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Canadian Nuclear Laboratories**

**Mémoire des
Laboratoires Nucléaires Canadiens**

In the Matter of the

À l'égard des

Chalk River Laboratories

Laboratoires de Chalk River

Application for the renewal of the Nuclear
Research and Test Establishment Operating
Licence

Demande de renouvellement du permis
d'exploitation d'établissement de recherche et
d'essais nucléaires

Commission Public Hearing

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Canadian Nuclear
Laboratories

Laboratoires Nucléaires
Canadiens

Commission Member Document for Licensing Decisions

Chalk River Laboratories Site Licence Renewal for 2018

Canadian Nuclear Laboratories

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EXECUTIVE SUMMARY

This commission member document is presented to the Canadian Nuclear Safety Commission (CNSC) Secretariat, in support of an application from Canadian Nuclear Laboratories Ltd. (hereafter CNL) to renew the Nuclear Research and Test Establishment Operating Licence for the Chalk River Laboratories (CRL) site, located in Renfrew County in the Province of Ontario, approximately 200 km northwest of Ottawa. Owned by Atomic Energy of Canada Limited (AECL), a federal Crown corporation, the CRL site has been in operation for more than six decades.



Figure: Aerial view of the Chalk River Laboratories site.

Planning for continued safe operation at CRL, CNL submitted an application to the CNSC Secretariat on 2017 March 30 for renewal of the site operating licence, for a ten-year term commencing on 2018 April 01. Required information for an application to renew the current licence was also submitted to the Secretariat in accordance with the requirements of the Nuclear Safety and Control Act and associated Regulations.

The application for renewal is presented for consideration by the Commission, consistent with the corporate vision, mission, and identity of CNL, which stands proud as a global leader advancing nuclear science and technology. CNL has the capability to solve some of the toughest technological challenges in the world and has developed effective industrial partnerships. The various CNL campuses are home to a vibrant community of the world's brightest innovators, and CNL staff members are proud to be recognized for the significant contributions they are making in improving the quality of life for people in Canada and the rest of the world.

The current CNSC operating licence for the CRL site is valid until 2018 March 31. As explained below, CNL maintains and operates the site under a Government-Owned Contractor-Operated model under agreement with AECL, who retains ownership of the site and associated liabilities on behalf of the Government of Canada.

During the current licence period which commenced on 2011 November 01, the CRL site has undergone significant change in how it is managed and operated. On 2013 February 28, the Government of Canada announced its intention to launch a formal competitive process for the private sector engagement in the management and the operation of the nuclear laboratories.

In 2014, AECL created a Site Operating Company, as a wholly-owned subsidiary of AECL, to be operated with essentially the governance, management systems, and the workforce that then existed within the Nuclear Laboratories. Restructuring progressed throughout 2014 with the Site Operating Company being named as Canadian Nuclear Laboratories Ltd. on 2014 May 30, following legal incorporation under the Canada Business Corporations Act. With the standing-up of CNL effective 2014 November 03, CNL assumed full responsibility for day-to-day operations of the nuclear laboratories with the coincident transfer to CNL of all CNSC licences formerly issued to AECL. On 2015 June 26, the Government of Canada announcement that the Canadian National Energy Alliance was the preferred bidder chosen to manage and operate CNL, and on 2015 September 13, AECL restructuring was concluded with share transfer from CNL to Canadian National Energy Alliance. Throughout the entire restructuring process, the CNSC was advised of progress, as appropriate.

The most recent major renewal of the CRL operating licence was approved by the Commission on 2011 October 27, for a period of 60 months. The licence was extended by 17 months following an appearance before the Commission in 2016 April. The extension was requested by CNL in order to reflect the permanent shutdown date (2018 March 31) for the National Research Universal (NRU) reactor, as directed by the Government of Canada. In addition, requested changes were incorporated into the licence regarding the extended shutdown process for the reactor.

Under the new Government-Owned Contractor-Operated management model, the mandate outlined objectives to address the nuclear legacy and historic waste liabilities, to expand the science and technology capabilities, and to fully enable the nuclear industry's needs for in-depth nuclear research and development.

Also under the new model, CNL established and implemented a revised Management System, which is the empowering platform to enable the continuance of safe operational practices at CRL throughout the proposed ten year licence period, and full realization of the corporate vision and mission. Major capital funding has been confirmed from AECL to enable the successful revitalization and transformation of the site, with the mandate to augment through commercial funding and public-private partnerships.

More specifically, activities are underway for the revitalization of the site through reduction in the nuclear legacy waste liabilities of historic operations with new research facilities under

construction, and others planned, to transform the CRL site as a sustainable world class nuclear laboratory site delivering science and technology capability structured to meet current and changing Canadian federal, commercial, and public priorities.

With specific regard to decommissioning and waste management, CNL will proceed with the decommissioning, environmental restoration, and waste management projects based on sound waste management and environmental principles. The culmination of these activities will generate space to allow construction of new world class research laboratories that enable the science and technology mission to flourish.

A significant change in the focus of site operations will be the planned permanent shutdown on 2018 March 31 of the National Research Universal reactor, which by then will have been in operation for a period of more than 60 years, advancing the quality of life of Canadians and people around the world in various fields such as medical isotope production, engineering research, training, and significant development in support of the Canadian CANDU® reactor program. Operation of the NRU reactor has been the most significant source of risk for potential off-site consequences and the single largest contributor to radiological emissions at CRL. As such, it was the subject of an integrated safety review in 2010, leading to a ten-year integrated implementation plan that was closely monitored during execution, to ensure that safety and reliability outcomes were achieved. The previous five-year licence term was primarily aligned with the first five-year term of the integrated implementation plan. The NRU reactor will progress to a permanent safe shutdown state early in the new licence period, followed by transition to storage with surveillance in 2021.

In addition to the long standing contribution of the NRU reactor, the other Class I and Class II nuclear facilities and radioisotope laboratories at CRL have continued operating safely throughout the current licence period.

This commission member document is structured such that it provides an overview of the integrated performance against each safety and control area, and the performance and future plans for the Class I and II nuclear facilities, and radioisotope laboratories, listed in the CRL licence conditions handbook. In addition, specific information is presented on other matters of regulatory interest (e.g., public information program). The CNSC CRL licence conditions handbook identifies the regulatory requirements and licensing basis for the CRL Nuclear Research and Test Establishment Operating Licence.

CNL's performance is at the "satisfactory" rating for all safety and control areas; two were improved from a "below expectations" rating during the current licence period.

There are currently 11 Class I and 4 Class II nuclear facilities located at the CRL site and relevant information is presented on past performance, operation and compliance since the 2011 licence renewal with an indication of future plans.

CNL currently operates 1 Class A, 20 Class B, and 25 Class C radioisotope laboratories, with radioisotope laboratory protocols that define how work is controlled.

Near Surface Disposal Facility

In parallel with CNL's application for the site operating licence renewal, a separate application has been provided by CNL to the CNSC to construct an engineered facility at CRL. The new facility, named the Near Surface Disposal Facility (NSDF), would be a modification to the waste management areas Class I nuclear facility. The purpose of the proposed NSDF is to provide a safe and permanent solution to the disposal of radioactive waste at CRL. The modification is intended to substantially reduce the risks associated with the CNL legacy waste liabilities, by creating an engineered disposal facility that will contain wastes and prevent migration of radiological and environmental wastes to the environment. Furthermore, the project will enable the site revitalization through improved environmental management of AECL legacy waste liabilities and the decommissioning of outdated infrastructure at the CRL property and other business locations. The proposed NSDF would accommodate the disposal of current and future radioactive waste at the site in a manner that is protective of human health and the environment.

As per the notice of public hearing issued by the Commission, submissions related to the proposed NSDF project will not be accepted, and no decision related to the project will be made at the public hearing for consideration of the operating licence renewal. It was further noted that a separate hearing for consideration of NSDF matters has been scheduled for 2018 July. In consideration of this ruling by the Commission, appropriate mention of the NSDF project has been made in brief terms only, throughout this commission member document, in order to place the project in the context of existing and planned future operation of the site. Detailed submissions and all official interaction on the project between CNL, the Commission and CNSC staff will take place under separate cover and with distinct separation from this commission member document and any other communication related to the CRL operating licence renewal application.

Conclusion

CNL's dedicated employees are its primary asset. The commitment, dedication, and technical excellence of CNL's employees have established a proud heritage over many decades. CNL is now embarking on a new chapter in its long history, building on the strong foundation set by the visionaries and innovators of the past, now under a Government-Owned Contractor-Operated arrangement, and with a revitalized mission and vision for an extended licence period to enable substantial redevelopment and revitalization of the site infrastructure and enabling facilities.

A core prerequisite for CNL's success in consistently bringing high value to its customers and stakeholders is the effective and efficient governance and management of the company. CNL is committed to excellence in management, thereby providing the foundation on which the company and employees can thrive.

CNL respectfully submits this commission member document for consideration to enable a further decade of nuclear innovation and science and technology development. Safety is the utmost priority for CNL operations. Nuclear safety remains paramount at CNL. Conventional, radiological, environmental performance, and security requirements are ensured through the dedication of staff and safety culture that is established through the implementation of the various processes, procedures, and programs governed by the improved Management System. Safe operation extends protection to the CNL employees working at the site, contractors, visitors, members of the public, and the environment.

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1. INTRODUCTION

The purpose of this document is to present information in support of the application from Canadian Nuclear Laboratories Ltd. (CNL) to renew the operating licence for Chalk River Laboratories (CRL) for a period of ten years.

The most recent major renewal of the CRL operating licence was approved by the Commission on 2011 October 27, for a period of 60 months. The licence was extended by 17 months following an appearance before the Commission in 2016 April. The extension was requested by CNL in order to reflect the permanent shutdown date (2018 March 31) for the National Research Universal (NRU) reactor, as directed by the Government of Canada. In addition, requested changes were incorporated into the licence regarding the extended shutdown process for the reactor. Since the licence renewal in 2011 (77 months), the NRU reactor will have benefitted from the extensive work under the Integrated Implementation Plan (IIP).

Furthermore, the extended licence enabled the incoming management team to become established prior to the submission of this long-term licence renewal application.

This introductory section presents a brief overview of the CRL site and surroundings with information also provided on the business and infrastructure development that is planned for the requested licence period. Further specific information is presented on various strategic science and technology (S&T) objectives that are expected to be achieved. Historical information is also presented to summarize the tremendous achievements of the NRU reactor over a period of six decades. Finally, a summary of the performance ratings is presented for the 14 CNSC Safety and Control Areas (SCAs), covering the period of 2011 November to 2017 June. During this period, CNSC staff performed regular assessments of CNL's performance against these SCAs, as further discussed in Section 1.5.

1.1 Canadian Nuclear Laboratories Corporate Vision

This application for renewal is presented for consideration by the Commission, consistent with the CNL corporate identity. The purpose of the company is to advance nuclear science and technology for a clean and secure world.

The mission is reflected as follows:

- Restoring and protecting Canada's environment by reducing and effectively managing nuclear liabilities.
- Providing the world with sustainable energy solutions including the extension of reactor operating lifetimes, hydrogen energy technologies, and fuel development for the reactor designs of tomorrow. Together with partners, demonstrating the commercial viability of advanced reactor designs including Small Modular Reactor (SMR).
- Collaborating with medical/educational institutions and pharmaceutical companies to pioneer new alpha therapies for cancer treatments that save countless lives.

- Leveraging all capabilities for commercial success in Canadian and international markets.

The CNL core values are:

- **Safety:** Freedom from harm, danger, injury, or loss to people and the environment. It is the foundation on which CNL's decision-making stands.
- **Respect:** Placing a high value on others, treating them fairly, and empathizing their needs.
- **Teamwork:** The ability to work together, in a collaborative way, toward a common goal.
- **Accountability:** An attitude and a set of actions that affect how CNL impacts people, situations, and results in a positive way.
- **Integrity:** Adhering to high ethical standards and strong moral principles, even under pressure.
- **Excellence:** Striving to achieve an ever-rising standard of quality through continual improvement and innovation.

1.2 Description of the Site

CRL is located in Renfrew County (population 102 000) in the Province of Ontario on the southern shore of the Ottawa River, approximately 200 km northwest of Ottawa (Figure 1 and Figure 2). The site is situated within the boundaries of the Corporation of the Town of Deep River. The surrounding terrain, except for the Laurentian Mountains directly north and east across the river, consists of gently rolling hills, interspaced with many small lakes. The Ottawa River flows from northwest to southeast. The Petawawa Military Reserve abuts the CRL restricted area to the southwest and extends to the Petawawa River 20 km downstream. A detailed description of the site location and its boundaries is given in the order [1] (Atomic Energy Control Act) designating CRL as a protected place.

Access to the CRL site is limited to CRL employees, approved contractors, and visitors. Other land uses are prohibited due to the restricted public access.

The population surrounding CRL lives predominantly in Renfrew County in the Province of Ontario. The majority of local residents live in or close to and around the town of Deep River and the Village of Chalk River. Surrounding these two population centres are Rolph, Buchanan, Wylie and McKay, which, with Chalk River, form the town of Laurentian Hills. The town of Petawawa and the military base (Garrison Petawawa) are located 20 km downstream from CRL. Another large population centre is Pembroke, 35 km downstream Ottawa River from CRL, and the Laurentian Valley Township around Pembroke. North Bay and Ottawa are more than 140 km up and 190 km downstream, respectively.

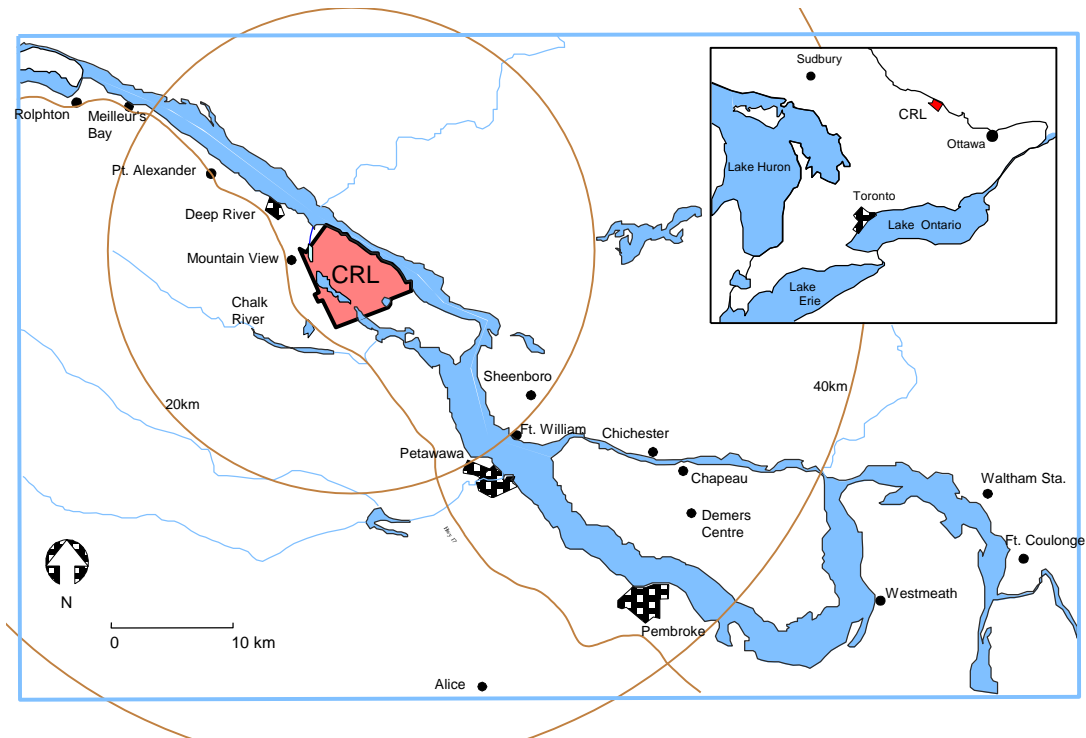


Figure 1 Chalk River Laboratories location including nearby population centres.



Figure 2 Aerial view of the Chalk River Laboratories site built-up area.

The portion of Pontiac County in the Province of Québec, north and east of the river and opposite the site, is normally uninhabited, except during the summer months when a few cottage dwellers may be present. The closest centres of population on the Québec side are Fort William and Sheenboro, about 15 km downstream.

Land use in the region consists primarily of forestry, recreation and tourism, with limited agriculture, trapping, and mining. The nearest area of significant agriculture and dairy farming is 15 km downstream on the Québec side of the river and 35 km downstream on the Ontario side. Upstream of CRL, except for the Municipality of Rapides Des Joachims in Québec, the majority of settlement and development is located on the Ontario side of the Ottawa River. Very little development has taken place on the Québec side of the river, northwest of Allumette Lake.

Because of its irregular boundaries, the eastern edge of Algonquin Provincial Park ranges from 8 to 15 km west of Highway 17. Most of the remaining land in the region is undeveloped.

The CRL property is mainly covered by forest consisting of white, red, and jack pine; white and yellow birch; hemlock; white, red, and black spruce; beech; sugar and red maple; red oak; and poplar. The Canadian Forest Service has approximately 30 established research plantations on the CRL site and these are managed and monitored by the Petawawa Research Forest (Figure 3). No commercial cutting of trees currently takes place at CRL.



Figure 3 Aerial view of one of the established research forest plantations.

The area supports a wide range of wildlife species including moose, deer, black bear, ruffed grouse, hare, and waterfowl. The area also supports many fur bearing animals such as beaver, mink, fisher, marten, otter, muskrat, fox, and raccoon. The surrounding area is not situated within a major waterfowl flyway; however, numerous wetlands provide a suitable nesting habitat for waterfowl. No hunting is permitted on the CRL property.

The Ottawa River is an important source of sport fishing. Fish found in local waters within and surrounding the CRL property includes pike, bass, walleye, muskie, and sturgeon. No fishing is permitted on the CRL property except for environmental monitoring purposes.

1.3 Evolution of the Chalk River Laboratories Site

CNL's most significant evolutionary initiatives, as listed below, will continue for the remaining period of the operating licence and throughout the term of the proposed renewed licence. Section numbers are indicated where further information is presented in this document.

- S&T program (Section 1.3.2)
- infrastructure improvements (Section 1.3.1)
- Management System evolution (Section 2)
- NRU reactor – execution of shutdown plans (Section 17.1.1.13)
- decommissioning and waste management (D&WM) (Sections 4.3 to 4.6, 12, 17.1.8, and 17.1.10)
- Near Surface Disposal Facility (NSDF)

CNL's diverse capabilities have contributed to the full spectrum of nuclear technology in Canada: mining, fuel production, reactor design, nuclear power generation, nuclear facilities operations, decommissioning, remediation, waste management, nuclear medicine, materials science, imaging, nuclear safety, regulation, and governance.

With a safe and permanent reduction of the nuclear legacy liability already underway at several locations and the imminent closure of the NRU reactor in 2018, Canada's premier nuclear laboratory at the CRL site will be strategically consolidated and modernized over the next ten years.

The long-term vision of CNL is that CRL continues as a sustainable world-class national nuclear laboratory delivering S&T structured to meet current and changing Canadian federal, commercial, and public priorities. CNL's enduring purpose is to continue the advancement of nuclear S&T for a clean, healthy, and secure world. Through close engagement with the Government of Canada and Atomic Energy of Canada Limited (AECL, a federal Crown corporation), under the Government-Owned Contractor-Operated model, it is the expectation that the CRL site will continue to be a world-class centre of excellence in technology and scientific research.

As depicted in Figure 4, the transformed CNL CRL location will include state of the art modern structures that will support the nuclear research needs of the Canadian government and the evolving science and technology needs of the Canadian and global nuclear industry. These include the Advanced Nuclear Materials Research Centre, a new business hub building, a CNL support facility, and redeveloped area at the site entrance.



Figure 4 Partial views of the proposed Chalk River Laboratories site revitalization.

Advanced Nuclear Materials Research Centre: this centre will combine the capabilities of Universal Cells, (Building 234), Fuels and Materials Hot Cells (Building 375), Recycle Fuel Fabrication Laboratories, the metallographic laboratories (Buildings 300, 375 and 380) and the NRU reactor rod bays into a modern shielded facility and laboratory research complex. CNL will be positioned to respond with nuclear fuels and materials handling, testing, characterization, and analysis capabilities that are modular and that can be reconfigured. This new centre will:

- Allow for successive expansions as federal and commercial demand increases.
- Provide flexible, open laboratory space.
- Facilitate future equipment deployment and accommodate large fuel and material assemblies.
- Facilitate safe and secure radioactive material transfer amongst a full suite of facilities, including hot cells, warm cells, glove boxes, fumehoods, radioisotope laboratories, and in-pool storage.

Business Hub: this detailed design multi-story building will provide office space for employees being relocated from buildings being turned over to decommissioning, and will provide a new modern collaborative work environment.

Logistics/Warehouse Building: this will provide a safer and more secure site while providing more cost-effective and efficient support services, in addition to supporting footprint reduction and modernization of the site. The warehouse will consist of a loading dock for shipment to and from the CRL site. It will also house materials and equipment for an on-site inventory from stores. This building will be built at the outer gate area and will also be the receiving area for all visitors and contractors.

CNL Support Facility: this will provide a safer and more secure site while providing more cost-effective and efficient support services, in addition to supporting footprint reduction and modernization of the site. The facility will provide space for several support shops for the CRL site and provide a safe and modern building for site maintenance shops to work together efficiently in a consolidated environment. The full scope of the project is currently being defined.

1.3.1 Chalk River Laboratories Infrastructure Improvements

CNL continued to reduce the risk and maintain stable operation of the steam, condensate, and air distribution systems across the CRL site through improved system start-ups, increased surveillance and maintenance with targeted reconstruction of aging service lines. This strategy continues to balance the current need to improve the safe operation of these systems with the responsibility for effective investment of capital upgrades.

Several infrastructure improvement projects gained momentum in 2016, as follows:

Domestic Water: will bring potable water from the Town of Deep River to the CRL site, for the following uses: potable water for food preparation, sanitary and personal facilities, and safe drinking water. Major construction activities continue, both within the site boundary and the

municipality of Deep River, with completion expected in 2018 March. More than 12 km of water main piping have been installed from the Town of Deep River into the controlled area at CRL. As of 2017 August, 100% of the water main from the Mattawa Road fence to the new reservoir has been installed, which accounts for 95% of the total water main installation planned. The remaining water main installation includes the final section of pipe from the new reservoir location to the tie in point inside the controlled area. A 2000 m³ concrete reservoir will be built and commissioned.

The Town of Deep River is completing their required portion of the upgrades. The new booster pump station (Figure 5), located beside the Deep River hospital, is constructed and currently being function tested. All water main piping has been installed and commissioned. Upgrades to the Water Treatment Plant and the Low Lift Pump Station are completed, and can now support the water demands of the CRL site.



Figure 5 Booster Pump Station located in Deep River, Ontario.

Natural Gas Installation: major construction activities were completed to bring natural gas to the CRL site (Figure 6). This project will address the increasing difficulty and costs associated with the supply of low sulphur Bunker C heavy oil currently used as the fuel source for the Building 420 Powerhouse boilers. Environmental benefits derived from converting to natural gas include the reduction of greenhouse gas releases and other harmful emissions (NO_x, SO_x). The CRL site carbon footprint will be reduced by approximately 8700 tons per year. The pipeline has been energized and work continues to convert Buildings 137, 350, and 420 to natural gas heating.



Figure 6 Natural gas pipeline project.

Sanitary Sewer Treatment Facility: new facility will be built on the old Building 567 footprint. Phase 1 was started in 2015 November to rehabilitate the old pipe from the existing facility and demolish Building 567. Construction activities for the new plant commenced in 2016 October, and the new facility will conform to both federal and provincial standards. As of 2017 September, work continues on the building structure with most concrete work completed. The construction phase is expected to be mostly completed by 2018 March, and testing will have commenced. The contractor will run the plant for a year after all the testing is complete which is expected in 2018 August or September. The new sewage plant is scheduled to be turned over to CNL around 2019 September.

Storm Water Management: work commenced in 2013 to allow the management of storm water outflows to the Ottawa River. This project enables CNL to be a responsible steward of the environment and to improve physical infrastructure of the site. In addition, the construction of two sets of capture ponds will enable CNL to capture potentially contaminated fire water runoff in the event of a fire in a nuclear facility. The project is summarized below:

- In 2013 December, stream diversion activities which entailed burying a new storm water pipe to divert an existing natural stream around the built up area of CRL were completed.
- In 2015 November, the construction of a new storm water pond outside of the controlled area fence east of Buildings 600 and 456 was completed. This pond captures

water coming from the supervised area and the majority of the controlled area improving drainage, as well as addressing flooding and erosion issues. Potentially contaminated fire water runoff is able to be captured and sampled prior to release to the Ottawa River or removal and processing by Waste Management.

- Construction of an underground main trunk line along the eastern edge of the built up area. This line intercepts multiple outflow pipes and redirects this flow to the main storm water pond reducing CNL's environmental liability.
- Construction of twin dry ponds and associated feeder line to capture storm water and potentially contaminated fire water from the lowest portion of the controlled area (Buildings 467, 539 and 610).

During the spring and summer of 2017, construction continued. Further construction activities will take place in 2018 to complete the current project.

Bulk Material Landfill: this landfill site was developed for the storage of all dewatered sewage sludge produced at the Sewage Treatment Plant at CRL. During the 2017/2018 fiscal period the existing landfill site will be expanded to double its capacity to 5000 m³ as Phase 2 of an anticipated four-phase development. The expansion will permit 10 to 15 years of additional sewage sludge deposits and enable year-round sludge deposits. The construction work will be performed by a general contractor, secured through competitive tender, and completed in 2017/2018 fiscal period.

Switch Yard: during the 2017/2018 fiscal period, project definition and detailed planning will continue on the new Switch Yard project. This project will not only make the electrical supply more robust but also enable long-term energy cost reductions.

CNL maintained focus on investment in high priority safety, environmental, and regulatory related infrastructure projects such as the final fulfilment of the exit strategy for Building 250. Construction of the relocated Tritium Laboratory (Figure 7) commenced and progresses to plan.



Figure 7 New Tritium Laboratory.

Construction of the new laboratory complex Building 350 was completed well ahead of schedule. Occupancy of the office and administration area occurred following completion of major construction activities. The building was officially opened on 2016 October 19 and named as the Harriet Brooks building (Figure 8). Final completion of these projects is the delivery of the Building 250 exit strategy.



Figure 8 New Harriet Brooks building exterior views.

Information regarding the Hydrogen Isotopes Technology (Building 137) laboratory is located in Section 1.3.2.2.3.

Other infrastructure improvements and updates within CRL facilities were achieved, such as the emergency power system additions and rebuilt boiler chemical dosing systems at the Powerhouse. A guaranteed Class III power system and cooling improvements have been provided for the Information Technology Department Data Centre, bringing improvements to the reliability of the Information Technology systems. Construction and testing of a new and dedicated Live Fire Fighting Complex have been completed, and the complex has been handed over to the CNL Fire Department to satisfy increased training needs. All parking lots at the CRL site have been improved and now all areas have an asphalt coating leading to a reduced safety hazard to all employees and enabling improvements for snow clearance.

The site-wide fire hazard analysis project associated with building upgrades, in response to recommendations from CNSC staff, continues to be executed to plan. As of 2017 September, 90% (664 of 738) of building specific recommendations have been addressed.

The fumehood project, established to bring existing fumehoods up to modern code standards, not in place at the time of installation, is progressing to plan. All fumehoods at CRL were assessed, and where required, compensatory measures were implemented, to maintain a safe environment. As of 2017 July, and as per the plan, 79% (197 of 248) of fumehoods have been replaced, upgraded, or removed from service.

1.3.2 Science and Technology Program

Canada's premier nuclear laboratory at the CRL site will be strategically consolidated and modernized over the next ten years, enabled by the proposed ten-year operating licence period. The transformed CRL site will support the nuclear research needs of the Canadian government and evolving S&T needs of the Canadian and global nuclear industry throughout the term of the proposed licence, and beyond.

CNL's mission includes:

- Development of sustainable energy solutions including advanced reactors, hydrogen-energy technologies, extension of reactor operating lifetimes, and fuel development for new reactor designs.
- Restoration and protection of Canada's environment by responsibly managing and removing nuclear liabilities.
- Working with external business partners to leverage our laboratories' internal capabilities for commercial success in the Canadian and international markets.
- Demonstration of the commercial viability of advanced reactors including the SMR and/or the very Small Modular Reactor.
- Support of radiochemical therapies pioneering alpha treatment for cancers, in collaboration with medical and educational institutions, and pharmaceutical companies.

CNL will be delivering a vibrant, forward-looking S&T portfolio that will continue to evolve to meet the needs of Canada and a broad base of commercial customers. CNL will be commercially competitive on the world stage, and known for its successful delivery of complex technical projects. CNL's differentiating capabilities in advanced nuclear materials and fuels; radiobiology; and nuclear safety and security will be recognized as being at a world class level.

During the proposed licence period, CNL will be at the core of worldwide innovation clusters through cooperation with technology partners, customers, academia, and government agencies. It will advance the successful development and deployment of new nuclear technologies as well as shape national and international agendas and regulations. With CNL being fully engaged and supporting development and execution of these initiatives, Canada will be delivering long-term

nuclear technology road maps that are integrated with federal and provincial energy needs, and that yield maximum benefit to Canadian communities and industries.

CNL's versatile, state-of-the-art campus and facilities will draw top-calibre scientific talent, partners, and users from across the globe. Modernized facilities, systems, and equipment will enable international collaboration on the majority of its projects, leveraging unique skills, facilities, and market presence.

Informed by Canadian and global trends and prospects, CNL will combine federal and commercial priorities and needs into focused application-driven research and technology development, which is categorized into four S&T programs (i.e., energy, health, safety and security, and the environment), and consideration of SMR technology.

1.3.2.1 Science and Technology Strategic Objectives

CNL will drive several S&T strategic objectives under these four programs, as described below. Also described is the ongoing discussion around SMR technology in Canada.

1.3.2.1.1 Energy

Life Extension and Long-Term Reliability of Existing Reactors: building on Canada's 50 year investment in S&T activities related to CANDU^{®1} reactor technology, CNL will support life extension and long-term reliability of the existing fleet of reactors domestically and internationally, and expand efforts to include support for other reactor designs.

Advanced Fuel Fabrication: CNL will support long-term reliability of existing reactors and the development of advanced reactors; advanced nuclear fuel concepts are being developed worldwide. These advanced fuels offer higher performance, improved failure tolerance, resistance to proliferation, increased safety and accident tolerance, and are recycled or recyclable.

Decarbonization of the Transport Sector and Remote Communities in Canada: building on capabilities developed to support hydrogen safety and heavy water and tritium management in CANDU reactors, CNL will play a leading role in the demonstration of hydrogen-based bulk transport by 2020.

1.3.2.1.2 Health

Radiobiology Research: CNL will continue to advance the understanding of the effects of low doses of radiation on humans, the health effects of uptakes of radionuclides, the therapeutic treatments to reduce radiation doses in case of human intake of radioactive material, and the research aimed at other potentially beneficial uses of radiation for human health.

¹ CANDU = CANada Deuterium Uranium, registered trademark.

Alpha Research Institute: the benefit of targeted alpha therapy for battling cancer and other diseases is that the radiation is targeted at just the cancer cell, unlike existing treatments that often involve radiation of all cells in the vicinity of a tumor, both healthy and cancerous. Due to an international shortage of key nuclides, severely restricted research in this area puts at risk the availability of effective treatment technology. Alpha-emitting isotopes, of the greatest interest for this therapy, must be activated and processed in specialized facilities. CRL will have the facilities to move ahead with this opportunity through completion of the Building 350 laboratory complex and revitalization of some other existing research facilities.

1.3.2.1.3 Safety and Security

Nuclear Cyber Security: Canada has responsibilities for safety, security, and provision of emergency response capability. CNL will support the Government of Canada in meeting its obligations and will also commission a nuclear cyber security testing facility by 2018, with the deployment of a nuclear industrial control cyber intrusion detection and mitigation system by 2022.

Centre for Nuclear Forensics and Response: by 2019, CNL will establish a centre for government agencies and commercial partners to develop, test, calibrate, and validate nuclear forensics, non-proliferation, security, and response technologies and materials.

In 2017 September, under the Canadian Safety and Security program, the Nuclear Materials Signature and Provenance Assessment Capability Project Charter was signed. Signing of the charter is a significant milestone and marks the commencement of this project. CNL and the CNSC are partners in this project with other industry representation.

1.3.2.1.4 Environment

Environmental Stewardship: CNL will expand understanding of how radioactive material is transported through ecosystems, and how this varies with isotopes, physical and chemical forms, and environments throughout Canada. In addition to supporting current government priorities, these activities will ultimately be used to inform the development and deployment of SMRs to minimize the liability of future technologies.

Radioactive Waste Management: CNL will support both waste generators and government agencies in developing a long-term waste strategy that enables the design and operation of waste management facilities. CNL will develop environmental S&T to increase the efficiency of decontamination and packaging practices in order to minimize low- and intermediate-level waste, and generation of spent fuel volumes.

1.3.2.1.5 Small Modular Reactors

Over the past decade, SMRs have been increasingly recognized as a potential alternative to large-scale nuclear reactors. This clean energy technology holds opportunities for Canada, particularly for remote communities or industrial sites. Small modular reactors may offer

several advantages over traditional technologies, notably the ability to purchase and construct in a modular way, decreasing up-front capital costs through simpler, less complex plants, and a reduced staff complement. Designs can also bring greater efficiency and systems which are inherently safe. In addition to electricity generation, SMRs could be integrated in overall energy plans with applications as varied as district heating, co-generation, energy storage, desalination, or hydrogen production.

CNL's goal is to demonstrate the commercial viability of the SMR concept, with a view to position Canada to take a leadership role in this emerging nuclear technology, and CNL becoming recognized globally as a leader in SMR prototype testing and S&T support. In 2017 June, Canadian Nuclear Laboratories began a discussion around SMR technology in Canada, and the role that CNL can play in bringing this technology to market, by launching a Request for Expressions of Interest on SMRs.

Canadian Nuclear Laboratories is advancing S&T for a clean and secure world. Building on decades of experience in supporting and deploying numerous prototype, demonstration, research, and power reactors, CNL is well-positioned to support the development and deployment of SMRs, including hosting a demonstration facility at one of its locations.

1.3.2.2 Science and Technology Capabilities

CNL will strategically renew and grow its differentiating capabilities to assure long-term sustainability and meet current and emerging needs of federal departments and agencies. The S&T programs at CNL will be delivered through its strategic capabilities which are underpinned by a broad suite of technical competencies and facilities.

1.3.2.2.1 Advanced Nuclear Materials and Fuels Research

The advanced nuclear materials and fuels research capability includes the examination of irradiated materials and the understanding of material behaviour. It also encompasses the development and delivery of experimental and theoretical nuclear fuel S&T, including fuel cycles, fabrication, testing, and post-irradiation examination. This capability is underpinned by a suite of shielded facilities that are vital to Canada's nuclear industry. The shielded facilities are capable of examining ex-service components from nuclear reactors, processing radioisotopes that are used for a broad range of industrial applications, and conducting nuclear forensics, which enables Canada to provide independent and impartial investigations for international counter-terrorism and non-proliferation.

To achieve CNL's SMR and fuel fabrication aspirations, as well as the projected increase in commercial work for existing reactors, the advanced nuclear fuels and materials research capabilities must be expanded.

Therefore, capital investment plans include the construction of a new Advanced Nuclear Materials Research Centre featuring new shielded facilities that will enable post-irradiation examination of SMR fuel and light-water reactor fuels, and glovebox facilities to support the

development of advanced fuel fabrication concepts. Colocation of these activities will simplify radioactive material transportation and improve overall work efficiency. Key areas of expertise where CNL will build additional depth include fuels, metallurgy and corrosion.

1.3.2.2.2 Radiobiology, Radioecology, and Dosimetry

The radiobiology, radioecology, and dosimetry capabilities include research and services related to interactions between radiation, radionuclides, biological systems, and the physical environment.

This includes the ability to:

- Study the effects of radiation on laboratory animals, as surrogates for humans, and biota within the laboratory and environment, with a particular focus on low-dose radiation, and environmental radioactivity.
- Measure, map, and model the fate of radionuclides within air, soils, and aquatic environment.
- Measure or estimate radiation exposures and calculate resultant doses and health risks to workers and the public.

In addition to the fields of radiological protection and safety in the nuclear industry, applications include many aspects of protection related to medical irradiations and environmental radioactivity. Through radionuclide separation and detection, biodosimetry methods, atmospheric dispersion modelling, and modelling for Environmental Risk Assessment (ERA), this capability also supports the Federal Nuclear Emergency Plan, the Federal Radiological Assessment Team, and federal emergency response dosimetry.

When combined with CNL's nuclear chemistry applications capability, nuclear waste applications include the following:

- selective separation of contaminants from gaseous and liquid effluents
- development of membrane technologies for wastewater treatment
- decontamination of solvents/oils contaminated with various radionuclides
- electrochemical processing for the removal of contaminants from liquid wastes
- bioremediation
- soil monitoring and sorting
- waste immobilization processes
- waste form evaluation

Coupled with CNL's nuclear chemistry applications, the capabilities in this area are well equipped to support the D&WM mission under the Environmental Protection program, as well as monitoring and emergency response needs of the safety and security programs.

Capital investment will be used to upgrade facilities and laboratory practices in order to meet modern standards in the radioisotope laboratories, such as the Biological Research Facility and the new laboratories in the Harriet Brooks building. In the near-to-medium term, alpha research will also be supported by the Recycle Fuel Fabrication Laboratories. In the longer term, gloveboxes will be used in the new Advanced Nuclear Materials Research Centre.

1.3.2.2.3 Hydrogen and Hydrogen Isotopes Management

The hydrogen and hydrogen isotopes management capability includes heavy-water production and management; tritium handling, separation and management; hydrogen safety and control for nuclear and non-nuclear applications; hydrogen production processes using nuclear and renewable energy sources; energy storage strategies; and applications of catalysis and polymers.

The repurposed Building 137, housing the Hydrogen Isotopes Technology laboratory (Figure 9), will provide Canadian and international scientists and engineers with access to versatile and specialized facilities for research and development, academic and industrial collaborations and commercialization of CNL products and technologies (Figure 10 and Figure 11).



Figure 9 Building 137, Hydrogen Isotopes Technology laboratory.



Figure 10 Testing hydrogen fuel cells to measure the performance of components developed at CNL, such as electrode catalysts and membrane materials.



Figure 11 Performance testing wetproofed catalyst for hydrogen isotope separation processes, such as tritium removal and heavy water production.

CNL's hydrogen and hydrogen isotopes management capability is well equipped with new hydrogen and tritium facilities at the CRL site, and a resident team of specialists with internationally recognized expertise. Completion of Building 215 will provide enhanced tritium facilities and enable the decommissioning of Building 250 to enhance standards of health and safety at the site.

1.3.2.2.4 Nuclear Safety, Security, and Risk Management

The nuclear safety, security, and risk management capability includes understanding and mitigating risks associated with nuclear activities in Canada and internationally in the areas of reactor operation; reactor safety; cyber security; waste management; non-proliferation; regulatory and compliance support; and forensics and detection. These capabilities have applications in small energy systems and advanced reactor technologies.

Reactor safety experiments and associated analyses enable the assessment of advanced reactor design and support systems for demonstration and licensing aspects. This encompasses design basis and beyond design basis consideration for normal operating conditions for the entire reactor system, from fuel behaviour up to and including containment performance. It also considers in-core cooling systems following loss of moderator as a heat sink, hydrogen behaviour (including detonation), and mitigation techniques for severe accident conditions. Integration with other capabilities enables the conceptual development and inspection and monitoring technologies for advanced reactors, sustainment of the SLOWPOKE^{®2} reactors around the world, as well as safety and sustainability evaluations for advanced small energy system concepts.

Advanced computing, modelling and simulation are essential enablers for a broad range of science and engineering disciplines and applications. These include, for example:

- reactor physics
- heat transport thermal hydraulics
- fuel and fuel channel thermal mechanical effects
- fission product release and transport
- containment thermal hydraulics and chemistry
- radiation physics, atmospheric dispersion, and biological effects
- severe accidents
- reactor component performance and monitoring
- nuclear fuel waste disposal technology
- advanced nuclear materials research

Cyber security for nuclear applications is an area of increasing interest to both the nuclear industry and the regulators, and CNL is uniquely positioned, having successfully developed and delivered cyber-secure systems for the nuclear industry. Border security, illicit transport of nuclear materials, and nuclear safeguards are an international concern. CNL's capabilities enable technology and methodology development to support policy decisions.

² SLOWPOKE = Safe Low Power Critical Experiment, registered trademark.

To best serve the government, expanded commercial markets, and the SMR initiative, the CNL nuclear safety, security, and risk management capability must become increasingly conversant with a variety of reactor technologies, codes, and models. Reactor safety support to the government in case of accidents will be sustained, and CNL will pursue certification of its nuclear forensics function to create opportunities with the International Atomic Energy Agency (IAEA).

1.3.2.2.5 Nuclear and Systems Engineering

The nuclear and systems engineering capability includes the design and development of components and integrated systems, such as complex “one-off” and “first-of-a-kind” devices, test rigs, tooling sets, inspection and monitoring tooling and techniques, and computer and control systems. These systems are sought after to anticipate and mitigate operational issues affecting the nuclear industry, small and research reactor technology development areas, counter-terrorism, non-proliferation, and D&WM. Applications include tooling systems for high radiation and extreme environments, non-destructive inspection tooling and analysis techniques, nuclear qualification of systems and components, sealing technology, nuclear instrumentation, and forensics of ex-service tooling systems and components.

Similar to advanced nuclear materials and fuels, the nuclear and systems engineering capability must increase to achieve CNL’s growth targets for supporting existing reactors, particularly in the area of aging management. To leverage CNL’s strength in delivering solutions to emergent complex issues, CNL will focus on becoming highly responsive and mobilizing multi-discipline teams quickly.

1.4 History of the National Research Universal Reactor

A summary of the NRU reactor history is presented further below in this section. Specific information regarding the performance and the operation of the reactor since the 2011 licence renewal is presented in Section 17.1.1.

The NRU reactor (Figure 12 and Figure 13) that went into service on 1957 November 03 is a landmark achievement in Canadian S&T. Following a period of six decades, NRU continues to play a key role in advancing the quality of life of Canadians and people around the world. The NRU reactor is among the largest and most versatile research reactors in the world, as well as being one of the oldest. It is a Canadian national treasure and has over the course of its life been involved in many developments in the nuclear industry within Canada.

The NRU reactor is a thermal, heterogeneous, heavy-water cooled and moderated research reactor and is currently licensed to operate at up to 135 MW. The reactor consists of a 3.5 m diameter by 3.7 m tall aluminum vessel with eight heat exchangers, two experimental test loops, six neutron beam facilities, and miscellaneous isotope facilities.

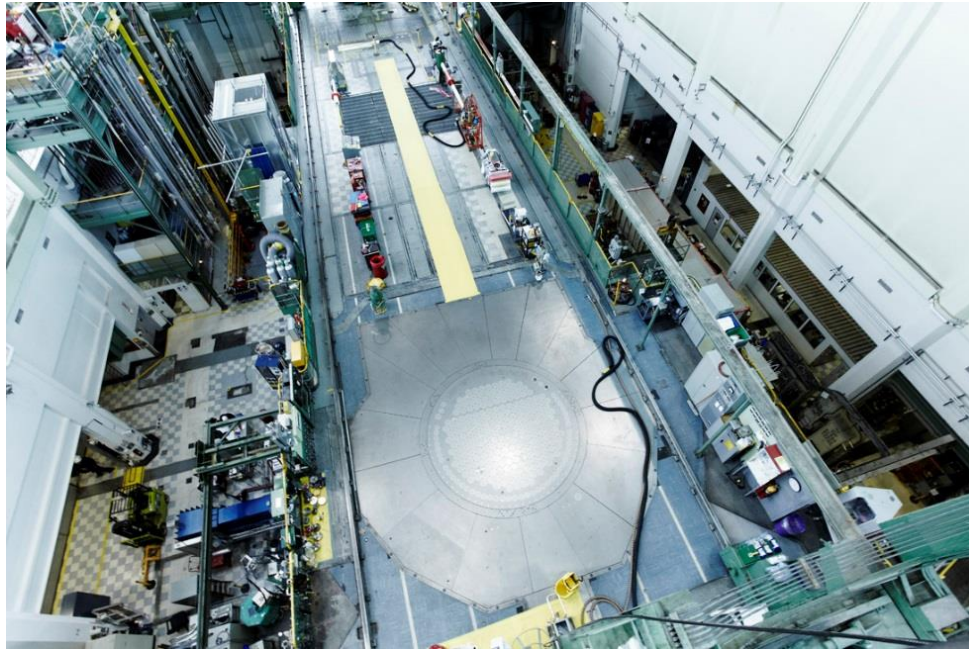


Figure 12 The current view of the top of the NRU reactor.

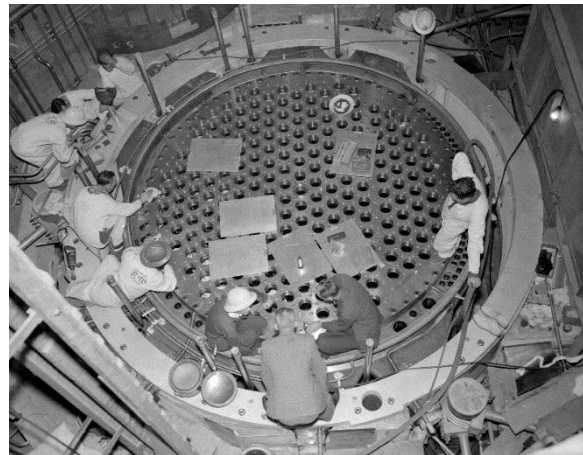
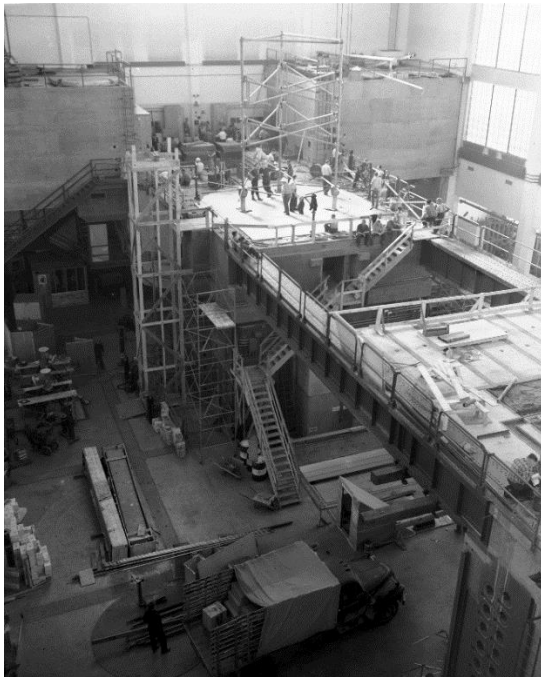


Figure 13 Top of the NRU reactor and calandria under assembly.

The reactor is due to be permanently shut down on 2018 March 31 after more than 60 years of service to Canadians and the world. The reactor produces industrial and medical isotopes used for the diagnosis and treatment of life threatening diseases, it provides engineering research, training, and significant development in support of Canada's CANDU reactor program, and is a major Canadian facility for neutron physics research and academia.

Figure 12 shows the operational top-of-reactor configuration and Figure 13 indicates the reactor hall and calandria under construction.

The following are details of some of the NRU reactor capabilities:

- Isotope Production: up until 2016 the NRU reactor was one of the leading producers of Mo-99 in the world. Today the reactor still produces Co-60, I-125, Xe-133, and Ir-192.
- Test Fuels and Materials for CANDU: the NRU reactor has a number of facilities where the changing material properties of components under irradiation can be studied. The reactor has been the proving ground for the development of various fuel cycles and the demonstration of various fuel designs including CANFLEX (high burn up), DUPIC (spent pressurized-water reactor fuel) and PARALLEX (uses weapons grade Pu) types of fuel.
- Nuclear Materials Research: the six neutron beam facilities are managed by the Canadian Neutron Beam Centre. The centre conducts material research experiments and hosts scientists and engineers from Canadian and international institutions in their execution of experiments using the NRU facilities. The use of neutrons to non-destructively measure internal stresses was developed at CRL.
- Training for the CANDU Industry: NRU has provided and continues to provide trained staff to other Canadian nuclear entities.

The following are some of the major milestones during the history of the NRU reactor:

- 1957: reactor goes critical on November 03 for the first time (Figure 14)
- 1957: first reactor to undergo refuelling at power
- 1957 to 1962: configured as a 200 MW natural uranium core
- 1958: fuel rupture incident; NRU reactor restarts after approximately three months
- 1960: U-2 experimental test loop comes into service
- 1962 to 1964: converted to a 135 MW core of highly enriched uranium (HEU) fuel
- 1965: U-1 experimental test loop comes into service
- 1969: production of I-125 started
- 1970: production of Mo-99 started
- 1972 to 1974: reactor shut down for vessel replacement
- 1986: NRU was recognized as a historic landmark by the American Nuclear Society
- 1993: converted to a 135 MW core of low enriched uranium

- 1994: Bertram Brockhouse wins the Nobel Prize for Physics for his work at National Research Experimental (NRX) and NRU reactors (Figure 14)
- 1997 to 2005: major safety upgrades were added
- 2007: reactor recognized by Canada on the occasion of its 50th birthday
- 2009 to 2010: shutdown for vessel repair; restarts after 16 months
- 2016: enters into standby mode for Mo-99 production (October 31)
- 2017: achieves 60 years of service since first achieving criticality (1957 November 03)



Figure 14 NRU Control Room during start-up on 1957 November 03 at 6:10 AM; and Bertram N. Brockhouse with the first version of the triple axis spectrometer.

After more than six decades of operation, the reactor will be permanently shut down on 2018 March 31. A systematic approach to transitioning the reactor to a storage-with-surveillance state is presented in Section 17.1.1.13 of this document.

1.5 Canadian Nuclear Safety Commission Safety and Control Area Ratings

The performance of the CRL site is analyzed and assessed by CNSC staff against 14 SCAs for which various compliance verification criteria are presented within the CRL Licence Conditions Handbook (LCH) [2]. Specific information with respect to the performance is presented below in Table 1, which indicates that CNL's performance is at the "satisfactory" rating for all 14 SCAs; two were improved from a "below expectations" rating during the current licence period.

This assessment aligns with the commitment to ensure that Canadians and the world receive energy, health, and environmental benefits from nuclear S&T with confidence that nuclear safety and security are assured.

Table 1 CNSC Safety and Control Area Ratings

Safety & Control Area	2012	2013	2014	2015	2016	2017
Management System	BE	SA	SA	SA	SA	SA
Human Performance Management	SA	SA	SA	SA	SA	SA
Operating Performance	SA	SA	SA	SA	SA	SA
Safety Analysis	SA	SA	SA	SA	SA	SA
Physical Design	SA	SA	SA	SA	SA	SA
Fitness for Service	BE	BE	BE	BE	BE	SA
Radiation Protection ^a	SA	SA	SA	SA	SA	SA
Conventional Health and Safety	SA	SA	SA	SA	SA	SA
Environmental Protection	SA	SA	SA	SA	SA	SA
Emergency Management and Fire Protection	SA	SA	SA	SA	SA	SA
Waste Management	SA	SA	SA	SA	SA	SA
Security	SA	SA	SA	SA	SA	SA
Safeguards and Non-Proliferation	SA	SA	SA	SA	SA	SA
Packaging and Transport	SA	SA	SA	SA	SA	SA

a Includes Dosimetry

Legend: FS = Fully Satisfactory; SA = Satisfactory; BE = Below Expectations

2. MANAGEMENT SYSTEM

CNL has embarked on a plan to significantly revise and improve the Management System suite of documentation whereby the company-wide support functions are centralized and standardized. The improved CNL Management System captures the development of the transformed organization from a federal entity to a Government-Owned Contractor-Operated company. Furthermore, there has been strengthening of the platform that enables CNL to satisfy the CNSC requirements for establishing and maintaining the 14 SCAs as prescribed in the CRL LCH.

The revised and transformed Management System provides, enables, and defines a detailed framework for continued safe operation of the nuclear facilities and laboratories at CRL and all CNL sites. The various mature programs and processes, already in place, will continue to evolve to ensure that all regulatory requirements are achieved. A transformation plan has been developed to ensure that the changes made to the Management System provide further focus on safe operational practices and compliance with the applicable regulatory frameworks. The revised Management System manual and sub-tier documents have been submitted to CNSC staff in three separate batches on 2017 January 10, February 21, and March 23 with focused discussion meetings being held on each occasion with CNL and CNSC staff management system

specialists. Submission of this revised suite of manuals and documentation is also consistent with the requirements of the CRL LCH, Criterion 1.1(7) for Licensing Basis.

The realigned Management System has been specifically developed to the requirements of the new business model and contracts of CNL, ensuring the achievement of regulatory compliance. It applies to all CNL management activities including: setting expectations, enabling, planning, budgeting, and assessing all aspects of business, thereby ensuring delivery against commitments within appropriate accountabilities and controls; and, execution activities including: safe, effective and efficient conduct of work across all CNL lines of business, performed by CNL employees and third parties engaged through external partnerships, collaboration, and supply chain.

CNL will continue the maintenance of the Management System, integrating both functional support programs and operations programs into a single, all-encompassing, integrated system that not only covers the compliance aspects of these programs, but also incorporates the key performance aspects of the business. These performance aspects include requirements for risk management, legal concerns, and other key considerations important to corporate governance.

2.1 Management of Safety

CNL's safety culture continued to be enhanced through execution of the action plan documented in the 2009 Voyageur II program that included 98 corrective and remedial actions addressing the following key areas:

- improve equipment reliability
- drive desired behaviour
- improve problem identification and resolution
- improve use of operating experience and reduce isolationism
- improve standards of operation
- improve management oversight

CNSC staff have monitored the implementation and effectiveness of the Voyageur II program through desktop reviews and periodic on-site verifications. CNSC staff verified the progress of the action plan to ensure that actions were complete, including evidence in support of action closure and the effectiveness of the plan.

CRL regularly monitors safety culture through execution of employee surveys. The data were collected during the surveys conducted in 2011 and 2012, analyzed for trends, and the high-level results were communicated to the staff, the Safety Review Committee³, and the Executive Committee. The survey results were also discussed with CNSC staff at a meeting in 2012 August.

³ Safety Review Committee ensures and provides independent technical reviews of major safety documentation related to CNL's facilities and activities.

Additionally, a detailed safety culture assessment was executed in the fall of 2012, and this comprised a comprehensive questionnaire delivered electronically to all staff; follow-up interviews with staff at CRL, Whiteshell Laboratories, and Port Hope Area Initiative; and, discussions with focus groups at all three sites. Results of this detailed assessment were compared with those from 2008 and were discussed with all managers in 2012 November. The survey results were communicated to all staff in 2012 December.

The surveys and the assessment indicated that additional effort was required to ensure that expectations were established and clearly communicated to employees. Furthermore, oversight was needed to monitor work execution in the field in order to reinforce the desired behaviours. These activities targeted reinforcement of the fundamentals and strengthened overall safety culture.

In 2013, safety culture improvements continued to be addressed through execution of the action plan documented in the Voyageur II program.

A significant accomplishment realized in 2013 was the establishment of the Practical Training Facility (Figure 15) at the CRL site. Dynamic learning activities were developed and implemented in this facility. A “Stop, Think, Act, and Review” (STAR) simulator was included, enabling participants to test and practise human performance event free tools, including: three-way communication, self-check, verification, procedure adherence, and peer checking. A larger simulator that includes various pieces of equipment (pumps, valves, pressurized equipment) was commissioned and opened for Operations staff to practise event free tools, procedure use and adherence, “Lock Out Tag Out”, and work execution, using a planning scenario developed by Human Performance (HU) program and facility staff.



Figure 15 Practical training facility for radiation protection, human performance, and occupational safety and health.

In 2013, CNL released its Nuclear Safety policy aligned with the industry’s ten Traits of a Healthy Nuclear Safety Culture. The traits evolved from the eight Nuclear Safety Culture Principles with a focus on behaviours at all levels of an organization. These traits were rolled out at the annual manager safety summit in 2013 November and were embedded within the leadership training.

In 2014, the organizational focus on safety culture continued through reinforcement of performance expectations, leadership skills development (Performance Leadership Essentials) training, engagement and support from HU program advocates, along with the roll out of multiple human performance dynamic learning activities (e.g., STAR Simulator, Maintaining Situational Awareness, Procedure Verification Exercise).

In 2015 January, an abridged safety culture assessment was performed. It included focus groups, one-on-one interviews, and an on-line survey. The conclusions from the survey were discussed with senior leaders and a plan for prioritization and addressing opportunities for improvement was formulated. All remaining actions from the Voyageur program Phase II self-assessment were closed in 2015, finalizing this initiative.

The engagement of the employees improves organizational performance – productivity, revenue and profitability, along with lowering turnover and absenteeism. The results of the 2016 September employee survey were shared with staff, including a video commentary by the President and Chief Executive Officer. Line-specific information was provided to each line area, and action plans were developed to facilitate the focus on the existing opportunities for improvement. CNSC staff were informed of the progress of the survey and the results.

To track the improvements compared to the 2016 baseline, the next employee survey was issued on 2017 September 21. Further surveys will continue on an annual basis.

2.2 Licensee Organization

A major change for the future of the nuclear laboratories was triggered on 2013 February 28 when the Government of Canada publically announced its intention to launch a formal competitive process for the greater private-sector engagement in the management and operation of the nuclear laboratories. Under the new management model, the mandate would have three objectives:

- Address nuclear legacy and historic waste liabilities.
- Provide nuclear S&T capabilities and services to federal government departments.
- Support the nuclear industry's needs for in-depth nuclear research and development, and for test and evaluation expertise.

AECL continued the restructuring process throughout 2014. CNL was established under the Canada Business Corporations Act on 2014 May 30. To enable the standing-up of the new CNL organization (which occurred on 2014 November 03) many interrelated activities were tracked to completion throughout 2014, including applications being made to CNSC to transfer from AECL to CNL the various licences and certificates issued by the Commission and by Designated Officers. Although the licensee name was changed, at that time there were no changes in corporate vision, strategic outcome, or value proposition.

In 2015, the Request for Proposal was completed (led by Public Services and Procurement Canada and Natural Resources Canada). On 2015 June 26 the Government of Canada

announced that the Canadian National Energy Alliance (CNEA) was the preferred bidder chosen to manage and operate CNL. Final implementation of the Government-Owned Contractor-Operated model was achieved on 2015 September 13 with the transfer of the shares of CNL from AECL to CNEA, which completed the process of restructuring.

Later in September, the incoming CNL President and Chief Executive Officer notified CNSC staff of the associated leadership team appointments with clear indication of the immediate organizational changes being made to the CNL board structure and key positions. Responsibility for the management and operations of each element of CNL's organizational structure was assigned to executives and senior management reporting to the President and Chief Executive Officer. CNL's transition is now complete and the management organization is stable. The current organizational structure is depicted in Figure 16.

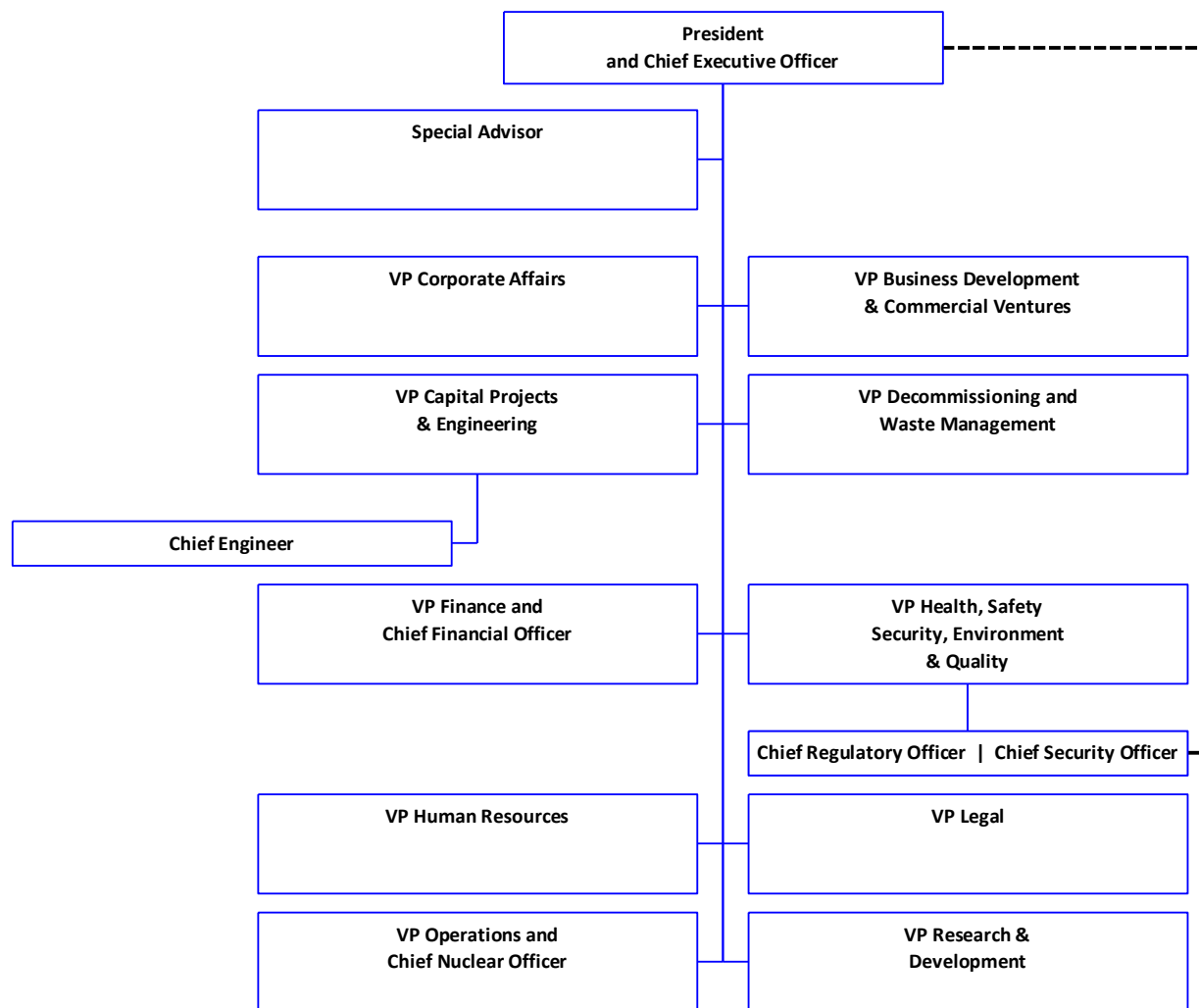


Figure 16 Canadian Nuclear Laboratories executive team and corporate authorities.

Internal organizational changes have been executed to be consistent with the requirements of the Organizational Change Control process. The purpose of the process is to ensure that organizational changes are controlled in a manner such that safety and business risks are minimized, and will not adversely affect the safe and reliable operations of facilities and sites.

2.3 Past Performance

Throughout the current licence period, CNL continued to strengthen the framework through which it manages and operates to ensure that CRL is operated safely and in full compliance with its CNSC licensing obligations. During that period the following actions to improve the Management System took place:

- A holistic, corporate framework for managing CNL was established to align and integrate safety, program delivery, people management, facilities management, and strategic improvement.
- Executive-level champions were appointed and held accountable for defining standards, institutionalizing, enabling processes, and providing oversight for each area of the corporate management system framework.
- Nuclear safety oversight mechanisms were strengthened by adjusting quarterly reporting to senior management to bring greater focus on health, safety, security, and environmental performance.
- Oversight was conducted of the health, safety, security, and environment risk mitigation system. These activities comprise several mechanisms including: independent assessments, self-assessments, regulatory oversight, and review of status of health, safety, security, and environment priorities.
- Management system areas provided a consistent and predictable framework for enabling integrated management, oversight and control of all aspects of the company's lines of business, while sustaining nuclear safety as the overriding priority.

In 2012, a gap analysis was conducted of the Management System procedures in effect at the time against the requirements of Canadian Standards Association (CSA) N286-05 [3], and a phased project execution plan was developed to progress improvements.

The following commitments were completed during the first year:

- The integrated Management System review process was revised and piloted, which included conducting a baseline analysis of the current processes and evaluation of the effectiveness of the management system.
- A detailed analysis identified areas where the Management System could not be demonstrated to fully meet the requirements laid out in CSA N286-05.

In 2013, the first project phase of the Management System transition to CSA N286-05 requirements was completed.

In 2014, computer based training modules specific to each of the six management areas were created in order to assist in the implementation of the Management System framework and to further solidify the knowledge of the CNL Management System.

During this period, CNL continued to focus on strengthening management system documentation and advancing management system awareness, as follows:

- Several improvements occurred in 2013 to align the management system documentation with the six management areas, including the creation of six overview documents, which describe the mechanisms by which expectations were set and management functions including planning, enabling, executing, and assessing were conducted.
- The Management System Contact and Responsibility List was renamed to the Management System Appointments Registry. This document was restructured and expanded to include the appointments of the Board of Directors, officers, managers, and subject matter expert roles that are integral to the Management System.
- To facilitate process ownership and strengthen the top down hierarchy of CNL Management System Documentation, the Management System Governing Documentation Index was also updated to align management system governing and enabling documentation to the management areas.
- Improvements at the start of 2014 included revising the Management System manual to clarify accountabilities, authorities, and reporting relationships.

In 2014, improvements to reflect the new business model were initiated. Beginning in 2015 changes included revisions to the Management System manual, the Management System Governing Documentation Index, Sites and Facilities Governing Documentation Index, and the Management System Appointments Registry. These revisions, to capture administrative changes, were coincident with the transfer of the ownership of CNL from AECL to the CNEA.

In 2015, Phase II of the Management System transition to the requirements of CSA N286-05 was completed. Improvement actions were planned and completed in accordance with the project schedule.

In 2016, CNL completed and submitted to CNSC staff for incorporation, the CRL LCH, Appendix K (Transitional Provisions) item which entailed the closure of the Phase III gaps identified in the Management System Transition to CSA N286-05, Project Execution Plan.

Also in 2016, a multi-phased project was launched to align the management system to the requirements of the new CNL business model; simplification of the management system framework; clarification of roles, responsibilities, authorities, and accountabilities; and, a reorganization of the management system documentation suite.

In year one (2016), a project team was assembled to develop improvements, to resource the writing of the new documentation suite, and to provide oversight to ensure that change was managed in a controlled manner. The focus of the project was to improve and simplify the

management system, while continuing its alignment with safety and operational principles already being implemented.

A new management system document type, Executive Management Directive, was developed to address and implement any actions from the President and Chief Executive Officer of CNL, in a timely manner. The directives may be developed to address compensatory measures or emergent requirements and are typically in effect for a specified period of time (generally less than six months), after which they may be incorporated into permanent document types, as necessary. The directives may contain implementing details, until such details can be captured in lower-level documents.

Three directives were released for use in 2016; “Working on Roofs”, safety protocols for working on roofs; “Gating and Sanctioning”, instruction on financial controls; and “Project Charge Codes Creation or Amendment”, instruction for the creation of a new project or change to an existing project.

Year two (2017) and three (2018) will focus on working within the newly established framework and completing the document hierarchy.

In 2017, CNL reported to CNSC staff the completion of CRL LCH, Appendix K (Transitional Provisions), Item 11 which details the gap analysis between the current management system and the requirements in CSA N286-12 [4] and a transition plan.

The first part of the analysis assessed compliance of CNL Management System documentation to CSA N286-12. All areas assessed against the associated Management System were found to be compliant by CNSC staff. The second part of the analysis looked at implementation of procedures, or need for improvements, to progress effectiveness of the CNL Management System. The resultant actions include revision to associated procedures to implement a consistent approach in the field execution; process updates to reflect the new CNL business model; interface improvements to ensure more effective implementation of the associated procedures; and introduction of a process improvement tool. Actions have been identified to address the opportunities to improve CNL’s Management System integration and effectiveness with regard to CSA N286-12 requirements (Table 2).

Table 2 CSA N286-12 Requirements

Source	Document #	Document Title	Version	Implementation Status
CSA	N286	Management System Requirements for Nuclear Power Plants	2005 (2007 Update 1)	Implemented
CSA	N286	Management System Requirements for Nuclear Facilities	2012	Implemented

2.4 Status of Regulatory Enforcement Actions

Since the last licence renewal, CNSC staff have conducted compliance inspections of the Management System. As of 2017 July, there were no outstanding regulatory enforcement actions.

2.5 Future Plans

Plans for the next licence period include:

- Implementing continuous improvement program to ensure that the integrated management system enables effective and efficient management of the company.
- Introducing initiatives to ensure continued alignment to changing regulatory and standards requirements.
- Reflecting best-of-class management practices as seen both in the nuclear industry and in large S&T organizations operating in highly regulated environments.

3. HUMAN PERFORMANCE MANAGEMENT

CNL has the number one priority to ensure the safety of its employees and the public, and to protect the environment from any potential hazards associated with its operation.

The HU program is managed by the Performance Assurance department within the Health, Safety, Security, Environment, and Quality organization at CNL. The program requires all functional support areas, line management, and employees to report various types of events and implement specific documented programs and processes in their respective areas. To achieve this goal, the performance assurance function provides tools, methods, training, and expertise. The program also interfaces with other programs with respect to risk management related to variability in human performance and maintains a high level of line engagement to provide efficient delivery of program services.

The main objectives of the program are to:

- Strengthen the safety culture at CNL.
- Evaluate human performance effectiveness in the work environment.
- Reinforce the use of human performance methodology through training, communication, and observations.
- Assist leaders in promoting and modelling safe work practices and behaviours.
- Assist employees to recognize and avoid error-likely situations.
- Evaluate error-likely situations, assess defences based on evaluations, and ensure defence-in-depth.
- Reduce the error rates through the use of human performance tools.

Through the application of human performance concepts and tools CNL continues to improve its capability to recognize, predict, and respond safely to physical hazards, unsafe acts or conditions.

The HU program has developed line-led human performance training which is geared towards creating a healthy safety culture based on internalization of human performance principles and personal accountability. Human performance training promotes learning across the organization by incorporating case studies where lines work alongside the HU organization to recognize and reinforce human performance fundamentals. In addition, a set of discrete behaviours and techniques, known as Event Free Tools, is employed that assists employees in maintaining positive control of a work situation. The seven tools were represented pictorially to staff as so-called “Eventicons” (Figure 17).



Figure 17 Eventicon for each of the Event Free Tools.

An additional instrument for enhancing human performance at CRL is the Event Free Day Reset process, which consists of two levels of criteria. The first is Site-Event Free Day Reset (S-EFDR), which addresses high consequence human performance events. The second is Departmental-Event Free Day Reset (DP-EFDR), which reflects less consequential events. However, such departmental events are considered to be significant as they are leading indicators to more serious site level events.

These two processes constitute the primary metric used to identify, track, and trend human performance events and communicate the results through all levels of the organization. These indicators reflect the effectiveness of management in improving organizational processes.

In 2015, an increasing trend of Event Free Day Resets was identified and a common cause analysis was conducted to determine the commonalities of the events. A corrective action plan was established which included development of Human Performance Line Lead training that

facilitates management discussions on events that have occurred within their work area. These discussions are leading to improved internalization of Human Performance and Event Free Tools for the work force.

Figure 18 illustrates the collected data from 2011 to 2017 June.

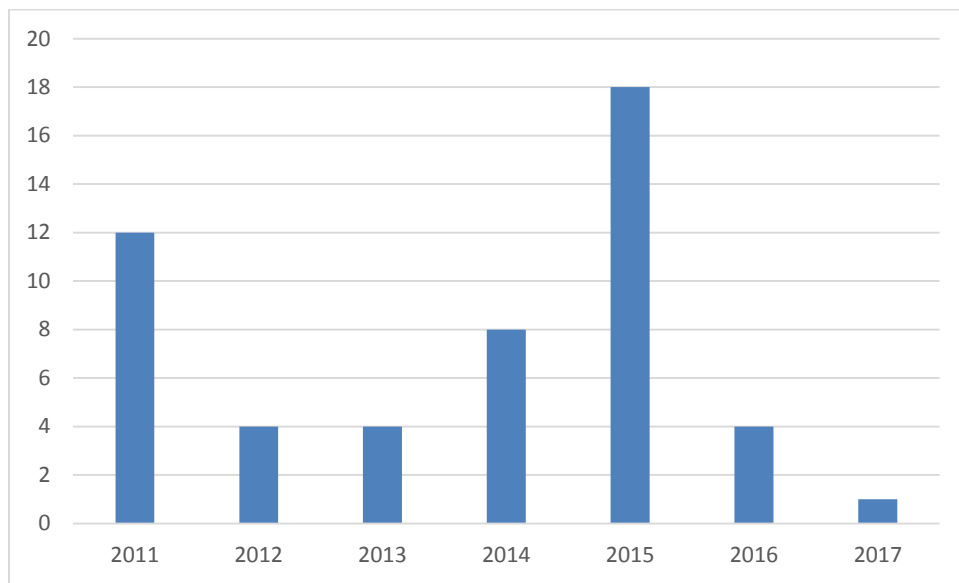


Figure 18 Number of Event Free Day Resets from 2011 to 2017 June.

3.1 Fitness for Duty

During this licence period, elements of a holistic approach to fitness for duty were in place and the process was initiated to articulate them within a formal program architecture. CNL also continued pre-employment medical screening and annual physical testing for firefighters and specific emergency and protective service roles.

Drug and alcohol testing is part of the process for post-incident response and investigation procedures. It can also be conducted in case of suspected breach of the Drug and Alcohol program. In 2013 and 2014, CNL purchased breathalyzers and trained staff to ensure that CNL has a 24/7 capability to conduct a legally admissible test to determine intoxication, if required. This technology has also been of assistance in helping employees safely return to work and ensuring their compliance with fitness-for-duty expectations.

Elements of a mature fitness-for-duty program have been in place at CNL since 2015 (e.g., Continuous Behavioural Observation program). The updated fitness-for-duty procedure addresses strategies for mitigating and recognizing the effects of fatigue in the workplace. The updates included guidance for employees on how to access assistance at any location where CNL operates.

Furthermore, a revision of the disability management and return-to-work programs was performed during 2015, and a third-party service provider has been contracted to support the disability management process for non-occupational illnesses and injuries.

CNL provides and continues to actively promote its third-party Employee and Family Assistance program in support of the overall health and the wellness of its employees.

CNL participated in industry meetings in order to provide comments to CNSC staff on REGDOC-2.2.4 (*Fitness for Duty*).

3.2 Systematic Approach to Training

Training and Development provides centralized leadership and management of training functions at CNL. The department is responsible for the assessment, development, implementation, and monitoring effectiveness of programs for training, authorization, and certification activities for CNL personnel company-wide.

CNL contracts stipulate the qualification requirements for contract staff performing specific work at CNL; this includes general safety orientation, facility-specific training, and radiation protection training.

Application of the systematic approach to training (SAT) is mandatory for all personnel in direct operating positions in CNL nuclear facilities. The scale and scope of application for non-direct operating staff is determined based on the importance of the job to nuclear safety.

In 2012, CNL updated and reissued the process documentation supporting SAT, based on internal reviews and external benchmarking. In 2013, the company-wide procedure outlining the process for the training and qualification of Facility Authorities was revised to update the training requirements and enhance the assessment process for qualification.

CNL continued to enhance the training oversight role through the establishment of a Training Oversight Committee with a mandate to evaluate how training addresses the needs of the company and improves performance. Additionally, Curriculum Review Committees were established at facility and program levels to provide a mechanism for line management to monitor training program compliance, and to identify opportunities for performance improvements. In 2016, CNL reorganized and centralized its training support services. "Operations Resourcing and Training" and "Organizational Development and Training" were amalgamated into a single training organization under the name "Training and Development", purposed to provide training support to CNL facilities and programs.

During 2016, Training and Development supported the planning and initial implementation of the initiative to retrain and redeploy staff in facilities slated to close in 2018. This included the development of a skills inventory tool and establishment of a Career Hub for affected staff.

Training was developed and implemented in support of: NRU/NRX fuel repatriation activities (ongoing since 2015); target residue material repatriation commissioning activities; and the NRU U-2 loop return to service (2016). Training for NRU Operations, the NRU Technical Support Group,

and CRL Emergency Operations Centre (EOC) personnel was developed and delivered to support the implementation of the Severe Accident Management Program (SAMP) at CNL (2016).

The Learning Management System at CNL was updated and new software was implemented in 2016 to enable more efficient and effective management of training records.

A training qualification process was developed in 2016 to support a Site Maintenance multi-skill initiative to train staff cross-functionally and enable more efficient work execution.

Training procedures are aligned with REGDOC-2.2.2 (*Personnel Training*) [5] and are applied in a graded approach.

The Training Oversight Committee is jointly chaired by the Vice-President of Human Resources and Vice-President of Operations with representation from all CNL divisions. The committee conducts the following:

- Approves employee and manager/supervisor curriculums.
- Recommends priorities for CNL training activities.
- Ensures that training relates to CNL vision, values, and direction.
- Monitors financial requirements for training.
- Ensures that training resources meet business needs.
- Considers lower-level curriculum review committee items, as required.

3.3 Staffing and Certification – NRU Reactor

Ten new Senior Reactor Shift Engineers have been certified since 2011 and six have completed the requalification training, shift performance and testing requirements, and were recertified. There are currently 12 certified Senior Reactor Shift Engineers and 3 certified Health Physicists supporting NRU Operations.

Training and qualification of NRU staff will align with changes to the NRU facility authorization as NRU transitions to the shutdown state.

3.4 Performance Leadership Essentials

In 2013, a leadership enhancement program called “Performance Leadership Essentials” was initiated at CNL. This best practice and engaging leadership program provided an optimal combination of essential and advanced skills to strengthen leadership performance.

At the core of the program were five key principles to meet personal needs (esteem, empathy, involvement, share, and support), a communication process, and tools such as self-assessments, job aids, and discussion planners that leaders could immediately apply on-the-job to efficiently guide conversations to optimal outcomes. Skills practice provided opportunities for participants to apply what they had learned and allowed them to receive immediate feedback and guidance.

3.5 Past Performance

During this licence period, the HU program worked towards strengthening the relevant processes to minimize the occurrence of human error, thus reducing the frequency and severity of unplanned events in the CNL organization.

The following improvement initiatives were carried out under the program:

- Established Human Performance Steering Committee.
- Completed the establishment and commissioning of the human performance laboratory; and developed and rolled out dynamic learning activities to support in-field activities.
- Developed, tested, and implemented a Department Event Free Day Reset program.
- Developed and implemented a Field Observation and Coaching Fundamentals Workshop.
- Improved training materials in support of a Safety Culture Workshop.
- Conducted a comprehensive Safety Culture Survey in 2012.
- Completed the implementation of a Nuclear Safety policy in 2014.
- Implemented and aligned the Traits of a Healthy Nuclear Safety Culture with the existing Nuclear Safety policy.
- Rolled out a communication strategy that included: Traits of a Healthy Nuclear Safety Culture posters, booklets, and weekly-topic bulletins.
- Developed dynamic learning activities with corresponding master-lesson directives.
- Developed, piloted, and released Observation-and-Coaching software (ObservationWay), which allows for building custom observation cards based on the requirement of each business line.
- Developed and piloted a training module for Event Free Tools for “Knowledge Workers”.

Several initiatives were implemented in support of the development of the HU program in 2016. In an effort to reinforce the understanding of Event Free Tools and aid staff with their utilization, the program developed and launched a new process called “Focus of the Week”. Additionally, so-called “Eventicons” were created (Figure 17) to promote Event-Free-Tools awareness, and consisted of promotional posters, magnets, and booklets. A line-led training initiative, called “Just-in-Time Training”, was created to promote human performance collaboration with the business lines, and to support the reinforcement and internalization of Event Free Tools. Line specific events are used to help strengthen learning across the organization, while engaged leaders support workers and aid in promoting improved leadership engagement.

Also during 2016, the HU program recognized that “slips, trips, and falls” are the leading cause for injuries (including lost-time injuries) at CNL. In an effort to help prevent such incidents from occurring, a Slip Simulator (Figure 19) was purchased by the HU program, installed at CRL, and made available to all employees.

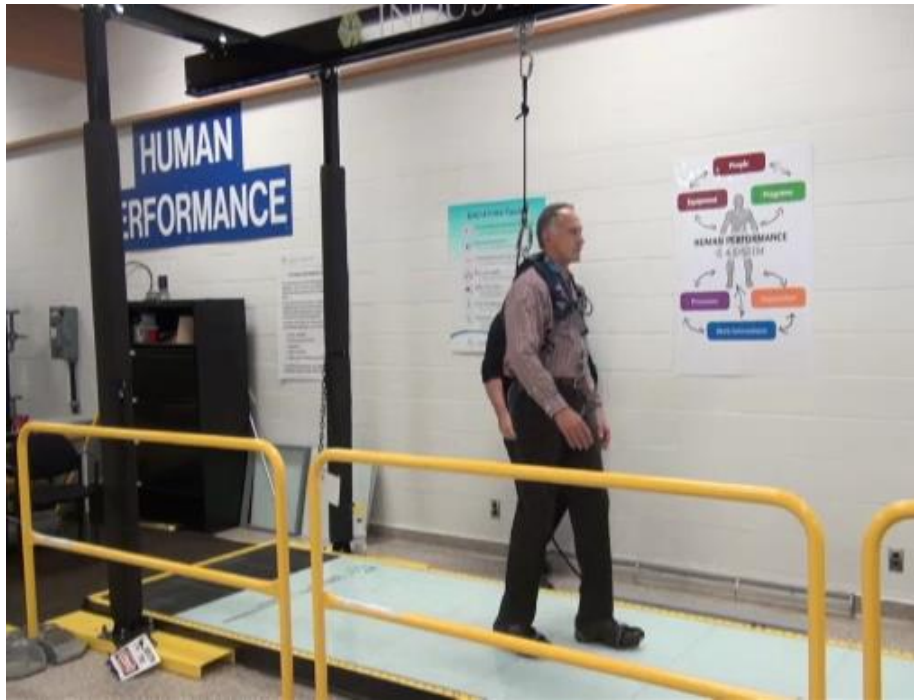


Figure 19 Slip simulator.

The program collaborated with the NRU business line to support the facility in mitigating events related to human performance. The performance indicators were examined and improvement actions were generated. Support was provided to the Design Engineering group to successfully develop an enhanced, line-specific “Observation and Coaching” program. This involved examining the line’s need and working with the line to develop specific training.

Based on industry-best practices, the HU program developed and implemented dynamic learning activities that support the use of error-reduction tools during the conduct of work in the field.

In 2017 May, the pilot program entitled “Good Catch” was introduced at CRL. This program seeks to acknowledge and reward individual contributions to personal safety and site improvement. Furthermore, it engages CNL’s workforce and provides immediate feedback to employees that exemplify the safety culture required to support a world class nuclear facility.

In 2017 June, the Conduct and Expectations handbook, including Event Free Tools, was introduced company wide. The intent of this booklet is to provide staff with a simple pocket-size set of expectations. Staff are expected to internalize the reference material, and CNL leaders are expected to use the booklet to reinforce expectations on the prevention of human performance events.

Commencing in 2017 July, HU has supported CNL in striving to achieve a safe and event-free environment with the “CNL Hub” weekly publication. Content and feedback is drawn directly from discussions with employees regarding CNL’s organization and company Conduct and

Expectations. Every week, questions are submitted regarding the next issue; to gain information on “what good looks like”, learning opportunities, or comments on how improvement can be achieved as a team. The weekly hub includes various themes posted to the company’s internal website to reinforce core fundamentals including:

- CNL Vision and Mission
- Site Requirements and Safety Tips
- Human Performance
- Rules to Live By
- Emergency Responses

3.6 Status of Regulatory Enforcement Actions

Since the last licence renewal, CNSC staff have conducted compliance inspections of the HU program. As of 2017 July, there were two open Action Notices for this SCA; refer to Section 17.1.1.10.

3.7 Future Plans

During the next licence period, the HU program plans to:

- Increase the strength of in-line ownership for human performance implementation.
- Execute line-led human performance training intended to drive increased line ownership.
- Integrate all aspects of safety culture, human performance, and transformation activities.
- Improve oversight from a program perspective to enable relevant learning from the business lines.
- Implement enhancements based on the feedback from stakeholders on established processes.
- Transform processes and practices to engage, enable, and empower the workforce.
- Conduct a safety culture survey within the next two years.

During the next licence period, the Training and Development program will continue to provide centralized leadership and management of training functions at CNL and will continue to be responsible for the assessment, development, implementation, and monitoring effectiveness of training programs and authorization activities throughout the company, including CRL. Efforts will continue to support retraining requirements for staff redeployed due to the shutdown of NRU and affected facilities, as well as the identification of training requirements for NRU staff as the facility moves to the state of permanent safe shutdown.

CNL’s Training and Development staff administer the CNL SAT documentation, the CNL Required Training Plan, and the Learning Management System, and will continue to maintain this accountability.

As CNL embarks on the various missions within its ten year plan including S&T, infrastructure projects, and D&WM, the Training and Development department will continue to provide the training support required to achieve success. Training procedures will be revised during the 2017-2018 fiscal period as part of the CNL-wide Management System documentation update.

4. OPERATING PERFORMANCE

The Class I and Class II nuclear facilities and the various radioisotope laboratories located at CRL continue to operate safely according to operating limits and conditions, facility authorizations, and laboratory protocols. Any non-compliances that were identified during the operation of the facilities and laboratories were reported to CNSC staff, as required, and were addressed.

This section of the CMD is laid out to align with the structure of the operating performance SCA from the CRL LCH.

4.1 Operations

Conduct of operations documents ensure appropriate integration and adequate reflection of safe operating practices to meet the business requirements.

4.1.1 Past Performance

In the current licence period, governing documentation for nuclear facilities has been in compliance with CSA N286-05 and is in the process of transitioning to meet the CSA N286-12 requirements. Furthermore, the document CSA N286-05 (*Management System Requirements for Nuclear Power Plants*), Sections 6.11 through 6.18 inclusive, provides elements specific to the operating environment. An additional element was created to establish a process for developing facility-specific Conduct of Operations plans. Additional inputs to the CNL Conduct of Operations Program include:

- site and facility licensing (acts, regulations, licences, handbooks)
- industry standards
- compliance programs (under CNL's Health, Safety, Security, Environment and Quality organization)
- policies
- commitments

The performance of the nuclear facilities is reviewed and assessed by the Nuclear Performance Assurance Review Board on a quarterly basis. All subsequent actions are being managed and tracked by the Facility Authorities.

Further information with regard to the operation, performance, and future plans of the Class I and Class II nuclear facilities and radioisotope laboratories located at CRL can be found under Section 17 (Facilities and Radioisotope Laboratories). Nuclear operations at CRL are consistent with requirements of the Management System as described in Section 2 of this document.

4.1.2 Status of Regulatory Enforcement Actions

Since the last licence renewal, CNSC staff have conducted compliance inspections of Operations. As of 2017 July, there were two outstanding regulatory enforcement actions; one relates to NRU (refer to Section 17.1.1.10), and the other relates to the Radioisotope Laboratories (refer to Section 17.3.2).

Any compliance inspections for the programs, facilities, and radioactive laboratories will have the relevant details presented in their respective sections.

4.1.3 Future Plans

Facility safety governance documentation (operating limits and conditions, facility authorizations, laboratory protocols, and nuclear criticality safety documents) will continue to be updated during the next licence period, as activities and business needs change at the CRL site. As the revised management system evolves, facilities will be required to update conduct of operations procedures and operating instructions to simplify and streamline processes.

4.2 New Nuclear Facilities

CNL will inform the CNSC staff under separate cover on a case-by-case basis of the intention to proceed with any new nuclear facilities, and obtain all necessary approvals, with information provided as required.

4.3 Nuclear Facilities in Permanent Safe Shutdown State

Since the cessation of operations for the Combined Electrolysis Catalytic Exchange Upgrading/Detrification (CECEUD) facility, no processing nor handling of heavy water has occurred within the facility. Work consisted mainly of routine surveillance and monitoring activities. In 2012 November, preliminary work began on the CECEUD relocation project. During 2015 and 2016, a change in purpose of the service building was conducted to accommodate the relocation of the Tritium Laboratory. The status of the relocation project is currently ongoing and details are in Section 17.1.11.

The Health Physics Neutron Generator (HPNG) facility houses the Texas Nuclear Neutron Generator 150 1H (Texas NG), a linear accelerator, which was disconnected in 2013 and is currently awaiting removal from the facility. The linear accelerator is permanently shut down and placed in a permanent safe shutdown state pending decommissioning and removal.

4.4 Nuclear Facilities in Extended Shutdown State

Since licence renewal in 2011, the Multipurpose Applied Physics Lattice Experimental (MAPLE) reactor cores remained in a defueled state. Since 2012, the operational focus for Dedicated Isotope Facilities (MAPLE reactors and New Processing Facility) was to monitor and maintain the facilities in an extended shutdown state, where only systems that are required to preserve assets are operational. Preventive maintenance and surveillance activities required for

Dedicated Isotope Facilities while in an extended shutdown state were performed as per the maintenance and operational surveillance plan.

4.5 Nuclear Facilities in Storage-With-Surveillance State

The NRX reactor and its ancillary buildings have been in a storage-with-surveillance state since 1997. During the period of 2011 to 2017, routine monitoring and surveillance activities continued. The principal activities included monitoring and surveillance, housekeeping, maintenance, and waste processing including size reduction, cleaning, segregation, and packaging of wastes generated from decommissioning activities. All planned maintenance, testing, and inspections were carried out according to the approved maintenance plan and storage-with-surveillance plan.

Activities were completed in 2015 to transition portions of the Dilute Effluent Disposal System to permanent safe shutdown state. Specifically, Building 240, Building 241, Tank 240-1 and Tank 240-2 underwent defined activities to disconnect systems and services from the Waste Treatment Centre and subsequently, the structures and tanks were transferred to CRL Facilities Decommissioning, in a storage-with-surveillance state. Decommissioning planning for these structures is underway. All planned maintenance, testing, and inspections were carried out according to the approved maintenance plan and storage-with-surveillance plan.

4.6 Nuclear Facilities Undergoing Decommissioning Activities

The Pool Test Reactor was transferred to decommissioning in 2011. CNSC authorization was received to decommission the reactor in 2011 October, and the dismantling field work and decommissioning were completed in 2012.

The Plutonium Tower was in a safe shutdown state between 2011 and 2012. During that time routine monitoring and surveillance continued. In 2013 September, approval was granted from the CNSC for decommissioning to commence in 2014, and decommissioning of all building annexes was completed.

The Waste Water Evaporator was in a safe shutdown state between 2011 and 2012. In 2013 April, approval was granted from the CNSC for decommissioning. The Waste Water Evaporator is being decommissioned in accordance with the approved plan.

During the period of 2011 to 2014, the NRX Fuel Storage Bays building was maintained in a storage-with-surveillance state. In 2014, approval was granted from the CNSC for decommissioning to commence. Several phases of decommissioning have been completed during this licensing period, including removal of residual water heel from the J-rod bays and successful reduction of radiological hazards to meet defined criteria. As well, activities were completed to remove the 10 000 gallon tank. In 2017, activities were completed to install a seal between Building 220 and Building 204, and to successfully remove residual water and sludge from the Isolation Bay and X-rod bays.

CNSC authorization was received to decommission NRX ancillary buildings in 2012. The upper wooden structures, the delay tanks, and valve house have been demolished. The entire length (~550 m) of the Above Ground Ventilation Stack Duct was removed in 2012. The Effluent Monitoring Building was decommissioned and upper wooden structure removed in 2017. This work was conducted in accordance with the approved plans.

The Plutonium Recovery Laboratory contains a reinforced concrete enclosure where reactor fuel dissolution was carried out; this building was in a storage-with-surveillance state since 1994 until 2016 when decommissioning commenced.

The Heavy Water Upgrading Plant was transferred to decommissioning in 2011. Decommissioning field activities began in 2012 April and were complete in 2016. As well, the Under Ground Heavy Water Storage tanks were also successfully retrieved and demolished during this licencing period. During that period day to day monitoring and surveillance was conducted.

The former Reactor Bay Deionization System continues to be decommissioned in accordance with the approved building removal plan. Monitoring and surveillance of remaining systems is conducted by the CRL Facilities Decommissioning project team.

The former MAPLE and decommissioning offices were decommissioned and demolished in 2016 in accordance with the approved building removal plan.

4.7 Modifications to Existing Facilities and Processes

All temporary and permanent modifications to facilities at CRL are made in accordance with CNL's Engineering Change Control process.

Engineering Change Control is a collaborative process, incorporating operations and engineering expertise including design control, safety analyses, and configuration management, to manage and control changes throughout CNL.

Engineering Change Control ensures the following:

- Assessment of the risks associated with a change.
- Execution of controls to manage those risks.
- Implementation of the change in accordance with any applicable procedures, codes, and standards.
- Maintenance of the design basis and associated design, licensing, maintenance, and operating documentation.

The process combines industry best practices for controlling risks and configuration management.

4.8 Operational Limits and Conditions

The operational limits and conditions for CRL facilities are currently documented in:

- Facility authorization documents (for Class I and Class II nuclear facilities).
- MAPLE reactors operational limits and conditions.
- New Processing Facility operational limits and conditions.
- Laboratory protocols, criticality safety documents, and procedural documents (for radioisotope laboratories and other workplaces where operations with fissionable materials are performed involving handling, use, processing, movement and storage).

4.9 Emergency Operating Procedures and Severe Accident Management

4.9.1 Severe Accident Management

Severe Accident Management Guidelines (SAMGs) and supporting documentation were given a detailed technical review by a third party and CNL subject matter experts, in addition to a table-top validation review. Following formal acceptance of the SAMGs by the project, the guidelines served as the basis for development of training materials and validation exercise plans.

All findings and recommendations from the CNSC staff assessment of NRU SAMP implementation were addressed by CNL. Notification of their successful resolution was provided to CNSC staff in 2016 March.

4.9.2 Emergency Operating Procedures

Key Emergency Preparedness (EmP) program and EOC procedures were revised to integrate the SAMP into CNL emergency response procedures. The revisions integrated the technical support group into the EOC organization, identified the roles and responsibilities and authorized the use of SAMGs and supporting documentation to manage a severe accident in NRU. Integration of the SAMP into the emergency procedure procedural framework also formally enabled the use of existing emergency procedure processes and procedures to maintain SAMP elements in the future (e.g., ongoing training requirements, drills and exercises).

A symptoms-based severe accident management entry emergency operating procedure was developed to monitor the severe accident management entry criteria parameters that were developed in the NRU severe accident management guidance technical basis document. Severe accident management Control Room guides were also developed to provide guidance for NRU Operations when in the severe accident management realm. Further, enabling instructions were developed to facilitate the implementation of severe accident management mitigation strategies identified in the SAMGs by providing guidance on the use of equipment or emergency mitigation equipment to respond to a severe accident in NRU.

4.9.3 Severe Accident Management Training

The CNL SAT-based approach was used in training program design, development, and delivery. Training plans were developed for CNL/NRU positions specific to roles and responsibilities identified to support the SAMP. Training was developed for all of NRU Operations, Technical Safety Group, and EOC personnel that would be involved in a response to a severe accident in NRU.

All of the training that has been delivered to date, including individual records of training completion, is documented in CNL's Learning Management System.

4.9.4 Installation of NRU Modifications

Physical modifications made to the CNL plant to enable full implementation of the SAMP in NRU included the installation of instrumentation to monitor symptoms-based severe accident management entry criteria parameters. In addition, fabrication of equipment was completed to facilitate the direct injection of water into the reactor core and connections to enable the supply of power to the Class III buss via portable diesel generators (i.e., the Fukushima diesels, see Section 16.4) during periods of extended loss of power.

4.9.5 Site Equipment and Modifications

Further to emergency mitigation equipment and other equipment procured during the project, additional improvements to the operation of the CRL EOC and to CNL's ability to respond to beyond design basis accidents were completed as part of the implementation phase.

The renovations and emergency mitigation equipment have been turned over to the EmP program or CNL branches supporting emergency response.

4.9.6 Severe Accident Management Validation

In accordance with regulatory guidance and best international practices, CNL adopted a structured and documented approach to validation during SAMP implementation, which was documented in the NRU SAMP validation plan. The objective of the validation plan was to confirm that individual component parts of the SAMP would work as intended. Accordingly, the plan identified specific validation activities that were necessary to confirm that the SAMP will meet its requirements. The validation activities culminated with the successful execution of comprehensive SAMP validation exercises on 2015 October 15.

The responsibility for overseeing the ongoing maintenance and oversight of the SAMP was formerly transferred from the Fukushima Implementation Project to the CNL EmP program via a project turnover document.

4.10 Nuclear Criticality Safety

CRL has a Nuclear Criticality Safety program providing oversight and direction to all nuclear criticality controlled areas at CRL. The Nuclear Criticality Safety program has also prepared criticality safety-related technical evaluations to meet nuclear criticality safety requirements that apply site-wide and are not just specific to one nuclear criticality controlled area. This has enabled a consistent approach to meeting requirements across the site.

Nuclear criticality safety applies to areas at CRL that have a certain quantity of fissionable materials (as defined in the regulations); these areas are called nuclear criticality controlled areas. Documentation is in place for these areas to ensure criticality safety with activities being performed and material being handled in accordance with limits and restrictions outlined in the relevant criticality safety document. Nuclear criticality safety is implemented by each nuclear criticality controlled area and is the responsibility of the nuclear criticality controlled area management to ensure that nuclear criticality safety regulations are met. A Nuclear Criticality Control Officer is appointed for each nuclear criticality controlled area. It is the responsibility of the Nuclear Criticality Control Officer, or their designate, to ensure that requirements for criticality safety are being met for their area.

Activities that enable effective performance of the Nuclear Criticality Safety program for CRL are as follows:

- Mitigation measures for off-site consequences.
- Dose contouring, exclusion zone, and evacuation route planning.
- Evaluations to determine need for and location of Criticality Accident Alarm Systems.
- Firefighting response evaluation.
- Appointments of Nuclear Criticality Control Officers.
- Annual compliance assessments and self-assessments.
- Risk-graded approach to updating criticality safety documents.
- Semi-annual meetings with CNSC staff to provide updates on the status of the Nuclear Criticality Safety program.
- Emergency response drills (to criticality alarms) and firefighting drills in nuclear criticality controlled areas.

4.10.1 Past Performance

Nuclear criticality safety is documented in the overall Nuclear Safety policy and incorporated into fire protection pre-incident plans. Criticality safety documents continue to be updated on a risk-graded approach.

Nuclear criticality safety awareness training is delivered via computer-based training and is part of the required training for all staff. Specific criticality safety training for emergency responders has been developed and is now delivered via computer-based training. A module for the

refresher of the full day in-class nuclear criticality safety course is also available. Refresher computer-based training alternates every two years with in-class training.

The effectiveness of CRL's Nuclear Criticality Safety program has been enhanced through:

- Updated high priority criticality safety documents to meet current standards.
- Criticality hazard identifications prepared for nuclear criticality controlled areas.
- A training process that categorizes all staff based upon their involvement with fissionable materials.
- A documented Criticality Accident Alarm System location assessment.
- Completion of detector location Criticality Accident Alarm assessment on a risk-graded approach.
- Review and acceptance by the Nuclear Criticality Safety program for approval of Nuclear Criticality Control Officer appointments.
- The completion of dose contouring, exclusion zoning, and evacuation planning.

4.10.2 Status of Regulatory Enforcement Actions

Since the last licence renewal, CNSC staff have conducted compliance inspections of the Nuclear Criticality Safety program. As of 2017 July, there were no outstanding regulatory enforcement actions.

4.10.3 Future Plans

As the transformation of the Management System is implemented, it is expected that the Nuclear Criticality Safety program will continue to incorporate all applicable changes into requirements, procedures, and processes.

The Nuclear Criticality Safety program continues to work on improving documentation to meet compliance verification criteria in the CRL LCH associated with criticality accident alarm systems; including finalization of all dose contours, and documenting all immediate evacuation zones and evacuation routes.

CNL will continue to update criticality safety documents to meet all nuclear criticality safety requirements using a risk-graded approach. All high-priority criticality safety documents have been updated. The focus is now on updating the lower priority criticality safety documents. As the site is revitalized, buildings decommissioned, and operations consolidated, it is expected that some of the lower priority criticality safety documents will no longer be required and will be cancelled.

Initial documentation is in place to ensure that Criticality Accident Alarm Systems are installed in the appropriate locations/nuclear criticality controlled areas on site and an effort is being made to benchmark the evaluation criteria with international organizations.

4.11 Pressure Boundary

The CRL Pressure Boundary program establishes a cross-organizational framework to provide assurance that CNL's obligations and risks pertaining to pressure boundary systems, structures, and components are being managed and executed safely and responsibly, in full compliance with the applicable codes, standards, and regulatory requirements. The program is governed by a set of quality assurance manuals specifically designed to ensure compliance with CRL licence Condition 4.9. This was achieved by incorporating the requirements of the CSA N285.0-08 [6] and its applicable referenced publications, and the specific provisions in the CRL licence.

The Authorized Inspection Agency agreement continued with the Ontario Technical Standards & Safety Authority to provide jurisdictional oversight at the CRL site. This oversight includes a triennial survey of program activities and, if deemed adequate, the issuance of Certificates of Authorization for the scope of activities. This survey was last conducted in 2015 May and Certificates of Authorization were issued for the complete range of activities requested. The next recertification survey is expected to be completed in 2018.

CRL classification, registration, and reconciliation of pressure-retaining systems is performed in accordance with code classification and design registration of pressure retaining systems/components procedure. This procedure prescribes the requirements, responsibilities, and process for interfacing with the appropriate regulatory bodies for classification approval, design registration, and reconciliation.

Overpressure protection reports are issued for nuclear systems by registered professional engineers to certify that overpressure protection of systems complies with applicable codes and standards.

4.11.1 Past Performance

The implementation and management of the Pressure Boundary program have been significantly strengthened. The cross-functional Pressure Boundary Working Group provides managerial oversight and ongoing assessment of all aspects of the program, meeting monthly to evaluate performance indicators, self-assessments, ImpActs⁴ and other areas for improvement. The pressure boundary specialists continue to support the program with active oversight of Pressure Boundary program activities in the field.

Implementation of the program is evaluated annually by the Nuclear Oversight organization. Audit findings, corrective action response and action effectiveness are subject to the oversight of the Corrective Action Review Board.

⁴ ImpAct = Improvement Action (process).

4.11.2 Status of Regulatory Enforcement Actions

Since the last licence renewal, CNSC staff have conducted compliance inspections of the Pressure Boundary program. As of 2017 July, there were no outstanding regulatory enforcement actions.

4.11.3 Future Plans

Future program improvements will focus on providing a greater level of field oversight. These improvements will assist with ensuring that a consistent understanding and application of key program requirements will continue among the various CRL organizations.

4.12 Fire Protection

The Fire Protection program provides an operational framework to implement CNL's safety and health requirements with respect to fire protection and to ensure compliance with applicable legal and other regulatory requirements. The program applies to design, operations, and other activities that may affect fire protection.

The Fire Protection program enables CNL to meet its obligations through the following goals:

- Minimize risk of radiological releases to the public that are a result of fire.
- Protect individuals from death or injury due to fire.
- Minimize economic loss resulting from fire damage to structures, equipment, and inventories.
- Minimize impact of radioactive and hazardous materials on the environment as a result of fire.

The program objectives are to:

- Protect life, property, environment, and provide fire safety.
- Prevent fire losses and degradation of fire protection coverage.
- Provide responsible fire protection and change control that enhances fire protection.
- Demonstrate compliance to applicable fire protection codes and standards.
- Improve fitness for duty with respect to fire protection.
- Improve the reliability of the existing facilities from a fire protection perspective.
- Improve business performance and provide risk management using various tools such as self-assessments, code compliance reviews, fire protection screening processes (engineering change control) and fire hazard analyses.

4.12.1 Fire Hazard Assessments

Fire hazard analyses have been completed for nuclear and associated nuclear facilities at CRL. An all-inclusive action implementation plan and dedicated project team are in place to remediate recommendations from the fire hazards analyses. The corrective action plan is continually updated with semi-annual updates submitted to CNSC staff.

4.12.2 Past Performance

Since the last licence renewal, a technical evaluation assessed the effects of the water-based firefighting agents/methods (i.e., pressurized water streams, fog, foam, and compressed air foam) proposed by the Fire Department, on the nuclear criticality safety of the nuclear criticality controlled areas at CRL. As a result of this evaluation, pre-fire plans have been updated to identify the appropriate firefighting agents in criticality controlled areas.

General fire protection services capable of providing fire suppression response to mitigate loss-of-life and property damage are provided 24 hours per day, 7 days per week to meet the requirements of CSA N293 [7] and NFPA 801 [8], by the CRL Fire Department, located in Building 700. The minimum staff level of emergency responders has been supplemented by one firefighter per shift. Firefighting equipment and components (e.g., portable extinguishers, fire water supply system, hydrants, standpipe and hose systems, and automatic sprinklers) are kept ready and functional at all times. An annual third-party review is conducted on operation, testing, inspection, and maintenance of CRL facilities to ensure compliance with the National Fire Code of Canada [9], and CSA N293, where applicable.

The Fire Department task analysis and associated training plan have been revised significantly to ensure that continuing training requirements are fully aligned with the knowledge and skills that are necessary to safely and effectively perform the required tasks.

The construction and commissioning of a four-storey live firefighting training building has enabled the implementation of realistic practical training (Figure 20). The training tower is also enabling a more lifelike drill and exercise program which has improved firefighter and integrated response training. Realistic integrated exercises are being implemented to practice and confirm that the interfaces with other workgroups will function effectively in the event of a major fire. For example, on 2017 September 28, there was a High Challenge Exercise for Building 150 (NRU); which was an integrated exercise between the CRL Fire Department, NRU Operations, health physicists, radiological assessment team, first aid, and Mutual Aid.



Figure 20 Four-storey live firefighting training building.

A summary of some of the significant improvements and achievements since licence renewal in 2011 for fire protection are:

- Monthly fire prevention inspections consistently implemented for facilities resulting in timely resolution of non-conformances.
- Implementation of paired monthly building inspections to educate building personnel and enable immediate resolution of non-conformances.
- Fire hazard assessments completed for all nuclear facilities and associated nuclear facilities.
- NRU fire hazard assessment completed and 93% of recommendations addressed.
- Dedicated project team formed to implement fire hazard assessment recommendations – as of 2017 September, 90% recommendations have been resolved.
- Fume Hood project was initiated to upgrade and/or remove fumehoods.
- Revised mapping and signage of roads in the outer area to improve emergency response.
- Increased fire response shift complement.
- Emergency response apparatus improvements:
 - Procurement of an aerial platform with 2000 GPM pump (Figure 21)
 - Procurement of a new pumper with compressed air foam system
 - Construction and commissioning of a four-storey live firefighting training building to improve firefighter and integrated response training (Figure 22).
 - Procurement of a confined space training simulator.
 - Five-year drill plan amended to include the requirement for annual fire response drills.
 - New fire alarm central monitoring control system (OPEN-GN) installed.
 - Fire panel upgrades continued.

- Sprinkler upgrades continued.
- Fire suppression system installed.



Figure 21 Emergency response aerial platform vehicle.



Figure 22 Integrated response training for fire protection.

4.12.3 Status of Regulatory Enforcement Actions

Since the last licence renewal, CNSC staff have conducted compliance inspections of the Fire Protection program. As of 2017 July, there were three outstanding Action Notices; one proposed closed and two in progress.

4.12.4 Future Plans

Throughout the next licence period the Fire Protection program will continue to manage fire risk using a defence-in-depth process that supports safe and efficient operational and D&WM activities, as well as capital project initiatives. Fire risk at CRL will continue to be reduced with the transition to CSA N393 [10], including implementation of fire hazard assessment actions, fire hazard assessment revisions, fumehood upgrades, the decommissioning of buildings, and ongoing oversight provided by monthly building inspections. Emergency response capabilities will continue to be enhanced with improved training opportunities enabled by the new Live Fire Fighting Training building (Figure 20).

In accordance with CRL LCH Criterion 4.11(1) for Fire Protection, CNL is transitioning to CSA N393 (*Fire Protection for Facilities that Process, Handle, or Store Nuclear Substances*). This transition requires fire hazard assessments to be revised and a code compliance review to be conducted against the standard. CNL has submitted a prioritized plan to CNSC staff for the fire hazard assessments revision process.

4.13 Operating Experience Program

The Operating Experience (OPEX) program is managed under the Performance Assurance department within CNL's Health, Safety, Security, Environment and Quality organization.

The program comprises two main elements, the Corrective Action Program and the OPEX program. These programs review and analyze incidents, events, operating experience, and lessons learned, from both internal and external sources.

The overall objective of the OPEX program is to achieve higher levels of operational safety and performance, and to reduce the significance and the occurrence of unplanned events at CNL. This is done by responding to and internalizing the "Lessons to be Learned" from unplanned events, both from CNL and from the industry in general.

The OPEX program provides and supports processes for identifying, recording, investigating, and implementing corrective actions to prevent recurrence of events. This includes reporting those events internally and externally to regulatory agencies and to the nuclear industry.

The process also includes responding to external events and disseminating "Lessons to be Learned" to prevent occurrence at CNL by providing the specific external information to internal organizations.

The OPEX program interfaces with facility and line management mainly through the Corrective Action Program.

4.13.1 Corrective Action Program

The Corrective Action Program is a real-time system that provides rapid identification of issues and an effective and efficient means for communicating reported issues to management. The purpose of the program is to document and (where warranted) remediate problems, prevent occurrence/recurrence of significant problems, and address opportunities for improvement and trending.

Corrective Action Program includes a comprehensive process for:

- Identifying, prioritizing, investigating, documenting, and resolving problems.
- Capturing and disseminating opportunities for improvement and operating experience (OPEX program).
- Initiating, monitoring, completing, and reviewing actions for effectiveness where warranted.
- Extracting facts, data, and trends of events and sharing them within the organization through the OPEX process.

The process is structured to provide for the timely and effective resolution of identified issues affecting personnel safety, operational safety, regulatory compliance, or business operations, which are entered into the ActionWay application. Assessment and analysis of issues is facilitated through use of different methods and techniques such as rapid learning and cause analysis.

4.13.2 Past Performance

The development, pilot, and release of new computer software that supports the operating experience process was launched. This software allows for an automated process, allowing for a strengthened audit trail for the review details of operating experience in the NRU business line. The users are given the capability to provide an additional layer of oversight and screening for applicability.

Following are some of the improvements for the Corrective Action Program:

- Trend codes were developed and uploaded into the ImpAct software to aid in the facilitation of analysis to ImpActs. Trends will now be easier to identify and will provide more accurate information for specific trends in each business line.
- Quarterly trend data report is provided to business lines for further analysis and review by management.
- Monthly trend reports are made available to NRU for analysis and action by their management.
- Low significance level events (Level 4) are continually being analyzed at increased frequency to identify adverse conditions/trends in keeping with industry best practices.

- Improvements identified through self-assessment activities have been implemented to improve the corrective action management program. These improvements include software and hardware upgrades and the introduction of a non-conformance module.
- Improvements have also been made in standardized reporting and trending of low significance level events to further align with the industry best practices.
- Training material to reinforce the expectations and improve understanding of the workflow processes has been regularly offered to staff.
- New training material was created to improve corrective action quality.
- A new process was developed in 2015 October, known as the Rapid Learning Morning Call, and this is conducted each business day. Managers and supervisors from across the organization present information related to any event that has any consequence to the health, safety, security, or environment. The focus is on ensuring that all immediate actions have been taken to minimize risk to employees. Rapid Learning training was developed and presented company wide. This process allows immediate investigation and resolution of unplanned occurrences by keeping the senior management teams informed in a timely manner.
- A process for a Contractor Assurance System was developed and implemented to provide comprehensive and integrated oversight and assurance for all aspects of CNL operations. This process has strengthened the corporate responsibility for the safety and health of workers.
- Improvements have been made to the apparent cause analysis certification and refresher training.

The number of ImpActs raised between 2012 January and 2017 June is indicated in Figure 23. The decrease in total number of ImpActs raised over the period can be explained by a decline in number of events happening due to effective performance assurance programs, reduction in no-value added ImpActs, the use of parallel process to capture minor equipment deficiencies, and quick resolution of issues through the daily Rapid Learning Morning Call.

4.13.3 Status of Regulatory Enforcement Actions

Since the last licence renewal, CNSC staff have conducted compliance inspections of the OPEX program. As of 2017 July, there were no outstanding regulatory enforcement actions.

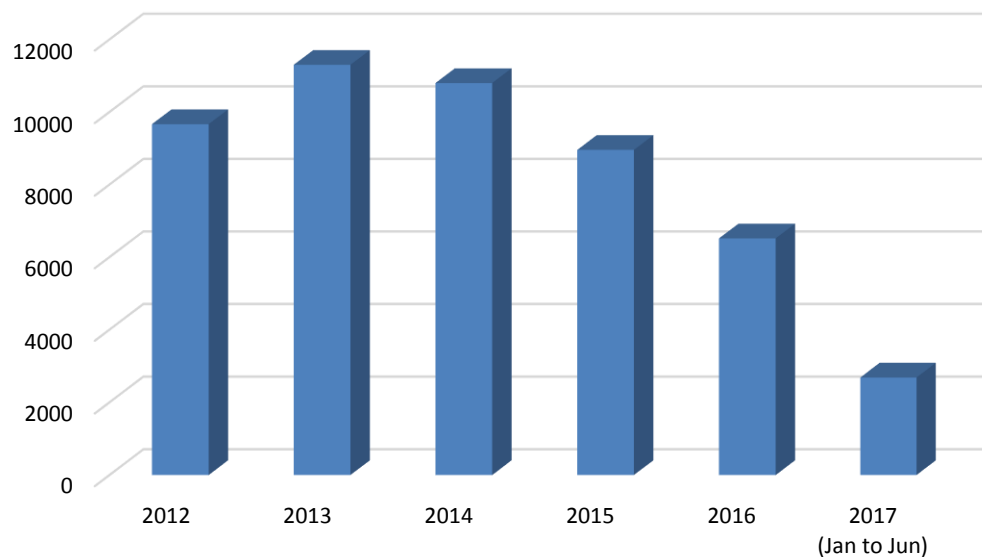


Figure 23 Number of ImpActs raised between 2012 January and 2017 June.

4.13.4 Future Plans

The OPEX program and the Corrective Action Program will develop as follows:

- Increased strength in line ownership for the programs implementation.
- Integration of all aspects of safety culture, human performance, and transformation activities.
- OPEX program built into line-led human performance training, intended to drive increased line ownership.
- Improved oversight from a program perspective that enables relevant learning from the business lines.
- Enhanced programs, by incorporating feedback received from stakeholders on established processes.
- Transformed processes and practices to engage, enable, and empower the workforce.

4.14 Sealed Sources

CNL has maintained an accurate inventory of sealed sources, both in use and in storage during the licensing period. On an annual basis the inventory of sealed sources and the controls for these sources are reviewed. The inventory has been provided to the CNSC upon request and as a minimum on an annual basis. The movement of sealed sources with nuclear substance and with activity equal to or greater than those set out in Table 4-6 (Activity Limits for Reporting the Transfer of Sealed Sources) of the CRL LCH was reported to the CNSC in written form. All changes of sealed sources in Class II prescribed equipment were performed by the

manufacturer, and dose rates at any location that were 1 m from these sources (when the equipment was not in the irradiation mode) were confirmed to be acceptable.

Consistent with the Nuclear Substances and Radiation Devices Regulations, the Radiation Protection (RP) program dictates the requirements for the management and leak testing of sealed sources used for their radiation emitting properties. The shipment of sealed sources follows a company-wide radioactive material transportation process under the Transportation of Dangerous Goods (TDG) program. The security of nuclear substances including sealed sources is set out by CNL's Security program and is consistent with REGDOC-2.12.3 (*Security of Nuclear Substances: Sealed Sources*) [11]; G-274 (*Security Programs for Category I or II Nuclear Material or Certain Nuclear Facilities*) [12]; and G-208 (*Transportation Security Plans for Category I, II, or III Nuclear Material*) [13].

4.14.1 Past Performance

Since 2011 licence renewal, no sealed sources were identified as lost or stolen. Significant efforts have been made to monitor and catalogue the number of registered sealed sources. By the end of 2016 December, the total number of registered sealed sources at CRL was 407.

Leak testing of sealed sources was performed as per regulatory requirements. Event reports have been raised for missing or late leak tests and actions to address deficiencies have been completed as per the CNL's Corrective Action Program. During the review period, there was no instance of potentially dangerous occurrence involving exposure devices or sealed source assembly that required reporting to CNSC staff. However, one event involving radiography, which resulted in unplanned area detection monitor alarms, was reported to CNSC staff due to inadequate planning and management of the 2.5 mrem/h boundary, and CNL has subsequently improved the applicable oversight processes.

Since the 2011 licence renewal many initiatives were taken to better streamline and improve the management of sealed sources.

- Numerous bulletins have been issued on the need to register newly purchased and legacy sources with the RP program.
- Several Responsible User courses were provided to source users that included a review of operational experience on legacy source issues.
- The Health Physicist maintaining the source registry performed and documented source inspections on a yearly basis. Registering the cabinets and assigning source cabinet owners will improve accountability for source cabinet inventory.
- A process was implemented to coordinate between the Procurement department and the Health Physics department before allowing the new purchase of radioactive materials to go forward. This process will reduce the likelihood of new source purchases bypassing the source registry process.

4.14.2 Future Plans

The RP program currently manages the inventory of registered sources in a restricted access database. Effort in maintaining the sources information has been placed on individuals with access privileges. The RP program intends to migrate this database into a web-based program so that source users can access this system to account for the sealed sources in their possession.

The management of sealed sources at CRL will continue to meet regulatory requirements. CNL will continue to adopt current industry best practices to ensure that exposures to workers, members of the public, and environment remain ALARA⁵.

The CRL site is undergoing a transformation to better position the site to meet its current mandate. As observed in the past, site modifications and clean up can reveal legacy radiation sources not previously identified and registered with the RP program. The Health Physics department will continue to provide oversight on such instances and CNL will continue to report these events to CNSC staff and take necessary actions to ensure that these newly found sources are properly managed.

4.15 Chemistry Control

Consideration of chemistry control program relates only to the NRU reactor and the Molybdenum-99 Production Facility (MPF).

For NRU, 26 separate systems are covered under the chemistry control program. The frequency, chemistry specifications, and sampling point are identified for each NRU system. The main goal of sampling is to ensure that the systems are not subjected to degrading conditions and to identify and monitor changes in chemistry control. CNSC staff concluded in 2016 August that CNL “has established specifications and control methods for 26 NRU systems to ensure suitable chemistry control”.

The Fissile Solution Storage Tank (FISST) solution was sampled monthly and the results were reported to the Nuclear Criticality Safety Panel and CNSC staff to meet the requirements of the MPF facility authorization. As per the CRL LCH requirement, the performance indicators for the chemistry control of FISST are reported to CNSC staff in the monthly FISST report.

4.16 Reporting of Unplanned Situations or Events

Reporting of unplanned situations and events at the CRL site is performed in accordance with the applicable program document, and with specific reference to the event descriptions itemized in the CRL LCH, Appendix H (Event Reporting Requirements).

⁵ ALARA = As Low As Reasonably Achievable, economic and social factors taken into account. An ALARA program is established for a specific facility or activity to ensure that radiation protective measures are optimized.

In 2016, the reporting procedure document was revised to fully incorporate the additional requirements (reporting to a Duty Officer) specified in the letter received from CNSC staff as per section 12(2) of the General Nuclear Safety and Control Regulations, regarding CRL. The relevant document was modified accordingly to be applicable to the other licensed CNL locations for which similar requests were also received (Whiteshell Laboratories, Port Hope Area Initiative Management Office, and Prototype Reactor waste facilities).

The revised reporting procedure was submitted to CNSC staff for review and acceptance in 2016 June. Training and implementation of the revised procedure was subsequently completed in 2016 for all CNL sites. In 2017 August, a minor revision to the procedure was issued to provide additional clarity for reviews of unplanned event reports, prior to the reports being submitted to CNSC staff.

Table 3 and Figure 24 show the use of CNL's event reporting through the ImpAct process.

Table 3 Reportable Events for CRL (2012 to 2017)

Significance	2012	2013	2014	2015	2016	2017 ^a
Level 1	0	1	0	0	1	0
Level 2	24	14	9	11	9	3
Level 3	95	110	80	62	55	26
Level 4	34	41	22	20	25	10
Total	153	166	111	93	90	39

a For the period of 2017 January 01 to June 30.

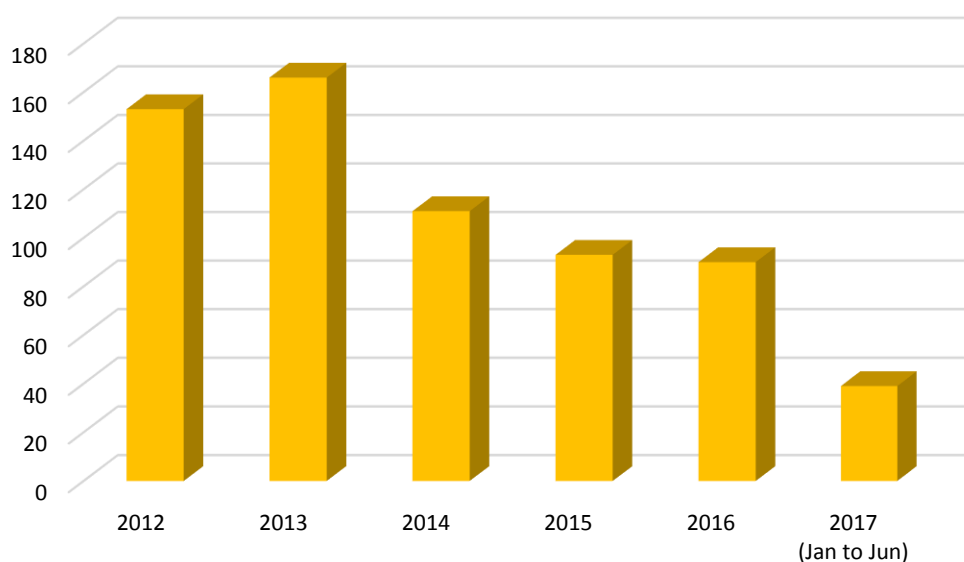


Figure 24 Number of reportable events between 2012 January and 2017 June.

4.17 Reporting of Annual Compliance Monitoring and Operational Performance

For each calendar period since licence renewal in 2011, annual compliance reports have been provided to CNSC staff in accordance with the specific requirements of the CRL LCH, Section 4.16 (Reporting of Annual Compliance Monitoring and Operational Performance). The annual report for 2016 was submitted to CNSC staff in 2017 April.

These documents provide CNL performance data for CRL and are organized by SCAs, matters of regulatory interest, operation of Class I and Class II nuclear facilities, Class II prescribed equipment, nuclear facilities in extended shutdown state, nuclear facilities in storage with surveillance, nuclear facilities undergoing decommissioning activities, radioisotope laboratories and facilities that handle nuclear materials, and essential support facilities.

5. SAFETY ANALYSIS

The Safety Analysis program develops and controls the suite of nuclear safety analysis documents required to support the licensing basis of all facilities at CNL.

This program applies to all safety analysis activities involving CNL structures, systems, and components, and all management, supervision, and staff.

5.1 Past Performance

5.1.1 Conduct of Safety Engineering

The Safety Analysis program has continued to be improved since 2011 through further roll-out, training and refinement of the safety management system in the form of the Conduct of Safety Engineering. The initial suite of documentation, produced in 2011 to guide the safety analysis activities at CRL has been updated. These updates incorporate improvements and lessons learned from use of the initial Conduct of Safety Engineering documentation. The documentation suite now comprises 25 procedures, guidelines, and instructions. The elements of the program have been incorporated into day-to-day safety analysis activities at CRL, both at the management and working level. Use of the Conduct of Safety Engineering has resulted in consistency in how safety analyses are produced and reported at CRL.

In fiscal year 2014/2015, an internal audit was conducted on safety analysis and NRU safety by the Nuclear Oversight division. The purpose of the audit was to satisfy a commitment under the IIP to audit safety analysis for NRU and to assess the quality and consistency of safety analyses conducted since the Conduct of Safety Engineering framework was formally introduced. The audit identified a number of strengths as well as opportunities for improvement. A self-assessment and an effectiveness review have been conducted to determine the effectiveness of the improvement initiatives, with the findings being used to feedback and adjust initiatives as necessary.

In 2017, a subsequent internal audit was conducted with specific reference to procedural adherence. The audit resulted in three audit findings and actions currently remain in progress for their resolution.

5.1.2 Integrated Safety Review for the National Research Universal Reactor

The integrated safety review for NRU has continued throughout the licence period. The review includes implementing improvements to both physical aspects of the NRU facility as well as programmatic elements in a number of areas, one area being safety analysis. Safety analysis is covered under “GIG 3” and includes a number of initiatives to improve safety analysis and to demonstrate NRU compliance with the site licence and integrated safety review commitments. A number of corrective action requirement definitions form the basis for the work to be conducted during the IIP phase with the ultimate aim of completing all associated activities.

5.1.3 Updates to Nuclear Facility Documentation

A number of updates to safety documentation have occurred during the licence period. The major updates include revisions to existing safety analysis reports and facility authorizations including the following:

Safety Analysis Reports:

- CECEUD (Upgrading Demonstration, Detritiation Demonstration, and Safe Shutdown State Report)
- Fuel Packaging and Storage Project
- Fuels and Materials Cells
- Gamma Beam Irradiation Facility
- HPNG
- NRU reactor
- Nuclear Fuel Fabrication Facilities
- Recycle Fuel Fabrication Laboratories
- Target Residue Material Retrieval and Transfer System (Detailed Design Safety Assessment)
- Tritium Laboratory
- Van de Graaff Accelerator
- WMA (Assessment of Proposal to Compact and Store Tritium Contaminated, Low Level Radioactive Waste in the Waste Handling Building and WMA H)
- WMA C Extension (plus addendum; cover operation of approved limited extension)

Facility Authorizations:

- CECEUD Test Facility
- Gamma Beam 150C Facility
- HPNG
- MPF
- NRU reactor
- Nuclear Fuel Fabrication Facilities
- Recycle Fuel Fabrication Laboratories
- Tritium Laboratory
- Van de Graaff Accelerator
- Waste Treatment Centre and associated facilities
- WMAs

5.2 Status of Regulatory Enforcement Actions

Since the last licence renewal, CNSC staff have conducted compliance inspections of the Safety Analysis program. As of 2017 July, there were no outstanding regulatory enforcement actions.

5.3 Future Plans

The NRU reactor will be permanently shut down at the end of 2018 March, at which point it will be defueled and the reactor vessel drained of heavy water as part of transitioning to a safe shutdown state. The rod bays contained within the NRU reactor building will remain operational in support of other activities on the CRL site past the reactor shutdown. The safety activities planned in order to enable the transition include:

- Preparation of an addendum to the NRU safety analysis report.
- Revision of the NRU facility authorization in support of shutdown activities.
- Preparation of a rod bay safety case.
- Preparation of a facility authorization that is specific to the rod bays.
- Further revision of the NRU facility authorization to reflect the safe shutdown state.

The MPF is currently in a state of standby, ready to produce Mo-99 up until the shutdown of NRU on 2018 March 31. This standby period will be followed by transition to a permanent safe shutdown state.

Safety analysis activities will continue on an as-required basis in support of new and modified facilities, S&T programs, and operational activities during the next licence period.

6. PHYSICAL DESIGN

Physical design is managed under the Design Authority and Design Engineering program. The Design Authority and Design Engineering program maintains and controls the design basis within approved safety margins and regulatory requirements, and applies to all design engineering activities at CRL.

The Design Engineering program is a functional support area under the CNL management system. The purpose of the program is to ensure that design is planned, executed, verified, and documented according to applicable codes, standards, regulatory, and customer requirements. The Design Engineering program complies with:

- CSA N286 (Management System Requirements for Nuclear Power Plants)
- CSA N285.0 (General Requirements for Pressure-Retaining Systems and Components in CANDU Nuclear Power Plants) when applied in conjunction with the applicable pressure boundary quality assurance manuals.
- International Organization for Standardization (ISO) 9001:2008 (Quality Management Systems – Requirements) [14]

The change control process at CRL is governed by the Configuration Management program, and is the mechanism by which Design Engineering collects customer requirements, obtains approvals, and plans work. The program provides the framework to maintain and control the physical configuration of structures, systems, and components at CNL. This program applies to all design, operations, decommissioning, and maintenance activities, as executed by all management, supervision, and staff. It applies to all non-nuclear and nuclear documents, policies, programs, and procedures which contain information or instructions that could impact:

- design (both regulatory and non-regulatory),
- any plant physical configuration, or
- any configuration item or information.

6.1 Past Performance

Design oversight and change control have been significantly strengthened, establishing a new organizational infrastructure as well as new and improved processes for design, engineering change control, field change control, item equivalency evaluations, and technical operability evaluations. The Chief Nuclear Engineer position continued as the Design Authority for the nuclear laboratories. This role is responsible for authorizing all design changes, and ensuring that all design, safety, and licensing requirements are satisfied prior to construction. Process improvements were made based on benchmarking of Canadian nuclear utilities as well as the WANO performance objectives and criteria. Change control has been expanded to the whole CRL site, and a more rigorous risk assessment process has been established to screen design changes. The Engineering Change Control Office was established to monitor all changes from initiation through to closeout to ensure that engineering and operational documents and

drawings were updated prior to closeout. This oversight and the establishment of the Configuration Management Oversight Committee have improved configuration management at the CRL site.

Over the years, design oversight and change control have undergone process improvement. Streamlining of procedures to appropriately grade the process to the risk has been implemented with the reduced risk engineering change and the addition of exclusions for very low risk changes that may be executed within the scope of the maintenance program.

CNL has begun the process of expanding the ability and accountability of staff who may execute the design process. The Chief Nuclear Engineer position continues to be an important oversight position and retains the responsibility to ensure that staff executing design processes understand their accountabilities. In addition, the Chief Nuclear Engineer has authority and provides oversight to the execution of the design program.

CNL continues to perform process reviews of the design program to appropriately grade the application of the program across all sites.

6.2 Status of Regulatory Enforcement Actions

Since the last licence renewal, CNSC staff have conducted compliance inspections of physical design. As of 2017 July, there were no outstanding regulatory enforcement actions.

6.3 Future Plans

Over the next licence period, improvements in the CRL physical design process will be gained through the implementation of key initiatives and enablers including:

- Establishing a formal design review board within the Office of the Chief Engineer that includes senior engineers, to focus on quality and consistency of engineering.
- Redistributing engineering functions to better leverage experience and knowledge in the workforce, strengthen work planning, and focus on engineering service delivery.
- Performing assessments of engineering competency and skills profile, with the objective of achieving quality and consistency.
- Completing a series of specific projects that will deliver the tools necessary to provide efficient design services to customers.
- Re-establishing an Engineering Field Office to improve accessibility to engineering services.
- Ensuring greater engagement with third-party supply chain to improve availability and quality of specialty engineering services and provide augmentation for delivery of core engineering services.

7. FITNESS FOR SERVICE

Since the new CRL licence format introduced the concept of SCAs in 2011, CNL has been improving, developing, and implementing processes and making physical changes to address fitness for service. Fitness for service has been defined by six specific areas: equipment performance; maintenance; structural integrity; aging management; chemistry control; periodic inspection and testing. The purpose of these activities is to improve the reliability of systems and thereby minimize risks to health, safety, security, and the environment, while also improving operating performance and enhancing compliance with regulatory requirements. The CRL site is assessed for fitness for service separately from the NRU reactor.

7.1 Past Performance

Significant progress was made in improving fitness for service since licence renewal. An extensive capital program to modernize the site and improve reliability has progressed on projects for domestic water supply, sanitary sewage treatment, storm water management, and natural gas supply. The project to repatriate FISST materials has completed major milestones.

In 2016 August, CNSC staff assessed the Fitness for Service SCA for non-NRU facilities as being “satisfactory”.

Significant progress has also been made on fitness for service for NRU since the last licence renewal, and as of 2017 April 12 NRU also received a “satisfactory” rating. In the area of equipment performance the mean time between reactor trips and forced shutdowns has increased by 326%; this has been correlated to the execution of the IIP GIG-1 hardware equipment modifications and replacements. The Phase 1 of the IIP was completed in 2017 January.

The maintenance area has improved as demonstrated in Figure 25 with significant reduction in preventive maintenance backlogs, the progress on master equipment lists, procurement of spare parts, formulation of technical basis for preventive maintenance, and the full implementation of a system health program and reporting for NRU.

Structural integrity, specifically the fitness for service of the NRU vessel, has been continually monitored through the in-service inspection program and the annual fitness-for-service assessment.

Aging management, chemistry control, and periodic inspection processes have all been maintained, and have received “satisfactory” assessment from CNSC staff.

A requirement to execute annual 30 day outages of the NRU reactor was removed in 2016 and replaced with a commitment to execute one week and two week outages on a quarterly basis. This change has provided flexibility to execute significant equipment upgrades in the reactor, earlier than would have been achievable with the previous outage constraints.

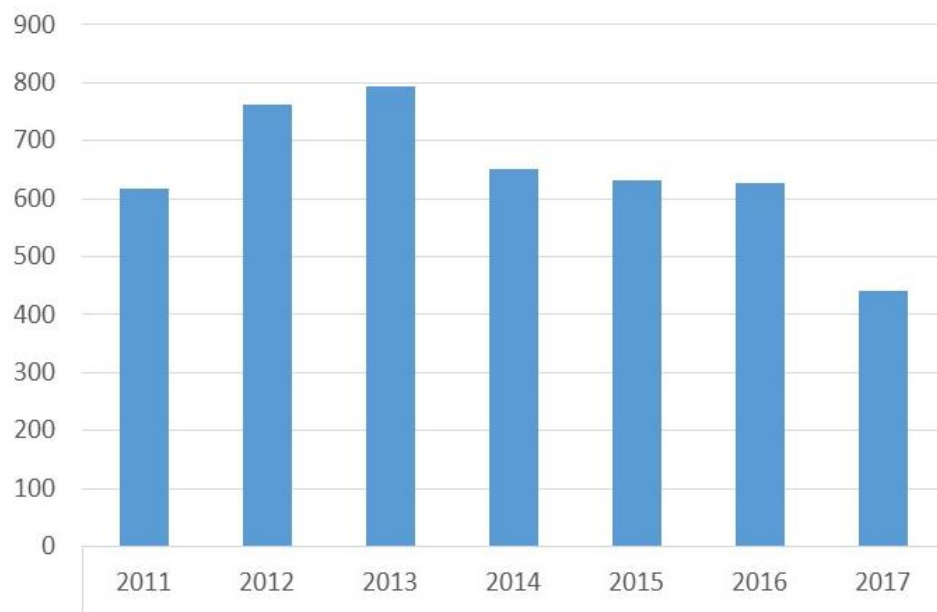


Figure 25 Executed preventive maintenance work for NRU.

Refurbishment of Power Systems was the final element to receive a “satisfactory” rating. This element included four high priority equipment/program groups with multiple sub items:

1. Replace Ion Chambers and Cables: all 11 ion chambers were replaced; preventive maintenance activities are in place allowing for analysis and system health reporting; and testing is complete for 11 spare ion chambers, ready for installation and placed in inventory.
2. Refurbish Class I, II, and III Power Systems: items that have been replaced are Inverters A, B, and C (including three Class I panels); Emergency Power System Battery Bank 1; two Class I rectifiers; all 23 Class I breakers with retrofit kits; Class II breakers and panel; all 21 Class III breakers with retrofit kits; and two motor generator sets with Inverters D and E. Spare Class III NRU and loop diesel generators have been procured. One new Class III diesel generator has been installed and final commissioning testing was completed. A technical issue with a rectifier load has prevented placing the generator in service.
3. Refurbish the Rod Monitoring System: the scope of the project was optimized to reverse engineer and test modern equivalent instruments to increase the fleet of spares for the existing thermovolt and transcope instruments. There were 25 thermovolt production units delivered to CNL and placed in inventory and 10 transcope production units shipped to CNL and placed in inventory.
4. Establish Systematic Equipment Reliability Programs: this item was declared “satisfactory” in 2016 December. The program now monitors all 46 safety-related systems and 39 balance of plant systems in NRU on an ongoing basis.

In summary:

- NRU's Mean Time Between Trips and unplanned shutdowns continued to increase since 2012 from 173 to 565 hours.
- NRU operated 230 planned days in 2016/2017 fiscal period, which is very high for a research reactor; equipment reliability and fitness for service are key enablers that support the 60 year old research reactor.

7.2 Status of Regulatory Enforcement Actions

Since the last licence renewal, CNSC staff have conducted compliance inspections on fitness for service. As of 2017 July, there was one outstanding regulatory enforcement action relating to Class II nuclear facilities (refer to Sections 17.2.1.2, 17.2.2.2, and 17.2.3.2).

7.3 Future Plans

Fitness-for-service programs will continue for site facilities.

Equipment performance will be monitored and improved through refurbishment and investment in new capital projects.

System health programs currently in place will continue to be monitored and the output utilized to improve equipment reliability. Maintenance management will focus on efficiencies to provide optimal programs for equipment and facilities.

The structural integrity and chemistry control of the FISST facilities will continue to be monitored until repatriation of this material is complete. Other existing and new facilities will continue to be assessed for their applicability to these programs.

Critical equipment and systems will continue to be assessed against the requirements for aging management and obsolescence management through the application of the system health program via a graded approach to CRL site facilities.

7.4 Environmental Qualification

The Environmental Qualification program identifies the development of the environmental assessment (EA) basis via the following major activities:

- Identification of the design basis accidents.
- Identification of the systems and equipment required to mitigate design basis accidents.
- Specification of system and equipment performance requirements and mission times.
- Specification of normal and accident service conditions.
- Identification of aging mechanism and equipment failure modes under design basis accident conditions.

Changes were made to the Engineering Change Control program to introduce environmental qualification screening questions into the risk assessment process in order to identify changes that may impact environmentally qualified systems.

With the defuelling of the NRU reactor, there will be no Class 1A facility at CRL requiring an environmental qualification program.

7.5 Site Maintenance

7.5.1 Past Performance

The Site Maintenance department has supported all CRL site operations. The department was responsible for the overall physical maintenance (roads, grounds, buildings etc.) at the CRL site. It was also responsible for all planned maintenance, testing, inspections, emergent repairs, and servicing of equipment and facilities.

The overall scope and objectives for Site Maintenance are summarized as follows:

- Safely fulfill the Site Maintenance mandate using cost-effective and regulatory-compliant practices.
- Complete site-wide maintenance and support work to customer requirements and satisfaction.
- Achieve right-sized resource levels for the effective execution of the Site Maintenance mandate.

Effective 2016 November 21, Site Maintenance and Work Management became an integrated team. Maintenance at the CRL site was split into five distinct areas (four zones and NRU). This transformation provided a customer focus in each zone, with resources that are familiar with zone equipment and buildings, while improving response times and driving efficiencies.

Maintenance Zones:

- Zone 1: research and development and S&T buildings in controlled area; and Operations buildings to support research and development.
- Zone 2: Nuclear Facilities; Operations buildings to support the nuclear facilities.
- Zone 3: Powerhouse; utilities and distribution/administration buildings; storage; maintenance shops.
- Zone 4: Administration buildings supporting research and development/S&T/D&WM in Supervised Area and Outer Area. Oversight for Deep River (contracts and utility workers).
- NRU and associated buildings.

Preventive maintenance consists of actions that detect, preclude or mitigate degradation of functional structures, systems, and components to sustain or extend their useful life by controlling degradation and failures to an acceptable level. Preventive maintenance may be periodic, planned, or predictive.

Predictive maintenance is used to monitor and diagnose equipment condition resulting in recommendations for corrective work to restore equipment to acceptable performance, and (when required) to adjust to the maintenance strategy to remediate the associated failure mechanisms which caused the equipment to fail. This type of maintenance includes vibration analysis, motor circuit analysis, tribology, oil/grease analysis and infrared/ultrasonic inspection and similar technologies used to assess current condition and compare them to baseline and past measurements.

Predictive maintenance techniques are designed to help determine the condition of in-service equipment to predict when maintenance should be performed. Knowing and trending the equipment's condition can help mitigate unplanned equipment failure.

The Predictive Maintenance program at CNL reflects current industry practice and guidelines from the Electric Power Research Institute, the IAEA and the Institute of Nuclear Power Operations. An effective program provides a non-intrusive method to monitor equipment health and also provides advance warning of equipment failure, so that corrective action can be planned before failure occurs. Unlike standard inspections or some preventive maintenance activities, equipment can often be monitored while in operation, which minimizes system unavailability. Through the use of novel tools and techniques, predictive maintenance also minimizes equipment downtime by identifying which internal component of the failed equipment is likely to be at fault, which enhances job planning activities.

As shown by the example toolkits in Figure 26,

- CNL collects vibration data via portable vibration monitoring equipment which can be downloaded into vibration analysing software to pinpoint deficiencies in rotating equipment.
- Ultrasound handheld devices are used to monitor bearing condition, bearing greasing, leak detection, electrical inspection, steam systems inspection, and valve condition monitoring.
- Infrared scans are performed to detect hot spots and/or temperature irregularities which are indications of equipment failing. CNL also has a new telephoto lens for long distance detection of hot spots.

7.5.2 Future Plans

Site Maintenance will continue to be responsible for the overall physical maintenance (roads, grounds, buildings, etc.) at the CRL site. It will also retain responsibility for all planned maintenance, testing, inspections, emergent repairs and servicing of equipment and facilities.

To effectively and safely continue with the transformation of Site Maintenance, various activities will be phased-in to deliver results, lower development costs, and improve the overall return on investment. The initiatives commenced in the 2016/2017 fiscal period will continue into the proposed ten-year licence period.

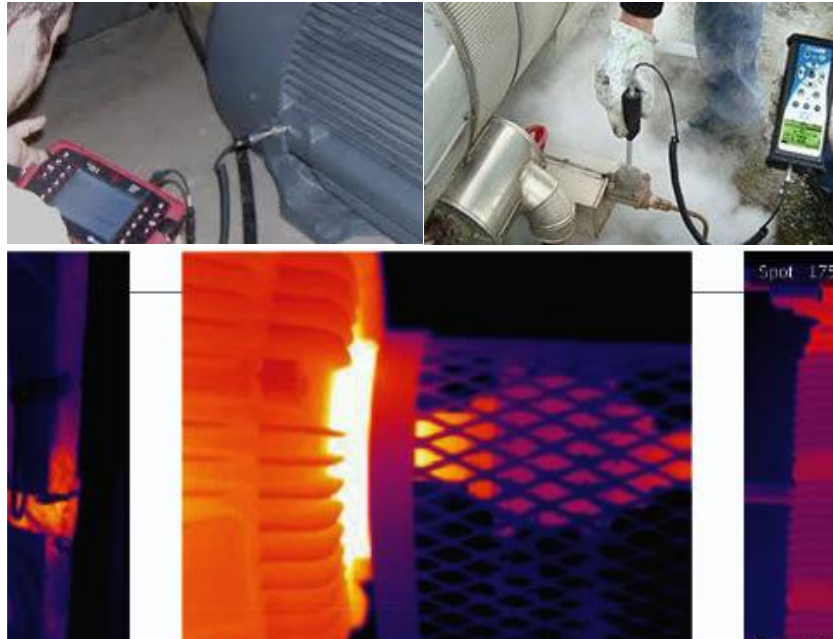


Figure 26 Some predictive maintenance toolkit items (e.g., portable vibration monitor, ultrasound device, infrared scan).

The CRL site footprint will undergo extensive changes. Its current footprint will be reduced by approximately 170 000 m², when more than 120 buildings/structures are decommissioned. New buildings and facilities will be constructed. The comprehensive nature of these changes will drive most of the objectives and strategic actions for Site Maintenance for the next ten years.

8. RADIATION PROTECTION

The RP program applies to the operation and activities that affect the safety of staff and equipment in terms of exposure to ionizing radiation at all CNL sites and applies to all employees and other personnel (visitors, contract staff, etc.) conducting work at CNL sites.

The program provides an overall framework, including organization and responsibilities, processes and procedures, and other related activities as it relates to radiation protection.

The overall objective of the program is to keep doses as low as reasonably achievable (ALARA). In doing so, the RP program will meet its objectives to:

- Limit the doses to less than the regulatory limits.
- Limit detrimental stochastic health effects in employees and members of the public to levels as low as reasonably achievable, social and economic factors being taken into account (ALARA principle).
- Prevent detrimental non-stochastic (deterministic) health effects caused in employees and members of the public by the CNL use of radiation.

Since the licence renewal in 2011, CNL's RP program was monitored and improved as necessary to ensure that CNL's radiation safety complied with or exceeded the requirements specified in the Nuclear Safety and Control Act and the associated Radiation Protection Regulations.

Radiation protection training continued to be provided during the licence period. Training included initial, refresher, and field check-outs. In 2013, a pilot course was completed for revised Group 3 training, based on CNL's SAT. With the successful pilot and implementation, the Group 3 training was modified from a five-day course to a three-day course to be more efficient, and in so doing, became more aligned with CNL business needs. The three-day course continues to effectively meet CNL's radiation protection training needs.

Numerous assessments of the RP program were conducted during the review period by internal and external parties including the Nuclear Oversight auditor, Nuclear Performance Assurance Review Board, WANO, and CNSC staff. These include an internal audit on respiratory protection, CNSC Type II compliance inspections, and audits of the RP program and Dosimetry Services program by internal groups. CNL's RP program documentation for radiation protection and dosimetry was updated on an ongoing and/or as-required basis. CNSC staff were provided with the updates as part of quarterly communications. Included in the updates were the radiation protection requirements document and associated mapping documents. Subsequent amendments requested by CNSC staff for the radiation protection requirements document have been addressed.

During the 2013 WANO peer review, there were two areas for improvements identified in Radiation Protection:

- Control of High Radiation Areas
- Contamination Control

The areas for improvement were aligned and ranked against CNL's IIP. The IIP is a product of the Integrated Safety Review with the objective to drive both physical and program improvements in NRU to align the facility with modern codes and standards.

CRL implemented a re-designation of radiological areas in 2014. This change redefined the CRL radiological areas to become more in line with IAEA guidance and industry best practice. The change also had the benefit to better reflect the necessary control of radiation work at CRL and the handling of dosimetry requirements for visitors and contractors.

In addition to audits and inspections, self-assessments were performed for personnel qualifications, implementation of S-106 (*Technical and Quality Assurance Requirements for Dosimetry Services*) [15] by Analytical Chemistry branch (a laboratory not managed by Dosimetry Services) in support of CRL Dosimetry Services for plutonium (TIMS) and uranium (ICP-MS) analyses, procurement and testing of critical items for Dosimetry Services, verification, document control, calibration, and control of measuring equipment. All actions are being managed and tracked by CNL's corrective action program.

8.1 Past Performance

Successful implementation of the ALARA program at CRL has ensured that no regulatory limit was exceeded in the review period and that individual and collective doses remained ALARA.

An individual sum of whole-body dose (external photon plus neutron plus tritium) and committed effective dose from non-tritium intakes is the quantity to be compared to the regulatory limit on effective dose. All workers and visitors at CRL who received annual doses approaching or exceeding 1 mSv were designated Nuclear Energy Workers. Radiation doses to members of the public did not exceed the annual dose limit of 1 mSv in a year for the most exposed members of the public. The maximum individual whole-body dose, with inclusion of committed effective doses, for CRL has remained at less than the CNL's action level of 20 mSv for every year during the current licence period. The highest individual dose was 12.24 mSv resulting from fuel repatriation activities (Table 4).

Table 4 Distribution of External Whole-Body Dose, Plus Tritium Dose, Plus Non-Tritium Committed Effective Dose

Dose Statistic	2012	2013	2014	2015	2016	2017 ^a	Regulatory Limit
Total Persons Monitored	4903	5080	4615	4410	4387	4191	
Average Effective Dose (mSv)	0.44	0.39	0.43	0.45	0.49	0.26	
Maximum Individual Effective Dose (mSv)	8.90	8.89	8.66	10.72	12.24	9.92	50 mSv per year

a For the period of 2017 January 01 to July 15.

During the review period, no worker at CRL received a dose (delivered plus committed) in excess of any of the respective radiation dose limits for radiation workers, as defined in the Radiation Protection Regulations.

The regulatory limit for surface dose and for extremity dose is 500 mSv per year. The total surface dose for an individual is the sum of external surface photon plus beta dose, tritium dose, and neutron dose. During the review period, no worker received a dose for either of these dose quantities approaching the regulatory limit (Table 5).

With the re-designation of radiological areas at CRL in 2014 July, monitoring requirements were changed such that Nuclear Energy Workers without significant exposure to radiation fields above site background were no longer required to wear Thermoluminescent Dosimeters (TLDs) in supervised areas. Instead, doses for these workers have been estimated and assigned on the basis of CRL site environmental monitoring data.

Table 5 Distribution of External Surface Dose (Photon Plus Beta Plus Neutron) Plus Tritium Dose

Dose Statistic	2012	2013	2014	2015	2016	2017 ^a	Regulatory Limit
Total Persons Monitored	4903	5080	4615	4410	4387	4191	
Average External Surface Dose (mSv)	0.50	0.46	0.53	0.55	0.60	0.31	
Maximum External Surface Dose (mSv)	12.23	13.08	21.73	15.75	16.54	14.33	500 mSv per year

a For the period of 2017 January 01 to July 15.

To support planned work, RP staff engaged in the provision of radiological work assessments, ALARA assessments, radiological work plans/procedures, and radiological isotope laboratory protocols during the review period. Through the use of the CNL's Corrective Action Program, issues were identified, reported, and resolved in a timely manner.

Improvement in source term reduction, shielding, and containment were also a focus at CRL during the review period. Some notable projects include:

- Cleanup and reduction of Sr-90 in South Swamp area at CRL.
- Construction of a shielding wall around the 12-inch diameter Mo-99 hot cell active ventilation duct that emerges out of the ground and rises vertically approximately 3 m on the exterior of the east wall of Building 206.
- Construction of an engineered cover in WMA C, designed to reduce migration of soluble wastes into the water table.
- Removal of liquid legacy waste from WMA A, thereby reducing hazard and liability from this waste going forward.

To further support the implementation of effective ALARA practices during the licence period, a number of significant projects and initiatives were undertaken at CRL. These include:

- Supplementing the existing whole-body monitors at the exit of the control area with implementation of a new model with alpha monitoring capability.
- Installation of new area radiation monitors.
- Upgrading site criticality monitors.
- Completing the evaluation and commissioning of the Canberra alpha/beta continuous air monitors (iCAMs).

Updating/modernizing key radiation protection equipment to meet or exceed industry best practices will be ongoing in the next licence period.

8.2 Status of Regulatory Enforcement Actions

Since the last licence renewal, CNSC staff have conducted compliance inspections of the RP program. Four Action Notices were open as of the end of 2017 July, one proposed closed and two in progress. The fourth Action Notice is proposed closed and relates to an NRU reactor inspection; refer to Section 17.1.1.10.

8.3 Future Plans

The RP program will continue to update documentation in the radiation protection requirements and manuals in response to changes in future work planned at CRL and changes in regulatory documents in the period of the renewed licence. The action levels currently defined in the RP program for CNL sites will be reviewed on a yearly basis, and the rationale for setting and/or maintaining currently established levels will be documented. Consistent efforts will be made to improve metrics to measure performance in contamination and exposure control to drive improvements so that CNL exceeds industry best practices.

CNL's RP program is continuously identifying areas for improvement. Moving forward, CRL will reduce the number of high contamination zones on site and increase the use of elevated surface contamination areas with the use of physical barriers system and signage. Additional whole-body monitoring and small article monitors will be implemented at strategic locations. Improvements to monitoring at facilities, and the storage of radioactive material will enable CRL to provide greater control of radioactive material at the source, allowing for the disposition of clean material from its point of origin. CRL is currently pursuing, and will continue to pursue, technologies which can provide remote monitoring and immediate visual indication to RP staff to reduce exposure to the source term.

Through various self-assessment activities, it has been noted that RP staff are frequently observed to participate in operational activities (operational drift) which removes the focus from the purpose of radiation protection in the planned work. Correcting this drift will result in a more fundamentally sound service and greater assurance that the RP program is properly implemented. Performance errors associated with operational drift whereby RP staff become involved in performing duties normally performed by operations staff and vice versa have been observed. To address these issues, the RP program is developing a framework for an embedded RP organization to provide greater granularity on the oversight function of the RP program/ RP Services organization.

The qualification and training of the Group 1 radiation protection surveyors will be revisited, and there will be a clear understanding of the means by which appropriate oversight will be achieved. The RP organization will commensurately adapt to ensure that enhanced oversight for this function (radiation protection training/qualification and staff performance) is implemented in adherence to RP program requirements.

Over the next licensing period, CNL at CRL will continue to improve radiation protection practices and incorporate well established good industry radiation protection practices into the

design and construction of new facilities. For example, focus will be placed on the modernization of infrastructure associated with radiological change rooms to achieve down-zoning, as well as to facilitate characterization for the transportation of controlled area clothing for decontamination. The work will include installation of whole-body monitors in various building change rooms. Efforts will be placed to control the potential spread of contamination at the source. The RP program will drive changes in the implementation of the movement of materials within a controlled area to enable determination of the radiological disposition of material at the facility/project boundary, and eliminate the need for redundant verification at the controlled area boundary. This will involve updating packaging and surveillance requirements for the storage of radioactive material outside of the facility or project but within the controlled area. Benchmarking at other nuclear sites focused on packaging of radioactive material outdoors for storage, or transfer will be performed.

As many CRL buildings and facilities are planned to be decommissioned and/or repurposed, CRL will continue to re-evaluate the radiological source term hazard in these areas to ensure that protection is optimized and exposures remain ALARA during the new licensing period.

9. CONVENTIONAL HEALTH AND SAFETY

CNL's Occupational Safety and Health (OSH) program applies to all work performed by CNL employees, and to work performed by others on sites or work places controlled by CNL.

The scope of the OSH program, as an element of CNL's Health, Safety, Security, Environment and Quality organization, includes the processes for the management of hazards to health and safety of employees and other persons at CNL sites and workplaces.

The purpose of CNL's OSH program is to prevent accidents and injuries to health arising out of, linked with or occurring to employees in the course of employment, and to all persons on sites or workplaces controlled by CNL.

9.1 Site Safety and Health Committee

Under the Canada Labour Code Part II, employers are responsible for providing safety-related information, instruction and training to employees, and for developing and implementing an OSH program. As an important and mandatory component of the program, group safety meetings provide an effective venue for occupational safety and health related information transfer between employers and employees.

The CRL Site Safety and Health Committee is the principal forum at CRL for joint employee/management consultation and development of solutions for safety and health concerns at the CRL site. The committee meets on a monthly basis and various subcommittees meet on an as needed basis.

The committee provides a mechanism for management/employee cooperative engagement on a range of safety issues, and a forum for addressing employee safety concerns. Activities conducted by the committee include the inspection of all CRL work locations, participation in

incident investigations, and provision of a two-way conduit for communication of safety concerns and improvement initiatives between management and employees.

9.2 Health and Safety Policy Committee

CNL has a corporate Health and Safety Policy Committee that meets on a quarterly basis. The committee is the principal corporate wide forum for joint employee/management consultation for the development of health and safety policies for CNL sites. Membership of the policy committee includes representation from the CRL Site Safety and Health Committee.

The policy committee provides perspective on programmatic safety issues, independent of the OSH program, and supports the development or revision of CNL's procedures related to safety.

9.3 Past Performance

Since the licence renewal in 2011 there has been an improving trend in the recordable lost-time accident frequency for activities by CNL employees at the CRL site. Similarly, an improving trend is noted for the severity of lost-time accidents.

In order to improve services by increasing the level of technical support, OSH and Industrial Hygiene staff have been deployed within various line organizations providing immediate access to assistance, when required.

Improvement actions continued to strengthen the occupational safety and health processes (e.g., working at heights, hazardous energy control, ergonomics, job safety analysis). The CRL Health Centre continues to support effective oversight by management of the return to work component of the Workers Compensation Program.

Although the injury rate data reflects some variability inherent to human behaviour, the general trend shows an improvement over the period examined (2011 through mid-2017), see Table 6.

Table 6 Summary of CRL Injury Rate Data

Year	2011	2012	2013	2014	2015	2016	2017 ^a
Person Hours Worked	4 944 828	6 198 320	6 482 585	6 248 900	6 294 295	6 405 670	4 333 333
Lost-Time Injuries	13	21	18	9	2	6	1
Working Days Lost	162	175	74	37	7	47	2
Lost-Time Frequency ^b	0.53	0.68	0.56	0.29	0.06	0.19	0.05
Lost-Time Severity ^c	6.55	5.65	2.68	1.18	0.22	1.47	0.09

a Information as of 2017 August 31.

b Frequency rate equals # of Lost-Time Injuries x 200 000 hrs of exposure divided by person hours worked (based on 100 Full Time workers).

c Severity rate equals # of Working Days Lost x 200 000 hrs of exposure divided by person hours worked (based on 100 Full Time workers).

9.4 Status of Regulatory Enforcement Actions

Since the last licence renewal, CNSC staff have conducted compliance inspections of the OSH program. As of 2017 July, there were no outstanding regulatory enforcement actions.

9.5 Future Plans

Over the next licence period, plans for the OSH program include:

- Align OSH program with the new OSH Management standard ISO 45001 (*Occupational Safety and Health Management System*) with the intent of pursuing certification within five years of release of the standard.
- Establish a process for competency assessment and internal validation of qualifications and skills development for positions within the OSH program.
- Enhance the method by which accurate contractor safety performance information is collected and evaluated, and use this information as an input for future procurement decisions.
- Implement an Information Technology software solution to support Workplace Hazardous Materials Information System, and manage chemical inventories.

10. ENVIRONMENTAL PROTECTION

CNL's Environmental Protection program is applicable to all operations and activities at CNL sites. The Environment policy, issued under the authority of the CNL Board of Directors, states CNL's commitment to protecting the environment (Figure 27) and establishes the overall principles and goals for environmental responsibility and performance expected of all CNL employees.

The Environment policy has recently been amended to include a clear commitment to sustainability with the addition of the following statement: "We set sustainability objectives and targets for energy efficiency, clean energy utilization, waste management and conservation of resources to support continual improvement of our performance." This change supports CNL's alignment to standards set by the Government of Canada, specifically the 2016-2019 Federal Sustainable Development Strategy as well as CNL's work to advance nuclear science and technology for a clean and secure world.



Figure 27 Protection of the environment.

To demonstrate CNL's commitment, sustainability objectives are being developed and the following are some projects (past, present, and future) which illustrate commitment to sustainability:

- Natural Gas Installation Project: reduces greenhouse gas and other harmful emissions (NO_x , SO_x)
- High efficiency and sustainable new construction: Harriet Brooks Building (Building 350) constructed to standards set by the Canada Green Building Council to become a Leadership in Energy and Environmental Design, Silver candidate.
- Energy conservation projects: High efficiency lighting installations and building automation system upgrades
- High occupancy vehicles and electric vehicle parking
- Development of an integrated waste strategy using a more comprehensive lifecycle approach
- Strengthening biodiversity programs; work in species at risk management
- Promoting "green" procurement practices and material reuse
- Storm Water Management Project
- Drinking Water Distribution System
- Sanitary Sewage Treatment Facility

- Conformance to ISO 14001:2015 Environmental Management System Standard

As a means of achieving protection of the environment and continual improvement in environmental performance, an Environmental Management System was re-registered to ISO 14001:2004 [16] in 2016 August. This system drives the identification of all facility and activity interfaces with the environment, the controls in place to mitigate impact, and establishes environmental objectives and targets.

Environmental performance at CRL is summarized through the CRL Site Integrated Environmental Monitoring program, comprised of three components: effluent, environmental, and groundwater monitoring. Together, these components comprise contaminant pathway monitoring at CRL, enabling the tracking of contaminants throughout the different compartments of the geosphere and biosphere. The CRL ERA is in compliance with CSA N288.6 (*Environmental Risk Assessment at Class I Nuclear Facilities and Uranium Mines and Mills*) [17]. The ERA serves not only as an indicator of environmental performance through its provision of human health and ecological risk assessments, but is aligned closely with the Integrated Environmental Monitoring program and influences the program's design. Conversely, the monitoring program helps verify predictions made by the ERA. All components of the monitoring program are designed to confirm that releases remain as low as reasonably achievable, social and economic factors being taken into account (ALARA).

10.1 Past Performance

Since the licence renewal in 2011, monitoring results verified that the levels of radiation and radioactive contaminants in the environment outside the CRL site due to operations at the site, and resulting radiation doses to members of the public did not exceed the annual dose limit of 1 mSv in a year for the most exposed members of the public, and that the dose to public due to the sum of all releases from CRL did not exceed 0.3 mSv in any period of 12 consecutive months. The main contributor to dose continues to be the release of mixed noble gases, primarily Ar-41 from NRU, I-131, and tritium. As a result of the shutdown of Mo-99 production in 2016 and the shutdown of NRU in 2018, radioactive emissions from CRL are expected to decrease by approximately 85 to 90%.

Non-radiological monitoring results were consistent with the previous years and verified that levels of non-radiological contaminant releases from operations at the CRL site did not negatively affect the quality of water on-site.

Groundwater monitoring results for 2011 to 2016 around the perimeters of the WMAs and other nuclear facilities and locations within the CRL site confirm that the conditions did not change from previous years. At the monitoring sites where impacts are observed, trending of key parameters shows that the groundwater concentrations of contaminants remained at similar levels or have decreased (indicating stable or improved environmental performance), and the changes that occurred were consistent with long-term trends.

Notable changes in groundwater quality over the past five years have included the following:

- A marked reduction in groundwater tritium concentrations immediately downgradient of WMA C in the fall of 2015, which is attributed to the installation of an impermeable cover in the fall of 2013.
- Significant reductions in groundwater tritium concentrations downgradient of the NRU rod bays.
- A stabilization of groundwater tritium concentrations downgradient of the cylindrical bunkers in the southern portion of WMA B.
- Monitoring upgradient and downgradient of the permeable reactive barrier installed downgradient of WMA A in 2013 shows marked reductions of Sr-90 in groundwater passing through the barrier. This passive plume treatment system was installed to intercept contamination that discharges to the South Swamp.

The following safety improvements were completed during the licence period from 2011 to 2016:

- implementation of CSA N288.4-10 (Environmental Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills) [18]
- implementation of CSA N288.5-11 (Effluent Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills) [19]
- issuance of an ERA for the CRL site (see Section 10.1.4) that is compliant with the CSA N288.6-12 (Environmental Risk Assessment at Class I Nuclear Facilities and Uranium Mines and Mills)
- closure of all follow-up monitoring programs established through EAs

10.1.1 Radiological Emissions

Radiological emissions from CRL for the last six years are presented in terms of percentage of the Derived Release Limit (DRL) in Table 7. As shown in Figure 28, airborne emissions continue to be dominated by AR-41, which has fluctuated within expected range. The DRLs are calculated using environmental pathway modelling and are set such that a continuous release of any radionuclide at a rate less than the DRL would result in exposures less than 1 mSv per year (the regulatory dose limit for a member of the public) as per the CSA N288.1-08 [20]. Updated DRLs were implemented at the start of the 2012 calendar year; there were some changes to the DRL values due to changes in the model (IMPACT computer code) which were in line with the recommended methodology. The DRLs were calculated using the latest guidance on the modelling of radionuclide transport through the environment and of the doses that result from exposure to the radioactivity. This guidance has been approved for use by the CNSC.

Table 7 Summary of Radiological Emissions from CRL and Estimated Doses to Critical Groups outside CRL Based on Environmental Monitoring from 2011 to 2016

Year	2011	2012	2013	2014	2015	2016	Six Year Average	2017 ^a
Total Airborne Emissions (% DRL)	6.71	6.17	6.42	7.78	8.06	6.30	6.91	6.69
Ar-41 (% DRL) (Included in total airborne emissions.)	4.94	4.23	3.83	4.18	5.86	4.81	4.64	5.91
Total Liquid Emissions (% DRL)	0.07	0.06	0.07	0.04	0.09	0.08	0.07	0.09
Total Effective Dose (mSv per year) to most affected individual airborne dominant pathway - infant living at upriver boundary of CRL.	0.059	0.063	0.059	0.060	0.082	0.077	0.067	N/A
Total Effective Dose (mSv per year) to most affected individual liquid dominant pathway - adult living downstream of CRL. ^b	0.0003	0.0007	0.0001	0.0003	0.001	0.0005	0.0005	N/A

- a The %DRL is an average of the emissions from 2017 January to June. This number will be updated with the remaining data for the year and reported in the CRL annual safety report submitted in 2018 April.
- b The total effective dose is only calculated annually since many of the samples used in the calculation are only collected annually (based on the seasons).

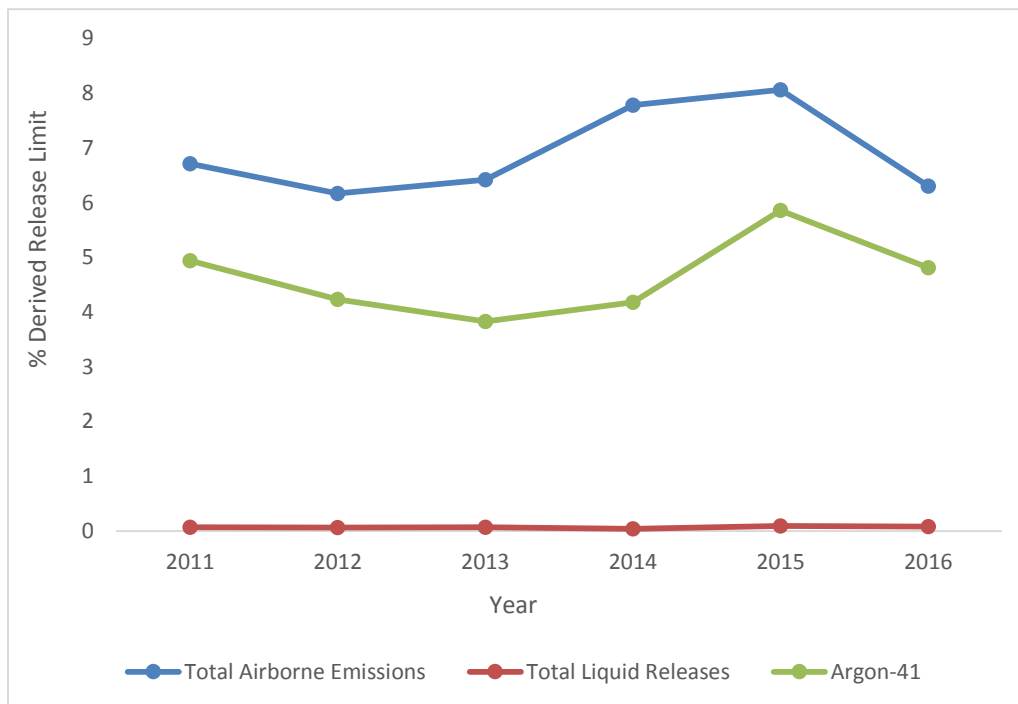


Figure 28 Summary of CRL Radiological Emissions from 2011 to 2016.

CNL continues to maintain extensive programs to monitor radioactivity in the environment in and around CRL, to verify effluent monitoring results. These monitoring locations and parameters correspond with the critical groups and exposure pathways identified in the DRL report. Monitoring included, for example, measurement of ambient gamma radiation, as well as sampling and analysis of drinking water, air, milk, fish, garden produce, and beach/river sediments. The results of the environmental monitoring continue to confirm that radiation doses resulting from CRL operations are well below the regulatory dose limit for members of the public (1 mSv per year), below the CRL licence-listed dose constraint of 0.3 mSv per year, and below the typical background dose from natural radiation in Canada.

Action levels were revised in 2014. These action levels remain performance based and release-point specific, and represent a level of emission that is significantly below the DRLs and is sufficiently low and close to operational performance such that the requirement to keep doses ALARA is not jeopardized if this level is reached.

All emissions of radioactive material in CRL airborne and liquid effluents between 2011 and 2016 were below regulatory limits as expressed by the DRLs. There were zero action level exceedances during the years 2012 and 2015.

There were two action level exceedances in 2011:

- During two separate monitoring periods, the I-131 releases from the Building 468 Decontamination Centre exceeded the action level. These were both attributed to contaminated airborne intake by the ventilation systems from outside sources (i.e., other facilities on site).

There were 30 action level exceedances in 2013:

- During the monitoring period of 2013 June 19 to 26, the gross alpha and gross beta releases from Building 250 Fan E2 (Tritium Laboratory) exceeded the action levels. These exceedances were determined to be associated with increased vibrations of a nearby fan; resulting excess vibrations within the ventilation ducting caused some legacy contamination to be released from the duct and/or sample probe. The fan was subsequently repaired, and exceedances subsided. As described in Section 17.1.7.3, Tritium Laboratory operations will be relocated to the newly renovated portion of Building 215
- During the monitoring period of 2013 September 11 to 18, the gross alpha and gross beta releases from Building 250 Fan E2 (Tritium Laboratory) exceeded the action levels, and the gross alpha action level was exceeded again during the subsequent monitoring period of 2013 September 18 to 25. These exceedances were determined to be associated with maintenance activities performed on the air effluent monitoring equipment. Legacy radioactive material that was attached to a probe and sample line inside the ductwork was dislodged during the maintenance activities and subsequently collected by the effluent monitoring equipment.

- The large majority of the remaining action level exceedances occurred throughout the period starting late 2013 August until mid-November (with most occurrences in the first two monitoring periods of 2013 October), and took place across 8 different buildings and 11 different release points; they were all I-131 exceedances. During this same period, while an action level was not exceeded at the MPF stack, I-131 emissions from the stack were also elevated. Further investigation showed that this suite of exceedances were related. During the first two monitoring periods of 2013 October (when the largest number of these exceedances occurred), the sum of these exceedances represented a very small fraction of the weekly DRL, less than 0.5%. The MPF stack and the Building 468 Decontamination Centre, both of which routinely handle I-131 bearing materials, accounted for 98% of the I-131 emissions in the two-week period. The remaining 2% of these emissions were from buildings that do not handle I-131 bearing materials in quantities that could explain the emissions. A review of operations in buildings that do not normally handle significant amounts of I-131 ruled out any in-building activities that could explain the I-131 emissions. It follows that the exceedances were the result of I-131 emissions from external sources being brought into the buildings via air intakes and/or open doorways/windows and then detected when the exhaust was monitored. The source of intake of I-131 was attributed to emissions from the MPF waste can and waste flask during loading, transportation, and emplacement in WMA B tile holes, from the tile holes after emplacement, and from the Decontamination Centre roof vent, and MPF stack emissions. The compaction of bagged waste from MPF containing I-131 also contributed to the exceedances at Building 591A Fan E1. Following this incident, a return to weekly decontamination of flasks was implemented, to reduce the amount of I-131 that builds up on the inside of the waste flask, and in turn to reduce the peak I-131 released from Building 468 during decontamination of a particular flask. Fresh charcoal adsorbers were installed in the MPF stack ventilation system in 2013 November, resulting in a decrease in I-131 emissions by two to three orders of magnitude. Procedures governing the frequency of flask decontamination and replacement of charcoal adsorbers were revised.

There were two action level exceedances in 2014:

- During the monitoring period 2014 February 26 to March 05, gross beta releases at the Building 468 Fan E1 (Decontamination Centre) exceeded the action level when a higher than normal contaminated flask arrived at the facility for decontamination.
- During the monitoring period 2014 April 02 to 09, gross alpha release at the Building 250 Fan E2 (Tritium Laboratory) exceeded the action level. The cause was similar to that in 2013, that is, maintenance work on the ductwork caused legacy contamination to be dislodged and released.

There were two action level exceedances in 2016:

- During the 2016 April monitoring period, gross beta releases at the Lower Bass Lake monitoring station exceeded the action level. This is a discharge source to Maskinonge Lake.

This monitoring station had been detecting increasing gross beta levels since 2014. Increased precipitation in 2016 may have altered the flow characteristics of the swamp and increased the contaminant load witnessed at the Lower Bass Lake monitoring station. There have been no subsequent exceedances.

- During the monitoring period of 2016 September 07 to 14, gross beta emissions from the MPF exceeded the action level. The MPF had experienced issues when a cell wash-down tank was overfilled with steam condensate. Resuspension of particulates resulted in an increase in in-cell gross beta radioactivity concentration, and subsequent elevated release via the airborne discharge point.

10.1.2 Non-Radiological Emissions

Liquid effluents from CRL are monitored for non-radioactive contaminants in order to measure conformance or compliance with a number of guidelines and limits for chemical substances in liquid effluents: CNL guidelines, site licence limits, internal control limits and Wastewater System Effluent Regulations limits.

- The CNL guidelines are comparable with Environment Canada effluent guidelines for federal facilities and various other federal and provincial effluent guidelines.
- Site licence limits are established in the CRL LCH, Appendix I (Action Levels for Chalk River Laboratories).
- Internal control limits are performance-based levels based on historical performance (first established in 2010).
- Wastewater System Effluent Regulations limits came into effect in 2013 and are reportable to Environment Canada under the Fisheries Act and are applicable only to the Sewage Treatment Plant (STP) monitoring location.

Any exceedances of these guidelines and limits are reported annually in the annual compliance monitoring and operational performance monitoring reports. Overall the majority of non-radiological emissions have either improved slightly or remained stable. The results demonstrate that the controls for the release of potentially hazardous substances currently in place at CRL, either through treatment systems or procedures, continue to provide adequate protection to the environment.

10.1.3 Groundwater Monitoring Program

As an element of the CNL Environmental Protection Program (and the CNL Environmental Management System), the company maintains a comprehensive Groundwater Monitoring Program (GWMP) to assess the impacts on groundwater quality from past and present operational activities at CRL. The GWMP is fully integrated with other environmental monitoring activities of the CNL Environmental Protection program, and the evaluation of environmental impacts of CRL operations (CRL environmental performance) includes the results of the GWMP. Combined with the CRL Effluent Verification Monitoring and the Environmental

Monitoring programs, the three programs provide ongoing monitoring of surface and groundwater quality and the impacts on soils, sediments, and biota in and around the CRL site (Figure 29).



Figure 29 Groundwater monitoring.

Although the GWMP is largely focused on the WMAs at CRL, groundwater monitoring also includes major nuclear and industrial facilities that have liquid waste handling systems for which there is no in-facility monitoring for potential releases to the subsurface, landfills, and lands affected by past operations.

The three components used to evaluate impacts on the quality of groundwater are:

- **Operational Control Monitoring:** entails routine (yearly or twice yearly) groundwater sampling from wells installed around the perimeters of the CRL WMAs, along the Ottawa River frontage of the built-up portion of the CRL site, and adjacent to specific facilities that pose a potential source of groundwater contamination and for which there are no other means of monitoring their integrity.
- **Plume Monitoring:** involves periodic (once every five or ten years) detailed evaluations of known groundwater contaminant plumes.
- **Special Investigations:** studies undertaken if anomalous conditions are encountered during either of the routine monitoring programs.

The main objective of Operational Control Monitoring is to evaluate the general environmental performance of CRL lands and facilities, providing timely information on groundwater quality to CNL's regulators, facility owners (site operations), and to the GWMP.

The objectives of the plume monitoring updates of known groundwater contaminant plumes are to characterize the migration of contaminants from release areas in detail, assess the potential environmental impacts of these groundwater plumes, and evaluate the suitability of planned remedial actions for the plumes.

Groundwater concentrations of a large suite of radiological and non-radiological parameters are reported annually to the CNSC for samples collected from approximately 180 monitoring wells located at 26 different monitoring sites at CRL. For the most part, the results from monitoring have not varied substantially from year-to-year, which is expected of the subsurface (i.e., hydrogeological) environment, where contaminant migration in groundwater flow systems is very slow compared to transport in effluents and surface waters. Where groundwater contamination is present, trends show that in many cases the groundwater concentrations at the monitoring sites have remained at similar levels or have decreased (indicating stable or improved environmental performance), and the changes that occurred were consistent with long-term trends.

10.1.4 Environmental Risk Assessment

The ERA for CRL was issued to CNSC staff in 2013 December, and is in compliance with the CSA N288.6. The ERA contains a total of ten recommendations for CNL follow-up. The schedule for completion of these recommendations is 2018 December in conjunction with the next scheduled update of the ERA. At present, four recommendations are complete, and work is in progress to complete the remaining six. Updates on the status of these recommendations are published annually in the CRL environmental monitoring report. These recommendations aim to resolve data gaps, address uncertainties, and increase transparency of inputs and results prior to the next scheduled update of the ERA.

10.1.5 Ottawa River Fish Impingement/Entrainment

Fish impingement monitoring for lake sturgeon was and still is, conducted annually; every lake sturgeon that is impinged is measured and recorded. Monitoring for other fish species was conducted throughout 2001, 2004, 2011, 2012, 2014, and on a reduced schedule in 2015 and 2016. A model was created for the most frequently impinged fish and the periodic monitoring conducted in 2015 and 2016 was done to verify that impingement trends seen in previous years were still valid. The results from the monitoring periods in 2016 were similar to the monitoring results from 2012 and 2014 and aligned with values predicted in the impingement rate model. Estimated biomass impinged in 2016 is 58.3 kg, with impingement at CRL dominated by two species, rainbow smelt (*Osmerus mordax*) and trout-perch (*Percopsis amicomaycus*) Figure 30. Targeted impingement monitoring will continue in 2017 during peak impingement periods to confirm if the rate of fish impingement remains constant, and to provide verification that the estimates provided in the model remain valid.



Figure 30 Two Ottawa River fish species monitored for impingement.

Entrainment monitoring began in 2016 June and continued through to 2017 June. This monitoring program was created using methods derived from established entrainment monitoring programs at other utilities. CNL's entrainment monitoring includes the collection and identification of fish eggs and larvae that enter into the intake well.

10.1.6 Chimney Swift Population at Molybdenum-99 Production Facility Stack

In North America, aerially-foraging insectivorous bird populations are declining. Among this group, the Chimney Swift (*Chaetura pelagica*, Figure 31) has experienced a 95% population decline in the past 40 years and has been listed as threatened in both Ontario and Canada. Although diet change has been shown to be a possible factor in this decline, swifts also face the added pressure of habitat loss. Historically, caves and hollow trees of old growth forests supplied natural nesting and roosting habitat, but swifts responded to the industrialization of North America by adopting man-made structures for both roosting and nesting sites.



Figure 31 Chimney Swift listed as "Threatened" on the Species at Risk list.

At CRL, roost counts at the MPF stack have been conducted every year since 2010. Counts were performed on dates established by the National Evening Roost Count since 2011, and weekly evening roost counts were performed. Figure 32 below illustrates the number of Chimney Swifts using the MPF stack since 2011 with Julian day 212 corresponding to May 01 and Julian day 243 corresponding to August 31.

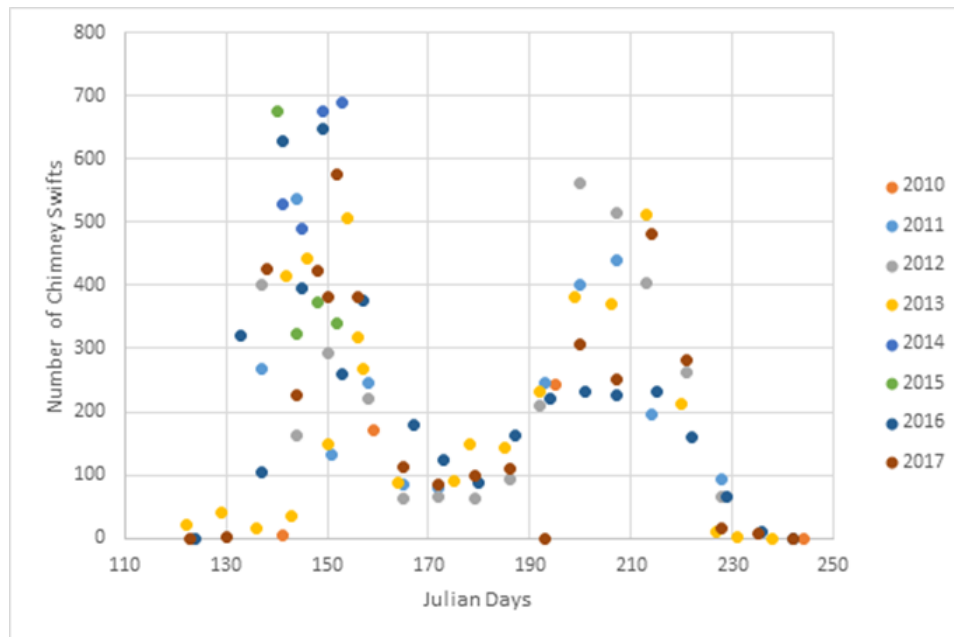


Figure 32 Molybdenum-99 Production Facility stack roost count results for the period 2010 to 2016.

In 2013 and in 2014, CNL moved forward on a very ambitious internal conditions assessment project that consisted of installing a video camera looking down the MPF stack (Figure 33). Other equipment such as temperature dataloggers, TLDs and Personal Alarming Dosimeters were also installed in the stack.

High quality images were collected as shown in Figure 34, as well as temperature data collected every 20 minutes. The Personal Alarming Dosimeter dose readings were also collected and the dose to Chimney Swifts residing in the MPF stack in 2013 and 2014, from May to October, was calculated in 2015. In 2013, Chimney Swifts were estimated to have received 66 mGy for the period of May 02 to October 02 for the reported release of $3.9\text{E}14$ Bq MeV (with a higher complement of Xe-133) for this period. In 2014, Chimney Swifts were estimated to have received 86 mGy for the period of April 28 to September 10 for the reported release of $5.9\text{E}14$ Bq MeV (with a lower complement of Xe-133) during this period. These dose estimates translate to an ERA Risk Quotient of less than one. The results of this field study will be incorporated into the next update of the ERA. CNL will be continuing the Chimney Swift roost count on a weekly basis at the MPF stack for another five years.



Figure 33 Video camera setup at the top of the stack roost site (Molybdenum-99 Production Facility).

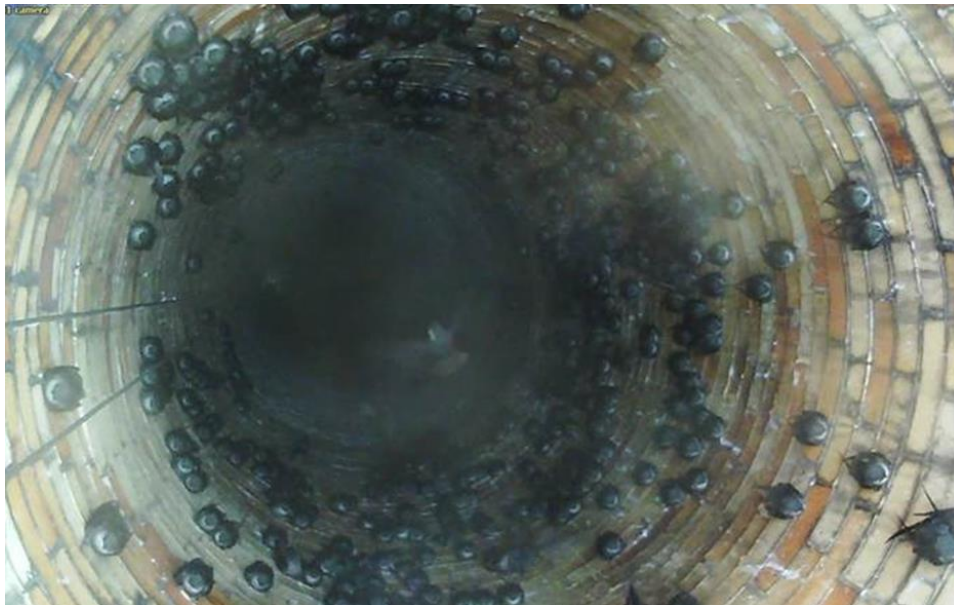


Figure 34 Image from video camera taken on 2013 June 04 (estimated 507 birds).

10.1.7 Barn Swallows

The Barn Swallow (*Hirundo rustica*, Figure 35), is an aerial insectivore that adapted really quickly to European settlement by shifting their nesting behaviour from caves, crevices, and ledges in cliff faces to anthropogenic structures such as barns, bridges, or road culverts. The Barn Swallow population at CRL is no different and, for decades, individuals have adopted a handful of structures to build their nests, which are typically being reused year after year.



Figure 35 Barn Swallow listed as “Threatened” on the Species at Risk list.

The structures with the largest number of nests were all built in 1944 and have reached the end of their useful life and in fact could represent a hazard. These structures are scheduled for decommissioning and demolition. In order to minimize the impact on the Barn Swallows residing in those buildings, alternative nesting habitats were built at CRL in 2017 April located in accordance to the Ontario Ministry of Natural Resources guidance document in order to offer to the species a long term and safe shelter during the breeding season (see Figure 36).



Figure 36 Locations of Barn Swallow alternative habitat sites.

10.1.8 Turtles

There are four turtle species on the site that are listed “Species at Risk” in Canada: Blanding’s Turtle, Snapping Turtle, Northern Map Turtle and the Eastern Musk Turtle (Figure 37). Species at Risk are listed under Schedule 1 of the Species at Risk Act.

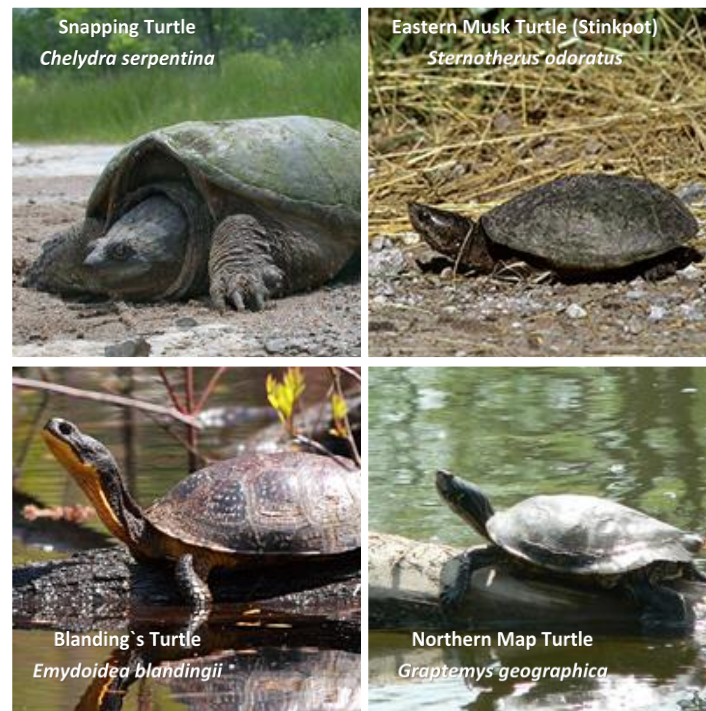


Figure 37 Turtles on the Species at Risk list located at CRL.

Some of these species prefer to remain in one wetland or lake their entire lives, while others require a number of wetlands and habitat types (marshes, swamps, bogs, creeks, etc.) to accommodate seasonal migrations.

CNL has a good understanding of the distribution and movement pattern of these turtle species on the CRL property. This understanding is supporting the development of mitigation measures during project review and conservation initiatives throughout the site.

10.1.9 Ottawa Riverbed Remediation Project

CNL has been sampling and analyzing riverbed sediments adjacent to, upstream, and downstream of the Process Outfall since the early 1950s. In 2001, the Ottawa River Sediment project was initiated to carry out a detailed examination of Ottawa River sediment. In 2005 July, during routine sampling, an active particle was discovered in the riverbed. The region of riverbed affected is located immediately adjacent to the discharge point of the Process Outfall, occupying an area approximately 400 m long and 200 m wide in water 8 to 30 m deep. In 2006, the Ottawa Riverbed Remediation project was initiated to address the contaminated

sediments. This work included a comprehensive human health risk assessment and ecological risk assessment, as well as determinations on remediation. The project was completed in 2014, with regular updates on status and progress provided to the CNSC as well as to CNL's Environmental Stewardship Council during the process.

The results of the human health risk assessment indicate that the potential risks to human health are very low and acceptable in the current setting. For all exposure scenarios, the levels of radiation exposure and mercury uptake were below the corresponding risk acceptance criteria. A qualitative evaluation of how the human health risks may change over time was included and it was concluded that the risks should remain very low and acceptable over time. Factors considered in this evaluation include an expected increase in land development and river use and decreases in contaminant concentrations from natural attenuation processes such as radioactive decay and continued deposition of cleaner sediments.

Similarly, the results of the ecological risk assessment show that there is negligible and declining risk to Ottawa River biota from the historical sediment contamination. Multiple lines of evidence point to little or no risk, including comprehensive measurements of contaminant concentrations in sediment and biota, measured and modelled contaminant biomagnification, laboratory sediment toxicity tests, and in-river benthic population and community assessments.

In conclusion, all lines of evaluation indicate that the potential human health and ecological risks from the presence of contaminated Ottawa River sediments are, and will continue to be, very low and acceptable. The project and its risk assessments concluded that there is no need to implement measures to reduce human health and ecological risks. It was determined that monitored natural attenuation is a viable and preferable remediation option. Routine monitoring and surveillance program was recommended and developed to confirm that the favourable conditions continue to exist.

The results of the completed Ottawa Riverbed Remediation project human health risk assessment and ecological risk assessment will be included and summarized in the next update of the CRL ERA at the end of 2018.

10.1.10 Environmental Assessments

The Canadian Environmental Assessment Act (CEAA) 2012 [21] is the federal legislation governing EAs of projects on CNL sites. Environmental assessments are invoked for projects listed in the Regulations Designating Physical Activities [22]. The regulations identify major projects that have the potential for significant adverse effects such as construction of nuclear power reactors, nuclear disposal facilities and uranium mines. Under CNSC's EA process, preparation of technical documentation to support the EA may be delegated to CNL.

Four EAs were completed over the period of 2011 November to 2016 December and are listed in Table 8. All EAs were completed under the former Environmental Assessment Legislation (CEAA 1992). Under this legislation, a large number of federal departments, agencies, and crown corporations including CNL were responsible authorities. Environmental assessments under the former legislation were invoked for a much broader suite of projects than under CEAA 2012. The CNSC, by virtue of licensing approval, was a responsible authority for the “Decommissioning of a Plutonium Tower at Chalk River Laboratories”. CNL as project proponent was the responsible authority for the remaining three projects. Natural Resources Canada was a responsible authority for projects through provision of project funding.

Table 8 Environmental Assessments for Projects at Chalk River Laboratories – Completed Over Period 2011 November to 2016 December

Proponent ^a	Responsible Authority	Project	EA ^b Start Date	Status	EA Type	CEAR Number ^c
CNL	CNSC	Decommissioning of a plutonium tower at Chalk River Laboratories	2004 Sep 14	Completed 2012 Jan 25	Screening	04-01-6513
CNL	CNL	Expansion of Parking Area “A” on the Chalk River Laboratories Site	2012 Feb 17	Completed 2012 Apr 19	Screening	12-01-66737
CNL	CNL	Environmental Liquid Effluent Monitoring Stations at Chalk River Laboratories	2011 May 16	Completed 2011 Nov 24	Screening	11-01-62091
CNL	CNL & NRCAN	South Swamp Groundwater Treatment System at Atomic Energy of Canada’s Chalk River Laboratories	2011 Feb 07	Completed 2011 Nov 16	Screening	11-01-60434

a Names referring to after 2015 transfer to Government-Owned Contractor-Operated model.

b EA = environmental assessment

c CEAR = Canadian Environmental Assessment Registry

There is one EA in progress for projects at CRL under CEAA 2012. This is the proposed NSDF at CRL. It is listed in Table 9 along with details of the EA including responsible authority, EA start date, and Canadian Environmental Assessment Registry number. Regulatory decisions pertaining to the NSDF will subsequently be determined by the Commission under a separate hearing process.

Table 9 Environmental Assessments for Projects at Chalk River Laboratories – In Progress

Proponent	Responsible Authority	Project	EA Start Date	Status	EA Type	CEAR Number
CNL	CNSC	Near Surface Disposal Facility	2016 May 05	In Progress	Environmental Assessment by Responsible Authority	80122

10.2 Status of Regulatory Enforcement Actions

Since the last licence renewal, CNSC staff have conducted compliance inspections of the Environmental Protection program. As of 2017 July, there were no outstanding regulatory enforcement actions.

10.3 Future Plans

Future plans include registration to ISO 14001:2015 [23], and alignment of programs to comply with CSA N288.7 [24] and CSA N288.8 [25].

Over the next licence period, improvements in the CRL Environmental Protection program will be gained through the implementation of:

- CSA N288.7-15 (Groundwater Protection Programs at Class I Nuclear Facilities and Uranium Mines and Mills)
- CSA N288.8-17 (Establishing and Implementing Action Levels for Releases to the Environment from Nuclear Facilities)
- ISO 14001:2015, Environmental Management Systems
- Environmental Risk Assessment update for CRL as per the five-year cycle
- a major project for disposal of radioactive waste at CRL, the proposed NSDF

Transitional provisions are required for achieving CRL compliance to CSA N288.7-15 and to CSA N288.8. A period of two full years from successful licence renewal is required for implementation of CSA N288.7, and one full year for implementation of the CSA N288.8.

11. EMERGENCY MANAGEMENT AND FIRE PROTECTION

The EmP program focuses on the prevention and mitigation of, preparedness for, response to, and recovery from abnormal or emergent events. The program supports emergency response as required through mutual assistant agreements, and as directed through AECL.

The program applies to design, operations, and other activities that may affect emergency preparedness at CNL sites and it is also used to enable and provide off-site response support.

The Fire Protection program applies a risk-graded approach in conjunction with the defence-in-depth principles to its operations and activities in so far as they may affect fire protection.

11.1 Emergency Management

11.1.1 Past Performance

Since the effective date of the current CRL licence, the EOC activated on 17 occasions, as indicated in the following list. On each occasion there were no significant radiological or chemical releases.

- Highway 17 Closure (2011 November 30): Highway 17 closed between Deep River and Mattawa for approximately five hours.
- Loss of Class IV Power (2012 March 20): 13 hour event due to external power supply issues. Site successfully switched to Class III power, which was sustained through the outage.
- Highway 17 Closure (2012 May 22): Highway 17 closed for several hours, with eastbound traffic rerouted through Garrison Petawawa.
- NRU Rod Bay Water Swap (2012 November 27): EOC activated for planned NRU rod bay water swap, in order to rapidly implement emergency response actions if required. Event was completed without incident.
- Partial Loss of Class IV Power (2013 February 28): six hour event due to external power supply issues, resulting in partial loss of Class IV power to site. Site successfully switched to Class III power, which was sustained through the outage.
- Building 375 Fire Alarm (2013 April 19): a suspected fire in Building 375 which turned out to be an overheated motor in Room 112.
- Earthquake (2013 May 17): a magnitude 5.2 earthquake occurred 18 km northeast of Shawville, QC, felt in the Ottawa-Gatineau area and out to Montreal, Toronto, and Waterloo. The earthquake was followed by a magnitude 4.1 aftershock.
- Loss of Class IV Power (2013 July 19): eight hour event due to severe storm with strong winds. Site successfully switched to Class III power, which was sustained through the outage.
- Loss of Class IV Power (2014 April 29): short-lived event of less than one hour duration due to external transformer fire. Site successfully switched to Class III power, which was sustained through the outage.

- Site stay-in due to false criticality alarm in Building 405, (2014 August 11, 2015 February 26 and July 20, 2016 June 15). Site-wide stay-in procedures were followed and emergency centres were activated.⁶
- Planned Site-Wide Electrical Outage (2015 September 17 to 20, 2016 July 07 to 10, 2017 July 06 to 09): partial activation of EOC team during first four hours of outage and final four hours, to ensure a rapid response in the event actions were required to prevent or respond to an emergency.
- Loss of Class IV Power (2017 July 30): four-hour event due to a tree falling onto the 115 kV circuit D6 that caused a break in the circuit and resulted in downed conductors leading to a brush fire which was quickly extinguished and no radiological release occurred.

Highlights of the EmP program include:

- All required annual drills and exercises completed: EmP program completes approximately 50 drills and exercises annually, in accordance with the CRL five-year drill and exercise plan. Drill and exercise types include fire, bomb threat, chemical spill, high radiation alarm, criticality, chlorine, PCB, transportation accident involving radiological materials, site stay-in, and site evacuation.
- Implementation and validation of a SAMG program: implementation and validation of a SAMG program was required by the CNSC, following the Fukushima accident. The program includes the training and exercising of five technical support group response teams, the development of emergency processes, and the capability to deploy emergency mitigation equipment in response to beyond design basis emergency at the NRU reactor. The program was validated in 2015.
- Several plans and procedures updated: emergency preparedness documentation is on a three year formal review and update schedule, with an informal review required annually. When significant changes are identified during informal reviews, a formal review and update is required.

Improvements in EmP program include:

- CRL EOC upgraded: in 2015 the CRL primary EOC underwent a number of upgrades, including but not limited to:
 - installation of eight 55 inch displays on the front wall which allow multiple layout styles
 - installation of a 55 inch display on the side wall for viewing news feeds via satellite
 - installation of new EOC table and desktop monitors
 - installation of a Crestron interface unit to control all technology (displays, audio, video/teleconferencing, lighting, etc.), within EOC

⁶ The criticality monitors were modified to employ a voting logic in order to overcome spurious single failure modes.

- improvement of EOC accommodations
- Severe Accident Management Upgrades to EOC: in support of CRL SAMGs for the NRU reactor. Some of the key capabilities and equipment include the following:
 - Class III power capability
 - dedicated telephone lines for each position
 - direct “hot line” telephone to NRU Control Room
 - computers for each position
 - Smart Video Display Board
 - video link to EOC
 - access to printer/plotter
 - Battle Box containing key drawings of systems/areas of NRU
 - SAMG reference material
 - SAMGs and log posters on walls
 - portable radios
 - satellite phone
 - whiteboards
- A Planning Section Room was also established for the purpose of future planning during operational emergencies. Some of the key capabilities and equipment include the following:
 - Class III power capability
 - dedicated telephone lines for each position
 - computers for each position
 - Smart Video Display Board
 - access to printer/plotter
- An Emergency Mitigation Equipment inventory and deployment capability was also established in 2015. The inventory contains numerous resources for deployment and use in preventing an emergency or mitigating against further damage due to an emergency. The inventory includes but is not limited to:
 - heavy equipment
 - surveying instruments
 - personal protective equipment and clothing
 - diesel generators
 - vehicles
 - communications equipment
 - medical supplies

Alignment with Ontario Incident Management System: in 2015, CRL adopted the Ontario Provincial Incident Management System. This system provides a standard framework for responding to an emergency, including command and control, common terminology, and technological interoperability. This system is utilized by the large majority of emergency response organizations in the Province of Ontario, including the Office of the Fire Marshall and Emergency Management. Figure 38 shows a municipal siren used in local communities as one of the components in responding to an emergency.



Figure 38 Municipal siren located in a nearby community.

Improved Interoperability (Internal and External) Through Joint Exercises: since 2015, there is a focus on the integrated response to the exercises, including interoperability, at the incident area, EOC, and off-site centres. An example of a transportation exercise is depicted in Figure 39. External first responders (fire, emergency medical services, and police) are invited to participate in these exercises as well. In 2016, an Integrated Training Team was formed to develop training specific to interoperability at the incident area.

CNL participated in one of the largest nuclear emergency preparedness exercises in Canadian history in 2014 May. The company partnered with municipal, provincial, and federal governments at a full-scale three-day exercise in Southern Ontario, as indicated in Figure 40 and Figure 41.

Enhanced Training for EOC Members: implementation of the SAT-based training program for EOC members, including the addition of a one week long training session for new members.



Figure 39 A picture of a scenario designed to practice and evaluate responses to a transportation accident.



Figure 40 Staff participating in the risk assessment component at the Radiation Protection Bureau in Ottawa, Ontario.



Figure 41 Radiological assessment team mobile command post in Orono, Ontario.

11.1.2 Distribution of Potassium Iodide Pills

Potassium iodide (KI) pills and information on medical use were distributed to all permanent residents within the CRL Primary Zone (9 km, Figure 42) both in Ontario and Québec. This task was completed in 2015.

Primary zone pre-distribution and secondary zone stockpiling requirements were 100% met and ongoing protocols remain in place.

- One hundred percent complete: property owners were provided an opportunity to own kits (issued by registered mail or express post). During distribution CRL personnel were at local post offices to answer questions during the mailing campaign, and public information sessions were held.
- Ninety-five percent complete: property owners have kits with KI; municipalities considered 100% complete with property vacancies and refusals.
- Ongoing: processes remain in place within the communities for ongoing pre-distribution in both Ontario and Québec. When a tax roll property is sold, the municipality provides the new property owner with an information/KI kit. The municipalities provide annual notifications on kit availability through municipal newsletters, tax bills, and/or local media.

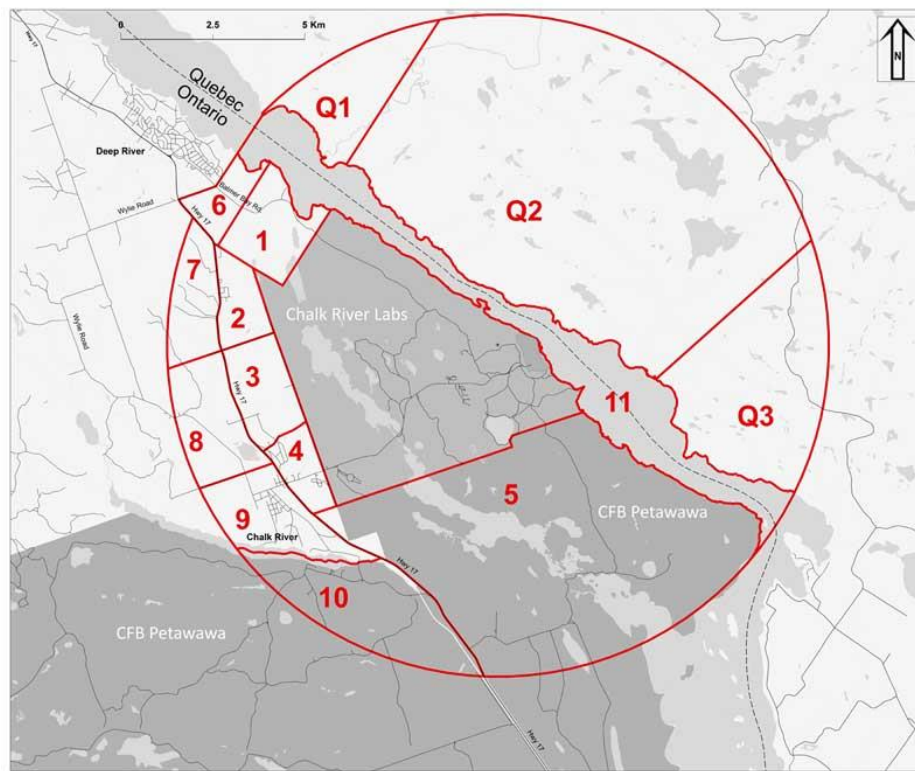


Figure 42 Chalk River Laboratories primary zone potassium iodide pill distribution.

Pre-stocked KI within “secondary” zone (50 km), both in Ontario and Québec was completed.

- One hundred percent: complete for total population⁷ including extras (221 400 tablets – supports approximately 58 000 persons for two days).
- Stockpile locations confirmed with communities and tablets provided.

Extra KI inventory:

- Stockpile has enough to support the full primary zone during an emergency (e.g., people may not find or have access to their “pre-distributed” tablets).
- Stockpile includes extra material to cover transient population.

During the next licence period, in accordance with the previously notified shutdown plans for the NRU reactor, there will be no requirement for distribution or stockpiling of KI pills. The rationale for this is that following the defuelling of the reactor, a large source term release, and subsequent airborne plume of radioactivity, could not result from a serious accident at the site.

⁷ As of 2015 December 31, the stockpile was sufficient for the sensitive population. As of 2016 January 30, the stockpile was upgraded and is sufficient for the full population.

11.1.3 Future Plans

The emergency preparedness improvement plan will continue to be implemented, revised, and prioritized as new needs arise. Major activities over the next five years will address the following:

- Implementation of a risk-based emergency management framework versus the current design-based program, through the utilization of a hazard identification and risk assessment.
- The hazard identification and risk assessment will continue to identify risks to the CRL site for all potential hazards, and also be applied at the facility level to determine what additional risks exist or could be magnified due to an external hazard occurring, that could potentially result in an emergency. The identified risks will continue to place a clear emphasis on areas that require a focus on planning, preventive/mitigative measures, training and drills/exercises.
- The Business Continuity Management program will provide the Crisis Management Team with a resource that can be applied to any business disruption that occurs, and a methodical approach to restore critical services within an acceptable period of time. The program will apply to a wide range of events including loss of information (e.g., information technology outage, cyber-attack), loss of a building (e.g., fire, flood, power outage), or loss of staff (e.g., labour stoppage, pandemic).
- Performance of a gap analysis for REGDOC-2.10.1 (*Nuclear Emergency Preparedness and Response*) [26] in preparation for transition of NRU operational state to safe state, and from Class IA facility to a Class IB.

11.2 Fire Response

11.2.1 Past Performance

Since the last licence renewal, the following improvements were implemented with regard to fire response capability:

- Revised mapping and signage of 130 roads in the outer area to improve emergency response.
- Increased fire response shift complement.
- Emergency response apparatus improvements:
 - procurement of an aerial platform with 2000 GPM pump
 - procurement of a new pumper with compressed air foam system
- Emergency response equipment improvements:
 - procurement of a new fire hall self-contained breathing apparatus compressor
 - procurement of a mobile self-contained breathing apparatus compressor

- radio system upgrades
- second set of bunker gear and ensemble purchased for responders
- self-contained breathing apparatus capacity doubled
- portable pumping equipment and strategy to support beyond basis events
- Emergency response qualification improvements:
 - revised and reissued training plan
 - qualified high angle rescue technicians
 - qualified confined space rescue technicians
 - certified HazMat technicians
 - requalified all response personnel to NFPA 1081 [27]
- Construction and commissioning of a four-storey live firefighting training building to improve firefighter and integrated response training.
- Procurement of a confined space training simulator.
- Five-year drill plan amended to include the requirement for annual fire response drills with a focus on integrated response.
- Commenced table-top exercises utilizing the new pre-incident plans and evaluation criteria from CSA N293-07.

11.2.2 Future Plans

Proposed improvements for fire response at CRL during the next licence period are integrated with the corporate Fire Protection program as described under the SCA for Operating Performance (Section 4.12).

11.3 Status of Regulatory Enforcement Actions

Since the last licence renewal, CNSC staff have conducted compliance inspections. As of 2017 July, there were no outstanding regulatory enforcement actions for the EmP program.

12. WASTE MANAGEMENT

12.1 Waste Management Program

The Waste Management program provides oversight, compliance, and services for waste management, supporting all waste generators to meet strategic priorities for all phases of the waste management lifecycle, and associated business needs.

CNL is enhancing management of waste at CRL in order to have a truly integrated strategy. Development of this integrated waste strategy is work in progress and CNL is taking a holistic view to manage the volumes of waste in an efficient and safe manner.

CNL will continue to provide waste processing and storage services that protect the environment, comply with regulations, and assure health, safety, and security for future generations of Canadians. This will include the management of legacy waste which originates from the earliest site operations (1940s). CNL is carrying out these activities in an integrated manner, taking into consideration the following strategic priorities: integrated D&WM activities; establishing an integrated waste strategy, consolidating intermediate-level waste and planning for construction and operation of the proposed NSDF. CNL ensures the continued availability of waste storage facilities and capability for both ongoing routine operations and special projects related to waste handling on the CRL site. Waste generated from off-site generators (including Whiteshell Laboratories and other CNL sites) will be managed and stored appropriately.

Through environmental remediation projects, CNL will progressively reduce the risk and liability to AECL through prudent management and cleanup of legacy waste. For example, in 2017 August work was completed using ground penetrating radar to identify underground services at CNL's electrical yard landfill. Surface gamma scans were also carried out to support this 2017 summer sampling campaign.

A variety of approaches are being used to meet these demands, which will continue to be fulfilled as part of the integrated waste strategy activities to ensure that gaps in waste management are addressed, and options considered are justified and underpinned to meet CNL business needs while meeting regulatory obligations.

The Waste Management program continues to implement current initiatives to improve CNL waste management. Program reviews and self-assessments are used to identify ways to continuously improve the adequacy, suitability, and effectiveness of the Waste Management program.

12.1.1 Past Performance

Since the 2011 licence renewal, expansion and development of the Waste Management program has been initiated and major achievements include the following:

- Drafted an integrated waste strategy to address waste lifecycle management across all CNL-operated sites and produced a CNL lifecycle waste forecast.
- Developed CRL low-level radioactive waste forecast for period 2016 to 2046.
- Developed CRL clean waste forecast through to year 2100.
- Initiated an interim waste storage plan for CNL to ensure adequate storage capacity against forecasted waste, to allow for continued site operation.
- Developed and issued interim waste acceptance criteria for the proposed NSDF to align D&WM waste generation processes with disposal requirements.
- Developed a D&WM integrated waste transportation strategy for CNL wastes.

- Completed housekeeping initiatives within the supervised and controlled areas at CRL to improve worker safety and site aesthetics.
- Enhanced support to existing activities and new activities in support of site revitalization. The support improved segregation and ensured continued adherence to waste processes.
- Conducted waste minimization assessments within facilities to assess the management of radioactive and non-radioactive waste by a facility, project, or workgroup against Waste Management program requirements, and to allow for increased waste minimization opportunities.
- CNL participated in “Waste Reduction Week in Canada”, an annual program that strives to educate, engage, and empower Canadians to reduce, reuse, and recycle waste. During the waste reduction week, various promotional activities were conducted to engage employees to learn about waste reduction and environmental sustainability.

12.2 Decommissioning

CNL’s mandate under the Government-Owned Contractor-Operated model is to significantly transform CNL to modernize the laboratories, deliver S&T to government and third-party customers, accelerate decommissioning and environmental remediation, and establish long-term waste management solutions while containing and reducing costs and financial risks for Canadian taxpayers over time.

The new mandate emphasizes an early reduction or elimination of hazards and liabilities and the D&WM organization is responsible for managing the radiological and hazardous waste. This includes wastes arising from past and current operation of CRL facilities, commercial sources, and decommissioning activities.

In accordance with CRL licence Condition 12.2, a comprehensive preliminary decommissioning plan for the CRL site is maintained and revised as required, at least every ten years.

CNL will proceed with the decommissioning, environmental restoration, and waste management projects based on sound waste management and environmental principles. The culmination of these activities will generate space to allow construction of new world class research laboratories that enable the S&T mission to flourish.

The Facility Decommissioning organization is responsible for decontamination and demolition activities on the CRL site (see Figure 43).



Figure 43 Removal of upper wooden structures of the NRX ancillary buildings delay tanks and valve house.

On the CRL site, CNL will focus on early reduction of liabilities in the supervised area footprint to build a skilled workforce, remove redundant buildings, and clear space for S&T and supporting facilities. Decommissioning & Waste Management will self-perform the majority of decommissioning activities to gain efficiencies and reduce risks associated with redundant, high-hazard facilities. In the supervised area, integrated teams will develop decommissioning skills on low-hazard buildings, which will prepare them for higher hazard work in the controlled area. With this progressive approach, decommissioning teams will continue to learn and build upon relatively low-risk experience, expanding into more difficult areas as they become more efficient in the treatment and management of industrial and radiological hazards. This approach will also support the acceptance and adaptation of site-wide program controls to enable an accelerated decommissioning schedule.

International decommissioning experience gained on multiple sites demonstrates that the development of a trained and experienced workforce with flexibility to move between buildings, as conditions require, is a key step in safely accelerating decommissioning scopes of this magnitude. Additionally, development of a core team and capabilities reduces incidents and costs, particularly those associated with multiple subcontractors performing a variety of tasks on a complex site. Decommissioning activities will be coordinated with capital project timelines to provide the space required for both permanent new facilities and temporary enabling facilities.

12.2.1 Past Performance

Significant progress has been made in decommissioning activities at CRL since 2011 including the following:

- As of 2017 July, successful removal of approximately 35 redundant structures during the licensing period.
- On 2017 June 03, the Building 444 water tower was safely demolished. The water tower was built in 1956 and stood approximately 92 m in the air (Figure 44).

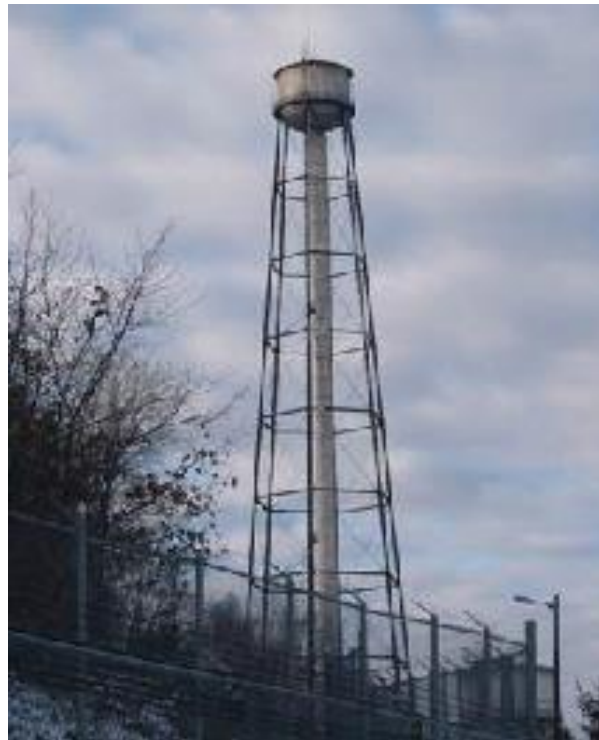


Figure 44 Building 444 water tower.

- Successful execution of decommissioning activities in the Heavy Water Upgrading Plant (Building 210) and CNSC staff acceptance of end state report to remove facility from regulatory control.
- Successful decommissioning activities in the NRX Fuel Storage Bays building, including removal of all residual bay water, successful reduction of radiological hazards in the building and installation of seal between Building 220 and Building 204.
- Removal of legacy structures in degrading condition, including the NRX Ancillary Above Ground Ventilation Stack Duct, plutonium tower annexes, upper wooden structures of the delay tanks and valve house, and upper wooden structure of the Effluent Monitoring Building.

- Implementation of new personal protection equipment (i.e., glove types, respirator types, air filled suits) to ensure that best equipment is available for the type of hazard and work activity.
- Preliminary activities to define transfer state of NRU ancillary buildings.
- Preliminary activities to define permanent safe shutdown state for NRU systems, MPF systems, Tritium Laboratory, and Chemical Engineering laboratories and offices.
- Since the last licence renewal, CNL continued its focus on early reduction of liabilities in the supervised area to remove obsolete buildings, and clear space for S&T and supporting facilities. Decommissioning activities are coordinated with capital project timelines to provide the space required for both permanent new facilities and temporary enabling facilities.

12.3 Status of Regulatory Enforcement Actions

Since the last licence renewal, CNSC staff have conducted compliance inspections of waste management and decommissioning. As of 2017 July, there were no outstanding regulatory enforcement actions.

12.4 Future Plans

The strategic priorities listed below will transform D&WM into a more efficient and effective organization, and provide an enduring program basis and skilled workforce to continue into the future:

- Improve integration of D&WM activities:
 - integrated site master plan involvement and progress monitoring
 - ability to respond to changes in site master plan
 - isolation of decommissioning and demolition activities in the controlled area to reduce impact on S&T mission
- Construct and operate the proposed NSDF (pending separate consideration by the Commission likely in the summer of 2018).
- Establish an integrated waste strategy for all CNL managed waste:
 - data gathering
 - critical evaluation of waste management options
 - identification of future activities
- Align decommissioning and environmental remediation to international best practice:
 - benchmarking of other decommissioning sites
- Accelerate remediation of WMAs and other affected areas:
 - implementation of environmental data management system
 - Repatriate special nuclear material to the country of origin.

Decommissioning activities in the controlled area will continue to focus on redundant NRX reactor buildings and laboratory buildings. The NRU reactor will undergo a post-operational cleanout and will be placed in a storage-with-surveillance state. The decommissioning priorities in the supervised and controlled areas will be coordinated with, and rely on, building turnover from S&T and Site Operations. For periods when multiple buildings are available to decommission, the priorities will be established by the potential to reduce maintenance costs and risk to health, safety, security, and the environment.

12.5 Nuclear Legacy Liabilities

In 2012, the decommissioning of the Pool Test Reactor was formally completed and the space successfully returned to the landlord for reuse. Additionally, the CRL Fire Hall (Building 407) was demolished, with only the foundations now remaining. The CNSC approval to decommission the Plutonium Tower (Building 223) was also received.

Waste solutions are an important part of CNL's revitalization of the CRL site. Stored liquid wastes have to be safely removed, stabilized, and packaged for disposal to meet one of CNL's missions, to restore and protect Canada's environment by removing and responsibly managing AECL's nuclear liabilities.

Retrieval and treatment of stored liquid wastes from Tank 40D began in 2012. For the other tanks of legacy liquids, formulae have been developed for 95% of the liquids and sludges that are to be solidified under the Stored Liquid Waste Cementation project, and bids are being solicited for completion of the design and fabrication of the system itself.

A detailed design was prepared in 2011 for the installation of a cover for WMA C. The cover materials chosen were a geotextile cushion, high-density polyethylene geomembrane liner, geocomposite drainage layer, cover soil, and grass seed with an erosion control mat. The engineered covered components are designed to prevent infiltration of atmospheric water into the waste and hence prevent leachate generation. The engineered covered installation was completed in 2013 November.

Construction, commissioning, and transfer to operations was completed for the Fuel Packaging and Storage facility in WMA B.

In 2013, CNL advanced a number of the key licensing milestones identified in the CNL/CNSC protocol for the Nuclear Legacy Liabilities program. Details on the progress have been provided to CNSC staff via quarterly updates (as committed in the protocol).

In 2015 July, Natural Resources Canada provided the CNSC with an updated financial guarantee letter for the scope formerly covered by the Nuclear Legacy Liability program.

With the transfer of CNL shares to CNEA in 2015 September, the Nuclear Legacy Liability program ended. All responsibilities associated with Canada's legacy and historic liabilities were transferred from National Resources Canada to AECL, but the activities continued under the

Government-Owned Contractor-Operated model. CNL is now interfacing with AECL, instead of Natural Resources Canada, for aspects of nuclear legacy liabilities.

From 2015, the activities under the Nuclear Legacy Liability program were managed through the D&WM portfolio.

Part of CNL's mission is to restore and protect Canada's environment by reducing and effectively managing nuclear legacy liabilities. Building 204 is located just beside the NRX reactor, and is one building within a collection known as the NRX Rod Bay Complex. Building 204 will eventually be safely taken down as part of the site revitalization.

After setting up the required arrangements, the treatment of bay water at the Waste Treatment Centre started on 2017 January 29 and continued until February 02, culminating in the successful processing of around 350 000 L of bay water. Throughout the entire project, there were no incidents or environmental exceedances. Team members demonstrated an exemplary work ethic while safely completing the transfer and treatment of the water.

Through environmental remediation projects, CNL will progressively reduce the risk and liability to AECL through prudent management and cleanup of legacy contaminated and affected sites at the CRL site. Targeted remedial actions have been executed to reduce environmental impacts; additional remedial actions will be taken to further reduce risks to the environment.

13. SECURITY

13.1 Physical Security

The Physical Security program applies to the operation and activities that affect the security in and around CNL sites.

13.1.1 Nuclear Response Force

A full time Nuclear Response Force is in place at CRL meeting the requirements of Nuclear Security Regulations SOR/2000-209 [28], and CNSC REGDOC-2.12.1 (*High Security Sites: Nuclear Response Force*) [29]. Opportunities for improvement were identified through CNSC inspections, performance testing, self-assessments, and peer reviews, and contributed to the continual development of the response force. Performance improvement of the Nuclear Response Force is depicted in (Figure 45).



Figure 45 Opportunities for improvement through performance testing.

13.1.1.1 Nuclear Security Officer Fitness for Duty

Nuclear Security Officer fitness for duty is managed in accordance with CNSC RD-363 [30]. CRL Security Officers continue to meet regulatory requirements relative to physical, medical, and psychological fitness for duty.

13.1.1.2 Drills and Exercises

CNL Security conducts training over the course of each fiscal year. Security drills are part of this training in which Security Officers must respond to simulated design basis threat events in accordance with the Security Tactical Plan. These drills ensure that all Security Officers are well versed in the approved response protocols, and enable areas for improvement to be identified with respect to officer responses. Furthermore, the drills enable full compliance with the Nuclear Security Regulations (Figure 46). Additionally, police of jurisdiction are invited to attend these drills for site and response familiarization on an annual basis in accordance with the Nuclear Security Regulations.

During the course of the current licence, CNL Security has conducted several CNSC audited force-on-force exercises at CRL at regular intervals. These exercises, which included the participation of municipal and provincial police forces as well as on-site emergency services contained challenging scenarios to prove the capabilities of the integrated response teams and command and control structure.



Figure 46 Group conducting security tactical plan training activity.

13.1.2 Past Performance

The Physical Security program has been rated as “satisfactory” in complying with Nuclear Security Regulations SOR/2000-209 in CNSC Type II inspections. Furthermore, internal assessments have shown continued development from CNL’s Nuclear Performance Assurance Review Board, Security program self-assessments, and third-party peer reviews. Significant security improvements have been completed, as listed below, since the 2011 licence renewal, and communicated to CNSC staff. Specific details are not presented due to the nature of being prescribed information.

- Access control measures
- Systematic training
- Physical Security system upgrades

13.1.3 Status of Regulatory Enforcement Actions

Since the last licence renewal, CNSC staff have conducted compliance inspections of the Security program. Specific details are not presented here due to the nature of being prescribed information.

13.1.4 Future Plans

Security improvements will continue in the following areas, during the next licence period:

- Physical and Integrated Security: primary focus on communication, integration, and culture
- system upgrades
- continued participation in force-on-force exercise

Details are communicated to CNSC staff, but are not presented here due to the nature of being prescribed information.

13.2 Cyber Security

The Cyber Security program covers all cyber assets owned and/or operated by CNL. The Cyber Security program is based on NIST SP 800-53 [31] low baseline controls. Controlled area computing is the secondary authorization boundary with additional requirements and controls as defined by CSA N290.7-14 [32].

13.2.1 Past Performance

During the period of 2014 July through 2017 March, CNL conducted unique cyber security assessments, each of which covered a broad spectrum of cyber security at CNL, with specific areas of focus. The findings from these assessments, along with both the NIST 800-53 and CSA N290.7 frameworks, have been used to define the basis of the Cyber Security program.

CNL Information Technology has implemented a number of security improvements at every layer of the infrastructure. Upgrades to CNL's email filtering have been implemented to prevent malware and non-malware threats.

From a governance perspective, the Cyber Security Handbook has been developed which aligns CNL's Cyber Security program with the NIST 800-53 framework and incorporates the requirements for the CSA N290.7-14. The handbook consists of the following control mechanisms:

- access control, identification, and authentication
- architecture governance
- audit and accountability
- training and awareness
- contingency, backup, and recovery
- incident response
- personnel security
- physical and media security, environment protection, and maintenance
- risk management and assessment
- system interconnection
- technical security
- controlled area computing

A full asset inventory of systems that are connected to the CNL business network has been completed which includes systems that are off-line, and peripheral devices.

13.2.2 Future Plans

The Cyber Security program improvements will continue during the next licence period with plans to implement and gather metrics. Additional program specifics have been provided to CNSC staff but it is considered as being prescribed information.

14. SAFEGUARDS AND NON-PROLIFERATION

The Nuclear Materials and Safeguards Management (NM&SM) program applies to all nuclear material and safeguards management activities performed at CNL facilities. It covers procurement, receipt, disposition, transfer, accounting, safeguards management, storage, and inventory management of nuclear material. The primary focus of the program is on facilities that contain fissionable material, and are therefore subject to regulatory safeguards measures and reporting requirements.

Areas at CRL that contain fissionable materials are defined as material balance areas. Documentation is in place for these areas to ensure that nuclear material accountancy and international obligations are met. The material balance area management is responsible for implementing requirements and ensuring adherence to regulations.

The program has developed a near real-time nuclear material accounting system to meet RD-336 (*Accounting and Reporting of Nuclear Material*) [33] requirements. Various policies and procedures, both internal to CNL and external from the CNSC and the IAEA, have imposed rigorous regulations with the requirement that CNL maintains an accurate and up-to-date inventory, and precise location records of all fissionable material on the CRL site to prevent diversion and misuse. The Integrated Nuclear Materials Accounting System currently provides the following:

- Records of all active and historical fissionable material transactions of any type, either within the CNL organization or with external facilities (domestic or foreign).
- A central ledger covering all material balance areas within CNL as well as off-site external facilities that are in possession of fissionable material for which CNL is accountable.
- Real-time inventory data for participating material balance areas (i.e., integrated material balance areas).
- Specialized inventory processing functionality for specialized material balance areas.
- An audit trail of all activities processed through the Integrated Nuclear Materials Accounting System.
- Compliance with regulatory (CNSC and IAEA) nuclear material reporting requirements.

14.1 Past Performance

CNL continues to meet the requirements of this SCA. The NM&SM program continues to meet IAEA expectations and requirements.

Reports are now submitted through a CNSC portal called Nuclear Materials Accountancy Reporting. This new submission method ensures accurate reporting, security verification, and efficient submissions of required reports. The CNSC staff requested that CNL participate in the first trials for this new e-submission portal. This required a dedicated effort on CNL's part to update and implement programming changes to the Integrated Nuclear Materials Accounting System. During a five month period in 2015, CNL submitted the monthly accounting reports to the portal. CNL worked closely with CNSC staff to resolve identified issues in a timely manner in order to fully implement the Nuclear Materials Accountancy Reporting submissions in 2016 January.

CNL staff fully supported IAEA activities at CRL to meet CNSC licensing commitments and international obligations. During the licensing period, there was an increase in IAEA inspector presence due to augmented repatriation activities. Other types of activities were also conducted, as part of the safeguards approach for CNL, including but not limited to, IAEA safeguards seals changes, implementation and/or maintenance of IAEA safeguards monitoring equipment, and technical visits.

14.2 Status of Regulatory Enforcement Actions

Since the last licence renewal, CNSC staff have conducted compliance inspections of the NM&SM program. As of 2017 July, there were no outstanding regulatory enforcement actions.

14.3 Future Plans

CNL will continue working with the IAEA and CNSC to implement improvements to IAEA activities and equipment to find efficiencies for both CNL and the IAEA. With an increased focus on repatriation for the next few years, as well as the closure of Whiteshell Laboratories, Douglas Point and Gentilly-1 waste facilities, IAEA safeguards will have a high profile with respect to CNL activities at CRL and elsewhere.

Implementation of a new IAEA reporting tool, Protocol Reporter 3 (PR3), is an updated software package that is required to report on buildings, activities, and research and development related to the nuclear fuel cycle at CNL.

The NM&SM program intends to have a single nuclear material inventory management system for all facilities at CNL. This will include the development of a new Nuclear Materials Accounting System to replace CNL's current system, with software upgrades to meet CNSC regulatory requirements currently defined in RD-336. This initiative will ensure that the accounting reports are less error prone as well as requiring less manual data entry.

A new heavy-water inventory management software system to replace the existing system is being developed and is planned to be implemented in late 2017.

The IAEA has developed, and will be implementing, a new state-level safeguards approach for all of Canada in the next licence period. The NM&SM program fully intends to adapt to these

upcoming changes and work with both the CNSC and IAEA to ensure that CNL remains in compliance with all regulatory requirements.

15. PACKAGING AND TRANSPORT

The TDG program provides an operational framework for the safe transport of dangerous goods by conforming to all applicable laws, regulations, company policies, and procedures. The program enables an effective, consistent, and comprehensive application of international standards.

The TDG program requirements apply to any activities involving the transportation of dangerous goods to or from any of the CNL sites, by all personnel, and all modes of transport, and ensures that all the regulatory and licence requirements are completed prior to packaging and shipment.

15.1 Past Performance

Since the last licence renewal the TDG program continues to meet regulatory expectations and requirements with a high level of cooperation and communication between CNL and external organizations.

Qualified Transportation Specialists apply the Transport Canada Act, Transportation of Dangerous Goods Regulations, CNSC and IAEA regulations, and implement the TDG program requirements with proficiency and diligence. The shipping documentation generated by Transportation Specialists, as applicable to various types of shipments, is consistent and in compliance with relevant requirements.

In 2014, the Radioactive Material Transportation program was renamed to the TDG program, and was expanded to include all nine classes of dangerous goods. The program is implemented at all CNL sites.

The TDG program has developed and implemented a package program to fully meet the requirements of the Nuclear Safety and Control Act, Packaging and Transport of Nuclear Substances Regulations 2015.

The program has implemented, and continues to maintain compliance in the following areas:

- Training of personnel who customarily prepare shipment of dangerous goods for off-site consignees.
- Preparation of all types of packages containing dangerous goods.
- Shipment and receipt of packages containing dangerous goods from off-site consignors.
- Preparation of the documentation required by the Packaging and Transport of Nuclear Substances Regulations and Transportation of Dangerous Goods Regulations.

15.2 Status of Regulatory Enforcement Actions

Since the last licence renewal, CNSC staff have conducted compliance inspections of the Packaging and Transport and TDG programs. As of 2017 July, there were no outstanding regulatory enforcement actions.

15.3 Future Plans

The new edition of IAEA safety standards (Regulations for the Safe Transport of Radioactive Material) is expected to be released in the near future, and shall be reflected in the TDG program.

The new edition of Transportation of Dangerous Goods Regulations is also expected to be released in the near future, as the result of Transport Canada enhancing compliance and strengthening safety in the transportation of dangerous goods by providing additional details and greater clarity of their requirements. These changes shall also be reflected in the TDG program.

The CNL strategy for D&WM is to safely accelerate decommissioning, environmental remediation, and waste management, thereby resulting in an increase in shipments under the TDG program. This strategy will achieve an overall reduction of risk to members of the public, workers, and the environment. The program staff will continue to work with facilities and projects to increase efficiency and effectiveness of the transportation of dangerous goods activities.

The new edition of the Transportation of Dangerous Goods Regulations will require implementation of a new training system as well as responding to an emergency. The TDG program fully intends to adapt the upcoming changes and work with Transport Canada to ensure that CNL remains in compliance with all regulatory requirements.

16. OTHER MATTERS OF REGULATORY INTEREST

16.1 Indigenous Engagement

CNL continues to engage with local Indigenous communities on activities related to the general operation of the laboratories, environmental, and employment matters. These engagement activities are ongoing and include engagement through the Environmental Stewardship Council. Furthermore, effective 2016 February, engagement activities specific to projects have been augmented through the implementation of requirements per CNSC REGDOC-3.2.2 (*Aboriginal Engagement*) [34].

16.2 Cost Recovery

CRL is in good standing with respect to the provision of CNSC licensing fees, and will continue to provide all necessary fees, as and when required.

16.3 Financial Guarantees

CNL understands the requirement for an acceptable financial guarantee. While ownership of CNL has transferred to the CNEA, AECL retains ownership of the lands, assets, and liabilities associated with CNL's licences. These liabilities have been officially recognized by the Minister of Natural Resources in a letter dated 2015 July 31, as per the CRL licence Condition 16.3 (Financial Guarantee).

16.4 Canadian Nuclear Laboratories Activities Following the Fukushima Event

Following a major earthquake on 2011 March 11, off the coast of Japan, a 15 m tsunami disabled the power supply and cooling of three Fukushima Daiichi reactors, causing a nuclear accident.

The CNSC issued a request pursuant to subsection 12(2) of the General Nuclear Safety and Control Regulations on 2011 March 17, requiring CNL, and other major nuclear facilities in Canada, to review initial lessons learned from the earthquake, and to use this information to re-examine existing safety cases, and report on its plans to mitigate any identified gaps.

CNL issued its formal reply on 2011 March 31, committing to: re-examine defence-in-depth for CNL nuclear facilities; review emergency procedures and equipment for the potential mitigation of beyond design-basis events; verify backup power supplies to its nuclear facilities; specifically evaluate mitigation capabilities of its nuclear facilities for both internal and external flooding; and evaluate the suitability and limitations of equipment required for fire or flood event mitigation.

CNL modified the scope of the existing IIP to address medium-term and long-term implementation of lessons learned from the Fukushima event. This ultimately resulted in the creation of the SAMGs.

Severe accidents in NRU are now determined to fit into two broad categories: the vessel is intact but there is no active heat sink available, or, the reactor vessel or piping is breached with leakage exceeding the capacity of the emergency core cooling system.

The five key response areas are:

- **Mitigate Activity Releases:** protect health of the public and workers; limit the spread of contamination; maintain habitability of critical areas of NRU; and minimize the flow of contamination into the Ottawa River.
- **Inject Coolant into the Reactor Vessel:** remove stored energy and decay heat, delay or prevent vessel failure, and provide a water cover to scrub fission products released from the core debris.
- **Protect Reactor Vessel Boundaries:** remove decay heat, provide cooling that avoids potential for energetic melt-coolant interactions, maintain debris in-core and below the melting point of aluminum, and terminate significant releases of fission products to the environment.

- Remove Heat from Reactor Vessel: minimize production of steam, prevent or mitigate melt coolant interactions, and remove decay heat to prevent further fuel damage.
- Protect the Rod Storage Bays and Fuel Storage Block: prevent overheating of irradiated fuel, provide water cover to minimize radiation levels and scrub fission products released from the core debris, maintain integrity of the storage block and mitigate fission product and tritium releases.

During 2013 April, CNL's Fukushima Response Project was formally launched. The IAEA guidance was applied to develop a philosophy of "repurpose, reuse, and augment" for safety equipment, and this resulted in procedural and physical improvements.

CNL augmented its existing emergency equipment with a fire truck having high-angle rescue capability, road-clearing equipment, mobile diesel generators (Figure 47), fuel storage and transport vehicles, and portable lighting.



Figure 47 Mobile diesel generators (Fukushima Response Project).

Additional emergency operations equipment, supplemental personal protective and radiation monitoring and protection equipment were also procured.

A permanent home for the technical support group was established in a newly-renovated building at CRL. Setup included the installation of communications and computing equipment, and hard copies of information resources such as procedures, manuals, and drawings.

Enhanced training was performed for EOC personnel. Firefighting personnel performed drills for replenishing the NRU qualified emergency water supply from the Ottawa River.

Field testing of the new mobile diesel generators, including load testing, operation of Main Heavy Water Pump 5, and the compressor providing NRU with process and instrument air, was completed.

In 2015, severe accident training was completed for NRU operating personnel (Senior Reactor Shift Engineers, Operators, Officer-in-Charge) and EOC personnel.

Through 2014 and 2015, CNL participated in CANDU Owner's Group workshops to support the development of severe accident management guidance for Canadian nuclear power plants. This included a review of modifications to CNSC regulatory documents.

CNL formally issued severe accident management procedural documents, which included entry criteria and response procedures. The SAMP validation exercises were performed to confirm that staffing levels are sufficient, and that response time for postulated severe accidents is acceptable, and to evaluate operator burdens. Modified reactor shielding plugs were installed in NRU and commissioned. These plugs permit the injection of emergency cooling via building fire water, portable pumps, or a pumper truck.

In 2016, additional SAMP instrumentation was installed in NRU and commissioned. Temperature and pressure readings were integrated into the existing NRU monitoring (Reactor Experimental Data Network) system, with displays to allow reading of these severe accident management entry parameters in the NRU Control Room, Qualified Emergency Response Centre, and locally at the instrument transmitters.

A Criticality Safety Parameter emergency operating procedure was issued for NRU, which provided a symptoms-based response plan for postulated events in which monitoring of fuel cooling may be lost. This is an extension beyond the severe accident management procedures, with the goal of preventing a severe accident.

In the 2016 July 06 record of decision by the Commission regarding CNL's application to renew and amend the Nuclear Research and Test Establishment Operating Licence for CRL, it was noted:

"The Commission assessed the information submitted by CNL and CNSC staff in regard to changes to design documentation, which included lessons learned from the Fukushima Daiichi accident. CNSC staff reported that it had verified CNL's physical design programs through desktop reviews and inspections, and was of the opinion that CNL continued to meet regulatory expectations in this SCA."

16.5 Nuclear Material Repatriation

For over 50 years, the United States has supplied Canada with HEU to fuel research reactors and manufacture targets in order to produce medical isotopes at CRL. The HEU being permanently repatriated to the United States is primarily in the form of used reactor fuel and target residue material generated from the Mo-99 production process. Scrap HEU material from fuel and target fabrication is also returned to the United States.

The United States Department of Energy, National Nuclear Security Administration oversees the Material Management and Minimization program to assist with the return of HEU to the United States. CNL has been participating in the Material Management and Minimization program since 2010 to safely repatriate HEU fuel to the United States for permanent disposition

and therefore eliminating a liability for future generations of Canadians. Previous projects included the successful repatriation of fuel from the Pool Test Reactor (2010) and SLOWPOKE cores in 2012 and 2013. CNL initiated repatriation of NRX and NRU fuel in 2015 and will continue these shipments into 2019. In 2012, CNL initiated plans for the safe and secure repatriation of target residue material. Construction of the process systems to retrieve and transfer target residue material was completed in 2016. Successful commissioning of the processing and support systems was completed in the first quarter of 2017.

16.5.1 Global Threat Reduction Initiative

Canada is a strong supporter of initiatives to enhance nuclear material security and participates in programs such as the Global Partnership Program and the Global Threat Reduction Initiative. As a result of the decision in 2008 to halt the operations of the Dedicated Isotope Facilities located at CRL, CNL was responsible to repatriate the inventory of feed materials to illustrate Canada's commitment to the Global Threat Reduction Initiative. In 2013, CNL successfully executed the MAPLE HEU Target Repatriation project thus reducing Canada's unirradiated HEU inventory in direct support of the Global Threat Reduction Initiative. This repatriation campaign was executed on schedule and without any safety, security, or radiological events to the employees, public or environment, with appropriate oversight by CNSC staff.

16.5.2 Future Plans

During the next licence period, CNL plans to continue safe and secure repatriation activities to assist Canada's commitment in support of the Global Threat Reduction initiative with appropriate approval and oversight by CNSC staff.

16.6 Nuclear Liability Insurance

The CRL site is designated as a nuclear installation under the Nuclear Liability and Compensation Regulations, and is in compliance with all requirements of the Nuclear Liability and Compensation Act 28(1) [35].

CNL has maintained nuclear liability insurance for CRL under the previous Nuclear Liability Act and continues to maintain nuclear liability insurance under the Nuclear Liability and Compensation Act which came into force on 2017 January 01.

16.7 Potassium Iodide Tablets

During 2015, CNL conducted a program for the pre-distribution of KI tablets to permanent residents located within CNL's primary zone. Support centred around distribution activities through the outlining of a schedule, identification of key stakeholders, identification and development of communication products, and delivery of products to support KI pill distribution efforts.

- Two public information sessions were held on 2015 October 26.

- Video presentation was produced and published (in both official languages) and made available on CNL's external website.
- Website (www.cnl.ca) content was produced and posted (including frequently asked questions, fact sheets, videos, etc.).

16.8 Public Information Program and Public Disclosure

The Public Information program is described in a document that covers communication activities that occur between CNL and neighbouring communities, and is prepared in accordance with CNSC RD/GD-99.3 (*Public Information and Disclosure*) [36]. The document was recently revised and reissued in both national languages, and posted to the corporate CNL website.

16.8.1 Promotional Material

CNL uses various promotional materials to reach specific audiences (e.g., neighbouring communities, industry, customers, employment prospects, etc.). All promotional materials are kept up-to-date and are made available to the public through the corporate website, highway billboards, marketing materials, posters, advertisements, recruitment materials, and related products. CNL also utilized Public Service Announcements aired on local radio that run four times daily with an estimated weekly reach of 35 000 listeners, identifying CNL's name and chosen message 1460 times yearly. In 2016, CNL also made material available through social media outlets: Facebook, Twitter, LinkedIn, and YouTube.

16.8.2 Website and Public Disclosure

The corporate website www.cnl.ca informs the public of unique facilities, and nuclear S&T activities, and it is a key part of the Public Information program. It is used as a mechanism to highlight significant activities such as major projects, provide environmental performance reporting, event reporting, attract potential employees, maintain contact with alumni staff, and enable access to various publications and reports.

In accordance with the CRL LCH, Criterion 16.2(5)(h) on Public Information Program and Public Disclosure, CNL makes available, through its corporate website, a list of events reported to CNSC staff; this list is published within 60 days following the end of the preceding quarter. The website also includes an archive of news releases listed in Table 10 and community information bulletins since 2012, listed in Table 11.

Table 10 News Releases (2012 to 2017)

Date	Title
2012 Jan 09	A year in review, AECL accomplishes great things in 2011
2012 Jan 30	AECL is honoured for strong corporate leadership in the Ottawa Valley
2012 Apr 23	Tyne Engineering and AECL celebrate official opening of new Deep River facility
2012 Jun 04	AECL marks 50th anniversary of nuclear power in Canada
2012 Jun 28	AECL hosts FireFit and TopCop
2012 Jul 10	AECL Chalk River Laboratories Opens its Doors to the Public this Summer
2012 Jul 11	AECL Statement on Labour Negotiations
2012 Jul 13	Joint Statement from PIPSC-CRPEG and AECL on Labour Negotiations
2012 Jul 17	FireFit and TopCop Competitions a Resounding Success for the Ottawa Valley
2012 Jul 30	AECL Releases Schedule of Events for 2012 Open House
2012 Aug 13	AECL holds public Open House for the first time in over a decade
2012 Sep 10	AECL receives decision on MAPLE Arbitration
2012 Sep 13	AECL Hosts OCI Suppliers Day at the Chalk River Laboratories
2012 Oct 23	PIPSC-WTEG members vote to ratify tentative agreement
2012 Oct 31	AECL Employees Shatter United Way Fundraising Record
2013 Feb 25	AECL Honoured with Chamber of Commerce Business Excellence Award
2013 Mar 19	AECL Comprehensive Review of its Nuclear Decommissioning and Waste Liability
2013 Aug 20	AECL and Nordion Reach Settlement Agreement
2013 Sep 13	AECL Hosts OCI Suppliers Day and Technology Commercialization Workshop
2013 Nov 13	AECL Employees Surpass their United Way Fundraising Goal
2013 Nov 14	AECL Launches New Website Offering New Look Into Canada's Nuclear Laboratories
2014 Feb 27	Isowater and AECL sign deuterium oxide (heavy water) marketing and collaboration agreement
2014 Oct 30	Launch of Canadian Nuclear Laboratories
2014 Dec 03	CNL employees shatter their United Way fundraising goal
2014 Dec 04	Learn more about nuclear science with CNL and CSTM
2015 May 21	CNL successfully completes major evacuation exercise
2015 Dec 16	CNL employees exceed their United Way fundraising goal
2016 Oct 05	Nuclear laboratories in Canada and the UK sign MOU
2016 Dec 15	CNL employees raise over \$113,000 for Renfrew County Organizations
2017 Apr 13	Canadian Nuclear Laboratories presents the Eyes on the Universe Exhibit
2017 May 09	Canadian Nuclear Laboratories Hosts Industry Day
2017 May 30	Public invited to visit the Chalk River Laboratories on 2017 August 12
2017 Jun 01	CNL seeks input on small modular reactor technology

Table 11 Community Information Bulletins Published (2012 to 2017)

2016	Title
2012 Apr 12	AECL Provides Update on NRU Planned Outage Activities
2012 Apr 18	Loss of a Chalk River Laboratories Colleague
2012 May 16	AECL Provides Update on NRU Planned Outage Activities
2013 Mar 12	AECL Provides Update on NRU Planned Outage Activities
2013 Apr 18	Testing of CRL Site Emergency Signal System
2013 May 16	AECL Provides Update on NRU Planned Outage Activities
2013 May 17	No Incidents Reported at AECL Chalk River Laboratories Following Earthquake
2013 May 17	AECL Chalk River Laboratories Secure Following Earthquake
2013 Aug 22	AECL Provides Information on Heavy Water Event
2013 Nov 19	AECL Reports on Unplanned Interruption to the Canadian Supply of the Medical Isotope Molybdenum-99
2013 Nov 23	Update – Medical Isotope Molybdenum-99 Processing Resumes
2014 Jul 08	AECL provides information about a (non-radioactive) halocarbon release of greater than 100 kg
2014 Aug 12	Building 405 false safety alarm
2014 Dec 01	Contractor incident at Canadian Nuclear Laboratories' Chalk River site
2015 Feb 06	The future of NRU and CNL
2015 Apr 13	CNL provides update on NRU Planned Outage Activities
2015 May 13	CNL completes NRU planned maintenance outage
2015 May 15	Emergency Preparedness Exercise at Canadian Nuclear Laboratories
2015 Jun 26	Canadian National Energy Alliance named as Preferred Bidder to manage CNL
2015 Jul 14	Repatriation project cask receives certification
2016 Jan 21	Training Incident
2016 Apr 27	Rod Bay Event
2016 May 05	ZED-2 Heavy Water Loss
2016 May 13	CNL confirms there are no safety concerns related to low-level radioactive waste mound in Fort McMurray
2016 Jun 10	NRU Electrical Circuit Breaker Testing Event
2016 Jun 16	Building 405 false safety alarm
2016 Jul 29	CNL provides information on a (non-radioactive) halocarbon release of 100 kg
2016 Aug 19	CNL confirms there are no safety concerns related to low-level radioactive waste mound found in Fort McMurray
2016 Sep 11	Loss of a Colleague at Chalk River Laboratories
2016 Dec 12	CNL provides information on a (non-radioactive) halocarbon release of greater than 100 kg
2017 Apr 07	CNL responds to alarm in small utility building
2017 Jul 31	Chalk River Laboratories power outage
2017 Aug 23	Smoke discovered during equipment testing

CNL's contact information is available through the "Contact Us" page. A dedicated interface on the same page permits external visitors to the website to submit a "Request for Information" on a subject of their interest. Data on the website inquiries since 2012 is shown in Table 12.

Table 12 Number of Website Inquiries Through "Contact Us" (2012 to 2016)

2012	2013	2014	2015	2016
262	206	237	163	930

The corporate website is updated regularly and enhanced on a continual basis.

In 2014, in addition to updates to CNL's principal website, a new Nuclear Legacy Liabilities program website was launched. The purpose was to provide up-to-date, program-related activities and offers factsheets, frequently asked questions, program timeline, newsletters, and a program descriptive brochure. As indicated in Section 12.5, the Nuclear Legacy Liabilities program ended in 2015.

16.8.3 Social Media and Internal Broadcasts

In 2016, to further engage the public, in addition to existing LinkedIn, Flickr, and YouTube accounts, CNL activated new Facebook and Twitter accounts.

The 2016 statistics for CNL's social-media accounts are as follows:

- 153 posts on Facebook – 1000 people reached on average per post
- 158 Tweets – 54 360 interactions
- 19 Videos on YouTube – 3672 video views
- 45 posts to LinkedIn

CNL has a combined total of 4392 followers on its social media platforms.

On 2017 September 25, CNL, launched the first 'live' event of myCNL TV, with a broadcast from the President's Office. This technology enables staff from across the company to connect to large events from the comfort of their desktops, and has great potential for future internal events and presentations to staff.

16.8.4 Newsletters

An internal newsletter called "Voyageur" is made available to all CNL employees; it is focused on accomplishments, and nuclear S&T activities. Voyageur is distributed both electronically and in hard copy, and employees are welcome to bring the newsletter home and share it with others. Voyageur is also provided to a limited external audience along with a monthly package of relevant internal news that is issued to CNL alumni, a group of former employees and retirees.

A second, bilingual newsletter, called "CONTACT", is published, mailed to residences, and made available at www.cnl.ca. Approximately 50 000 homes in Renfrew (Ontario) and

Pontiac (Québec) counties receive this newsletter. This publication informs its readers on activities undertaken at CNL and by CNL within the local communities; additionally, electronic versions of CONTACT are available on the corporate website.

16.8.5 Journals

The “CNL Nuclear Review” provides researchers with the opportunity to publish work that showcases innovative and important nuclear S&T in a peer-reviewed publication. Editions are published biannually (June and December), and are available in print and online at www.cnl.ca/anr.

16.8.6 Media Releases

CNL news releases issued through www.cnl.ca are sent directly to local media. In addition, there is regular local media coverage regarding CNL.

16.8.7 Public Engagement and Outreach

CNL shares information with the public through a number of activities including: public information sessions, media releases, corporate website, toll-free line, social media accounts and participation in community events. The employees are CNL’s greatest ambassadors and they are kept informed on the latest developments so that they can share the information with relatives, friends, and neighbours. CNL also regularly engages with the public at a number of local, national, and international events, as listed in Table 13.

Table 13 Engagements and Events (2012 to 2017)

Date	Engagement/Event	Location
2012 Feb 22 to 24	Canadian Nuclear Association Conference	Ottawa, ON
2012 Mar 01	Science Olympics	Pembroke, ON
2012 Mar 07	NRCAN Site Visit	Chalk River, ON
2012 Mar 22	Breakfast Connections Meeting	Pembroke, ON
2012 Mar 22	Science Fair Judging	Petawawa, ON
2012 Mar 31	Renfrew County Regional Science Fair	Petawawa, ON
2012 Apr 20 to 22	Petawawa Showcase	Petawawa, ON
2012 Apr 23	Canadian Nuclear Workers Council Site Tour	Chalk River, ON
2012 Apr 25	U15 Canada’s Research Universities Site Tour	Chalk River, ON
2012 May 07	Canadian Heart and Stroke Foundation Big Bike Ride	Deep River, ON
2012 May 10	Excellence in Manufacturing Site Tour	Chalk River, ON
2012 May 17	Salvation Army Red Shield Breakfast	Pembroke, ON
2012 May 23	Canadian Nuclear Society & Women in Nuclear Annual Joint Speaker Event	Deep River, ON
2012 Jun 10 to 14	Canadian Nuclear Society Annual Conference	Saskatoon, SK
2012 July 06 to 08	TOPCOP/Firefit	Chalk River, ON

Table 13 Engagements and Events (2012 to 2017)

Date	Engagement/Event	Location
2012 Aug 02 to 05	Deep River Summerfest Planetarium Booth	Deep River, ON
2012 Aug 11	Open House	Chalk River, ON
2012 Sep 12	Organization of Canadian Nuclear Industries (OCNI) Supplier's Day	Chalk River, ON
2012 Sep 14	Canada Museum of Science & Technology Site Visit	Chalk River, ON
2012 Oct 12	National Science and Technology Week Guinness Book of World Records Attempt	Chalk River, ON
2012 Oct 16	Science & Technology Week AECL Display	Pembroke, ON
2012 Nov 11	Remembrance Day Ceremonies	Renfrew County, ON
2013 Feb 16	Cool Science Saturday	Ottawa, ON
2013 Feb 27 to Mar 01	Canadian Nuclear Association Conference	Ottawa, ON
2013 Mar 20	Breakfast Connections Meeting	Pembroke, ON
2013 Apr 19 to 21	Petawawa Showcase	Petawawa, ON
2013 May 01	Pembroke Area Clergy Association Civic Leaders Breakfast	Pembroke, ON
2013 May 25	Excellence in Manufacturing Consortium Site Tour	Chalk River, ON
2013 Jun 05 to 08	Skills Canada National Competition	Vancouver, BC
2013 Jun 07	Canadian Cancer Society Relay for Life	Petawawa, ON
2013 Jun 9 to 12	Canadian Nuclear Society Conference	Toronto, ON
2013 Jun 13	400 th Anniversary Event – Ottawa Valley Historical Society	Pembroke, ON
2013 Jun 18	Breakfast at St. Anthony's Catholic School	Chalk River, ON
2013 Jul 27	Old Fort William Cottager's Association (OFWCA) Annual General Meeting	Sheenboro, QC
2013 Aug 27	MRC Pontiac Council Meeting/Presentation	Campbell's Bay, QC
2013 Aug 29	Nuclear Leadership Forum Working Group Meeting	Chalk River, ON
2013 Summer	AECL Environmental Protection Lifestyle Survey	Renfrew County, ON
2013 Sep 13 to 15	Petawawa Showcase	Petawawa, ON
2013 Oct 06	Renfrew County Regional Science & Technology Fair	Petawawa, ON
2013 Oct 18	National Science and Technology Week World Record Science Lesson Event	Deep River, ON
2013 Nov 17	Petawawa Santa Clause Parade	Petawawa, ON
2013 Dec 04	Upper Ottawa Valley Chamber of Commerce Annual General Meeting	Pembroke, ON
2013 Dec 05	Deep River Science Academy Annual General Meeting	Deep River, ON
2014 Feb 11	Ottawa Valley Tourist Association on-site visit	Chalk River, ON
2014 Feb 26 to 28	Canadian Nuclear Association Conference	Ottawa, ON
2014 Mar 21 to 23	Renfrew Home Show	Renfrew, ON
2014 Mar 31	Pandora's Promise Movie Screening	Deep River, ON

Table 13 Engagements and Events (2012 to 2017)

Date	Engagement/Event	Location
2014 Apr 16	Organization of CANDU Industries (OCI) China International Nuclear Industry Exhibition	Beijing, China
2014 Apr 25 to 27	Petawawa Spring Showcase	Petawawa, ON
2014 May 07	Pembroke Area Clergy Association Annual Civil Leader's Breakfast	Pembroke, ON
2014 May 13	OPTIONS Skilled Trades & Career Fair	Pembroke, ON
2014 Jun 28	Algonquins of Pikwàkanagàn Makwa Fest	Golden Lake, ON
2014 Aug 24 to 28	Pacific-Basin Nuclear Conference (Canadian Nuclear Society Annual Conference)	Vancouver, BC
2014 Sep 03 to 06	Renfrew Fair	Renfrew, ON
2014 Sep 21 to 23	Women in Nuclear Annual Conference	Saint John, NB
2014 Nov 03 to 05	SecureTech Conference	Ottawa, ON
2014 Nov 11	Renfrew County Remembrance Day Ceremonies	Renfrew County, ON
2014 Nov 14	Renfrew County Restructuring Community Engagement Meeting	Pembroke, ON
2015 Jan 08	Science and Technology Infrastructure Event Building 137 - Hydrogen Isotopes Technology	Chalk River, ON
2015 Feb 19	Enbridge Public Open House (Natural Gas Pipeline Project)	Chalk River, ON
2015 Feb 24 to 27	Canadian Nuclear Association Conference	Ottawa, ON
2015 Mar 20 to 22	Renfrew Home Show	Renfrew, ON
2015 Apr 17 to 19	Petawawa Spring Showcase	Petawawa, ON
2015 May 14	OPTIONS Skilled Trades & Career Fair	Pembroke, ON
2015 May 27 to 30	Skills Canada National Competition	Saskatoon, SK
2015 Jun 05	Renfrew County Canadian Cancer Society Relay for Life Event	Petawawa, ON
2015 Aug 01	Deep River 70 th Anniversary Celebration	Deep River, ON
2015 Sep 26	Deep River & District Hospital Foundation Strategic Planning Workshop 2015 to 2018	Deep River, ON
2015 Oct 16	Dr. Arthur B. McDonald Nobel Laureate Talk	Deep River, ON
2015 Nov 08 to 10	Women in Nuclear Annual Conference	Ajax, ON
2015 Nov 11	Renfrew County Remembrance Day Ceremonies	Renfrew County, ON
2015 Nov 22	Petawawa Santa Clause Parade	Petawawa, ON
2016 Jan 30	Upper Ottawa Valley Chamber of Commerce Business Awards	Pembroke, ON
2016 Feb 06	Chalk River Winter Carnival	Chalk River, ON
2016 Feb 24 to 26	Canadian Nuclear Association Conference	Ottawa, ON
2016 Mar 06 to 09	Waste Management Symposia	Phoenix, Arizona
2016 Apr 13	CNL All-staff and media - \$800 Million Infrastructure Announcement	Chalk River, ON
2016 Apr 29 to May 01	Petawawa Spring Showcase	Petawawa, ON

Table 13 Engagements and Events (2012 to 2017)

Date	Engagement/Event	Location
2016 May 04	Pembroke Area Clergy Association Annual Civil Leader's Breakfast	Pembroke, ON
2016 May 11	OPTIONS Skilled Trades & Career Fair (The award-winning program has been introducing youth in Renfrew County to skilled trades career opportunities for more than a decade)	Pembroke, ON
2016 May 09 to 11	CNL Advanced Reactor Forum	Ottawa, ON
2016 May 19	Renfrew County Canadian Cancer Society Git'er Done Mud Run Media Day	Foresters Falls, ON
2016 May 28	Renfrew County Canadian Cancer Society Git'er Done Mud Run Event	Foresters Falls, ON
2016 Jun 01	Ottawa Riverkeeper Gala	Ottawa, ON
2016 Jun 03	Renfrew County Canadian Cancer Society Relay for Life Event	Petawawa, ON
2016 Jun 19 to 22	36 th Annual Canadian Nuclear Society Conference	Toronto, ON
2016 Jul 15	World Nuclear University Summer Institute CNL Site Tour	Chalk River, ON
2016 Jul 20	CNL overview meeting with the Métis Nation of Ontario (MNO)	North Bay, ON
2016 Aug 26 to 28	23 rd Métis Nation of Ontario Annual General Assembly	North Bay, ON
2016 Sep 23 to 25	Petawawa Fall Showcase	Petawawa, ON
2016 Oct 19	Building 350 Opening and Media Event	Chalk River, ON
2016 Nov 11	Renfrew County Remembrance Day Ceremonies	Renfrew County, ON
2016 Nov 12	TEDxPembroke	Pembroke, ON
2016 Nov 20	Petawawa Santa Claus Parade	Petawawa, ON
2016 Dec 01	Garrison Petawawa CNL Site Tour	Chalk River, ON
2016 Dec 01	Deep River Christmas Tree Lighting	Deep River, ON
2016 Dec 07	Algonquins of Pikwàkanagàn CNL Site Tour	Chalk River, ON
2017 Jan 25	Renfrew County Council Vision 2026 Presentation	Pembroke, ON
2017 Jan 25	Deep River Town Council Vision 2026 Presentation	Deep River, ON
2017 Jan 27	Ottawa Valley Chamber of Commerce Vision 2026 & Supply Chain Presentation	Pembroke, ON
2017 Jan 31	Eastern Ontario Wardens Caucus (Rural Ontario Municipality Association Annual Conference) Vision 2026 Presentation	Toronto, ON
2017 Feb 08	Prescott Russell County Council Vision 2026 Presentation	Prescott, ON
2017 Feb 14	MRC Pontiac County Council Presentation	Campbell's Bay, QC
2017 Feb 22 to 24	2017 Canadian Nuclear Association Conference	Ottawa, ON
2017 Feb 23	CNL Advertising/Branding Launch Event	Ottawa, ON
2017 Apr 03	Sheenboro Council Vision 2026 Presentation	Sheenboro, QC
2017 Apr 08	Renfrew County Regional Science Fair	Petawawa, ON
2017 Apr 13 to May 16	Eyes on the Universe exhibit - Nobel Prize winner Dr. Arthur McDonald and the Sudbury Neutrino Observatory Laboratory (SNOLab)	Deep River, ON

Table 13 Engagements and Events (2012 to 2017)

Date	Engagement/Event	Location
2017 Apr 28 to 30	Petawawa Spring Showcase	Petawawa, ON
2017 May 08	Industry Consultation Day - CRL Site Revitalization	Pembroke, ON
2017 May 27	Renfrew County Canadian Cancer Society Git'er Done Mud Run Event	Foresters Falls, ON
2017 Jun 09	Renfrew County Canadian Cancer Society Relay for Life Event	Petawawa, ON
2017 Jun 04 to 07	37 th Annual Canadian Nuclear Society Conference	Niagara Falls, ON
2017 Jul 11	MRC Pontiac Mayors & Council Site Visit – NSDF/NPD & SMR presentations	Chalk River, ON
2017 Aug 12	CNL Public Open House	Chalk River, ON
2017 Sep 16	CRL-NRU Friends and Family for NRU 60 th Anniversary	Chalk River, ON

In 2012, CNL celebrated their 60th anniversary. For the first time in over ten years, an Open House was held for the public on 2012 August 11. Over 1750 visitors attended presentations, displays, and demonstrations setup by various CNL departments and programs. Other nuclear and science-related organizations also participated in the Open House with their display booths, including: the Canadian Nuclear Association, CNSC, Canadian Nuclear Society, Canadian Nuclear Workers Council, Women in Nuclear-Canada, and the Deep River Science Academy.

In 2014, Natural Resources Canada, Public Works, and Government Services Canada led host community restructuring engagements that included participation from CNL, local elected officials, community leaders, and business representatives. They were held to ensure that host communities and stakeholders are informed on CNL restructuring; two restructuring engagements occurred for CRL, one in 2014 April and the second in 2014 November.

In 2014, several restructuring milestones were reached. The President and Chief Executive Officer of the company, and Corporate Communications provided updates to local elected officials and host communities on the following occasions:

- Incorporation of “Canadian Nuclear Laboratories”, 2014 May.
- Host Community stakeholders naming update, 2014 October.
- Business update to the Environmental Stewardship Council; stand-up of CNL, 2014 October.
- CONTACT newsletter; first CNL edition, 2014 November.

In 2015, CNL transitioned to a Government-Owned Contractor-Operated management model. The move to this type of model was part of the Government’s commitment to establish a solid foundation for Canada’s nuclear sector and to create and seize new opportunities. With this came a new vision for CNL and CRL. CNL led a number of “Vision 2026” Host Community engagements with the participation from CNL staff, local elected officials, community leaders, and business representatives, as follows:

- Algonquins of Pikwàkanagàn
- Town of Deep River
- Garrison Petawawa
- Professional Engineers of Ontario
- Ottawa Valley Economic Development Summit
- Renfrew County Council
- Renfrew County Elected Officials and Stakeholders

On 2017 August 12 an Open House (Figure 48) was held at the CRL site with in excess of 1700 public visitors. The event was designed from the outset to serve as an opportunity to educate the public with respect to the operation and research work conducted at the CRL site. With 90% of participants indicating that they “have a better understanding of the work done at the laboratories”, this event without question fulfilled its intended purpose.



Figure 48 2017 August CRL open house.

The Open House provided important context on past accomplishments, the transformation of the site and the organization, and the laboratories’ bright future. The support of family and friends in communities both far and near is critical to the ongoing success of the organization. This event allowed visitors to see with their own eyes the difference that CNL makes in the world; and as importantly, clearly demonstrated the interest that others have in the work conducted at CRL.

Following the successful CNL Open House, as part of the NRU 60th anniversary celebration, a “Friends and Family” event was held on 2017 September 16. Around 250 visitors attended the facility with support by 97 NRU employee “ambassadors”. This presented an opportunity for proud NRU employees to show off the facility and their collective achievements. The day was considered a great success and enjoyed by attendees.

16.8.7.1 Education/Science and Technology Communities

CNL continues to build relationships (Figure 49) with schools by offering site visits to local high school science classes. These visits are tailored to the specific needs of the participants and are aligned with their curriculum through three different streams: environment, biology, and physics.



Figure 49 Outreach activities with the public.

In an effort to grow CNL’s Nuclear Education Outreach program, Corporate Communications, the Renfrew County Catholic District School Board, and the Renfrew County District School Board began meetings in 2014 to discuss how to further facilitate the participation of local schools in visits to site, high school co-operative education placements, and opportunities for CNL scientists to speak and present in classroom settings.

School visits include both secondary and post-secondary students with an emphasis placed on engagement with local schools; a list of school visits over the last several years is shown in Table 14. In addition to the information presented in Table 14, a further 10 visits were made to secondary schools, and a further 11 visits to post-secondary schools, between 2012 and 2014.

Table 14 Secondary and Post-Secondary School Tours (2015 to 2017)

Date	School	School Location
2015 Apr 08	Opeongo High School	Cobden, ON
2015 Apr 15	John McCrae Secondary School	Ottawa, ON
2015 May 01	Bishop Smith Catholic High School	Pembroke, ON
2015 May 26	St. Joseph's Catholic High School	Renfrew, ON
2015 Jul 22	Canadian Ecology Centre	Mattawa, ON
2015 Jul 23	OPP Leadership Camp	Renfrew County, ON
2015 Aug 14	University of Montreal - Nuclear Medicine	Montreal, QC
2015 Sep 22	Fellowes High School - Women in Trades	Pembroke, ON
2015 Oct 16	Carleton University - Mechanical Engineering/Aerospace	Ottawa, ON
2015 Oct 21	The Ottawa Hospital - Nuclear Medicine students	Ottawa, ON
2015 Nov 26	Renfrew Collegiate Institute	Renfrew, ON
2015 Dec 07	Bishop Smith Catholic High School	Pembroke, ON
2016 Jan 21	Cégep Heritage College	Gatineau, QC
2016 Jan 28	Ashbury College	Ottawa, ON
2016 Apr 13	Madawaska Valley High School	Barry's Bay, ON
2016 Apr 26	St. Peter's Catholic High School	Ottawa, ON
2016 May 05	École élémentaire et secondaire publique l'Équinoxe	Pembroke, ON
2016 Jul 21	Canadian Ecology Centre	Mattawa, ON
2016 Aug 24	Ministry of Natural Resources and Forestry Environmental Stewardship Rangers	Pembroke, ON
2016 Oct 20	Rotary Club Nepean	Nepean, ON
2016 Nov 16	École Secondaire Catholique Jeanne-Lajoie, Pavillon Secondaire	Pembroke, ON
2016 Nov 24	Algonquin College - Medical Radiation Technology	Ottawa, ON
2016 Dec 09	Algonquin College - Environmental Technician Program	Ottawa, ON
2017 Jan 31	Cégep Heritage College	Gatineau, QC
2017 Mar 07	Ashbury College	Ottawa, ON
2017 Mar 15	Dawson College	Montreal, QC
2017 May 02	Pontiac High School	Shawville, QC
2017 May 09	Royal Military College	Kingston, ON
2017 May 11	Renfrew Collegiate Institute	Renfrew, ON
2017 Jun 08	Ashbury College	Ottawa, ON
2017 Jul 20	Canadian Ecology Centre	Mattawa, ON

Annually, CNL participates in several scientific and technology based engagements that include both the public and students:

- Let's Talk Energy Week
- National Science and Technology Week
- Take Our Kids to Work Day (Figure 50)



Figure 50 Take Our Kids to Work Day

- Renfrew County Regional Science Fair
- Renfrew County School(s) Science Fair judging
- Canada Science and Technology Museum's Cool Science Saturday

In 2014 December, CNL and the Canadian Science & Technology Museum posted the S&T video "Nuclear Fission 101" at their websites and YouTube channels. The results of a joint collaboration, this was the first of a series of seven nuclear S&T videos. The following six videos were posted in 2015:

- Nuclear Energy
- Nuclear Radiation and Decay
- Nuclear Reactor Safety
- Recycling Nuclear Fuels
- Surface Science of Nuclear Reactors
- Nuclear Border Security

16.8.7.2 Environmental Stewardship Council

The Environmental Stewardship Council was established in 2006. The objective of the council is to build working relationships and create opportunities for open dialogue between various stakeholder groups, local communities, and CNL. During regularly scheduled meetings, members are presented with information about CNL, including its environmental practices, and are given the opportunity to ask questions and discuss the presented information. The presentation topics are aligned with the interests of the members, and include updates on CNL business; D&WM; environmental projects and initiatives; and research and development projects underway at CRL. Members are asked to take meeting information back to their respective constituents. These conversations are an integral part in providing CNL with a wide range of viewpoints, and are very important for CNL. The open dialogue, and the sharing of information, ensure that perspectives from our neighbours and closest non-governmental organizations are heard and considered in the planning and execution of the missions of CNL.

The following is a list of the participants in the council:

- Public Dialogue Alternatives (Facilitator⁸)
- City of Pembroke (Member⁹)
- Concerned Citizens of Renfrew County (Member)
- Deep River Horticultural Society (Member)
- Four Seasons Conservancy (Member)
- Garrison Petawawa (Member)
- Métis Nation of Ontario (Member)
- Municipalité Régionale de Comté de Pontiac (MRC) (Member)
- Old Fort William Cottagers' Association (Member)
- Ottawa River Keeper (Member)
- Pembroke and Area Field Naturalists (Member)
- Petawawa Research Forest (Member)
- Renfrew County Council (Member)
- Town of Deep River (Member)
- Town of Laurentian Hills (Member)
- Town of Petawawa (Member)
- Upper Ottawa Valley Chapter of Ducks Unlimited (Member)

⁸ Facilitates all aspects of the Environmental Stewardship Council meetings.

⁹ Local community groups and environmental organizations.

- Algonquins of Pikwàkanagàn (Observer¹⁰)
- AECL (Observer)
- Canadian Nuclear Safety Commission (Observer)

The regular meeting dates of the ESC, three times per year, for the period between 2012 and 2017, are shown below:

- 2012 Mar 07, Jun 22, and Nov 01
- 2013 Mar 25, Jun 27, and Oct 24
- 2014 Mar 27, Jun 26, and Oct 16
- 2015 Apr 01, Jun 17, and Oct 26
- 2016 Mar 24, Jun 16, and Oct 31
- 2017 Mar 23, Jun 22, and Oct 26

16.9 Communications Support for Facility Environmental Assessment Engagements

Corporate Communications provided support to the D&WM program for project environmental assessments during the licence period. These are key projects identified by CNL as part of the overall integrated D&WM approach to safely manage and reduce Canada's legacy liabilities. As stated in the Executive Summary, this CMD relates specifically to matters pertaining to renewal of the Nuclear Research and Test Establishment Operating Licence for the CRL site. Results of engagement for each environmental assessment project will be included in any applicable licence submissions as required.

16.10 Communications Support for Facility Environmental Assessment Aboriginal Engagement

In accordance with CNSC REGDOC-3.2.2, CNL has identified First Nations and Métis communities whose potential or established Aboriginal and/or treaty rights may be adversely affected by a proposed project, and will ensure that any adverse impacts from the activity are avoided, mitigated, or addressed through offset measures. As stated above in Section 16.9, results of engagement for each environmental assessment project will be included in any applicable licence submissions as required.

17. FACILITIES AND RADIOISOTOPE LABORATORIES

The Class I and Class II nuclear facilities located at CRL as well as the radioisotope laboratories, are operated and managed in accordance with the requirements of the compliance verification criteria embedded within the 14 SCAs, as defined by the CRL LCH. With specific regard to training, application of the SAT is mandatory for all personnel in direct operating positions in

¹⁰ Official observers, alternative delegates, and members of the public.

CNL nuclear facilities. The facility authorization documents for operating facilities include staffing and qualification requirements for operation of the facility. Systematic approach to training is applicable in a graded manner based on the importance of the job to nuclear safety.

17.1 Class I Facilities

There are currently 11 Class I nuclear facilities located at the CRL site designated as such and operated in accordance with the Class I Nuclear Facilities Regulations [37]. Relevant information is presented below in Sections 17.1.1 to 17.1.11 on past performance, operation and compliance since the 2011 licence renewal with an indication of future plans for the proposed new licence period.

17.1.1 National Research Universal Reactor

17.1.1.1 Past Performance and Major Modifications or Improvements

During the licence period commencing in 2011 November, the NRU reactor operated safely to support the production of medical isotopes, research in support of the safe and reliable operation of Canada's nuclear power reactors, and basic materials research performed through external agencies. The safety of the reactor, the personnel, and the environment remained the foremost consideration in the management policies.

Physical improvements to NRU over the last few years have been aided through the successful execution of the Isotope Supply Reliability program, IIP, and Voyageur II program. Significant investments have been made in a range of activities, such as: increasing the number of dedicated staff that supports NRU operations; enhancing training programs; improving processes, including procedures and programs that improve equipment reliability; and, a wide range of physical improvements to the structures, systems, and components in the reactor itself.

The NRU organization was a member of WANO between 2011 and 2016, and has been utilizing their assistance in peer reviews, technical support, and access to a global library of operating experience in driving performance improvement and improving the safety and reliability of the reactor. Key performance indicators have been adopted from the WANO Performance Indicator program. Over the years, several NRU employees attended two levels of the leadership development training courses (First Line Leaders Training and Next Line Leaders Training) offered by WANO, based on their levels of responsibility within the organization. The NRU organization completed its full WANO membership at the end of 2016. CNL continues to review operating experience provided by WANO through the CANDU Owners Group.

Throughout the current licence period, the performance of the emergency management and fire response has been improved primarily due to the new Fire Alarm and Detection System. The reactor emergency procedures have been updated to better enable dealing with emergency conditions (e.g., fire, flood, etc.). Emergency operating procedures have also been created or revised to address the operational considerations when faced with conditions challenging the

safety of operations (e.g., loss-of-coolant accident, loss of primary flow, etc.). These procedures provide NRU Operations with a systematic protocol for responding to a specific event.

The implementation plan status for the NRU fire hazards analysis was 95% complete, as of 2017 July, with 64 of 67 recommendations completed or dispositioned. The last three outstanding items are scheduled to be completed by 2017 November 30.

The Loops Project Team has completed the return to service of U-2 loop, performing maintenance on the loop and modifying the Loops Emergency Cooling System. Construction of the modified Loops Emergency Cooling System was completed in 2016 August. The U-2 experimental loop was successfully returned to service in 2016 September for the purposes of CANDU fuel testing.

17.1.1.2 Emergency Operating Procedures

Key EmP program and EOC procedures were revised to integrate the SAMP into CNL emergency response procedures. The revisions integrated the technical support group into the EOC organization, identified the roles and responsibilities and authorized the use of SAMGs and supporting documentation to manage a severe accident in NRU. Integration of the SAMP into the emergency procedure enabled the use of existing emergency procedure processes to maintain SAMP elements in the future (e.g., ongoing training requirements, drills and exercises).

A symptoms-based severe accident management entry emergency operating procedure was developed to monitor the severe accident management entry criteria parameters that were developed in the NRU severe accident management guidance technical basis document. Severe accident management Control Room guides were also developed to provide appropriate guidance for NRU Operations in severe accident management. Instructions were also developed to facilitate the implementation of severe accident management mitigation strategies identified in the SAMGs by providing guidance on the use of equipment.

17.1.1.3 Severe Accident Management

Severe Accident Management Guidelines and supporting documentation that were prepared in the definition phase were given a detailed technical review by a third party and CNL subject matter experts. The guidelines served as the basis for development of training materials and validation exercise plans.

All findings and recommendations from the CNSC staff assessment of the NRU SAMP implementation were addressed by CNL. Notification of their successful resolution was provided to CNSC staff in 2016 March and subsequently accepted in 2016 June.

17.1.1.4 Severe Accident Management Training

The CNL SAT basis was used in training program design, development, and delivery. Training plans were developed for CNL/NRU positions specific to roles and responsibilities identified to support SAMP. Training was developed for all NRU Operations, Technical Safety Group, and EOC personnel that would be involved in a response to a severe accident in NRU.

All of the training that has been delivered to date, including individual records of training completion, is documented in the CNL Learning Management System.

17.1.1.5 Severe Accident Management Validation

In accordance with regulatory guidance and best international practices, CNL adopted a structured and documented approach to validation during SAMP implementation, which was documented in the NRU SAMP validation plan. The objective of the validation plan was to confirm that individual component parts of the SAMP would work as intended. Accordingly, the plan identified specific validation activities that were necessary to confirm that the SAMP would satisfy requirements. The validation activities culminated with the successful execution of a comprehensive SAMP validation exercise on 2015 October 15.

The responsibility for overseeing the ongoing maintenance and oversight of the SAMP was transferred from the specially formed Fukushima Implementation project to the CNL EmP program.

17.1.1.6 Installation of NRU Modifications

Physical modifications made to the CRL site to enable full implementation of the SAMP in NRU included the installation of instrumentation to monitor symptoms-based severe accident management entry criteria parameters. For example, fabrication of equipment was completed to facilitate the direct injection of water into the reactor core and connections to enable the supply of power to the Class III buss via portable diesel generators (i.e., Fukushima diesels) during periods of extended loss of power.

17.1.1.7 Site Equipment and Modifications

Further to emergency mitigation equipment and other equipment procured during the project, additional improvements to the operation of the CRL EOC and to CNL's ability to respond to beyond design basis accidents were completed as part of the implementation phase.

The renovations and emergency mitigation equipment have been turned over to the EmP program providing emergency response services.

17.1.1.8 NRU Fitness for Service

In 2017 April, CNSC staff presented the NRU fitness-for-service update at a CNSC Commission public meeting, where the Commission accepted the CNSC staff recommendation of a

“satisfactory” rating for NRU fitness for service. This achievement is the outcome of a significant effort in programmatic and hardware upgrades by CNL staff, principally through the IIP GIG-1 hardware updates. CNL was able to meet the Fitness for Service SCA criteria, enabling CNSC staff to upgrade CNL’s performance rating to “satisfactory”. Refurbishment of power systems was the final element to receive a “satisfactory” rating.

In summary:

- NRU’s Mean Time Between Trips and unplanned shutdowns continued to increase since 2012 from 173 to 565 hours.
- NRU operated 230 planned days last 2016/2017 fiscal period, which is very high for a research reactor; equipment reliability and fitness for service are key enablers that support the 60 year old research reactor.

More information is presented in the Fitness for Service SCA (see Section 7).

17.1.1.9 Integrated Implementation Program

The IIP is the improvement plan resulting from the Integrated Safety Review of NRU, as described in the global assessment report. The report concluded that “NRU can continue to operate safely, with acceptable risk to the public, workers and the environment, contingent on timely implementation of the high priority, safety-related activities in the IIP.” The first phase of the IIP was completed successfully in 2016 October.

The final progress report for Phase 1 IIP, report demonstrates the completion of the Phase 1 scope of work. The Phase 1 activities that were moved by approved change control requests to Phase 2 of the IIP, have no significant adverse effect on safety, either individually, or from a cumulative effect. Overall progress supports ongoing confidence in the safety of NRU to its end of operation in 2018 March.

The IIP is organized into six GIGs, as follows:

- Current Plant Condition and Plant Life Management
- Managed System and Organization Effectiveness
- Safe Operating Envelope and Safety Analysis
- Training and Nuclear Programs
- Engineering and Design Changes Related to Modern Standards
- Lessons Learned from Fukushima

The IIP identifies a set of high priority improvement activities for senior CNL management oversight. These activities are deemed particularly important to ensure the ongoing safety of NRU. Overall, all 42 Phase 1 high priority improvement activities due prior to 2016 October 31 have been closed.

17.1.1.10 Status of Regulatory Enforcement Actions

Since the last licence renewal, CNSC staff have conducted compliance inspections of the facility. Four Action Notices were open as of the end of 2017 July; one proposed closed (SCA – Radiation Protection), and three in progress (one in SCA – Operating Performance and two in SCA – Human Performance Management). One of the Action Notices for Human Performance Management was closed in 2017 August.

17.1.1.11 Staffing and Certification

CNL will continue to ensure that persons appointed to the positions of Senior Reactor Shift Engineer and NRU Health Physicist hold all required certifications, until these are no longer applicable.

17.1.1.12 Resourcing

Following the announcement of the planned NRU shutdown, CNL implemented a resourcing strategy of “Retain, Retrain, and Redeploy”. CNL staff required for the safe continued operation of NRU were issued retention offer letters in 2016 September. Staff received offers for financial compensation in return of their agreement to continue their employment in the facility. This will enable the continued safe operation of the reactor throughout its remaining mission time.

As part of the retraining initiative, CNL extended an offer to employees to take up opportunities for requalification, and to apply for tuition reimbursement. Other staff are participating in group retraining that aligns their qualifications with future opportunities at CRL.

As part of the redeployment, staff are encouraged to apply for future employment opportunities within CNL. Staff may be selected as the successful incumbent for a posted position and have the position remain available until their release from their duties within NRU.

17.1.1.13 Shutdown Plans for the Next Licence Period

The Government of Canada has directed CNL as follows:

- Operate the NRU reactor until 2018 March 31.
- Permanently cease operation of NRU and Mo-99 stand-by capability on 2018 March 31.

During the proposed period of the next operating licence (2018 to 2028), the NRU reactor facility will transition from regular production operation to a state suitable for storage with surveillance, and will be formally transferred to CNL Facilities Decommissioning organization.

Storage with surveillance is a planned stage in a decommissioning program during which the remaining contaminated materials, equipment, and associated buildings are placed under controlled surveillance for a specified period of time. Regulatory oversight by the CNSC remains in effect during such a period.

The rod bays will continue to operate as a separate entity. A new safety case and authorization as a stand-alone facility will support its continued safe operation by the NRU Operations organization or a future qualified owner. These operations will include repatriation activities and spent fuel shipments. In addition, rod bays staff will be required to empty all materials from the bays and support waste volume reduction activities.

The NRU Permanent Safe Shutdown project also includes the turnover of all NRU ancillary facilities to Facilities Decommissioning. In preparation for the NRU closure, CNL is developing a detailed permanent shutdown plan to ensure a safe, orderly, compliant, and cost-efficient transition to a storage-with-surveillance state and turnover to the Facilities Decommissioning organization in 2021. This will include the transition of all ancillary facilities to a safe shutdown state where operational wastes are removed and systems are shut down. The turnover of ancillary buildings to Facilities Decommissioning will be through site transition. Once Facilities Decommissioning takes ownership, decommissioning of the facility and buildings will commence.

NRU will be transitioned to a storage with surveillance condition that requires minimal monitoring activities and entails minimal maintenance in the long term. Major stages to achieve storage with surveillance are summarized below:

- Stage 0: the current operating period prior to NRU shutdown, fiscal period 2017/2018. Systems currently not operating and no longer required can be shut down.
- Stage 1: commences on 2018 March 31 after the last shutdown of the NRU reactor. During this stage, the reactor vessel will be defueled. The unloading of fuel from the loops will be considered in the core unload plan. Any systems not required to support the reactor in a fuelled shutdown state will be shut down. Stage 1 will begin under all existing requirements for operating NRU including: certified staff, and limiting conditions for operation from the facility authorization. Mid-way through Stage 1, a revision to the facility authorization will be required in order to set limiting conditions for operation which would allow to complete defueling.
- Stage 2: this is the period after all fuel assemblies have been removed from the reactor core and have been stored in the rod bays; the cobalt absorber assemblies are removed, and any system not required to support the reactor in a defueled shutdown state will be shut down. Heavy water will remain in the core during this stage.
- Stage 3: begins after all assemblies requiring cooling or shielding have been removed from the reactor core and have been stored in the rod bays. In this stage, core cooling systems are no longer required and the heavy-water moderator will be drained. Additionally, the purification circuit and back-up electrical power systems are shut down. After the core is defueled and dewatered, a significant revision to the facility authorization will be required in order to remove the majority of the limiting conditions for operation and to permit the final shutdown and dismantling of the reactor safety systems.

- Stage 4: in this stage, the reactor heavy-water systems and remaining systems are shut down after all core assemblies have been removed and the heavy-water moderator has been drained from the core.
- Stage 5: all major systems are down and systems are dismantled for the removal of operational wastes and hazards, followed by ensuring that the facility is in compliance with the requirements of storage with surveillance, obtaining regulatory approvals, and turning the responsibility for initiating storage with surveillance over to D&WM, Facilities Decommissioning.

17.1.2 Nuclear Fuel Fabrication Facility (Buildings 405 and 429A/B)

Although physically apart on the CRL site, there are two separate buildings with the name of Nuclear Fuel Fabrication Facility; Buildings 405 and Building 429A/B.

Building 405 has been in operation since 1993. The primary purpose was to produce low enriched uranium driver fuel replacing the HEU fuels that were previously in use. The final processing steps for Mo-99 targets (machining, welding and x-ray) were also performed in Building 405.

Building 429 A/B has been in operation since 1948, first as an active machine shop and then as a fuel production plant. For many years these two buildings were used for the production of HEU products (driver fuel and Mo-99 targets). After 1982, Building 429B was used to cast HEU-Al billets and Building 429A was used to manufacture Mo-99 targets and for the assembly of low enriched driver fuels (Figure 51).



Figure 51 Nuclear Fuel Fabrication Facility

17.1.2.1 Past Performance and Major Modifications or Improvements

Since the 2011 licence renewal, NFFF was operated primarily for NRU driver fuel and Mo-99 target fabrication, but also performed fabrication trials of various experimental fuel types. The fuel fabrication activities were conducted in two of the facility buildings, Buildings 405 and 429.

Building 405 was used to perform the following fuel fabrication steps:

1. NRU driver fuel: raw materials receiving, melting and casting, heat treatment, powder processing, fuel meat forming, drawing and machining, fuel meat washing and drying, cladding extrusion with end seals, fuel element seal weld, fuel rod assembly, and quality control inspections (including uranium distribution, cladding integrity, and weld quality).
2. Mo-99 targets: target fuel meat drawing, cladding extrusion, end seal welding, and quality control inspections (including uranium distribution, cladding integrity, and weld quality).

Building 429 was used to perform the following fuel fabrication steps:

1. NRU driver fuel: fuel meat drawing and machining, element seal welding, fuel rod assembly, and quality control inspections.
2. Mo-99 targets: raw materials receiving, melting and casting, target fuel meat forming and drawing, target machining.

A project to consolidate the NRU driver fuel and partial Mo-99 target fabrication activities from Building 429 into Building 405 was completed in 2015. Since 2016 November, Building 429 has remained in a standby status for Mo-99 target fabrication, and will be in the future decommissioning plans of CNL.

Building 405 was also used to fabricate various experimental fuel elements for irradiation tests in the NRU reactor, such as uranium-molybdenum dispersion fuel based on low enriched uranium, plate-type uranium-silicon and uranium-aluminum dispersion fuel.

In 2014, the Nuclear Fuel Fabrication Facility started to consolidate the fabrication activities of NRU driver fuel from Building 429 into Building 405, and by the end of 2014, a number of operations including: fuel meat machining, element seal welding, and fuel rod assembly have been relocated to Building 405. In 2015, target machining for Mo-99 was also relocated from Building 429 to Building 405.

In 2017, the Criticality Accident Alarm System in Building 405 was modified and commissioned. The new Criticality Accident Alarm System significantly improved the reliability of the system and lowered the probability of false alarms by upgrading the voting logic from "1-out-of-2" to "2-out-of-3" voting scheme. The upgrade also minimized the chance of false activation of the site-wide stay-in alarm, which according to the CRL current emergency preparedness procedure is activated when a criticality alarm is present.

Since late 2016, a few new pieces of equipment, including a rolling mill, preheat oven, sheet metal shears, metallographic equipment, etc., have been installed in Building 405 to support the ongoing business, and research and development projects.

17.1.2.2 Status of Regulatory Enforcement Actions

Since the last licence renewal, CNSC staff have conducted compliance inspections of the facility. As of 2017 July, there were no outstanding regulatory enforcement actions.

17.1.2.3 Future Plans

During next licence period the Nuclear Fuel Fabrication Facility will discontinue the fabrication of driver fuel and Mo-99 targets for NRU after NRU's permanent shutdown in 2018 March.

In accordance with the CNL ten-year strategic plan the facility will maintain and upgrade its capabilities in nuclear fuel manufacturing. The Nuclear Fuel Fabrication Facility will build on its current knowledge and expertise in fuel fabrication, characterization and performance of materials, and on new expertise in advanced manufacturing methods, such as additive manufacturing.

The existing fuel fabrication expertise and capabilities will be augmented through partnerships with other fuel manufacturers and international collaborations, developed to address the need to irradiate and examine any prototype fuel.

17.1.3 Recycle Fuel Fabrication Laboratories

The Recycle Fuel Fabrication Laboratories nuclear facility was first operated in 1975 for the purpose of fabricating experimental quantities of alpha-active ceramic fuels, typically comprising uranium-plutonium, thorium-plutonium, thorium-U-233 or thorium-U-235. The facility consists of several laboratories with the main laboratory housing three interconnected lines of negative-pressure ventilated gloveboxes and fumehoods to enable fabrication of sintered pellets of mixed-oxide fuel, which are then clad and sealed into CANDU-type fuel elements. Elements may then be assembled and welded together as fuel bundles by the attachment of end-plates. Numerous experimental regimes of fuel production have been performed in the facility including the Advanced CANDU Reactor mixed oxide campaign in 2008/2009, in which 41 bundles were fabricated; the Parallex campaign in 2001, in which 20 mixed oxide elements were fabricated; and (Th, Pu)O₂ fabrication experiments in 2013/2014, in which small batches of fuel pellets were produced to study the effect of processing parameters.

17.1.3.1 Past Performance and Major Modifications or Improvements

Since the 2011 licence renewal, the Recycle Fuel Fabrication Laboratories was used primarily for experimental purposes.

A series of (Th, Pu)O₂ fuel fabrication studies were conducted to determine the effects of processing parameters on the microstructure of the fuel. A preliminary study to investigate techniques for the separation of americium from plutonium feedstocks was conducted. The decay of Pu-241 with time results in increased amounts of americium, which emits relatively

high gamma fields, causing a radiation hazard. This project was conducted to investigate potential methods to remove built-up americium and reduce doses to fuel fabrication workers.

Another ongoing project at the facility is the development of Th-229 generator for the production, through natural decay, of Ac-225 and Bi-213. Alpha radiotherapy using Ac-225 and its daughter Bi-213, is a new promising treatment for many forms of cancer and micro-metastatic disease. Clinical trials have demonstrated the effectiveness of the alpha emitter Bi-213 in killing cancer cells. One of the major limitations for this new therapy is insufficient supply of Ac-225 and Bi-213 isotopes to support the current world research and therapeutic needs. CNL has in its possession a small stockpile of U-233 which decays by alpha emission to generate trace amounts of Th-229. Work in the Recycle Fuel Fabrication Laboratories (Figure 52) has consisted of developing a method for the dissolution of U-233, and methods for the initial separation of Th-229.



Figure 52 Recycle Fuel Fabrication Laboratory

A plutonium repackaging campaign for the Nuclear Materials Management branch was conducted in 2011. The goal of this project was to repack and consolidate materials containing plutonium and thus optimize the use of the available storage space to ensure the ongoing safe storage of material.

Under the supervision of the IAEA, packages were received, opened, and contents verified at the facility.

The Recycle Fuel Fabrication Laboratories implemented a glovebox glove change program in 2011, limiting the service life of gloves to seven years. Large bag-in/out ports were installed in two gloveboxes in 2011 and the large bag-in/out on another glovebox was reopened in 2013, allowing for the removal of larger waste items and the replacement of larger pieces of equipment. Sintering Furnace 2 was refurbished in 2013 including the replacement of heat

shields and heating elements. Halon cylinders were refurbished in 2014. A new waste assay system was installed in 2015, improving the characterization of the waste leaving the facility.

17.1.3.2 Status of Regulatory Enforcement Actions

Since the last licence renewal, CNSC staff have conducted compliance inspections of the facility. As of 2017 July, there were no outstanding regulatory enforcement actions.

17.1.3.3 Future Plans

The facility remains fully operational and available for mixed oxide fuel fabrication work, actinide chemistry experiments, and for supporting the Nuclear Materials branch in repackaging and verification activities under the IAEA.

Experiments towards the development of a Th-229 generator will continue into the next licence period.

17.1.4 Zero Energy Deuterium-2 Reactor

The Zero Energy Deuterium-2 (ZED-2) reactor was based on the design of Canada's first research reactor, the Zero Energy Experimental Pile reactor. It was used in reactor physics research and was initially built to test the fuel arrangement of Canada's first nuclear power plant - the NPD reactor. The ZED-2 reactor first achieved criticality in 1960 September, and therefore 2017 marks the 57th anniversary for this research facility reactor.

The reactor is a tank type, low-power research reactor, moderated by heavy water (Figure 53). The tank (the calandria) is made of aluminum and is surrounded by a graphite reflector and concrete shielding. The fuel assemblies are suspended in the calandria from steel beams, which allows the fuel to be arranged in practically any desired configuration.



Figure 53 ZED-2 reactor.

17.1.4.1 Past Performance and Major Modifications or Improvements

Since the 2011 licence renewal, the ZED-2 reactor continues to be used predominantly for experimental purposes. Series of criticality measurements were conducted using a core containing mixed-oxide and thoria fuel under an S&T project. The data was used for future bias and sensitivity analysis, reactor physics code validation, and benchmarking.

Along with the criticality measurements under another project, a series of reactor-kinetics measurements were conducted with the goal to observe the time-dependent neutron flux during reactor transients, in order to study the kinetics parameters applicable to the core.

Since 2011, the “ZED-2 Reactor Safety and Instrumentation School” has been held annually to fulfill the CNL mandate to attract, develop, and retain highly qualified personnel in the field of nuclear S&T. During the school sessions, the students enjoy the unique opportunity to observe the ZED-2 reactor approaching and achieving criticality, to examine the behaviour of an experimental in-core reactivity oscillator, and to be exposed to firsthand knowledge in reactor physics, radiation detection, and nuclear instrumentation.

The ZED-2 facility and the associated laboratory, was also used for commercial purposes, such as calibration of neutronic equipment, in particular, ion and fission chambers and self-powered flux detectors.

The facility is a nuclear criticality controlled area and the limits and restrictions on fuel handling and storage activities are contained in the ZED-2 criticality safety document that was updated in 2015 December.

CNL reported the discovery of a loss of heavy water to CNSC staff on 2016 April 26. With respect to this event CNL confirms that there was no threat to workers, the public, the environment, or nuclear safety. On 2016 May 05, CNL issued a bulletin concerning the shortfall of heavy water, in accordance with the ongoing commitment to provide public information on important events. Based on the initial details of the event, it had been estimated that approximately 300 kg heavy water was lost. During subsequent investigation, and after recovery activities in 2016 April and May, the actual loss was determined to be 160 kg. The heavy water used in ZED-2 does not contain fission products and has a minimal tritium content.

The ZED-2 reactor replaced the dump valve electronics, and the trip relays of the safety system in 2013. New dump valve electromagnets were installed in 2014. A passive data acquisition system was installed in 2015 to capture all the signals from the safety system, and to provide multi-channel, high resolution, sequential data for post-event analysis. The two recorders at the console were also replaced as part of the data acquisition system. The safety-system auxiliary relays were replaced in 2015, as well as some dump valve mechanical accessories. The comparator in the safety system was overhauled in 2016 January, new fuel storage cabinets were installed and anchored in 2016, and the timers of the safety system were replaced in 2017.

17.1.4.2 Status of Regulatory Enforcement Actions

Since the last licence renewal, CNSC staff have conducted compliance inspections of the facility. As of 2017 July, there were no outstanding regulatory enforcement actions.

17.1.4.3 Future Plans

During the next licence period, ZED-2 will continue to serve as a facility for lattice physics measurements and for calibration of neutronic equipment. The lattice physics measurements will cover a broad range of applications, including:

- Assessment of the reactivity of a given lattice type and pitch (i.e., moderator-to-fuel ratio).
- Macroscopic flux distribution within a lattice, and fine structure flux measurements within fuel bundles and even fuel pins.
- Assessment of the reactivity change associated with varying core parameters, including but not limited to coolant density, moderator purity, moderator poison, and coolant temperature.
- Measurement of a variety of fuel types and bundle types, including natural uranium, lightly enriched uranium, and mixed oxides of uranium, plutonium, and thorium.
- Development, characterization, and calibration of in-core and ex-core flux detectors for use in power reactors. The clean and extremely low activity moderator means that neutronic equipment calibrated in the reactor can be returned to the customer within a day of irradiation.
- Conducting static and transient benchmark experiments of reactivity and kinetic parameters for internal and external users to verify and validate reactor physics codes and nuclear data.

17.1.5 Universal Cells

The Universal Cells facility performs post-irradiation examination of irradiated fuels and fuel channel materials as well as cobalt processing. A variety of operations on irradiated fuel is conducted including receipt of CANDU fuel from stations, visual examination, fuel bundle disassembly, and gamma scanning (Figure 54). A variety of operations on fuel channel components including size reduction, visual examination, rough machining, hydriding of samples, homogenization of samples, and burst testing are all within the suite of activities performed.



Figure 54 Universal Cells fuel scanner.

17.1.5.1 Past Performance and Major Modifications or Improvements

The Universal Cells facility continues to be used primarily for post-irradiation examination support for operating CANDU reactors in Canada and abroad, examination of experimental fuel bundles, and Co-60 isotope production. The facility is also used to safely package spent NRU and Waste Management resin for transfer to the WMA for storage, SLOWPOKE fuel repackaging and repatriation, and emplacement of decayed Co-60 and Cs-137 sources.

The facility is a nuclear criticality controlled area and the limitations and the restrictions of fuel handling and storage activities are described in the Universal Cells criticality safety document which was updated in 2016.

Universal Cells replaced the obsolete fumehoods to meet modern standards in 2015 January, and installed an emergency closer on the rear shielding door of Universal Cell 1 in 2016 May. The facility is in the process of repairing the inner shielding doors of Cell 1 and Cell 2 with two of the five repairs completed. A new apparatus was developed to puncture fuel and collect the fission gas to analyze two different experimental fuels that were irradiated in NRU. The new equipment is undergoing verification and in 2017 September passed active testing. When fully operational, the apparatus will also be used to collect fission gas from CANDU fuel for analysis. The upgraded and modernized facility is an enhancement in both reliability and safety. Application of CNL's Engineering Change Control process was utilized for these various modifications, and CNSC staff were informed as required.

17.1.5.2 Status of Regulatory Enforcement Actions

Since the last licence renewal, CNSC staff have conducted compliance inspections of the facility. One Action Notice was open as of the end of 2017 July and is in progress.

17.1.5.3 Future Plans

Universal Cells plans to complete the repairs to the Cell 1 and Cell 2 transfer doors, install the fission gas puncture apparatus, and continue operations on the approved activities described in Section 17.1.5.

17.1.6 Molybdenum-99 Production Facility

The main purpose of the MPF is the production of medical isotopes Mo-99 and Xe-133. The production process is based on chemical separation of the isotopes from HEU targets irradiated in the NRU reactor. The facility uses specialized cells and equipment, as the irradiated HEU targets are highly radioactive and can be handled safely only with the help of heavy biological shielding and remote operation methods (Figure 55).



Figure 55 Molybdenum-99 Production Facility

Until 2016 October 31 medical isotopes were in regular production at the MPF. Currently, the facility is in a standby state, and production can be resumed should the need arises. The standby state will be maintained until the end of the NRU reactor mission.

17.1.6.1 Past Performance and Major Modifications or Improvements

The facility performs the following licensed activities:

- Production of the medical isotopes Mo-99 and Xe-133.
- Solidification of target residue material arising from the production of medical isotopes.
- Storage of target residue material generated from historical medical isotope production.
- Removal of target residue material from the storage tank and repatriation to the United States.

During the licence period the following major activities were completed:

- In 2011 May, the active ventilation control loop was upgraded to correct an impairment and restore automatic control of the balancing damper.
- Between 2011 June and October the heat detectors for the active ventilation ducts and the Mo-99 Cell were replaced to improve the reliability of the fire suppression system.
- In 2012 May, a new uninterruptible power supply was installed to improve the reliability of the instrumentation system monitoring the FISST in the event of a power outage.
- In 2012 June, MPF began using predictive maintenance techniques to improve the reliability of facility equipment.
- In 2012 November, a new radiation monitoring system was installed in the building replacing the obsolete system that had previously been installed.
- In 2014 October, construction began for the Target Residue Material Repatriation project. Active commissioning of the Target Residue Material Repatriation equipment began in 2017 March.
- In 2014 November, a new level monitoring system for the Mo-99 cell washdown tank was installed replacing an older alarm that had failed.
- During 2015, a number of improvements were made in MPF to address fire hazard assessment issues identified in the facility.

The MPF completed a condition assessment of the active ventilation system. From this assessment, a number of initiatives were undertaken to improve the reliability and performance of the active ventilation system.

The facility implemented a number of improvements to the solidification process for target residue material, to reduce the amount of contamination on the surface of the cans. These changes had positive environmental and safety outcomes, such as fewer personnel contaminations, lower contamination in MPF, and reduced contamination spread to ground in the WMAs.

As of 2016 October 31, MPF stopped the production of Xe-133 completely. The Xe-133 equipment was removed from the facility under the MPF Safe Shutdown project as a hazard reduction initiative.

Also as of 2016 October 31, MPF stopped the routine production of Mo-99 and entered a standby period where the facility remains poised to produce Mo-99 if requested to do so by AECL. The standby period ends on 2018 March 31 when NRU completes its mission and is shut down, at which time no further Mo-99 will be produced in MPF.

17.1.6.2 Status of Regulatory Enforcement Actions

Since the last licence renewal, CNSC staff have conducted compliance inspections of the facility. As of 2017 July, there were no outstanding regulatory enforcement actions.

17.1.6.3 Future Plans

The MPF plans to perform the following licensed activities during the next licence period:

- Storage of target residue material generated from historical medical isotope production.
- Removal of target residue material from the storage tank and the repatriation of the material to the United States.
- Completion of hazard reduction initiatives within the facility as part of the MPF Facility Safe Shutdown project.
- Support of other CNL missions as requested, such as repurposing the facility to support other medical isotope production.

17.1.7 Tritium Laboratory

The Tritium Laboratory supports research and development programs and commercial activities associated with tritium technology. These programs are carried out to support CNL's technology needs, to dispense tritium for sale, and to perform commercial work associated with the application of Canadian tritium technology (e.g., tritium gas standards and gas chromatograph columns). The activities in the facility are largely experimental in nature, and are diverse in terms of their complexity, tritium inventory, duration, and requirements. The laboratory is a Class A radioisotope laboratory as well as being a Class 1B nuclear facility.

17.1.7.1 Past Performance and Major Modifications or Improvements

Since the 2011 licence renewal, the facility continued to:

- Operate the facility in compliance with the CRL site licence.
- Support S&T projects associated with the development of tritium and fusion-related technologies by providing the required infrastructure and tritium handling capabilities. The S&T program currently includes: development of direct and indirect tritium batteries for low-power devices, Proton Exchange Membrane exposure studies to high-activity tritiated water, a closed loop Combined Electrolysis and Catalytic Exchange System to demonstrate the radiation resistance of electrolyser components for tritium service, tritium permeation

characterization of materials for fusion and Gen IV Very High Temperature Reactors, and the extraction and purification of He-3.

- Sustain the commercial tritium dispensing business and the tritium gas standards business, as well as grow other commercial opportunities. The Tritium Laboratory offers a three-day Tritium Safe Handling Course to CNL and external participants. The course consists of a mixture of lectures and practical exercises in the laboratory. The latest one was held in 2017 June.
- Provide expertise and support to external agencies and clients on tritium-related issues.
- Maintain the skill, knowledge, and expertise in the area of tritium, to ensure that the Tritium Laboratory remains a valuable asset to the federal government.

Major modifications to the Tritium Laboratory include:

- The installation of a new research test rig that is currently in active commissioning. This rig is a closed loop Combined Electrolysis and Catalytic Exchange System which will be used to demonstrate the radiation resistance of electrolyser components for tritium service.
- As part of CNL S&T activities, an Inert Atmosphere Glove Box was installed in the Tritium Laboratory for low-level tritium activity experiments.
- The installation of an oxygen combustion apparatus began in 2016, for the conversion of organic materials to water for tritium analysis, and currently remains in the construction stage. This apparatus will add to the capabilities for material characterization within the Tritium Laboratory; and is commonly used for chemical analysis of combustible samples.

17.1.7.2 Status of Regulatory Enforcement Actions

Since the last licence renewal, CNSC staff have conducted compliance inspections of the facility. As of 2017 July, there were no outstanding regulatory enforcement actions.

17.1.7.3 Future Plans

During the next licence period, the Tritium Laboratory operations will be moved from Building 250 to the newly renovated portion of Building 215. The repurposing phase of construction is targeted to be completed in 2017.

Once the new Tritium Laboratory is fully commissioned in Building 215, the commercial and S&T activities will be transferred from Building 250 to Building 215 (Figure 7), and the old premises of the Tritium Laboratory in Building 250 will be transferred to Facilities Decommissioning.

17.1.8 Waste Treatment Centre and Associated Facilities

The Waste Treatment Centre processes low-level radioactive liquid waste streams that are generated at the CRL site; generating discharges that meet regulatory guidelines for contaminant and radioactivity release limits and producing solids suitable for long-term storage in the CRL WMAs. The Waste Treatment Centre associated facilities provide storage for historical radioactive liquid wastes (Figure 56).



Figure 56 Waste Treatment Centre

17.1.8.1 Past Performance and Major Modifications or Improvements

Since the last licence renewal, the Waste Treatment Centre Liquid Waste Evaporator concentrated 13 972 m³ of liquid waste and transferred the concentrate to the Liquid Waste Immobilization System, generating 347 product drums of bituminized waste that was shipped to the WMA for storage. The baler at the Waste Treatment Centre received and compacted 14 581 bags of solid waste producing 374 waste bales for storage in the WMA.

Major modifications since the 2011 licence renewal include:

- Waste Treatment Centre
 - Installed and commissioned the mercury analyzer to improve operational control for mercury in the Liquid Waste Evaporator distillate.
 - Upgraded the electrical grounding and bonding to improve the reliability of instruments.
 - Completed vehicle access bridge upgrades.
 - Completed sprinkler system upgrades to meet NFPA 13 regulations.

- Installed bells and fault alarms on all area gamma monitors.
- Completed active commissioning of Tanks 2 and 3 in the Holding Tank Facility (Building 574). Tank 2 was designed to receive Chemical Active Drain Waste from Laboratory Operations, while Tank 3 was designed to receive high activity waste. The tanks are located in individual concrete vaults that provide secondary containment and shielding.
- Active Drain System
 - Initiated an Equipment Reliability program in 2013 and completed condition assessments for Building 242 in 2014 and Building 243 in 2015.
 - Installed new hardwired alarms from the active drain system, and modified the supervisory alarm to security in 2013.
 - Completed pressure testing of all the carbon steel secondary containment piping in 2014 with the exception of the line from Building 243 to Building 234. The primary containment piping for the line from Building 243 to Building 234 was leak tested with no evidence of a leak.
 - Replaced the obsolete Low Point Leak Detectors in 2014.
 - Developed a preventive maintenance program for the inspection and testing of the building sumps.
 - Placed Building 240/Building 241 and tanks into a safe shutdown state in 2015 and drained, cut, and capped the liquid dispersal area lines from Building 240 to the Liquid Dispersal Area in 2016. Transferred Building 240/Building 241 and tanks to Facilities Decommissioning in 2016.
- Holding Tank Facility
 - Installation of the drum unloading station to receive drums and totes of active waste via overland transport, was completed.
 - As part of the Equipment Reliability program, a condition assessment for Building 574 was completed in 2013.
- Rod Bay Water Storage Facility
 - Completed the transfer of 1 070 000 L of rod bay water in 2012.
- Waste Tank Farm
 - Recovered 33 000 L of legacy waste from Tank 40D from 2012 to 2014.
 - Recovered 8 000 L of legacy waste from Tank 40F in 2016.

17.1.8.2 Status of Regulatory Enforcement Actions

Since the last licence renewal, CNSC staff have conducted compliance inspections of the facility. As of 2017 July, there were no outstanding regulatory enforcement actions.

17.1.8.3 Future Plans

The process systems for volume reduction and immobilization of low-level radioactive liquid waste will reach the end of their design life before the end of the proposed licence period.

Once the NRU reactor is placed in a safe shutdown state in 2018, the volume of low-level radioactive liquid waste from the reactor drain and the Decontamination Centre will decrease significantly.

A capital upgrade of the immobilization system is required in 2019 to support the management of legacy waste and the receipt of low-level radioactive liquid waste generated during the decommissioning of facilities in support of the CRL site transition.

The identification of a new capital project for a replacement to the Waste Treatment Centre is planned for 2019 so that an options evaluation, the planning, definition, and implementation of the project can be completed before the end of the next licence period.

The plan for the disposition of the inventory at the Rod Bay Water Storage Facility will be defined and implemented near the end of the proposed licence period.

During the proposed licence period, the Legacy Waste Management Project will design, fabricate, install, and operate the systems necessary to access, retrieve and process the legacy radioactive liquid wastes and sludge stored at the Waste Tank Farm and the Active Area Liquid Waste Facility, and prepare the tanks and associated facilities for decommissioning.

17.1.9 Fuels and Materials Cells

The FMC facility performs post-irradiation examination on irradiated fuels and fuel channel materials. A variety of operations including visual examination, fuel element leak testing, optical microscopy, and mechanical testing on non-fissile materials are some of the operations within the suite of activities performed (Figure 57).

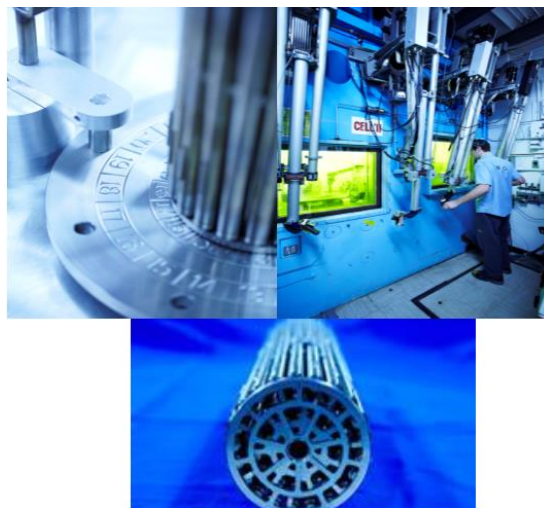


Figure 57 Fuels and Materials Cells

17.1.9.1 Past Performance and Major Modifications or Improvements

Since the 2011 licence renewal, the FMC continues to be used primarily to provide post-irradiation examination support for operating CANDU power reactors in Canada and abroad as well as the NRU reactor at CRL. The FMC also performs long-term tests in the hot cells such as delayed hydride cracking of pressure tubes.

As the facility is a nuclear criticality controlled area, the limits and restrictions on fuel handling and storage activities are contained in the FMC criticality safety document. This document was updated, reviewed, and accepted in 2017 by CNL's Safety and Review Committee.

As a nuclear facility, FMC is required to have an up-to-date safety analysis report that examines all of the activities performed and documents how these activities are performed safely. The safety analysis report for the FMC was updated, reviewed, and accepted in 2012 by CNL's Safety and Review Committee, and in 2013 by CNSC staff.

In 2017 August, facility staff completed the imaging of garter springs using a new macroscope in FMC Cell 10. The new instrument is capable of capturing superior images, and staff feedback has been very positive.

Fuels and Materials Cells has replaced the obsolete isolation room crane with a modern crane system known as Wäli, with a power manipulator (Figure 58). The crane consists of a mechanical manipulator arm which can move at the shoulder, elbow, and wrist joints, and has a telescoping mast which allows for vertical movement and a 360° degree rotation. It is mounted on a carriage which moves in the East and West direction and on a bridge which moves in the North and South direction allowing for full movement around the isolation room. Along with the manipulator arm there is a 3.5 metric ton vertical lifting crane mounted on the same bridge but on a separate East and West carriage. This new system allows the FMC to complete everyday tasks more efficiently by reducing the amount of radiation exposure to the staff. The new system has also increased capability to complete tasks that were not possible prior to installation.

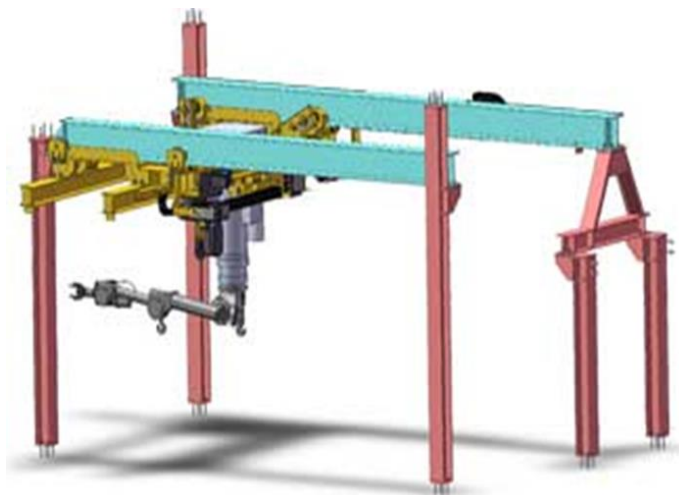


Figure 58 Three dimensional design view of the new Wäli crane.

17.1.9.2 Status of Regulatory Enforcement Actions

Since the last licence renewal, CNSC staff have conducted compliance inspections of the facility. As of 2017 July, there were no outstanding regulatory enforcement actions.

17.1.9.3 Future Plans

Fuels and Materials Cells plans to complete the repairs to the Cell 3 active ventilation system, and continue operations on approved activities as described in Section 17.1.9.

17.1.10 Waste Management Areas

The WMAs at CRL provide various facilities for storing a variety of radioactive wastes, ranging in activity from very low levels up to that of irradiated nuclear fuel. Currently, there are nine physically distinct WMAs, plus dispersal areas, and other facilities that are licensed as a single WMA facility.

Waste emplacements began in approximately 1946, and the wastes originate in part from the operation of CRL and in part from various Canadian off-site organizations such as isotope users, isotope manufacturers, hospitals, government agencies, industrial plants, and commercial radioactive waste brokerage firms. Currently, there are two general types of WMA facilities: operating (those facilities that are approved to receive wastes for storage) and non-operating (those facilities that are not approved to receive waste for storage, and are in a state of ongoing monitoring and surveillance).

17.1.10.1 Past Performance and Major Modifications or Improvements

Since the 2011 licence renewal, radioactive waste generated on-site and off-site continued to be safely emplaced, stored, and monitored in the WMAs. Routine operations continued safely and efficiently.

WMA A: initiated and completed a project to retrieve radioactive liquids from Active Liquid Waste Tanks. The soils around the Active Liquid Waste Tanks 1 and 2 as well as the contents inside the tanks, were characterized. Along with this, the liquid fractions from these two legacy tanks were recovered and processed by an off-site service provider. Retrieval of liquids from these structures enhanced CNL's ability to sustain safe storage of waste within the structures and minimize the potential for, and consequence of, contaminant release from the structures. Completed construction of a permeable reactive barrier to treat Sr-90 plume emanating from WMA A.

WMA B: radiological surveys of tile holes continued. The PCB mixed waste repackaging campaign was completed. The campaign involved transferring and processing radioactive PCB liquid waste to an off-site service provider to remove radioactivity from the liquid.

Fuel Packaging and Storage Facility: completed construction and commissioning of the facility. The facility was transferred to the Operations organization in 2016. As of 2017 September 07, there have been 57 historic storage containers retrieved and placed for long-term storage in the facility. Figure 59 shows the facility interior and some of its fuel transfer equipment and storage.



Figure 59 Fuel packaging and storage facility.

Spring B Groundwater Treatment Plant: upgrades were made to the Spring B Groundwater Treatment Plant to improve reliability. A total of 5000 m³ of Sr-90 contaminated water was treated and discharged since the last licence renewal campaign.

Waste Handling Building: a total of 2400 m³ of compactable waste was processed at the building since the last licence renewal campaign.

WMA C: an engineered cover was installed in WMA C to minimize leachate generation by minimizing the infiltration of surface water into the waste fill.

WMA D: efforts were undertaken to reduce the number of drums in the marine containers by bulking and transferring to off-site locations for processing. The items were suspected of being contaminated and shipped for processing, accordingly. The inventory included drums from legacy waste as well as operational waste. An estimated 300 000 kg of steel items were recycled since the last licence renewal. Over 1000 tons of characterized legacy metal from salvaged equipment was shipped off-site for recycling from the WMA D recoverable surface storage area.

Low-Level Radioactive Waste Management Office Buildings: metal crates were placed into overpack bins to improve the integrity of the original packaging.

WMA E: the above ground waste in WMA E consists primarily of mounds of concrete and large rocks, with some metal and asphalt. A detailed radiological survey with 100% surface coverage was performed to provide additional characterization of the area. A project to assess and dispose of the waste stored on the surface of WMA E was initiated.

WMA H: a third Shielded Modular Above Ground Storage (SMAGS-3) was constructed, commissioned, and placed in operation with CNSC approval.

17.1.10.2 Status of Regulatory Enforcement Actions

Since the last licence renewal, CNSC staff have conducted compliance inspections of the facility. As of 2017 July, there were no outstanding regulatory enforcement actions.

17.1.10.3 Future Plans

The Waste Management organization at CRL plans to perform the following activities during the next licence period:

- Once regulatory approval is received, construction, commissioning, and operation of the NSDF; develop additional interim low-level waste storage capabilities until NSDF is available; establish capabilities to sort, segregate, and repackage legacy waste materials to make them ready for placement in the NSDF.
- Establish integrated waste strategy for all CNL waste.
- Consolidate intermediate-level waste and high-level waste for long-term storage.
- Accelerate remediation of WMAs.
- Continue advancing repatriation of special nuclear material.
- Continue environmental restoration of WMAs.
 - Progressively reduce risk and liability related to CRL.
 - Progressively reduce risk and liability to AECL.
 - Produce agreement with stakeholders that identifies end land uses for the CRL site and cleanup criteria required to achieve each particular use.
 - Create a system that provides a single repository of CNL environmental data.
 - Mitigate the effects of the Sr-90 plume emanating from the Chemical Pit.
 - Construct, commission, and operate a new Spring B effluent treatment facility that will provide an increase in flow from the current 8 to 50 L per minutes, thus expanding the capability for removal of Sr-90 from effluent draining to the Perch Lake watershed. This will enable decommissioning and demolition of the current Spring B effluent treatment facility.

- Continue the following efforts with Stored Liquid Waste Management:
 - ensure that legacy radioactive liquid wastes and associated facilities are maintained in a safe and compliant state until the tanks are emptied
 - prepare a plan to decommission and disposition the resulting waste from the emptied tanks
 - retrieve and immobilize legacy radioactive liquid waste and sludge
- Continue the following efforts with legacy waste processing and storage:
 - operate and maintain CRL waste management facilities and operations
 - provide regular monitoring, investigation and support for long-term strategic planning
 - improve current low-level waste management practices
 - operate and maintain the Fuel Package and Storage facility and continue transfer of fuel from the tile holes
 - design and construct an outdoor secure footing to store waste containers to safely transfer to NSDF when it becomes operational
 - monitor the environmental performance of the WMAs
 - maintain an effective Waste Management program and implement improvements

17.1.11 Combined Electrolysis and Catalytic Exchange Upgrading and Detritiation Test Facility (Building 215)

The CECEUD Test Facility has been maintained in a safe shutdown state since 2001 May.

17.1.11.1 Past Performance and Major Modifications or Improvements

The service building portion of the facility has been repurposed as part of the project to relocate the Tritium Laboratory from Building 250. The existing service building will house four laboratories and the tritium storage vault. Two new sections have been added to the building as part of the renovation. One new building section will house an office area, meeting room, and change rooms, while the other section will act as a shipping and receiving area. Repurposing of the building has a target date to be completed in 2017. During the renovation, a temporary tritium storage vault was constructed and commissioned.

17.1.11.2 Status of Regulatory Enforcement Actions

Since the last licence renewal, CNSC staff have conducted compliance inspections of the facility. As of 2017 July, there were no outstanding regulatory enforcement actions.

17.1.11.3 Future Plans

During the next licence period, renovations in the service building and the new portions of the building will be completed. Once the repurposing activities have been completed, the renovated portions of the building will undergo inactive and active commissioning, and subsequent operation.

17.2 Class II Facilities

There are currently four Class II nuclear facilities located at the CRL site and operated in accordance with the Class II Nuclear Facilities and Prescribed Equipment Regulations [38]. Relevant information is presented below in Sections 17.2.1 to 17.2.4 on their past performance, operation and compliance since 2011 licence renewal with an indication of future plans for the proposed new licence period.

17.2.1 Health Physics Neutron Generator

The HPNG facility houses the Texas Nuclear Neutron Generator 150 1H (Texas NG, Figure 60), a linear accelerator, which was disconnected in 2013 and is currently awaiting removal from the facility.



Figure 60 Texas Neutron Generator

A Cf-252 source delivery system is also located in the facility and was used for the calibration of radiation detection instruments and as a resource for research and development projects.

17.2.1.1 Past Performance and Major Modifications or Improvements

Since 2011, the HPNG facility has been operated as per the requirements outlined in the facility authorization. Activities conducted in the facility since 2011 have supported research and development initiatives within CNL involving neutron interaction studies, biological research, and neutron detection instrumentation development, testing and calibration.

During the current licence period, the Cf-252 delivery system was modified to include a more robust operating system, which implemented new safety features in addition to the existing safety-related systems. The system was designed and refurbished in 2014 and commissioned and put into service in 2015.

17.2.1.2 Status of Regulatory Enforcement Actions

Since the last licence renewal, CNSC staff have conducted compliance inspections of the facility. One Action Notice was open as of the end of 2017 July (in SCA – Fitness for Service) and is in progress.

17.2.1.3 Future Plans

The new DD-109 neutron generator has a target date of operation set for 2017. Plans are currently being discussed to accredit the HPNG facility into a Secondary Standards Calibration facility. This would include reloading the existing Cf-252 source, which has decayed significantly since its purchase in 2011. Currently, there is one resource in Canada which provides primary standards for neutrons. As a secondary standards laboratory, CNL's HPNG facility can provide characterization of sources and irradiation services for industry and research and development.

Also planned for the next licence period is the decommissioning and removal of the Texas Neutron Generator which has been in a permanent shutdown state since 2013. This will aid in the characterization of the new DD-109 NG and the accreditation of the facility as a secondary standards laboratory.

17.2.2 Gamma Beam Irradiation Facility

The facility contains two gamma irradiators, the Gamma Beam 150C (GB-150C), manufactured by Nordion International Inc., and the GC60-1000, manufactured by Hopewell Designs, Inc. (Figure 61).

Both devices, which can provide gamma exposures with both Cs-137 and Co-60, are used to support research and development initiatives investigating the effects of ionizing radiation on DNA damage and repair, immune and adaptive response, and gene expression changes and the testing and validation of radiological detection instruments by various departments within CNL.



Figure 61 Gamma Beam Irradiation Facility

17.2.2.1 Past Performance and Major Modifications or Improvements

Since 2011, the Gamma Beam Irradiation Facility has been operated as per the requirements outlined in the facility authorization. Activities conducted in the facility since 2011 have supported research and development initiatives within CNL such as: investigating the effects of ionizing radiation on DNA damage and repair, immune and adaptive response and gene expression changes, testing and validation of radiological detection instruments, and investigation of chemical corrosion in the presence of gamma radiation.

In 2016, the GC60-1000 gamma irradiator manufactured by Hopewell Designs, Inc., was commissioned and placed into service in the Gamma Beam Irradiation Facility. This irradiator was purchased in order to eventually replace the existing aging GB-150C irradiator, but also to increase the capabilities of the facility for work requiring a higher dose environment.

17.2.2.2 Status of Regulatory Enforcement Actions

Since the last licence renewal, CNSC staff have conducted compliance inspections of the facility. One Action Notice was open as of the end of 2017 July (in SCA – Fitness for Service) and is in progress.

17.2.2.3 Future Plans

Plans are currently being discussed to add a new Co-60 source to the GC60-1000 irradiator which will further increase the capabilities of the facility for ultra-low dose ionizing radiation research. Also planned is the replacement of the area monitor which will be implemented under the Engineering Change Control process.

17.2.3 Gamma Irradiation (GC60 Facility)

The GC60 is a gamma beam irradiator manufactured by Hopewell Designs, Inc. The GC60 irradiator houses three Cs-137 sources and one Co-60 source. The GC60 facility is used for the calibration of radiation protection portable instruments (gamma survey meters), gamma area monitors, irradiation of TLDs with known doses, and for the irradiation of other types of detectors for research purposes. It is also the location of the X80 x-ray irradiator, which is used for whole-body dosimetry and extremity TLD intercomparisons and type-testing of various instruments and dosimeters.

17.2.3.1 Past Performance and Major Modifications or Improvements

Since 2011, the GC60 facility has been operated as per the requirements outlined in the facility authorization. Activities conducted in the facility since 2011 have supported operations and research and development initiatives including the calibration of CNL radiation monitoring instrumentation, testing of radiological detection instrumentation and for regulation-related dosimeter intercomparisons with utilities. The X-80 X-Ray Beam Irradiator shares the linear positioning track with the GC60 facility and is also used for the calibration of instruments and research and development applications.

With the X-80 x-ray device installed and commissioned in 2010, the facility has had a complete complement of equipment needed to perform the intended functions throughout the current licensing period.

17.2.3.2 Status of Regulatory Enforcement Actions

Since the last licence renewal, CNSC staff have conducted compliance inspections of the facility. One Action Notice was open as of the end of 2017 July (in SCA – Fitness for Service) and is in progress.

17.2.3.3 Future Plans

Plans are currently being discussed to replace the Co-60 source in the GC60 irradiator which has decayed beyond its intended use. The decayed source will be removed and transferred into the GC60-1000 irradiator in the Gamma Beam Irradiation Facility to provide ultra-low dose capabilities for research and development applications in that facility. Other plans include adding a new Cs-137 source to replace the current decaying source to ensure that higher dose rates are available for instrument calibration and research and development work.

17.2.4 Van de Graaff Electron Accelerator

The Van de Graaff Accelerator facility located in Building 320 operates and maintains a 2.5 MeV electron accelerator. The accelerator is used to study chemical reactions caused by irradiation, through a single pulse of electrons or multiple pulses to accumulate dose over time. The

accelerator is also suitable for studying the effects of high doses of radiation on small samples, typically less than 2 mL.

17.2.4.1 Past Performance and Major Modifications or Improvements

In 2014, the CNSC changed its policy concerning the regulation of low-energy particle accelerators such that any accelerator operating above 1 MeV is to be licensed as a Class II nuclear facility. As such, the Van de Graaff Accelerator facility has since then been classified as Class II prescribed equipment and reported annually to CNSC staff in the annual safety report for the CRL site.

The Van de Graaff facility conducted a major upgrade to the safety interlock system between 2014 and 2015 under the Engineering Change Control process that included replacement of the light beam with a light curtain, replacement of the vacuum gauges with digital devices, and replacement of the radiation detectors with digital area monitors (RMS3). Another noteworthy physical modification that is underway is the replacement of the anode feedthrough on the cathode flange. This change is also captured through the Engineering Change Control process.

17.2.4.2 Status of Regulatory Enforcement Actions

Since the last licence renewal, CNSC staff have conducted compliance inspections of the facility. As of 2017 July, there were no outstanding regulatory enforcement actions.

17.2.4.3 Future Plans

During the next licence period, the Van de Graaff facility will continue to be operated safely and the safety analysis report and facility authorization documents will be updated.

17.3 Radioisotope Laboratories

Radioisotope laboratories at CRL are classified on the IAEA hazard-graded scale of A, B, and C that takes into account the nature of the operations performed and the relative toxicity of the radionuclides handled in the laboratories. CNL currently operates 1 Class A, 20 Class B, and 25 Class C laboratories (Figure 62), each with a radioisotope laboratory protocol that defines how work is controlled. In addition, the individual radioisotope laboratory protocol specifies the laboratory operating limits and identifies the basis for maintaining safe operations within each laboratory.

CNL has a long history in the research and development of technologies around hydrogen and its isotopes. This entails the market areas of heavy water, tritium and hydrogen. CRL opened a world-class Hydrogen Isotopes Technology laboratory (in Building 137) in 2015 (Figure 9, Figure 10 and Figure 11). In recent years, efforts are refocused to seek out opportunities and find partners to help exploit CNL's hydrogen expertise in new markets and to seek commercial work in this burgeoning field.



Figure 62 Various radioisotope laboratories at Canadian Nuclear Laboratories.

A delegation from CNL attended the biennial Hydrogen + Fuel Cells Summit in Vancouver (2017 summer) in search of partners to support a demonstration of a hydrogen production process that CRL researchers have developed in partnership with the University of Ontario Institute of Technology. The summit was an event hosted by the Canadian Hydrogen and Fuel Cell Association, of which CNL is a member, to increase awareness of the economic, environmental and social benefits of hydrogen and fuel cells.

To date, CNL has developed the crucial step among the four-step process, while University of Ontario Institute of Technology has developed the other three. CNL is currently in the process of demonstrating the integration of the four steps in our hydrogen laboratories in Building 137. Together, the organizations are looking for partners to help them plan a demonstration of the hydrogen production process. At the summit, the presentation was very well received, and led to follow-up meetings with Canadian stakeholders. The event itself was attended by delegates from China, Germany, India, Indonesia, Japan, Netherlands, New Zealand, South Africa, South Korea, Spain, Taiwan, the United Kingdom, and the United States.

17.3.1 Past Performance and Major Modifications or Improvements

Since the 2011 licence renewal, work performed in these laboratories varied from experimental powder and pellet fuel fabrication to refurbishment and calibration of radioactive pressure

tube sampling tubing. The laboratories continued to support CANDU Owners Group commercial projects, federal S&T, and internal CNL compliance.

Since licence renewal in 2011, the following laboratories have been declassified:

- Corrosion Test Laboratory
- Waste Processing Technology Laboratory
- Molecular Biology Tissue Research Laboratory

Since licence renewal in 2011, the following laboratories have been renovated or are in the process of being renovated as part of the fumehood upgrade project:

- Radiochemistry Research Laboratory; renovated in fiscal period 2012/2013.
- Environmental Radiochemistry Laboratory; renovated in fiscal period 2012/2013.
- Active Wet Chemistry Laboratory; renovated in fiscal period 2014/2015.
- Radiochemical Analysis Laboratory; renovated in fiscal period 2014/2015.
- Bioassay Laboratories; renovated in fiscal period 2014/2015 and Room 115 is currently undergoing renovation.
- Chalk River Advanced CANDU Fuel Development Laboratories; currently undergoing renovation.
- Tritium Monitor/Technique Development Laboratory; currently undergoing renovation.

17.3.2 Status of Regulatory Enforcement Actions

Since the last licence renewal, CNSC staff have conducted compliance inspections of the radioisotope laboratories. One Action Notice was open as of the end of 2017 July (in SCA – Operating Performance) and is in progress.

17.3.3 Future Plans

For the next licence period, CNL plans to complete the relocation of Class C laboratories in Buildings 250 and 380 to the newly constructed Harriet Brooks building (Building 350). Radioisotope laboratories in the remaining buildings will undergo general renovations to improve health, safety, security, and environmental aspects, primarily with reference to issues related to fire safety and fumehoods.

The following radioisotope laboratories associated with NRU will be declassified following reactor shutdown in 2018 March:

- Irradiation Creep and Growth Laboratory
- Control/Loop Laboratory Coupons for Corrosion Test
- Iodine Preparation Laboratory

Future improvements include temporary relocation of fuel fabrication laboratories in Building 300 to Building 380. Following that, the fuel fabrication laboratories in Building 380 and Building 375 will be relocated to the proposed Building 370 laboratory complex (Advanced Nuclear Materials Research Centre).

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19. ACRONYMS

AECL	Atomic Energy of Canada Limited
ALARA	As Low As Reasonably Achievable, economic and social factors taken into account.
CANDU	Canada Deuterium Uranium (registered trademark)
CEAA	Canadian Environmental Assessment Act
CECEUD	Combined Electrolysis Catalytic Exchange Upgrading/Detritionation (Facility)
CNEA	Canadian National Energy Alliance
CNL	Canadian Nuclear Laboratories
CNSC	Canadian Nuclear Safety Commission
CRL	Chalk River Laboratories
CSA	Canadian Standards Association
D&WM	Decommissioning and Waste Management
DRL	Derived Release Limit
EA	Environmental Assessments
EmP	Emergency Preparedness (Program)
EOC	Emergency Operations Centre
ERA	Environmental Risk Assessment
FISST	Fissile Solution Storage Tank

GIG	Global Issue Group
GWMP	Groundwater Monitoring Program
HEU	Highly Enriched Uranium
HPNG	Health Physics Neutron Generator
HU	Human Performance (Program)
IAEA	International Atomic Energy Agency
IIP	Integrated Implementation Plan
ImpAct	Improvement Action (Process)
ISO	International Organization for Standardization
LCH	Licence Conditions Handbook
MAPLE	Multipurpose Applied Physics Lattice Experimental (Reactor)
MPF	Molybdenum-99 Production Facility
NFPA	National Fire Protection Agency
NIST	National Institute of Standards and Technology
NM&SM	Nuclear Materials and Safeguards Management
NPD	Nuclear Power Demonstration (Reactor)
NRU	National Research Universal (Reactor)
NRX	National Research Experimental (Reactor)
NSDF	Near Surface Disposal Facility
OPEX	Operating Experience (Program)
RP	Radiation Protection (Program)
S&T	Science and Technology
SAMG	Severe Accident Management Guideline
SAMP	Severe Accident Management Program

SAT	Systematic Approach for Training
SCA	Safety and Control Area
SLOWPOKE	Safe Low Power Critical Experiment (registered trademark)
SMR	Small Modular Reactor
STAR	Stop, Think, Act, and Review (Simulator)
TDG	Transportation of Dangerous Goods
TLD	Thermoluminescent Dosimeter
WANO	World Association of Nuclear Operators
WMA	Waste Management Area
ZED-2	Zero Energy Deuterium-2 (Reactor)