sources that do not produce any radioactive releases.

BTL safely manages hazardous liquid effluents from routine operations. They are collected, temporarily stored on-site, and then regularly removed for disposal by a certified third party contractor. Lubricating oil for on-site boring and milling machines are recovered and recirculated. Therefore, there would be no hazardous waterborne releases into the environment requiring controls or effluent monitoring.

Hazardous airborne emissions from BTL are related to the exhausting of the lead pouring, paint booth, fire torching and sand blasting areas. Engineering controls, such as filters and ventilation, are in place to reduce or eliminate emissions generated during operations. As a result, BTL does not have an effluent monitoring program or an environmental monitoring program.

Assessment and monitoring

BTL does not conduct environmental monitoring around its facility as there are no radiological releases that require controls or monitoring. Hazardous airborne emissions pertain to exhausting associated with the lead pouring area. BTL submits a report on lead, and its compounds, to the National Pollutant Release Inventory, maintaining annual compliance with the *Toxics Reduction Act*. There have not been any abnormal instances within the licensing period.

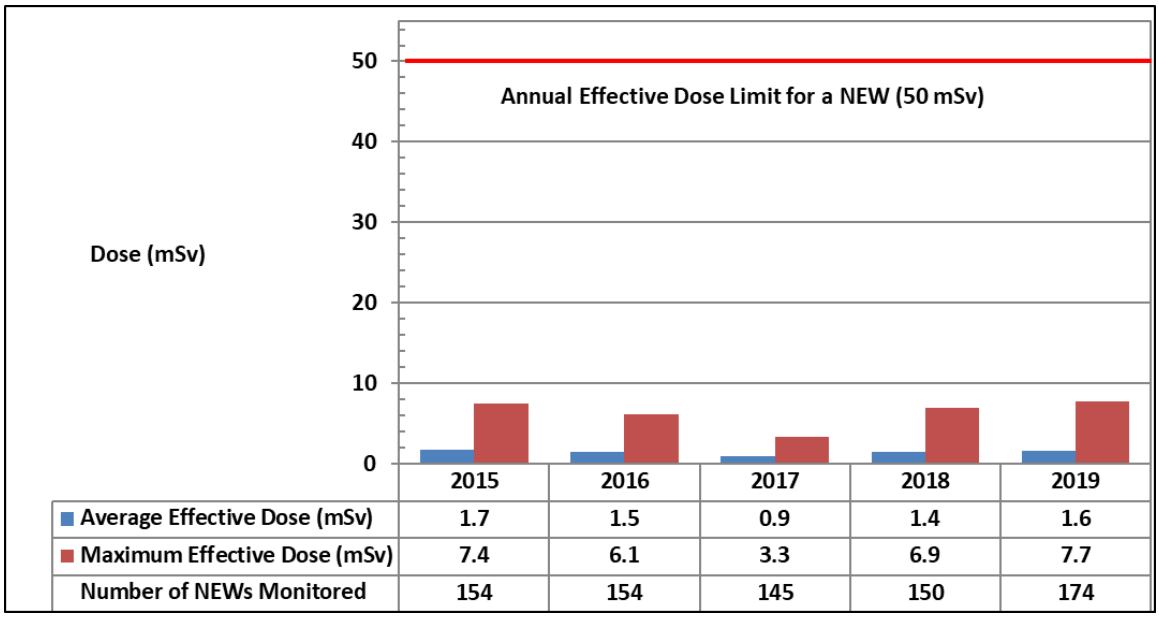
J. Worker dose data

This appendix presents information on doses to Nuclear Energy Workers (NEWs) and non-NEWs at uranium and nuclear substance processing facilities.

Cameco BRR

Figure J-1 provides the average and maximum effective doses for NEWs at BRR between 2015 and 2019. The maximum effective dose received by a NEW in 2019 was 7.7 mSv, which is approximately 15% of the CNSC's regulatory effective dose limit of 50 mSv in a one-year dosimetry period. Average and maximum total effective doses over this five-year period are reflective of the work activities at BRR, and increased in 2019 due to production levels and operating days that increased over previous years.

Figure J-1: Effective dose statistics for Nuclear Energy Workers, Cameco Blind River Refinery, 2015-2019



	2015	2016	2017	2018	2019
Average Effective Dose (mSv)	1.7	1.5	0.9	1.4	1.6
Maximum Effective Dose (mSv)	7.4	6.1	3.3	6.9	7.7
Number of NEWs Monitored	154	154	145	150	174

Average and maximum equivalent dose results for the skin and extremities of NEWs, from 2015 to 2019, are provided in Tables J-1 and J-2. In 2019, the maximum individual skin dose received by a NEW at BRR was 29.2 mSv, which is approximately 6% of the CNSC's regulatory equivalent dose limit of 500 mSv in a one-year dosimetry period. The maximum individual extremity dose received by a NEW at BRR was 11.9 mSv, which is approximately 2% of the CNSC's regulatory equivalent dose limit of 500 mSv in a one-year dosimetry period. The average and maximum equivalent doses have been relatively steady over this five-year period.

Table J-1: Equivalent (skin) dose statistics for NEWs, BRR, 2015–19

Dose data	2015	2016	2017	2018	2019	Regulatory limit
Average skin dose (mSv)	3.9	3.3	3.1	4.1	4.8	**N/A**
Maximum individual skin dose (mSv)	28.1	26.0	16.2	28.4	29.2	**500 mSv/year**

mSv = millisievert; N/A = not applicable

Table J-2: Equivalent (extremity) dose statistics for NEWs, BRR, 2015–19

Dose data	2015	2016	2017	2018	2019	Regulatory limit
Average extremity dose (mSv)	1.5	1.2	1.0	3.5	3.9	**N/A**
Maximum individual extremity dose (mSv)	15.3	10.6	13.6	14.5	11.9	**500 mSv/year**

mSv = millisievert; N/A = not applicable

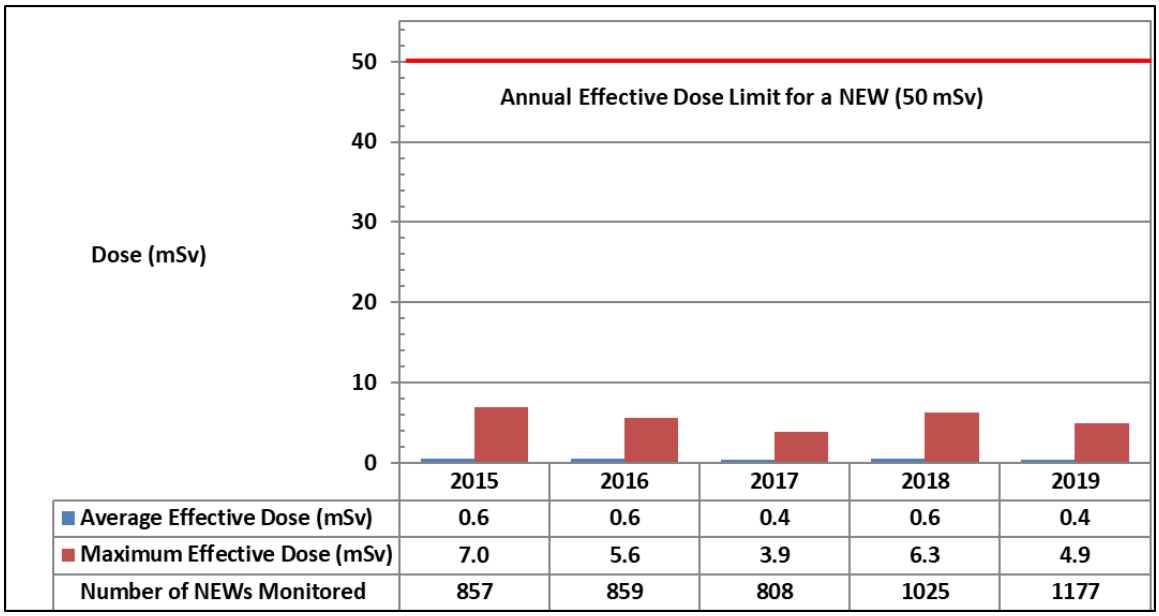
Non-NEWs at BRR

Site visitors and contractors that are not considered NEWs are issued external dosimetry to monitor their radiological exposures while at BRR. In 2019, the maximum individual effective dose received by a site visitor or contactor that was not a NEW was 0.4 mSv, which is well below the CNSC's regulatory effective dose limit of 1 mSv per calendar year for a person who is not a NEW.

Cameco PHCF

Figure J-2 provides the average and maximum effective doses for NEWs at Cameco's PHCF between 2015 and 2019. The maximum individual effective dose received by a NEW in 2019 was 4.9 mSv, which is approximately 10% of the CNSC's regulatory effective dose limit of 50 mSv in a one-year dosimetry period. The average and maximum total effective doses over this five-year period are reflective of the work activities and production levels at PHCF.

Figure J-2: Effective dose statistics for Nuclear Energy Workers, Cameco Port Hope Conversion Facility, 2015-2019



	2015	2016	2017	2018	2019
Average Effective Dose (mSv)	0.6	0.6	0.4	0.6	0.4
Maximum Effective Dose (mSv)	7.0	5.6	3.9	6.3	4.9
Number of NEWs Monitored	857	859	808	1025	1177

Average and maximum equivalent dose results for the skin of NEWs, from 2015 to 2019, are provided in Table J-3. In 2019, the maximum individual skin dose received by a NEW at PHCF was 20.1 mSv, which is approximately 4% of the CNSC's regulatory equivalent dose limit of 500 mSv in a one-year dosimetry period. Average and maximum skin doses over this five-year period have been relatively steady.

Table J-3: Equivalent (skin) dose statistics for NEWs, PHCF, 2015–19

Dose data	2015	2016	2017	2018	2019	Regulatory limit
Average skin dose (mSv)	0.8	0.8	0.6	0.7	0.5	**N/A**
Maximum individual skin dose (mSv)	23.4	16.9	13.7	14.9	20.1	**500 mSv/year**

mSv = millisievert; N/A = not applicable

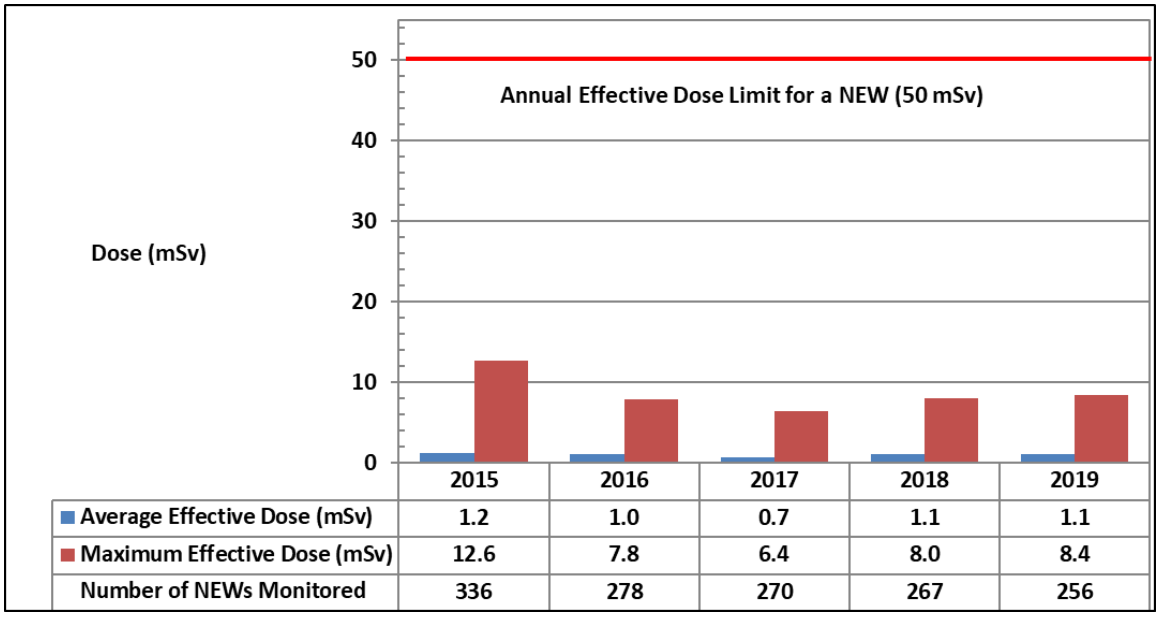
Non-NEWs at PHCF

Cameco employees, site visitors and contractors whose work does not require NEW status may be issued whole-body dosimeters and participate in the internal dosimetry program to monitor their radiological exposures while at PHCF. In 2019, the maximum individual effective dose received by a person who is not a NEW was 0.13 mSv, which is well below the CNSC's regulatory effective dose limit of 1 mSv per calendar year for a person who is not a NEW.

CFM

Figure J-3 provides the average and maximum effective doses for NEWs at CFM between 2015 and 2019. The maximum individual effective dose received by a NEW in 2019 was 8.4 mSv, which is approximately 17% of the CNSC's regulatory effective dose limit of 50 mSv in a one-year dosimetry period. Average and maximum total effective doses over this five-year period are aligned with the work activities and production levels at CFM.

Figure J-3: Effective dose statistics for Nuclear Energy Workers, Cameco Fuel Manufacturing Inc., 2015-2019



	2015	2016	2017	2018	2019
Average Effective Dose (mSv)	1.2	1.0	0.7	1.1	1.1
Maximum Effective Dose (mSv)	12.6	7.8	6.4	8.0	8.4
Number of NEWs Monitored	336	278	270	267	256

Average and maximum equivalent dose results for the skin and extremities of NEWs, from 2015 to 2019, are provided in Tables J-4 and J-5. In 2019, the maximum skin dose received by a NEW at CFM was 56.9 mSv, which is approximately 11% of the CNSC's regulatory equivalent dose limit of 500 mSv in a one-year dosimetry period. The maximum extremity dose received by a NEW at CFM was 90.8 mSv, which is approximately 18% of the CNSC's regulatory equivalent dose limit of 500 mSv in a one-year dosimetry period. The average and maximum equivalent doses over this five-year period have been decreasing. CFM attributes this trend to improvements made to work practices and work areas, such as enclosing the grinder lines.

Table J-4: Equivalent (skin) dose statistics for NEWs, CFM, 2015–19

Dose data	2015	2016	2017	2018	2019	Regulatory limit
Average skin dose (mSv)	6.3	6.6	5.5	3.4	3.1	**N/A**
Maximum individual skin dose (mSv)	95.6	95.7	88.1	59.0	56.9	**500 mSv/year**

mSv = millisievert; N/A = not applicable

Table J-5: Equivalent (extremity) dose statistics for NEWs, CFM, 2015–19

Dose data	2015	2016	2017	2018	2019	Regulatory limit
Average extremity dose (mSv)	15.5	13.2	10.6	15.8	18.4	**N/A**
Maximum individual extremity dose (mSv)	87.0	98.4	59.0	57.1	90.8	**500 mSv/year**

mSv = millisievert; N/A = not applicable

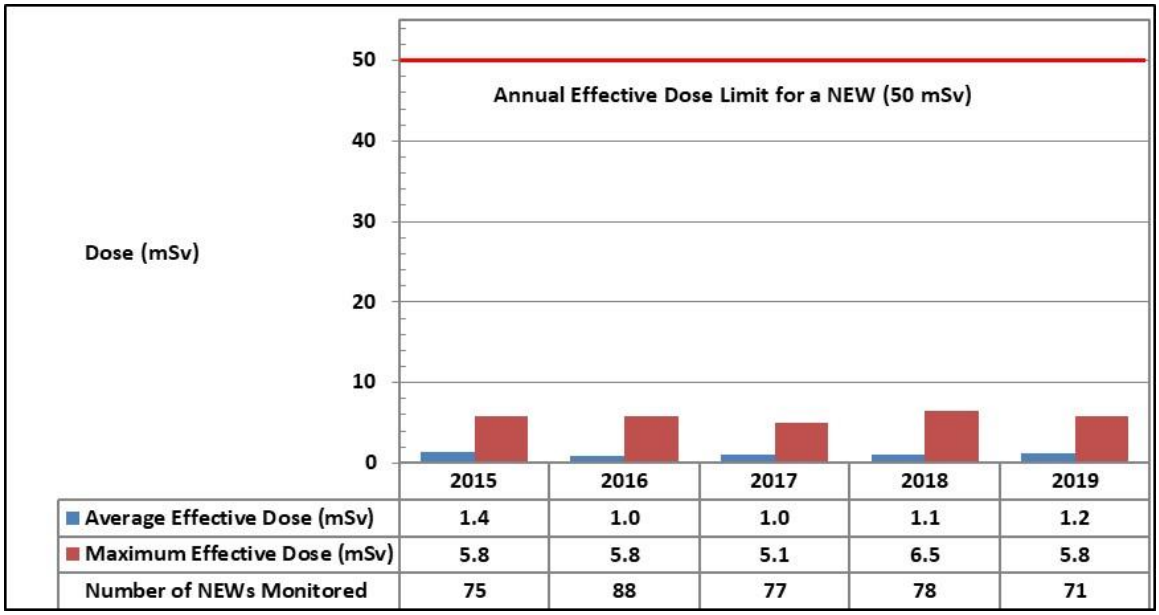
Non-NEWs at CFM

Visitors and contractors that are not considered NEWs are issued dosimeters to monitor their radiological exposures while at CFM. In 2019, there were no measurable doses recorded on dosimeters issued to non-NEWs.

BWXT

Figure J-4 provides the average and maximum effective doses for NEWs at BWXT NEC's Peterborough facility between 2015 and 2019. The maximum effective dose received by a NEW in 2019 at the Peterborough facility was 5.8 mSv, or approximately 12% of the CNSC's regulatory effective dose limit of 50 mSv in a one-year dosimetry period.

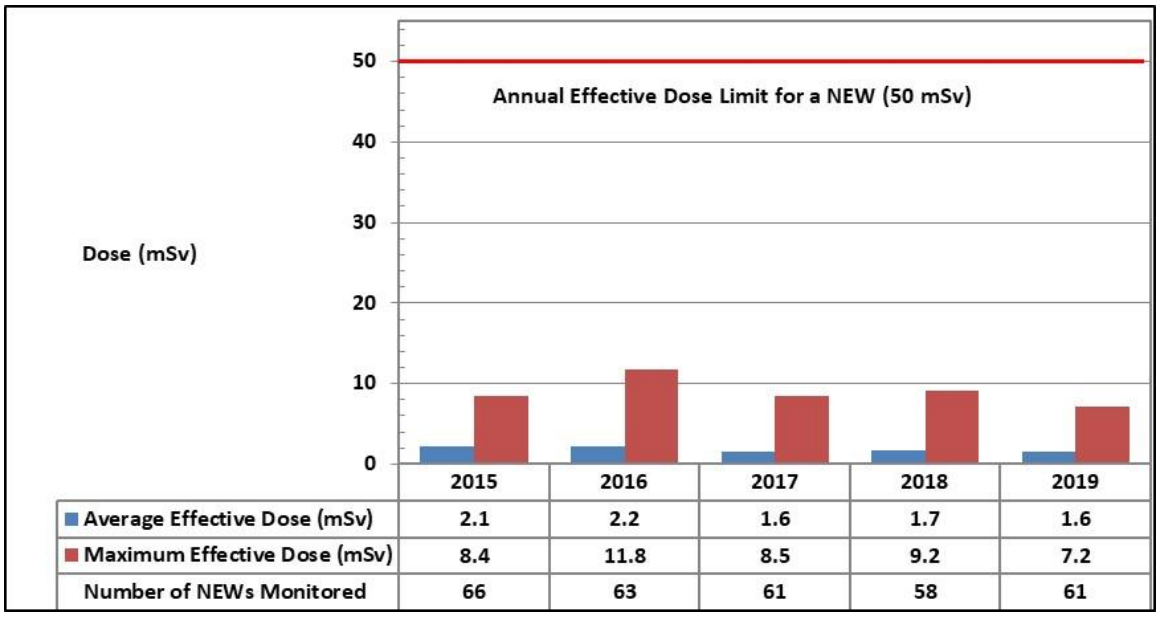
Figure J-4: Effective dose statistics for Nuclear Energy Workers, BWXT Peterborough Facility, 2015–19



	2015	2016	2017	2018	2019
Average Effective Dose (mSv)	1.4	1.0	1.0	1.1	1.2
Maximum Effective Dose (mSv)	5.8	5.8	5.1	6.5	5.8
Number of NEWs Monitored	75	88	77	78	71

Figure J-5 provides the average and maximum effective doses for NEWs at BWXT NEC's Toronto facility between 2015 and 2019. The maximum effective dose received by a NEW in 2019 at the Toronto facility was 7.2 mSv, or approximately 14% of the CNSC's regulatory effective dose limit of 50 mSv in a one-year dosimetry period.

Figure J-5: Effective dose statistics for Nuclear Energy Workers, BWXT Toronto Facility, 2015–19



	2015	2016	2017	2018	2019
Average Effective Dose (mSv)	2.1	2.2	1.6	1.7	1.6
Maximum Effective Dose (mSv)	8.4	11.8	8.5	9.2	7.2
Number of NEWs Monitored	66	63	61	58	61

Annual average and maximum equivalent dose results from 2015 to 2019 are also provided in tables J-6 and J-7 below. In 2019, the maximum individual equivalent skin dose at the Peterborough facility was 17.44 mSv, while in Toronto, it was 39.76 mSv.

Table J-6: Equivalent (skin) dose statistics for NEWs, BWXT Peterborough, 2015–19

Dose data	2015	2016	2017	2018	2019	Regulatory limit
Average skin dose (mSv)	4.1	2.66	2.77	2.87	3.00	**N/A**
Maximum individual skin dose (mSv)	22.47	21.15	25.14	17.87	17.44	**500 mSv/year**

mSv = millisievert; N/A = not applicable

Table J-7: Equivalent (skin) dose statistics for NEWs, BWXT Toronto, 2015–19

Dose data	2015	2016	2017	2018	2019	Regulatory limit
Average skin dose (mSv)	9.89	10.23	7.85	8.92	8.07	**N/A**
Maximum individual skin dose (mSv)	54.99	74.26	54.27	58.36	39.76	**500 mSv/year**

mSv = millisievert; N/A = not applicable

In 2019, the maximum individual equivalent extremity dose at the Peterborough facility was 29.41 mSv, while in Toronto, it was 79.67 mSv, as provided in tables J-8 and J-9 below.

Table J-8: Equivalent (extremity) dose statistics for NEWs, BWXT Peterborough, 2015–19

Dose data	2015	2016	2017	2018	2019	Regulatory limit
Average extremity dose (mSv)	12.61	9.78	13.62	14.34	11.30	**N/A**
Maximum individual extremity dose (mSv)	39.34	32.84	43.18	46.06	29.41	**500 mSv/year**

mSv = millisievert; N/A = not applicable

Table J-9: Equivalent (extremity) dose statistics for NEWs, BWXT Toronto, 2015–19

Dose data	2015	2016	2017	2018	2019	Regulatory limit
Average extremity dose (mSv)	30.30	29.58	27.36	24.56	20.67	**N/A**
Maximum individual extremity dose (mSv)	109.62	119.47	115.07	83.33	79.67	**500 mSv/year**

mSv = millisievert; N/A = not applicable

These maximum individual equivalent doses (Toronto) are approximately 8% and 15% (respectively) of the CNSC's regulatory equivalent dose limit of 500 mSv in a one-year dosimetry period. Over the past five years, average equivalent extremity and skin doses have been relatively stable at both facilities. The reason for the consistently lower skin

and extremity doses at the Peterborough facility is the low likelihood of direct pellet handling, as opposed to the Toronto facility, where this practice is considered routine. At the Peterborough facility, except in the end cap welding station, all pellets are shielded in zirconium tubes, bundles or boxes.

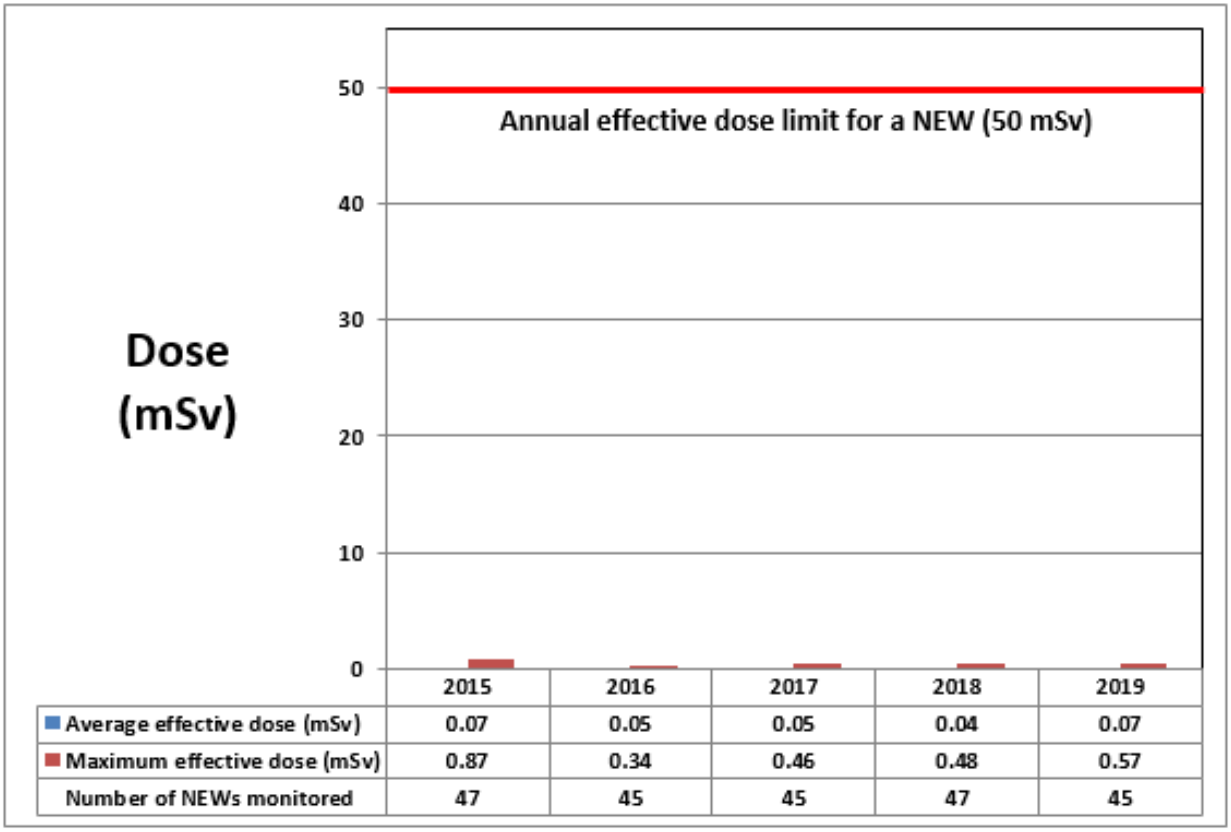
Non-NEWs at BWXT

For both the Peterborough and Toronto facilities, non-NEWs and contractors (which are all considered non-NEWs) are not directly monitored. Doses are estimated based on in-plant radiological conditions and occupancy factors, to ensure that radiation doses are controlled well below the CNSC's regulatory effective dose limit of 1 mSv per calendar year for a person who is not a NEW.

SRBT

Figure J-6 provides the average and maximum effective doses for NEWs at SRBT from 2015 to 2019. The maximum effective dose received by a NEW in 2019 was 0.57 mSv, approximately 1% of the CNSC regulatory effective dose limit of 50 mSv in a one-year dosimetry period. There was an increase in both average and maximum effective dose this year. This is attributed to four instances of elevated exposure for a particular worker over the course of the year, in addition to an increase in processing and three special projects. A subsequent investigation into the elevated exposure found it was caused by work practices leading to an increased number of light source breakages. As a consequence, corrective actions were implemented to enhance how light sources are handled to reduce worker exposures.

Figure J-6: Effective dose statistics for Nuclear Energy Workers, SRBT, 2015-2019



	2015	2016	2017	2018	2019
Average effective dose (mSv)	0.07	0.05	0.05	0.04	0.07
Maximum effective dose (mSv)	0.87	0.34	0.46	0.48	0.57
Number of NEWs monitored	47	45	45	47	45

Due to the uniform distribution of tritium in body tissues, equivalent skin doses are essentially the same as the effective whole-body dose and are therefore not reported separately. For this same reason, extremity doses are not separately monitored for workers at SRBT.

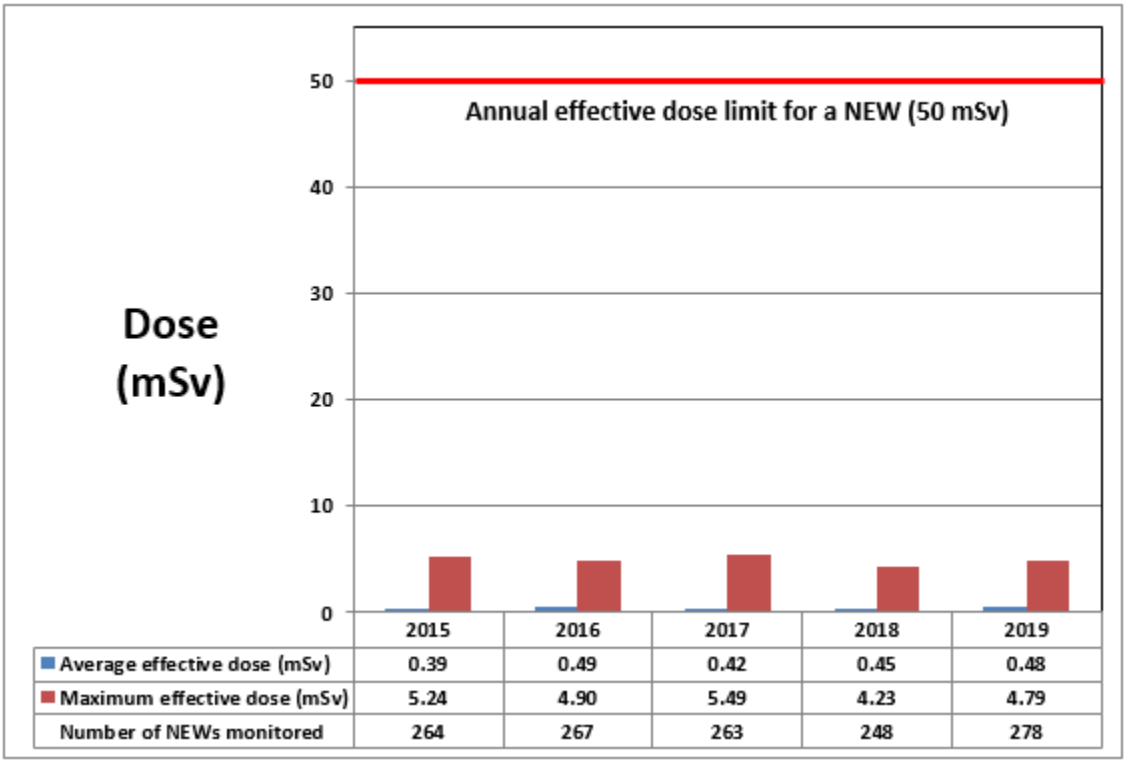
Non-NEWs at SRBT

While contractors are not generally identified as NEWs, since they do not perform radiological work, their radiological exposures are monitored while they are at the SRBT facility to ensure that their doses remain ALARA and below the CNSC regulatory dose limit of 1 mSv/year for a person who is not a NEW. In 2019, no contractors received a recordable dose that resulted from work activities performed at the facility.

Nordion

Figure J-7 provides the average and maximum effective doses to NEWs at Nordion from 2015 to 2019. Nordion reported that the maximum effective dose received by a NEW in 2019 was 4.79 mSv, approximately 9.6% of the CNSC's regulatory effective dose limit of 50 mSv in a one-year dosimetry period. Average and maximum effective doses have been relatively stable over these years.

Figure J-7: Effective dose statistics for Nuclear Energy Workers, Nordion, 2015-2019



	2015	2016	2017	2018	2019
Average effective dose (mSv)	0.39	0.49	0.42	0.45	0.48
Maximum effective dose (mSv)	5.24	4.90	5.49	4.23	4.79
Number of NEWs monitored	264	267	263	248	278

Tables J-10 and J-11 shows annual average and maximum equivalent (extremity) and equivalent (skin) dose results from 2015 to 2019. Nordion reported that the maximum equivalent skin dose for all NEWs monitored at Nordion in 2019 was 4.78 mSv, and that the maximum equivalent extremity dose for a worker in the active area was 20.93 mSv (table E-5). These doses represent approximately 1% and 4% respectively of the CNSC's regulatory equivalent dose limits of 500 mSv in a one-year dosimetry period. The maximum extremity dose was received by a worker during a Cobalt hot cell manipulator change.

Table J-10: Equivalent (skin) dose statistics for NEWs, Nordion, 2015–19

Dose data	2015	2016	2017	2018	2019	Regulatory limit
Average skin dose (mSv)	0.42	0.59	0.42	0.45	0.49	**N/A**
Maximum individual skin dose (mSv)	5.24	5.20	5.52	4.26	4.78	**500 mSv/year**

mSv = millisievert; N/A = not applicable

Table J-11: Equivalent (extremity) dose statistics for NEWs, Nordion, 2015–19

Dose data	2015	2016	2017	2018	2019	Regulatory limit
Average extremity dose (mSv)	0.46	0.79	0.53	0.96	1.14	**N/A**
Maximum individual extremity dose (mSv)	9.3	8.3	16.4	9.08	20.93	**500 mSv/year**

mSv = millisievert; N/A = not applicable
Note: Only the workers who routinely work in the active area are monitored for extremity dose.

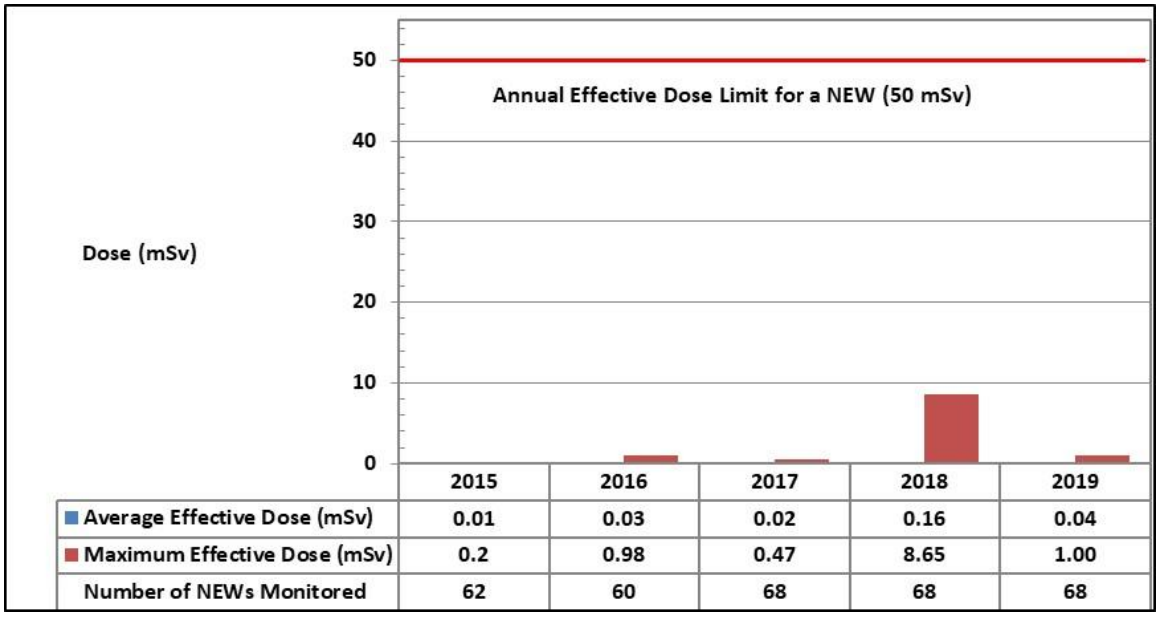
Non-NEWs at Nordion

Nordion also identifies non-NEWs who may enter the active area but do not perform any radiological work. Nordion monitors non-NEWs as required and provides relevant training to ensure that their doses are kept ALARA. In 2019, Nordion monitored 125 non-NEWs which is an increase from previous years. The large increase of non-NEWs monitored is due to construction activities in the Medical Isotopes facility. Nordion reported that the maximum effective dose received by a non-NEW was 0.26 mSv, which is well below the CNSC's regulatory effective dose limit of 1 mSv in a calendar year for a person who is not a NEW. The average effective dose for non-NEWs in 2019 was 0.03 mSv.

BTL

At BTL, employees are classified as Nuclear Energy Workers (NEWs) if they are expected to have a reasonable probability of receiving an occupational dose greater than 1 mSv. Employees performing work under the Class 1B license are reported below. Doses for Class II servicing employees are reported separately under the Annual Compliance Reports associated with BTL's Class II Servicing Licenses. Figure J-8 provides the average and maximum effective doses for NEWs at BTL between 2015 and 2019. In 2019, the maximum effective dose received by a NEW at BTL under the Class 1B licence was 1.0 mSv, or approximately 2% of the CNSC's regulatory effective dose limit of 50 mSv in a one-year dosimetry period. Over the past five years, annual effective doses at BTL have remained stable and very low.

Figure J-8: Effective dose statistics for Nuclear Energy Workers, BTL, 2015-2019



	2015	2016	2017	2018	2019
Average Effective Dose (mSv)	0.01	0.03	0.02	0.16	0.04
Maximum Effective Dose (mSv)	0.2	0.98	0.47	8.65	1.00
Number of NEWs Monitored	62	60	68	68	68

The higher than normal maximum effective and equivalent extremity doses in 2018 were due to an unplanned upset condition that resulted in an Action Level exceedance. Annual average and maximum equivalent extremity dose results from 2015 to 2019 are provided in table J-12 below. The maximum equivalent extremity dose for 2019 was 2.51 mSv, which is approximately 0.5% of the CNSC's regulatory equivalent dose limit of 500 mSv. Over the past five years, average extremity equivalent doses have remained very low, between approximately 0 mSv and 2 mSv.

Table J-12: Equivalent (extremity) dose statistics for NEWs, BTL, 2015–19

Dose data	2015	2016	2017	2018	2019	Regulatory limit
Average extremity dose (mSv)	0.00	0.09	0.07	1.41	0.22	**N/A**
Maximum individual extremity dose (mSv)	0.00	1.1	0.5	13.51	2.51	**500 mSv/year**

mSv = millisievert; N/A = not applicable

Although equivalent skin doses are ascertained; due to the nature of exposure, they are essentially equal to the effective dose and are not included in this report.

Non-NEWs at BTL

BTL workers identified as non-NEWs, such as administrative staff, are not permitted in controlled areas, and are therefore not occupationally exposed to radiation.

K. Health and safety data

Table K-1 Lost-time injury statistics, uranium and nuclear substance processing facilities, 2015-19

Facility	Statistic	2015	2016	2017	2018	2019
BRR	LTI[1]	0	0	0	0	0
	Severity Rate[2]	0	0	0	0	0
	Frequency Rate[3]	0	0	0	0	0
PHCF	LTI	1	4	1	2	0
	Severity Rate	7.64	2.40	1.67	7.58	0
	Frequency Rate	0.26	0.80	0.28	0.49	0
CFM	LTI	1	0	0	0	0
	Severity Rate	0.6	0	0	0	0
	Frequency Rate	0.6	0	0	0	0
BWXT	LTI	0	0	0	0	0
	Severity Rate	0	0	0	0	0
	Frequency Rate	0	0	0	0	0
SRBT	LTI	0	0	3	0	0
	Severity Rate	0	0	17.7	0	0
	Frequency Rate	0	0	7.6	0	0
Nordion	LTI	0	3	1	0	2
	Severity Rate	0	70.04	5.61	0	4.15
	Frequency Rate	0	2.32	0.93	0	0.69
BTL	LTI	1	3	1	2	2
	Severity Rate	0.68	37.61	15.04	8.21	5.47
	Frequency Rate	0.68	2.05	0.68	1.37	1.37

1 An LTI is an injury that takes place at work and results in the worker being unable to return to work for a period of time.
2 The accident severity rate measures the total number of days lost to injury for every 200,000 person-hours worked at the site. Severity = [(# of days lost in last 12 months) / (# of hours worked in last 12 months)] x 200,000.
3 The accident frequency rate measuring the number of LTIs for every 200,000 person-hours worked at the site. Frequency = [(# of injuries in last 12 months) / (# of hours worked in last 12 months)] x 200,000.

Table K-2: LTIs, Nordion, 2019

LTI	Action taken by licensee
An employee sustained a low back injury when trying to open double lead doors on cell 34. The employee was pulling the doors with force on several attempts door wouldn't open (issue with doors). The injury resulted in five days' lost time.	Nordion investigated the incident and determined that the door status was in a "fault condition" which would not allow the door to open. Technicians are now required to verify the status of cell doors before attempting to open them.
An employee incurred lower back pain when removing wood bracing from the ground of a sea crate container. This was a routine task. The injury resulted in seven days' lost time.	Nordion will no longer be removing the blocking and bracing from the ocean containers. Blocking and bracing materials will remain in the containers once the Nordion flasks are removed, with the trucking company now responsible to remove the blocking and bracing materials.

Table K-3: LTIs, BTL, 2019

LTI	Action taken by licensee
A worker strained their back when physically moving wooden ramps to loading dock instead of using the overhead crane.	Individual was reminded to not lift the loading ramps without the use of the overhead crane.
A worker cut hand while working on a product that was not deburred.	Individual was reminded to deburr all sharp edges prior to working on them.

L. List of identified Indigenous groups with an interest in uranium and nuclear substance processing facilities

Blind River area (Cameco Blind River Refinery (BRR))

- Atikameksheng Anishnawbek First Nation
- Mississauga First Nation (MFN);
- Sagamok Anishnawbek Nation (SAN);
- Serpent River First Nation (SRFN);
- Thessalon First Nation (TFN); and
- Métis Nation of Ontario (MNO) (Region 4).

Facilities in Port Hope, Toronto and Peterborough areas (Cameco Port Hope Conversion Facility (PHCF), Cameco Fuel Manufacturing facility (CFM), and BWXT Nuclear Energy Canada Inc. facilities in Toronto and Peterborough.)

- Williams Treaties First Nations (WTFN), which include Alderville First Nation (AFN), Curve Lake First Nation (CLFN), Hiawatha First Nation (HFN), the Mississaugas of Scugog Island First Nation (MSIFN), the Chippewas of Beausoleil First Nation (CBFN), the Chippewas of Georgina Island First Nation (CGIFN) and the Chippewas of Rama First Nation (CRFN);
- Mississaugas of the Credit First Nation (MCFN);
- Métis Nation of Ontario (MNO) (Region 8);
- Mohawks of the Bay of Quinte (MBQ).

Ottawa Valley facilities (SRB Technologies Inc. (SRBT), Nordion Canada Inc., and Best Theratronics Limited (BTL))

- Algonquins of Ontario (AOO);
- Algonquins of Pikwàkanagàn First Nation (APFN);
- Kitigan Zibi Anishinabeg;
- Algonquin Anishinabeg Nation Tribal Council (AANTC);
- Kebaowek First Nation;
- The Algonquin Nation Secretariat;
- Métis Nation of Ontario (MNO) (Regions 5 and 6).

M. Fact sheet – Licence limits for releases to the environment

E-Doc 6082890 English

Fact Sheet

Licence Limits for Releases to the Environment

July 2020

What are licence limits?

A licence limit is a value or condition that, if exceeded, indicates that the licensee is operating outside of its licensing basis during normal operations and is not in compliance. The licensing basis is the set of requirements and documents for a regulated facility or activity, including:

- the regulatory requirements
- the safety and control measures described in the facility's or activity's licence and the documents referenced in that licence
- the safety and control measures described in the licence application and the supporting documents

Licence limits for releases to the environment are one such requirement.

What are licence limits for releases?

The Canadian Nuclear Safety Commission (CNSC) ensures that licence limits for releases are included in CNSC licences, in order to protect human health and the environment, confirm that pollution prevention and control technologies are implemented, drive continuous improvement and verify that the licensee is operating within its approved licensing basis. Two types of licence limits for releases are implemented at CNSC-regulated facilities: exposure-based and technology-based. Exposure-based limits ensure that releases do not exceed levels that are protective of people and the environment. Technology-based limits ensure that licensees are implementing the best available pollution prevention technologies and techniques.

Do CNSC staff review and accept licence limits for releases?

Quick facts

- The CNSC establishes licence limits for releases to the environment to protect human health and the environment
- Effluent monitoring programs are implemented at CNSC-licensed facilities to ensure that releases to the environment are below licence limits
- CNSC staff review licence limits before they are accepted in a licence, to verify that they are protective of human health and the environment
- A derived release limit (DRL) is a sub-type of licence limit that applies to radiological substances and is based on an individual receiving a dose of 1 millisievert (mSv) per year
- The CNSC recommends that licensees harmonize licence limits for releases with those from other federal/provincial/territorial requirements that the CNSC considers protective

CNSC staff provide guidance to licensees on how to derive licence limits for releases and how to determine which contaminants require them. Before these limits for releases become part of the licensing basis, CNSC staff review them to verify that they are protective of human health and the environment.

Furthermore, as stipulated in some licences, certain licensees are required to periodically update their licence limits. This update can be triggered by new scientific information, operational changes or new regulatory/licence requirements. CNSC staff also review and approve updated licence limits for releases.

How do CNSC staff verify that licensees are in compliance with their licence limits for releases?

Licensees of Class I nuclear facilities are required to submit data, in their quarterly and/or annual compliance reports, for both radiological and hazardous (non-radiological) releases to the environment. CNSC staff review these results and verify that the corresponding licence limits have not been exceeded. CNSC staff also perform environment-focused inspections at nuclear facilities and review effluent data to ensure that the licensees are in compliance with their licence limits for releases.

As part of section 29(1)(c) of the *General Nuclear Safety and Control Regulations*, licensees are required to immediately submit a preliminary report once they become aware of a release into the environment of a nuclear substance that is above the licence limit.

How are licence limits for releases determined?

Exposure-based licence limits for releases are established with the objective of ensuring that releases to the receiving environment do not exceed levels that are protective of people and the environment. For example, a derived release limit (DRL) is determined using site-specific information to calculate the level of a nuclear or hazardous substance that would be harmful. This limit ensures that this level is not exceeded. (See next section for more details on DRLs.)

Technology-based licence limits for releases are based on what is achievable by the best available pollution prevention technologies and techniques. A technology-based licence limit can be sector specific (based on pollution prevention technology and best practices common in an industry sector) or case specific (based on the pollution prevention technology and administrative practices in place at a specified facility).

The licensee proposes which of the two approaches it will use to calculate its licence limits for releases. For either approach, the licensee must demonstrate that these proposed licence limits respect the regulatory public dose limit and are protective of human health or the environment.

What are derived release limits?

For nuclear substances released from Class I nuclear facilities, the CNSC's licence limits are DRLs. A DRL is an exposure-based licence limit which ensures that members of the public do not receive radiation doses that would be harmful. For most facilities, the DRL is based on a most-exposed person receiving a radiological dose of 1 mSv/yr from radiological releases of a facility during normal operations. This most-exposed person is a person who would have a higher dose than the average member of the public due to a combination of factors,

such as location, lifestyle and food consumption. This person is determined from site-specific surveys and can be based on an actual or hypothetical person. The dose of 1 mSv/yr is the annual dose limit established in the *Radiation Protection Regulations*.

Some facilities use a lower radiological dose, known as a dose constraint, to determine a DRL. A dose constraint is still an estimate of the dose received by a most-exposed person, but based on a dose that is less than 1 mSv/yr. If the most-exposed person's dose is below that limit, then all members of the public will also have doses below it. The purpose of a dose constraint is to ensure that the sum of all doses from multiple nuclear activities in a region is less than 1 mSv/yr. This means that the DRL itself would be based on a dose that is less than 1 mSv/yr.

Based on recommendations from the Integrated Regulatory Review Service (IRRS), CNSC staff will be adding dose constraints to radiological releases. More information on dose constraints will be documented in draft REGDOC-2.9.2, *Controlling Releases to the Environment from Nuclear Facilities*, which is scheduled for public consultation in late 2020.

How are DRLs calculated?

The DRL is derived using the methodology and calculations published in CSA N288.1, *Guidelines for Calculating Derived Release Limits for Radioactive Material in Airborne and Liquid Effluents for Normal Operation of Nuclear Facilities*. CSA N288.1 is a model that describes the transfer of radioactive materials through the environment to humans. DRLs are calculated separately for releases to air and to surface water.

The first step in the process is to identify all of the radionuclides released in air and liquid. Then, the exposure pathways and most-exposed person(s) are identified from site-specific surveys. An exposure pathway is a route by which a person can be exposed to radiation. Examples of exposure pathways include ingestion and inhalation. The DRL for a radionuclide is calculated by dividing the annual dose limit to the public of 1 mSv/yr (or the dose constraint) by the sum of all doses from that radionuclide through the exposure pathways. For airborne releases, an atmospheric dispersion model is used to determine how much radioactivity from the source radionuclide is transferred to a most-exposed person through the atmosphere. For releases to surface water, an aquatic dispersion model is used to determine how much radioactivity from the source radionuclide is transferred to a most-exposed person through water. DRLs are calculated for all of the identified most-exposed person(s) and are calculated separately for different age classes (e.g., infant, child and adult).

What other types of licence limits for releases exist?

There are other federal, provincial and territorial limits for releases to the environment. Federally, the *Metal and Diamond Mining Effluent Regulations* and *Wastewater Systems Effluent Regulations* apply to uranium mines. Provincially and territorially, there are permits or approvals for releases to the environment. Municipalities have sewer bylaws. Licensees are required to meet all of these regulations, approvals and/or bylaws that apply to their operations.

When establishing licence limits for releases, the CNSC recommends that licensees harmonize with available federal, provincial, territorial and/or municipal requirements that the CNSC considers adequately protective of the environment. For example, for the uranium mines and mills, the CNSC adopted authorized effluent discharge limits from Schedule 4 of the *Metal and Diamond Mining Effluent Regulations* that are established

under the *Fisheries Act*. These limits are technology-based release limits that were derived considering the best available pollution prevention technologies and techniques economically achievable at the time. These limits are specific to the metal mining industry.

What happens if a licence limit is exceeded? Is there any risk to the public or to the environment?

Exceeding a licence limit represents a loss of control of part of the licensee's programs or control measures. Hence, it is an indication that the licensee is operating outside of its licensing basis during normal operations. However, it does not necessarily imply an unreasonable risk to the environment, to the health and safety of persons or to national security; that is, it does not mean that actual harm will come about.

Most technology-based release limits and exposure-based release limits are set below levels required to protect human health and the environment. For this reason, exceeding a limit does not necessarily imply that either the health of the public or an ecosystem is at risk, but the exceedance triggers a requirement for the licensee to take specific actions, such as mitigation measures, to restore the effectiveness of the program, and increase downstream monitoring to demonstrate that the environment is protected. An exceedance of a DRL indicates that the facility has exposed a member of the public to a dose greater than the regulatory annual dose limit and will be subject to regulatory action.