



Canadian National Report for the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management

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Canadian National Report for the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management

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Preface

Information in this report covers the period up to March 31, 2014. However, in some instances the reporting period extends beyond this to the time of writing the report: July 31, 2014. Examples include the current status of the Canadian Nuclear Safety Commission's regulatory documents, the Nuclear Waste Management Organization's (NWMO) Adaptive Phased Management (APM) approach, and Ontario Power Generation's (OPG) Deep Geologic Repository (DGR).

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Executive Summary

1.0 Introduction

This fifth Canadian report demonstrates how Canada continues to meet its obligations under the terms of the *Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management* (hereinafter referred to as the Joint Convention) during the reporting period from April 2011 to March 2014. A collaboration of government, industry and the regulatory body, this report focuses specifically on the progress of long-term management initiatives for spent fuel and radioactive waste in Canada, revisions and updates to Canada's fourth national report, and comments and issues raised at the Fourth Review Meeting, which took place in May 2012. Specifically, it includes additional information on:

- Canada's progress in finding solutions for the long-term management and disposal of different types of radioactive waste and/or spent fuel
- continued implementation and ongoing funding of the Nuclear Legacy Liabilities Program (NLLP)
- the status of the Nuclear Waste Management Organization's (NWMO) site selection process for a deep geological repository for the long-term management of Canada's spent fuel
- the status of Ontario Power Generation's (OPG) Deep Geologic Repository (DGR) for its low- and intermediate-level radioactive waste (L&ILW) site preparation and construction licence application

2.0 Canada's key highlights and current priorities

- In June 2007, the Government of Canada selected the Adaptive Phased Management (APM) approach, recommended by the NWMO, for the long-term management of Canada's spent fuel. The NWMO is responsible for implementing this plan. The NWMO is currently in the site selection phase of the process, with 14 communities interested in learning more about the project as of June 2014. For more information about the NWMO and the APM project, see sections G.16 and K.4.
- The NLLP is implementing Canada's long-term strategy for dealing with nuclear legacy liabilities at Atomic Energy of Canada Limited (AECL) sites across Canada. These nuclear legacy liabilities are a result of 60 years of nuclear research and development carried out on behalf of the Government of Canada by the National Research Council and AECL. (Program progress and achievements are summarized in section K.6.2.) In 2013 the Government of Canada re-estimated the cost to implement the NLLP over 70 years to be \$10 billion.
- The Canadian Environmental Assessment Agency (CEA Agency) and the Canadian Nuclear Safety Commission (CNSC) established a Joint Review Panel in January 2012 to review OPG's environmental impact statement and other documents in support of OPG's application for a site preparation and construction licence concerning a deep geological repository for its L&ILW. The Joint Review Panel is continuing with its public review of the information, including public hearings. Following the closure of the public record, the panel's report on the environmental impacts of the repository will be prepared. The report will be submitted to the Minister of the Environment for decision. If permitted by the decision of the Minister, the panel will act as the Commission and decide whether to issue the requested licence. The environmental assessment (EA) decision is expected to be received in 2015. If permitted, a decision on the issuance of a site preparation and construction licence would be expected to follow shortly after. If the licence is issued, the earliest in-service date for the completed DGR facility would be approximately 2025.
- Canada continues to manage and address historic waste as a priority. The Port Hope Area Initiative (PHAI) will result in the long-term management of historic low-level radioactive waste in two above-ground mounds that will be constructed in the local communities. The \$1.28 billion initiative includes two projects – the Port Hope Project and the Port Granby Project. A number of

enabling activities have been initiated to prepare for the remediation and consolidation of the low-level radioactive waste (LLW), including construction of a wastewater treatment plant and radiological investigations of residential properties in Port Hope to identify occurrences of LLW not included in the major sites. For further information, see section K.6.3.1 and annexes 8.2.1.1 and 8.2.1.2.

- After the sale of the assets of AECL's former CANDU Reactor Division to Candu Energy Inc. in October 2011, the Government of Canada formally turned its attention to the restructuring of AECL's nuclear laboratories in 2012, with an announcement that it would engage in a competitive procurement process to restructure AECL's management and operations. The government is seeking to implement a government-owned, contractor-operated (GoCo) model, as is done in other jurisdictions such as the United States and the United Kingdom. For further information, see annex 1.3.
- On December 28, 2012, the Gentilly-2 Nuclear Generating Station was permanently shut down. For more information on the decommissioning of the facility, refer to annex 7.9.

3.0 Progress since the Fourth Review Meeting

During the peer review of Canada's Fourth National Report in 2012, contracting parties to the Fourth Review Meeting identified long-term waste management challenges and planned measures to improve safety. The following section (3.1) provides an update and summarizes the progress made toward the long-term management of spent fuel and radioactive waste.

3.1 Canada continues progress for long-term management strategies by:

- a. finding an acceptable site for a spent nuclear fuel (SNF) repository
- b. developing long-term management options for radioactive waste
- c. demonstrating the safety of old interim storage facilities to support re-licensing
- d. addressing a wide variety of legacy wastes in several areas and in several forms which require treatment and disposal
- e. addressing historic and legacy waste issues
- f. implement "gap analysis" findings for improving the regulatory framework
- g. updating, revising and developing new regulatory documents to provide guidance to the licensee
- h. implementation of Fukushima Action Plan

3.1(a) Finding an acceptable site for a spent nuclear fuel (SNF) repository

Momentum has been sustained for implementing the long-term management approach for spent fuel since the NWMO received its 2007 mandate to implement the APM approach approved by the Government of Canada. Between 2011 and 2014, significant progress was made on the site selection process (initiated in 2010) as the NWMO worked with interested communities. The NWMO reached an important milestone on September 30, 2012, with its suspension of the "expressions of interest" phase for communities wishing to engage in the site selection process for a deep geological repository for Canada's spent fuel. The NWMO reached a further milestone in 2012 with its initiation of Step 3, Phase 1 of the site selection process: desktop assessments with 20 requesting communities that had passed initial screenings. As of June 2014, 11 communities had completed the Step 3, Phase 1 process, out of which four communities were identified as having strong potential for proceeding with fieldwork. Currently, 14 communities are actively engaged in exploring interest in the project. For further information, see section K.4.

3.1(b) Developing long-term management options for radioactive waste

Ontario Power Generation

OPG's plan for the long-term management of its L&ILW is a DGR 680 metres below the ground surface in argillaceous limestone at the Bruce nuclear site in the Municipality of Kincardine. The L&ILW DGR will be adjacent to OPG's Western Waste Management Facility, where OPG centrally stores all its L&ILW from OPG-owned nuclear reactors. In 2011 OPG submitted to the CNSC its environmental impact statement, preliminary safety report and technical support reports for review. Subsequent to OPG's submission and the appointment of a Joint Review Panel, a public review lasting 15 months and a public hearing with 25 hearing days was carried out. On June 3, 2014, the panel scheduled approximately two weeks of additional public hearing days in September 2014. It is expected that a decision on the environmental assessment will be made by the federal Minister of the Environment in 2015.

Atomic Energy of Canada Limited

The L&ILW at AECL sites is safely and securely stored according to the CNSC's requirements. Current practice includes the use of above-ground concrete storage structures, commonly referred to as shielded modular above ground storage (SMAGS) structures, and below-ground structures such as bunkers and tile holes. The storage integrity is verified on an ongoing basis through appropriate monitoring of the containment and the surrounding environment. This L&ILW will be maintained in secure storage until permanent disposal facilities are available.

Several options are being considered for the long-term management of these radioactive wastes. The range of options includes surface, near-surface and deep geological facilities. The investigations are currently in the option-assessment stage. Feasibility studies are either planned or already underway to inform decision making on the types of waste management facilities required to safely manage these radioactive wastes over the long term. To date, these studies have included an assessment of the suitability of the Chalk River Laboratories (CRL) site to host a geological repository at a nominal depth of 500 to 700 metres in the bedrock, and conceptual and detailed designs for a very-low-level waste facility, also potentially at the CRL site.

Further, AECL completed a comprehensive review of its long-term decommissioning strategy in 2013. As a result of this review, AECL has included a near-surface LLW facility and a decommissioning landfill in its reference strategy for the CRL site. The feasibility of such facilities will now be studied.

New Brunswick Power

New Brunswick Power (NB Power) is currently investigating long-term management options for radioactive waste generated from the Point Lepreau Nuclear Generating Station.

In the meantime, a volume reduction strategy has been implemented whereby radioactive waste is sent to EnergySolutions' Bear Creek Radioactive Waste Management Facility in Oak Ridge, Tennessee to be incinerated. The resulting ash and non-processable material, which is returned to NB Power, accounts for only approximately 6 percent of the storage volume previously occupied by the radioactive waste.

Further storage structures can also be built as needed in the future, as will be done for spent fuel canisters in 2014 and 2015.

Uranium mines and mills

Since 2011, applications to expand capacities of tailings management facilities (TMFs) have been made for all three milling sites in northern Saskatchewan.

Cameco is proposing to increase the tailings capacity at its Rabbit Lake operation. The expansion will involve the excavation of an additional pit to the north of the existing Rabbit Lake TMF. It is anticipated that the additional tailings capacity may extend the life of the Rabbit Lake operation to approximately 2028 or longer.

Cameco also proposes to increase the capacity of the Deilmann tailings management facility (DTMF), which is currently used to manage tailings generated at the Key Lake operation. The project will involve increasing the approved elevation of the tailings within the facility to about 505 metres above sea level. Extending the use of this facility is not expected to change the facility's intended performance or require modification to supporting infrastructure over and above ongoing/planned activities carried out within the existing licensing framework. It is anticipated that the additional tailings capacity may extend the life of the Key Lake operation to approximately 2040 or longer.

AREVA has proposed to expand the existing McClean Lake TMF to provide the ability to store tailings above the currently approved elevation for consolidated tailings of 434 metres above sea level, through the construction of an embankment around the John Everett Bates (JEB) TMF perimeter and placement of a natural liner to contain the pond above the tailings during the operating period. It is anticipated that the additional tailings capacity may extend the life of the JEB TMF by 25 years.

3.1(c) Demonstrating the safety of old interim storage facilities to support relicensing

The following are examples of how Canada is demonstrating the safety of long-standing interim storage facilities to support relicensing activities.

Ontario Power Generation

The objective of OPG's radioactive waste management program is to provide safe transport, handling, processing, and interim storage and monitoring of the spent fuel and L&ILW generated from OPG-owned reactors until alternative long-term radioactive waste management facilities are available. The OPG radioactive waste management facilities operate safely to protect the public, workers and the environment.

OPG's radioactive waste storage facilities are designed to provide safe interim storage for both spent fuel and L&ILW. Storage facilities are designed to withstand design-basis earthquakes, to prevent water ingress, to be as watertight as practical for in-ground storage, to allow waste to be retrievable, to meet OPG radiation protection requirements and dose limits specified by the CNSC, and to lay out the radioactive waste in a manner that assists in the separation of radioactive materials from personnel for safe, efficient operation.

An aging management program has been implemented to quantify the factors affecting the aging of the facilities. Aging management plans have been developed for the critical, safety-credited structures, systems and components (SSCs) for the transportation of radioactive material, the storage of L&ILW and the storage of dry spent fuel. Ongoing inspection and maintenance ensures that the storage facilities maintain integrity throughout their design life. Aging management is especially important for the older storage components, such as quadricells and trenches. Aging management activities are in place to ensure the safety functions of the quadricells are maintained. Detailed inspections of the quadricell structures and routine monitoring of the interspace between the two concrete barriers are performed. Aging management activities for trenches include inspection of the exterior surfaces, periodic sealant re-caulking between the walls of the trenches and the surface asphalt, and sampling for water intrusion so the water can be removed, sampled for radioactivity and disposed of properly. Internal inspection of a sample of the trenches has been performed, and future internal inspections are planned. Overall, OPG's radioactive waste storage components are in good to very good condition. All safety-credited components are continuously assessed and confirmed to be operating safely within their designed life.

Over OPG's radioactive waste facility operating lifetimes, environmental targets have been met; radiation exposures to workers and the public have been far below regulatory limits and OPG control levels. OPG

has met its obligations arising from the Canada/International Atomic Energy Agency (IAEA) nuclear safeguards agreement, and the transport of nuclear substances and radiation devices has not resulted in a serious injury or radioactive release in the 40-year history of OPG and its predecessor company.

At OPG's Western Waste Management Facility, the Waste Volume Reduction Building provides for the management of LLW, such as radioactive waste receiving and handling, compaction and incineration prior to storage. An incinerator and a box compactor are housed in the Waste Volume Reduction Building and are used to reduce volume for the LLW. OPG continues to implement waste minimization initiatives to reduce the environmental footprint for L&ILW from OPG's nuclear generating stations.

Atomic Energy of Canada Limited

The Canadian nuclear industry and the Government of Canada are developing long-term radioactive waste management solutions that will protect health, safety, security and the environment. Currently, AECL stores the radioactive waste at various storage facilities in a safe manner. Legacy L&ILW is stored in historic facilities such as sand trenches. The operating facilities used for interim storage of radioactive waste include in-ground structures (tile holes and bunkers) for intermediate-level radioactive waste (ILW), and above-ground facilities for LLW. An above-ground, dry storage facility to store selected spent legacy research fuel, located in the Fuel Packaging and Storage (FPS) facility at CRL, is currently being commissioned. The storage structure will be engineered to last at least 50 years and will provide safe interim storage for the packaged fuel until a long-term management facility is available. All these facilities undergo regular maintenance and assessments to ensure interim storage of the radioactive waste in a safe manner.

AECL is seeking to repatriate much of the irradiated highly enriched uranium (HEU) spent fuel from its research reactors and the target residual material from medical isotope production to the United States through agreements with the United States Department of Energy and as part of the Global Threat Reduction Initiative, a broad international effort to consolidate HEU inventories in fewer locations around the world.

In 2012, AECL expedited the Tank 40D leak avoidance project to reduce the environmental risk of a leak in an aging storage structure. To date, AECL has removed 75 percent of the contents and processed it in the Waste Treatment Centre (WTC). Refer to section K.6.2.3 for more information.

New Brunswick Power

The storage structures and packaging used in the Solid Radioactive Waste Management Facility (SRWMF) are designed to provide at least two physical barriers to prevent the release of radioactive material to the environment.

These structures, which include vaults, quadricells, filter storage structures, retube canisters and spent fuel canisters, were built to achieve the attenuation of gamma radiation required to limit the maximum external contact dose rate to 25 $\mu\text{Sv/h}$.

Radioactive waste destined for the SRWMF is packaged in containers to provide a second radiation barrier for storage purposes and to limit exposure of plant personnel while handling the material.

Storage methods and handling operations are done in accordance with the as low as reasonably achievable (ALARA) principle.

Canadian Nuclear Safety Commission

In March 2014, the CNSC published REGDOC-2.6.3, *Aging Management*, a regulatory document that sets out and provides guidance to licensees on the CNSC's requirements for managing the aging of SSCs in a nuclear facility. REGDOC-2.6.3 defines aging management as the set of engineering, operational,

inspection and maintenance actions that control, within acceptable limits, the effects of physical aging and obsolescence of SSCs that occur over time or with use. An aging management program or plan is a set of policies, processes, procedures, arrangements and activities for managing the aging of nuclear facility SSCs. Effective aging management ensures that required safety functions are reliable and available throughout the facility's service life in accordance with the licensing basis.

The CNSC also has a rigorous, risk-informed, compliance verification program in place, which includes routine inspections at all nuclear facilities to ensure the radioactive waste management structures remain fit for duty. For more information, see section E.6.3.

3.1(d) Addressing a wide variety of legacy wastes in several areas and in several forms which require treatment and disposal

As described in section K.6.2, the Government of Canada initiated the Nuclear Legacy Liabilities Program (NLLP) to deal with legacy radioactive waste and liabilities at AECL sites. Program progress and achievements during the last three years of implementation are summarized in sections K.6.2.1 to K.6.2.3.

The inventory of legacy waste at AECL sites includes high-level radioactive waste (spent fuel), L&ILW, and liquid radioactive waste. The spent fuel will be safely stored at the AECL sites until a national deep geological repository becomes available. The process for the long-term management of Canada's spent fuel is currently undertaken by the NWMO. The largest component of the legacy waste is L&ILW, which contains a wide variety of materials including spent ion-exchange resin, typical laboratory waste such as rubber, plastic and cellulose materials, and soil, concrete and rubble. This radioactive waste type is stored in various engineered storage facilities at the AECL sites until long-term management facilities become available. Legacy liquid radioactive waste is stored in monitored storage tanks, and a project to retrieve and cement the liquid radioactive waste has been initiated (as described in K.6.2.3).

A number of studies are currently underway to better define the waste processing and long-term management facilities required to deal with the wide variety of legacy radioactive waste types at AECL sites. This will help to define, for example, the volume reduction and waste immobilization technologies to be used, the extent to which buried waste can be managed in place over the long term, and the available options for the long-term management of the radioactive waste that needs to be recovered.

3.1(e) Addressing historic and legacy waste issues

Historic low-level radioactive waste (LLW) in Canada refers to LLW that was managed in the past in a manner no longer considered acceptable but for which the current owner cannot reasonably be held responsible and for which the Government of Canada has accepted long-term responsibility. In 1982, the Government of Canada established the Low-Level Radioactive Waste Management Office (LLRWMO) within AECL as the federal agent for the cleanup and management of historic LLW in Canada. Natural Resources Canada (NRCan) provides policy direction and funding to the LLRWMO to carry out its work. The LLRWMO has completed historic low-level radioactive waste cleanup across Canada and continues to monitor several sites with historic radium or uranium contamination. At some sites, materials have been placed in interim storage pending the development of a long-term management approach. Ongoing site monitoring, inspection and maintenance are conducted at these sites.

AECL is currently commissioning a new above-ground dry storage facility to store selected spent legacy research fuel. The new dry storage system is located in a Fuel Packaging and Storage (FPS) facility. Spent legacy research fuel recovery operations will commence once the facility has been fully commissioned and regulatory approval has been received.

Over a 60-year period, liquid radioactive waste accumulated from various projects at AECL. At the time of the last report, the liquid radioactive wastes had been stored in 21 monitored storage tanks at AECL's CRL site. Since that time, the liquid radioactive waste contained in seven of those tanks has been removed and managed through the CRL WTC. The contents of 13 of the 14 remaining tanks, together with the sludge residue from the seven emptied tanks, are to be retrieved and cemented by the Stored Liquid Waste Cementation (SLWC) Project using a field cementation system. Significant pre-project development work

has been undertaken. This includes engineering studies, development of waste product performance criteria, radiation dose evaluations and cement formulation and testing. SLWC project design activities are beginning in 2014.

The Tank 40D leak avoidance project deals with a single-walled, direct-buried tank from the 1950s. Tank 40D contained concentrated ion exchange regenerant waste; a leak of this waste to the ground would have a detrimental effect on the environment and would require expensive remediation. AECL took the opportunity to be proactive and reduce this risk using existing equipment, facilities and experienced resources years ahead of when risk would be reduced by the SLWC Project. To date, AECL has removed 75 percent of the contents (i.e., about 30 cubic metres of the liquid waste) and processed it in the WTC. In addition, not all the tanks (among the 20 tanks) are full, as some contain a heel of liquid and sludge. The SLWC objective is to retrieve and cement the inventory of the 20 tanks.

The final tank's target residue material (TRM), held in the Fissile Solution Storage Tank (FISST), is to be repatriated to the United States, and a discrete project is underway to manage this inventory. See section K.6.2.3 for further information on AECL's SLWC Project.

3.1(f) Implementing "gap analysis" findings for improving the regulatory framework

In response to one of the recommendations made by the IAEA's Integrated Regulatory Review Service (IRRS), the CNSC conducted a gap analysis of the regulatory framework on radioactive waste management. This also included a five-year plan for new or updated regulations or regulatory guides, with the focus on spent fuel and radioactive waste. For more information, see section E.8.2.3.

The CNSC also initiated the introduction of the *Administrative Monetary Penalties Regulations* during the reporting period, which came into force in May 2013. For more information, refer to section E.3.2.

In addition, the CNSC contributes to and promotes the use of many of the CSA Group (formerly called Canadian Standards Association (CSA)) standards for the management of spent fuel and radioactive waste. In 2013, CSA standard N292.2, *Interim Dry Storage of Irradiated Fuel*, was revised and reissued; CNSC staff sat on the technical committee for this standard. A standard such as N292.2 is often referenced in licence conditions as a requirement with which the licensee must comply. As an interim measure, some gaps previously addressing improving the regulatory framework are bridged through national and international standards as the CNSC moves toward new regulations and guidance documents.

3.1(g) Updating, revising and developing new regulatory documents to provide guidance to the licensee

The CNSC is continually reviewing, updating and developing regulatory documents as the guidance and requirements for licensees are enhanced. Section E.6.2 provides a full list of the CNSC's regulatory documents current to the reporting period.

In March 2012, the CNSC published regulatory document RD/GD-370, *Management of Uranium Mine Waste Rock and Mill Tailings*. This document provides guidance to the licensee for the sound management of mine waste rock and mill tailings during site preparation, construction, operation and decommissioning of new uranium mine or mill projects and/or of new waste management facilities at existing uranium mines and mills in Canada.

Additionally, the CNSC is currently working with the CSA Group committee on amendments to CSA standard N294-09, *Decommissioning of Facilities Containing Nuclear Substances* (2009), which is planned for release in 2014.

3.1(h) Implementation of Fukushima Action Plan

Canada responded effectively to the Fukushima nuclear accident and is applying the lessons learned to improve safety. The CNSC issued requests to the licensees to confirm the safety case for each facility and to address the lessons learned from Fukushima. After assessing the responses and examining its own regulatory framework, the CNSC developed an action plan with clear deliverables in the short, medium and long terms for both nuclear power plant licensees and the CNSC. The numerous activities to address the actions have included, but are not limited to:

- deterministic and probabilistic safety assessments
- revisions to regulatory documents
- enhancements to modelling and analysis tools
- installation of new equipment that enhances defence in depth
- upgrades to emergency plans
- proposals to amend regulations
- procurement of emergency mitigating equipment and backup power
- conduct of large-scale emergency exercises
- enhancements to near-boundary radiation monitoring

All the short-term actions have been completed and all remaining actions are scheduled for completion during the next reporting period. See sections E.3.2 and E.8.2.3 for more information.

The CNSC's response to Fukushima was assessed by independent reviewers as being prompt, comprehensive and effective, and as taking into account the various lessons learned from the accident. In addition to the Fukushima review during the follow-up IRRS mission in 2011, the CNSC also established an external advisory committee of independent regulatory experts to assess its regulatory response to Fukushima. These reviews identified specific findings that complemented the draft CNSC Action Plan (in particular, related to emergency preparedness, communications, and human and organizational factors), as identified by the Commission during the public review phase of the draft report. CNSC staff incorporated activities to address these findings into its CNSC Integrated Action Plan, which covers not only nuclear power plants, but also other regulated nuclear facilities.

Overall, the actions taken by Canada will address the lessons learned from Fukushima and help prevent a similar accident or help mitigate its effects should it occur. For more information on Canada's implementation of the Fukushima Action Plan, refer to the 2013 *Canadian National Report for the Convention on Nuclear Safety, Sixth Report* at nuclearsafety.gc.ca/eng/resources/publications

4.0 Conclusion

Spent fuel and radioactive waste in Canada are currently managed in interim storage facilities that are safe, secure and environmentally sound. Interim storage facilities are continually monitored by the licensees and regulator to ensure fitness for service. Canada recognizes that enhanced, long-term management approaches will be required for all its spent fuel and radioactive waste and is progressing towards solutions. This Fifth National Report identifies several key initiatives that demonstrate Canada's commitment to identifying and implementing long-term management approaches that do not place an undue burden on future generations.

Section A – Introduction

A.1 Scope of the section

This section is a general introduction to the main themes of the report.

A.2 Introduction

The Government of Canada has jurisdiction over nuclear energy, and Natural Resources Canada (NRCan) is the department responsible for nuclear energy policy. The Government of Canada has long funded nuclear research as well as supported the development and use of nuclear energy and related applications. As a result of this investment:

- nuclear energy now supplies about 15 percent of Canada’s electricity
- the nuclear industry is a significant contributor to the Canadian economy, currently generating several billion dollars in economic activity and accounting for more than 30,000 highly skilled jobs
- Canada is one of the world’s largest suppliers of uranium, which continues to rank among the top 10 metal commodities in Canada for value of production

The Government of Canada is currently restructuring Atomic Energy of Canada Limited (AECL) with a view of reducing risks and costs to Canadian taxpayers while putting in place the conditions for Canada’s nuclear industry to succeed. In 2011, AECL’s Candu Reactor Division was successfully sold to Candu Energy Inc., a wholly owned subsidiary of the SNC-Lavalin Group. Canada’s government is now in the process of implementing a government-owned, contractor-operated (GoCo) model at AECL’s nuclear laboratories and will focus the work of the nuclear laboratories on three missions: managing the government’s radioactive waste and decommissioning responsibilities, performing science and technology activities to meet core federal responsibilities, and supporting Canada’s nuclear industry through access to science and technology facilities and expertise on a commercial basis. The process to procure the services of a private-sector contractor to manage and operate the nuclear laboratories is currently underway, with a pre-qualification stage launched in March 2014.

Throughout the restructuring of the nuclear laboratories, the Canadian government will continue its role in maintaining safety, security and environmental stewardship in all aspects of the nuclear industry. The Canadian Nuclear Safety Commission (CNSC), Canada's independent nuclear regulator, will continue to regulate all parts of the entire nuclear industry in Canada.

Under the new management model, the nuclear laboratories will focus on three key objectives:

1. managing Canada’s radioactive waste and decommissioning responsibilities accumulated during the more than 60 years of nuclear research and development at the Chalk River Laboratories (CRL) and Whiteshell Laboratories
2. ensuring that Canada’s world-class nuclear science and technology capabilities and knowledge continue to support the federal government in its nuclear roles and responsibilities – from health protection and public safety to security and environmental protection
3. providing access to industry to address its need for in-depth nuclear science and technology expertise – including ongoing access to the nuclear laboratories at fair market rates for owners and operators of CANDU reactors as well as the broader nuclear supply chain in Canada

Radioactive waste has been produced in Canada since the early 1930s when the first radium and uranium mine opened in Port Radium, Northwest Territories. Pitchblende ore was transported from the Port Radium mine to Port Hope, Ontario, where it was refined to produce radium for medical purposes and, later, uranium for nuclear fuel and military applications. Research and development on the application of nuclear

energy to produce electricity began in the 1940s at CRL. At present, radioactive waste is generated in Canada from the various stages and uses associated with the nuclear fuel cycle:

- uranium mining and milling
- refining and conversion
- nuclear fuel fabrication
- nuclear reactor operations
- nuclear research
- radioisotope manufacture and use

The Government of Canada gives high priority to the safety of persons and the protection of the environment from the various operations of the nuclear industry and has put in place modern legislation that provides the basis for Canada's comprehensive and robust regulatory regime. Canada's nuclear regulatory body is the CNSC. In addition to Natural Resources Canada (NRCan) and the CNSC, the major Government of Canada organizations involved in the Canadian nuclear industry include:

- **Health Canada (HC):** HC recommends radiological protection standards and monitors occupational radiological exposures.
- **Transport Canada (TC):** TC develops and administers policies, regulations and services for the Canadian transportation system, including the transportation of dangerous goods.
- **Environment Canada (EC):** EC contributes to sustainable development through pollution prevention to protect the environment and human health from the risks associated with toxic substances. EC is responsible for the administration of the *Canadian Environmental Protection Act* (CEPA).
- **Canadian Environmental Assessment Agency (CEA Agency):** The CEA Agency is responsible for the administration of the *Canadian Environmental Assessment Act, 2012* (CEAA 2012), the primary federal legislation (see annex 2.5 for a further description of the CEAA 2012). The CEA Agency works to provide Canadians with high-quality environmental assessments (EAs) that contribute to informed decision making in support of sustainable development, as does the CNSC for nuclear projects.
- **Major Projects Management Office (MPMO):** The MPMO is a sector within NRCan that provides overarching project management and accountability for major resource projects in the federal regulatory review process and that is responsible for facilitating improvements to the regulatory system for major resource projects. The MPMO serves as the single point of entry into the federal regulatory process for all stakeholders. The MPMO Initiative, an interdepartmental initiative across 12 federal departments and agencies, supports the Government of Canada's Responsible Resource Development plan, which was launched in 2012 to support government-wide efforts to improve the performance of the federal regulatory system for major natural resource projects. Under the plan, federal regulatory departments and agencies are working collaboratively to improve the efficiency and effectiveness of EA, regulatory permitting and Aboriginal consultation processes related to the review of major resource projects.
- **Northern Projects Management Office (NPMO):** The NPMO was established to improve the environmental review process for proposed major resource development and infrastructure projects in northern Canada. The NPMO has a mandate to improve the timeliness, predictability and transparency of northern regulatory processes to foster a more stable and attractive investment climate in the territories.

Annex 1 provides information on Canada's federal structure and detailed descriptions of federal institutions involved in nuclear energy.

The *Nuclear Safety and Control Act* (NSCA), the *Nuclear Fuel Waste Act* (NFWA), the *Nuclear Liability Act* (NLA) and the *Nuclear Energy Act* (NEA) are the centrepieces of Canada’s legislative and regulatory framework for nuclear matters. The NSCA is the key piece of legislation that ensures the safety of the nuclear industry and radioactive waste management in Canada. A detailed description of this legislative and regulatory framework is provided in annex 2.

Provincial governments are responsible for deciding their energy mix, including the role of nuclear energy. Provincial ministries may play roles in nuclear activities and radioactive waste management, with the details of those roles determined by each province.

A.3 Nuclear substances

Under the NSCA, the CNSC regulates nuclear substances in order to protect human health and the environment. The nuclear substances defined in the NSCA include any radioactive substance, plus deuterium, or any related compounds, as well as any substance that regulations define as being required for the production or use of nuclear energy.

Both radioactive waste and spent fuel contain nuclear substances and therefore are regulated in the same manner as any other nuclear substance. Section B.5 describes the policy on managing spent fuel and radioactive waste.

A.4 Canadian philosophy and approach to safety

Canada actively promotes and regulates safety within the nuclear sector. Canada’s approach is based upon several factors, including the review of international standards (e.g., International Atomic Energy Agency (IAEA) standards and guides) and improvements to regulatory policies and standards (e.g., regulatory policy P-299, *Regulatory Fundamentals*). Canada considers the adoption of international recommendations, such as those regarding radiological dose limits to the public and workers in the International Commission on Radiological Protection (ICRP) publication, *Recommendations of the International Commission on Radiological Protection* (ICRP-103, 2007), as well as protection of the environment. For example, limits for controlled release of gaseous or liquid effluents or solid materials are adopted from complementary regulatory regimes (such as Ontario’s *Provincial Water Quality Objectives* or *Metal Mining Effluent Regulations*) or derived from specific licence conditions (such as the derived release limits). The CNSC may also adopt other standards, established by organizations such as the CSA Group or the American Society of Mechanical Engineers (ASME).

The Commission sets the standards and conditions; it is then the responsibility of the person in possession of the associated nuclear substance, or the operator of the associated facility, to ensure the safety. For example, it is the licensee’s responsibility to demonstrate to the satisfaction of the regulatory body that a spent fuel facility or radioactive waste management facility can and will be operated safely throughout the lifetime of the facility. The regulatory regime is flexible about how licensees comply with regulatory requirements. The licensee must demonstrate how the design meets all applicable performance standards and will continue to do so throughout its design life.

A.5 Fundamental principles

The Canadian regulatory approach to the safety of spent fuel and radioactive waste management is based on three principles:

- lifecycle responsibility and licensing
- in-depth defence
- multiple barriers

A.6 Main safety issues

The main safety issue that this report begins to address is the long-term management of spent fuel and radioactive waste.

Currently, interim storage of all waste forms is being conducted in a safe manner. The Canadian nuclear industry and the Government of Canada are developing long-term waste management solutions that will protect health, safety, security and the environment. Key initiatives underway are described in section K of this report. Some of the most important challenges will be to bring these initiatives to fruition and develop and implement appropriate long-term solutions that instill and uphold the public's confidence.

In Canada, the development and implementation of the long-term management of radioactive waste is the responsibility of the waste owner. Ontario Power Generation (OPG), Canada's largest nuclear utility, has initiated this process for the long-term management of its low- and intermediate-level radioactive waste, with the submission of a licence application to the CNSC for its deep geological repository, which is further described in section K.6.1.

The long-term management of radioactive waste from past practices has presented the federal and provincial governments with challenges in developing and implementing appropriate remedial strategies and long-term waste management solutions. Several initiatives have been completed or are underway to address these sites, as described in sections H.6.1 and K.6.3.

A.7 Survey of the main themes

The main themes in this report are as follows:

- Canadian government departments and agencies and the nuclear industry have roles and responsibilities – confirmed in the 1996 *Radioactive Waste Policy Framework* – to ensure the safe management of spent fuel and radioactive waste.
- The primary responsibility for safety rests with the licensees. All licensees take their responsibilities for safety seriously and are able to raise adequate revenue to support safe operations.
- The Canadian safety philosophy and requirements, applied through the regulatory process, ensure that the risk to the workers, the public and the environment associated with spent fuel management and radioactive waste management is kept as low as reasonably achievable (ALARA), social and economic factors taken into consideration.
- The Canadian regulatory body has sufficient independence, authority and resources to ensure compliance with and enforcement of regulatory safety requirements that pertain to the management of spent fuel and radioactive waste.
- Industry and various levels of government are engaged in a number of initiatives to develop and implement long-term solutions for spent fuel and radioactive waste, as well as cleanup of wastes from past practices such as uranium mining and processing.

Section B – Policies and Practices

B.1 Scope of the section

This section addresses article 32 (Reporting) (1) of the Joint Convention and provides information on Canada's policies and practices for spent fuel and radioactive waste management.

B.2 Introduction

Under the current legislative and regulatory framework, spent fuel is considered to be another form of radioactive waste. As a result, legislation and policies on managing radioactive waste apply equally to spent fuel and other forms of radioactive waste.

B.3 Legislative instruments

Federal legislation used to regulate and oversee the nuclear industry, including the management of radioactive waste and spent fuel, comprises the *Nuclear Safety and Control Act* (NSCA), the *Nuclear Fuel Waste Act* (NFWA), the *Nuclear Liability Act* (NLA) and the *Nuclear Energy Act* (NEA), all described in annex 2. The nuclear industry is also subject to the *Canadian Environmental Assessment Act, 2012* (CEAA 2012), the *Canadian Environmental Protection Act* (CEPA) and the *Fisheries Act* (FA).

A number of Government of Canada departments are involved in administering these legislative instruments. Where multiple regulators are involved, the Canadian Nuclear Safety Commission (CNSC) establishes joint regulatory groups to coordinate and optimize the regulatory effort.

In addition, the nuclear industry is subject to the provincial acts and regulations in force within the individual provinces and territories where nuclear-related activities are carried out. Where there is an overlap of jurisdictions and responsibilities, the CNSC takes the lead in efforts to harmonize the regulatory activities, including joint regulatory groups, which involve provincial and territorial regulators.

B.4 National framework for radioactive waste management

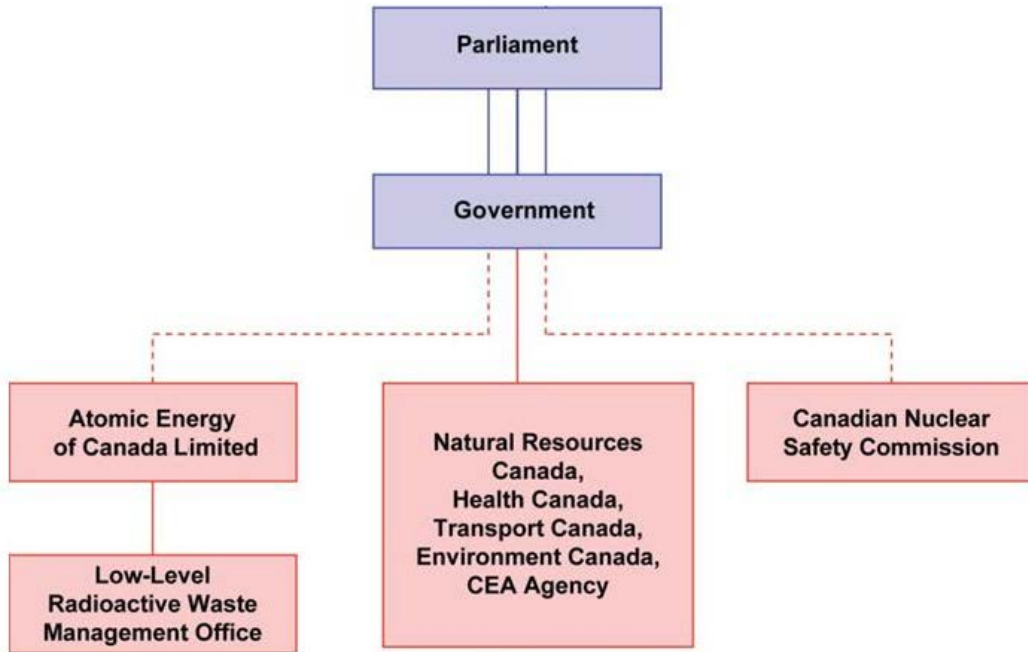
The 1996 Government of Canada *Policy Framework for Radioactive Waste* sets the stage for institutional and financial arrangements to manage radioactive waste in a safe, comprehensive, environmentally sound, integrated and cost-effective manner. The *Policy Framework for Radioactive Waste* specifies that:

- the Government of Canada is responsible for developing policy and regulating and overseeing radioactive waste producers and owners so that they meet their operational and funding responsibilities in accordance with approved long-term waste management plans
- waste owners are responsible, in accordance with the “polluter pays” principle, for funding, organizing, managing and operating long-term waste management facilities and other facilities required for their waste

The policy framework recognizes that arrangements may be different for the four broad categories of radioactive waste found in Canada: spent fuel, low-level radioactive waste, intermediate-level radioactive waste, and uranium-mine waste rock and mill tailings.

The Canadian institutional framework surrounding radioactive waste management is shown in figure B.1.

Figure B.1: The Canadian institutional framework



Natural Resources Canada (NRC) is the lead government department responsible for developing and implementing uranium, nuclear energy and radioactive waste management policies. It also administers the NFWA and is responsible for funding and managing a number of programs in the areas of historic low-level radioactive waste, legacy waste and uranium mine and mill tailings.

Historic low-level radioactive waste (LLW) is waste that was managed in the past in a manner no longer considered acceptable, for which the current owner cannot be reasonably held responsible and for which the Government of Canada has accepted responsibility for long-term management.

Legacy wastes (in the Canadian context) specifically date back to the Cold War and birth of nuclear technologies in Canada; these wastes are located at Atomic Energy of Canada Limited (AECL) sites. These wastes include existing radioactive wastes and wastes resulting from decommissioning disused buildings and infrastructure, as well as from environmental remediation.

Uranium mill tailings are wastes produced during the processing of uranium ores. These wastes are located at uranium mine sites in Saskatchewan, Ontario and the Northwest Territories. Most of the closed mine sites have been remediated and are now licensed by the CNSC. The closed mine and mill sites that have not yet been remediated are located in northern Saskatchewan. These mines and mills were operated in the late 1950s to early 1960s by companies that no longer exist, and government-funded projects are underway to remediate these sites (see annex 8 for more information).

Several other federal departments have been assigned roles and responsibilities for the safe management of spent fuel and radioactive waste, including Health Canada, Environment Canada and the Canadian Environmental Assessment Agency (CEA Agency). Additional information on all these departments and organizations, as shown in figure B.1, is provided in annex 1.

Atomic Energy of Canada Limited (AECL) and the CNSC are connected to the Canadian government by dashed lines to illustrate their arms-length relationships. They both report to Parliament through a Minister within the government. AECL is a Crown corporation, owned entirely by the Government of Canada and run by a Board of Directors. AECL's mandate includes the management of the waste it generates from ongoing research, legacy radioactive waste and decommissioning liabilities on its properties, as well as for the waste it accepts for long-term management from non-utility radioactive waste producers across Canada on a fee-for-service basis. AECL also staffs and manages the Low-Level Radioactive Waste Management Office (LLRWMO), which is the national agent for the cleanup and management of Canada's historic low-level radioactive waste. The LLRWMO is operated via a Memorandum of Understanding between Natural Resources Canada (NRCan) and AECL, through which NRCan provides the funding and policy direction for the LLRWMO.

The CNSC is Canada's independent nuclear regulatory body. Its mandate is to regulate the use of nuclear energy and materials to protect health, safety, security and the environment, and to implement Canada's international commitments on the peaceful use of nuclear energy; and to disseminate objective scientific, technical and regulatory information to the public. The CNSC's regulatory decision process is fully independent from the Government of Canada.

B.5 Regulatory policy on managing spent fuel and radioactive waste

In July 2004, the CNSC issued regulatory policy P-290, *Managing Radioactive Waste*, following extensive consultation with the public and industry stakeholders. The policy outlines the philosophy and six principles that govern the CNSC's regulation of radioactive waste. It is fully consistent with the federal *Policy Framework for Radioactive Waste*. The CNSC's regulatory policy P-290 identifies the need for long-term management of radioactive and hazardous waste arising from licensed activities.

The policy statement in regulatory policy P-290 defines radioactive waste as any form of waste material containing a nuclear substance as defined in the NSCA. This definition is sufficiently comprehensive to include spent fuel without any other special consideration. The policy indicates that, when making regulatory decisions about the management of radioactive waste, the CNSC will seek to achieve its objectives by considering certain key principles in the context of the facts and circumstances of each case, as follows:

1. The generation of radioactive waste is minimized to the extent practicable by the implementation of design measures, operating procedures and decommissioning practices.
2. The management of radioactive waste is commensurate with its radiological, chemical and biological hazard to the health and safety of persons, to the environment and to national security.
3. The assessment of future impacts of radioactive waste on the health and safety of persons and the environment encompasses the period of time when the maximum impact is predicted to occur.
4. The predicted impacts on the health and safety of persons and the environment from the management of radioactive waste are no greater than the impacts that are permissible in Canada at the time of the regulatory decision.
5. The measures needed to prevent unreasonable risk to present and future generations from the hazards of radioactive waste are developed, funded and implemented as soon as reasonably practicable.
6. The transborder effects on the health and safety of persons and the environment, which could result from the management of radioactive waste in Canada, are not greater than the effects experienced in Canada.

The differences between spent fuel and other forms of radioactive waste are addressed by the application of the second principle described above, indicating that waste is expected to be managed according to its hazard.

The principles contained in regulatory policy P-290 are consistent with those recommended by the International Atomic Energy Agency (IAEA) in Safety Series 111-F, *The Principles of Radioactive Waste Management*. The P-290 policy statement recognizes the regulatory body's commitment to optimizing regulatory effort, as indicated by the following statement:

It is also the policy of the CNSC to consult and cooperate with provincial, national and international agencies to:

- promote harmonized regulation and consistent national and international standards for the management of radioactive waste, and
- achieve conformity with the measures of control and international obligations to which Canada has agreed concerning radioactive waste.

B.6 Regulatory guide G-320, *Assessing the Long Term Safety of Radioactive Waste Management*

Published in December 2006, regulatory guide G-320, *Assessing the Long Term Safety of Radioactive Waste Management*, helps licensees and applicants assess the long-term impacts that radioactive waste storage and disposal methods have on the environment and the health and safety of people. Specifically, the guide addresses:

- assessment approaches, structures and methodologies
- level of detail of assessments
- confidence to be placed in assessment results
- application of radiological and non-radiological criteria
- definition of critical groups for impact assessments
- selection of time frames for impact assessments
- setting of post-decommissioning objectives
- long-term care and maintenance considerations
- use of institutional controls

Regulatory guide G-320 does not, however, address the social acceptability or economic feasibility of long-term management methods, nor does it address the assessment of facility operations. A copy of the guide is available on the CNSC website at nuclearsafety.gc.ca/eng/acts-and-regulations/regulatory-documents

B.7 Classification of radioactive waste in Canada

Established in 1919, the Canadian Standards Association (now called the CSA Group) is a not-for-profit organization composed of representatives from the government, industry and consumer groups. Its primary product is safety and performance standards, including those for electronic and industrial equipment, boilers and pressure vessels, compressed gas handling appliances, and environmental protection and construction materials. The CSA provides training materials and information products. It also revised the CAN/CSA Z299 series of quality assurance standards in 2012 to CSA N286; these standards are used today and represent an alternative to the ISO 9000 series of quality standards.

As reported in the Fourth National Report, the CSA Group – in collaboration with industry, government and the CNSC – developed a standard that includes a radioactive waste classification system, CSA 292.0-14, which takes into account IAEA Safety Guide GSG-1, *Classification of Radioactive Waste*, along with the

needs of the Canadian industry. The standard was published in March 2008. The radioactive waste classification system described below recognizes four main classes of radioactive waste:

- high-level radioactive waste (HLW) (see section B.7.1)
- intermediate-level radioactive waste (ILW) (see section B.7.2)
- low-level radioactive waste (LLW) (see section B.7.3)
- uranium mine and mill waste (see section B.7.4)

Sub-classes for LLWs are also identified to provide better guidance on the appropriate waste management needs.

Organization of classification system

The radioactive waste classification system is organized according to the degree of containment and isolation required to ensure safety in the short and long terms. The classification system also takes into consideration the hazard potential of different types of radioactive waste.

A definitive numerical boundary between the various categories of radioactive waste, primarily between LLW and ILW, cannot be provided because activity limitations differ between individual radionuclides and radionuclide groups, and will be dependent on short- and long-term safety-management considerations. For example, a contact dose rate of 2 millisieverts per hour (mSv/h) has been used in some cases to distinguish between LLW and ILW.

The following sections provide an overview of the four main classes of radioactive waste in Canada.

B.7.1 High-level radioactive waste

High-level radioactive waste (HLW) is used (irradiated) nuclear fuel that has been declared radioactive waste or waste that generates significant heat (typically more than 2 kilowatts per cubic metre) via radioactive decay. In Canada, “irradiated nuclear fuel” or “used nuclear fuel” are more accurate terms for spent fuel, because discharged fuel is considered a waste material even when it is not fully spent. In spite of the name difference, in this report the term “spent fuel” is used to be consistent with the terminology found in the Joint Convention.

Spent fuel is associated with penetrating radiation, which requires shielding. Furthermore, spent fuel contains significant quantities of long-lived radionuclides, meaning that long-term isolation is also required. Waste forms derived from spent fuel (e.g., nuclear fuel reprocessing wastes) can exhibit similar characteristics and may be considered HLW.

Placement in deep, stable geological formations is considered the preferred option for the long-term management of HLW.

B.7.2 Intermediate-level radioactive waste

Intermediate-level radioactive waste (ILW) is waste that typically exhibits sufficient levels of penetrating radiation to warrant shielding during handling and interim storage. This type of radioactive waste generally requires little or no provision for heat dissipation during its handling, transportation and long-term management. However, some ILW may have heat generation implications in the short term (e.g., refurbishment waste) because of its total radioactivity level.

B.7.3 Low-level radioactive waste

Low-level radioactive waste (LLW) contains material with radionuclide content above established clearance levels and exemption quantities, and generally limited amounts of long-lived activity. LLW requires isolation and containment for up to a few hundred years. LLW generally does not require significant shielding during handling and interim storage.

Very-short-lived low-level radioactive waste

Very-short-lived low-level radioactive waste (VSLLW) is waste that can be stored for decay for up to a few years and subsequently cleared for release. This classification includes radioactive waste containing only short half-life radionuclides of the kind typically used for research and biomedical purposes. Examples of VSLLW are iridium-192 and technetium-99m sources, as well as industrial and medical radioactive waste that contains similar short half-life radionuclides.

Generally, the main criterion for VSLLW is the half-life of the predominant radionuclides. In practice, the management of VSLLW should be applied only to radionuclides with a half-life of 100 days or less.

Very-low-level radioactive waste

Very-low-level radioactive waste (VLLW) has a low hazard potential, but is nevertheless above the criteria for exemption. Long-term waste management facilities for VLLW do not usually need a high degree of containment or isolation. A near-surface repository with limited regulatory control is generally suitable. Typically, VLLW includes bulk material, such as low-activity soil and rubble, decommissioning wastes and some uranium-contaminated wastes.

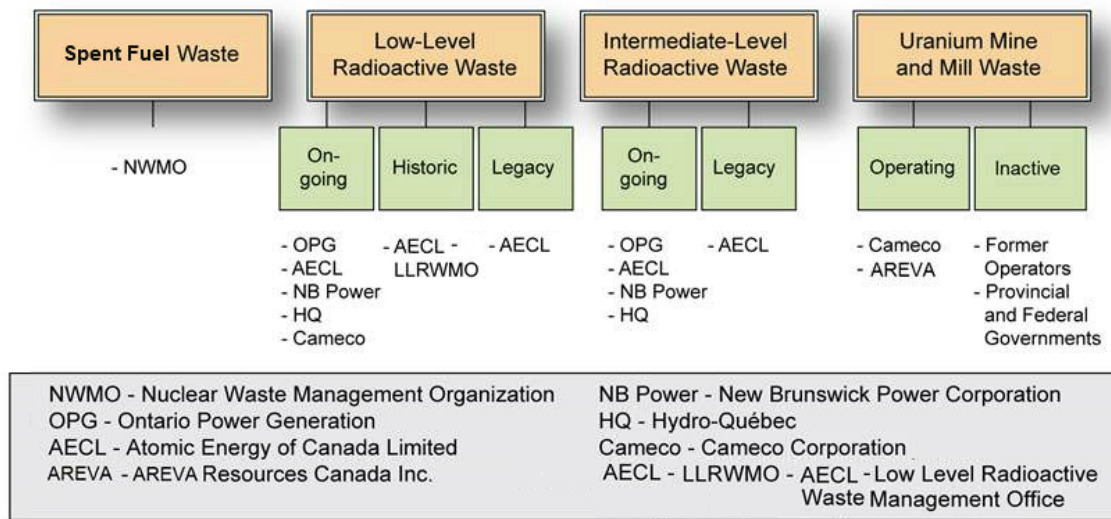
B.7.4 Uranium mine and mill waste

Uranium mine waste rock and mill tailings are a specific type of radioactive waste generated during the mining and milling of uranium ore and the production of uranium concentrate. In addition to tailings, mining activities typically produce large quantities of mineralized and clean waste rock excavated to access the ore body. The tailings and mineralized waste rock contain significant concentrations of long-lived radioactive elements, namely thorium-230 and radium-226.

B.8 Operational responsibilities for long-term management

Although numerous government departments, agencies, hospitals, universities and industry members are involved in the management of radioactive waste, only a limited number of organizations are involved in long-term management. Figure B.2 shows the organizations responsible for the long-term management of spent fuel and radioactive waste in Canada.

Figure B.2: Organizations responsible for the long-term management of spent fuel and radioactive waste in Canada



The Nuclear Waste Management Organization (NWMO) is responsible for implementing the Adaptive Phased Management (APM) approach as selected by the Government of Canada for the long-term management of spent fuel. (See sections G.16 and K.4.)

Ontario Power Generation (OPG), New Brunswick Power (NB Power) and Hydro-Québec (HQ) are responsible for the long-term management of L&ILW generated from nuclear reactor operations. This includes the spent fuel generated at their respective reactor sites until the NWMO is ready to accept the spent fuel for management in a facility constructed under the APM approach. OPG is also responsible for the long-term management of low- and intermediate-level radioactive waste and spent fuel generated at the Bruce Nuclear Generating Station. Refer to section K.6.1 for information on OPG's proposed Deep Geologic Repository for the long-term management of its low- and intermediate-level radioactive waste.

Atomic Energy of Canada Limited (AECL) is responsible for the long-term management of L&ILW generated by Whiteshell Laboratories, Chalk River Laboratories and the three partially decommissioned prototype reactors (Gentilly-1, Nuclear Power Demonstration (NPD) and Douglas Point), as well as for the low- and intermediate-level radioactive waste it accepts from other Canadian licensees on a fee-for-service basis. AECL is responsible for spent fuel, including spent research reactor fuel, until the NWMO is ready to accept the spent fuel for management in a facility constructed using the APM approach, as well as for spent CANDU fuel sent to its laboratories for examination. (For information on AECL's long-term waste management strategy for its low- and intermediate-level radioactive waste, refer to section K.6.2.)

The AECL-LLRWMO manages historic low-level radioactive waste on behalf of the Government of Canada. (See sections H.6.1, K.6.2 and K.6.3.)

Cameco Corporation and AREVA Resources Canada Inc. manage the only operating uranium mines and mills in Canada (see annex 6). Inactive uranium mines and mills sites are located in Ontario, the Northwest Territories and Saskatchewan, as described in annexes 7 and 8.

The term "inactive" is used to describe several different types of inventories, including:

- tailings sites that are currently being decommissioned

- tailings sites at operating mill sites where closure activities are in progress (e.g., Rabbit Lake and Key Lake)
- tailings sites at former milling locations – including recently decommissioned sites with engineered tailings containment systems, such as some of the Denison Mines and Rio Algom sites in the Elliot Lake area, as well as sites that date back to the earliest era of nuclear energy production in Canada when tailings were deposited in lakes or low areas near lakes (e.g., Port Radium)

All of these inactive sites are either already licensed by the CNSC or in the process of becoming licensed. The site owners are responsible for monitoring and any future remedial work that may be required to protect human health and safety or the environment. Two former uranium mine tailings sites in Saskatchewan have yet to be fully decommissioned: the Gunnar and Lorado sites. The provincial government will decommission the sites, as described in annex 8.1.1.2 and 8.1.1.3.

B.9 Management practices for spent fuel

Spent fuel consists of irradiated fuel bundles removed from commercial, prototype and research nuclear reactors. Three provincial nuclear utilities (OPG, HQ and NB Power) own about 98 percent of the spent fuel in Canada. AECL owns the remaining two percent. Spent fuel includes nuclear fuel waste, as well as any research reactor fuel waste that is not in the form of a CANDU fuel bundle.

Canada does not have a long-term waste management facility for spent fuel. All spent fuel is currently held in interim wet or dry storage at the nuclear generating stations where it is produced, with the exception of the spent fuel produced at the now-closed NPD nuclear facility, which is stored at AECL Chalk River Laboratories. Spent fuel discharged from CANDU reactors is placed into special wet storage bays for several years, depending on site-specific needs, and is eventually transferred to an interim dry storage facility. Three designs of dry storage containers are used in Canada:

- AECL silos
- AECL Modular Air-Cooled Storage (MACSTOR)
- OPG dry storage containers

For a complete description of these dry storage containers, refer to annex 4.3.

To address the long-term management of spent fuel, the three major waste owners – OPG, HQ and NB Power – established the NWMO in 2002 under the NFWA.

For a full description of the NWMO's long-term management plan for Canada's spent fuel and site selection process, refer to sections G.16 and K.4.

B.10 Management practices for low- and intermediate-level radioactive waste

In Canada, low- and intermediate-level radioactive waste (L&ILW) refers to all forms of radioactive waste except spent fuel and waste derived from uranium and thorium mining and milling.

OPG, which owns 20 of Canada's 22 CANDU reactors, is responsible for approximately 68 percent of the annual volume of L&ILW resulting from the generation of nuclear power. Meanwhile, AECL is responsible for approximately 19 percent of the annual volume through its research and development activities at the Chalk River Laboratories (CRL). AECL also accepts L&ILW for long-term management from a number of small producers and users of radioactive materials, which amounts to a further three percent of Canada's annual volume. The other two CANDU reactors (owned by NB Power and HQ) and Cameco Corporation's uranium processing and conversion facilities in Ontario generate the majority of the remaining waste. The owners of L&ILW are licensed by the CNSC to manage and operate storage facilities

for their radioactive wastes. In addition, the two major waste owners, OPG and AECL, are pursuing long-term management solutions.

For electricity generation, OPG's L&ILW from its CANDU reactors is safely stored in a central location at the Western Waste Management Facility at the Bruce nuclear site in Kincardine, Ontario. OPG entered into an agreement with the Municipality of Kincardine on October 13, 2004, to host a deep geological repository designed to hold current and future L&ILW from OPG's 20 CANDU reactors. More information on this initiative is provided in section K.6.1. NB Power and HQ have their own facilities for the interim storage of L&ILW at their reactor sites.

For research and development, AECL has waste storage facilities at its two laboratory sites – CRL and Whiteshell Laboratories – as well as at its three prototype reactor sites. Operational storage facilities include the Bulk Materials Landfill for dewatered sewage sludge, modular above-ground storage structures (MAGS), shielded modular above-ground storage (SMAGS) structures, concrete bunkers and tile holes. AECL also accepts L&ILW from small generators, such as those from hospitals, universities and small industries, on a fee-for-service basis.

As described in section K.6.2, the Government of Canada initiated the Nuclear Legacy Liabilities Program (NLLP) to deal with legacy radioactive waste and decommissioning liabilities at AECL sites. The program involves developing and constructing the infrastructure required to characterize, condition, treat, process, package and store legacy waste and to implement long-term solutions. The L&ILW that is generated by AECL's ongoing operations, as well as that accepted from third-party generators, will also be managed in these facilities. Program progress and achievements during the last three years of implementation are summarized in sections K.6.2.1 to K.6.2.3.

Radioactive waste from hospital nuclear medicine departments and from universities and similar facilities contains only small amounts of radioactive materials with short half-lives. The radioactivity of this waste normally decays within hours, days or months. Institutions such as hospital nuclear medicine departments and universities have implemented delay-and-decay programs, after which waste can be treated using conventional means.

Canada has significant volumes of LLW, referred to as historic waste, that was once managed in a manner no longer considered acceptable, but for which the current owner cannot be reasonably held responsible. Canada's historic waste inventory consists largely of radium- and uranium-contaminated soils in the form of spilled ores on the Northern Transportation Route (NTR) associated with a mine site in Canada's North, and refinery process residues in the area of Port Hope, Ontario. The Government of Canada has accepted responsibility for the long-term management of these wastes.

The bulk of Canada's historic LLW is located in the southern Ontario communities of Port Hope and Clarington. These wastes and contaminated soils amount to roughly 1.7 million cubic metres and relate to the historic operations of a radium and uranium refinery in the Municipality of Port Hope dating back to the 1930s. Although the LLW materials under management do not pose an immediate unacceptable risk to human health and the environment, there is general consensus in the local community, as well as in professional and regulatory communities, that the *in situ* management systems currently implemented are not suitable long-term solutions.

In March 2001, the Government of Canada and the local municipalities agreed to community-developed proposals as potential solutions for the cleanup and long-term management of historic LLW in the Port Hope area, launching the Port Hope Area Initiative (PHAI). The PHAI and other initiatives dealing with historic waste are described in section K.6.3.1 and annexes 8.2.1.1 and 8.2.1.2.

AECL, under the PHAI Management Office, continues to ensure the safe management of the historic LLW until the implementation of the PHAI is complete. At some sites, decontamination has proven to be technically and economically feasible. The management methods used included packaging the historic LLW in drums and consolidating the material into engineered, above-ground containment cells on access-

controlled sites. Regular inspection and monitoring verify the continued safety of these sites. (Refer to section K.6.3 for more information.)

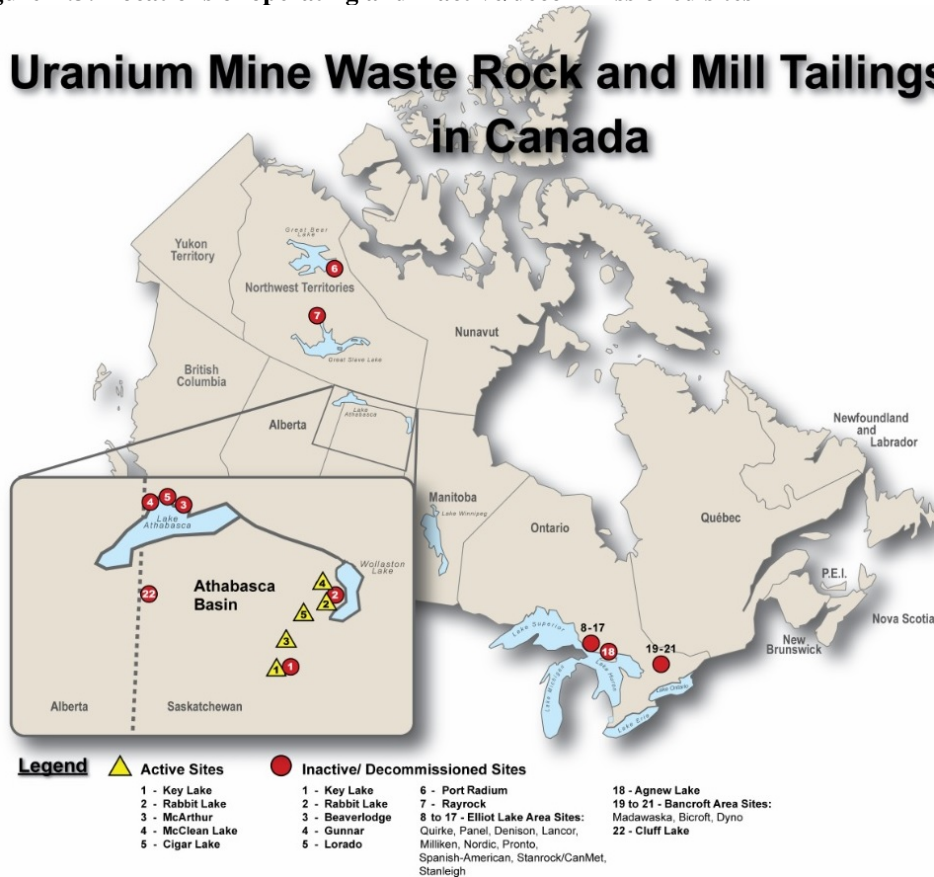
Up until May 2014, the NTR was issued a licensing exemption. CNSC staff informed the Commission that the current licensing exemption for the NTR will be lifted, as the radiation levels are so low that they are below regulatory clearance levels. The NTR is now being safely managed through the associated land management agencies, where applicable.

B.11 Management practices for uranium mine waste rock and mill tailings

Uranium mining and milling processes generate two major sources of radioactive waste: mine waste rock and mill tailings.

Over 200 million tonnes of uranium mill tailings have been generated in Canada since the mid-1950s. There are 25 tailings sites in Ontario, Saskatchewan and the Northwest Territories (figure B.3), 22 of which no longer receive waste material. The three remaining operational tailings management facilities (TMFs) are located in Saskatchewan. The ore mined at McArthur River is transported to Key Lake for milling, resulting in no tailings management areas at the McArthur mine site. Similarly, the ore from Cigar Lake is transported to McClean Lake for milling; tailings reside at the McClean Lake TMF. Both milling and mining are conducted at Rabbit Lake, resulting in tailings being managed at that site. All operational and inactive uranium tailings sites are the joint regulatory responsibility of the CNSC and the provinces and territories where the sites are located.

Figure B.3: Locations of operating and inactive/decommissioned sites



Historically, tailings were used as backfill in underground mines, deposited directly into lake basins or placed in low areas on the ground surface and confined by either permeable or water-retaining dams. Surface tailings were left bare, covered with soil or flooded; some bare or covered tailings may have been vegetated. In response to evolving regulatory requirements, the containment structures for surface tailings have become much more rigorously engineered for long-term storage and stability. Tailings management methods at operational facilities include chemically treating tailings to control their mineralogy prior to placing them in hydrostatically contained TMFs converted from mined-out open pits.

Contaminated industrial wastes are typically either recycled or landfilled at the site-specific TMF. The quantities of contaminated industrial wastes are tracked and recorded; however, in the context of the overall site inventory of radioactive wastes, the actual amount of low specific activity material contained in this volume is negligible and is effectively accounted for in the overall tailings quantity for each site.

In addition to the tailings produced from milling uranium ore, millions of cubic metres of waste rock are excavated to gain access to ore. At the Athabasca Basin open-pit sites, most of this waste rock is sandstone, which is environmentally benign and suitable for surface disposal. Some of the waste rock, however, contains either low-grade, uneconomic ore or significant concentrations of secondary minerals. If left exposed on the surface indefinitely, this “special waste rock” could generate acid or release contaminants at rates that could impact the local environment. The current method of managing special waste rock is to either blend it with high-grade ore for processing or isolate it from atmospheric conditions (e.g., locate it at the bottom of a flooded pit), keeping it in an environment similar to that from which it was mined and preventing oxidation reactions. In underground mines, waste rock can be used in the mine as backfill material. Waste rock materials used for purposes underground are not classified as waste materials in the waste inventory.

The inventory of nuclear substances in some inactive uranium tailings management areas can result in these areas being licensed as Class I nuclear facilities under the *Class I Nuclear Facilities Regulations*, pursuant to the NSCA. (Refer to section E.3.2.) This has implications for the licensing requirements and long-term management of such facilities. Those responsible for inactive tailings management areas with smaller inventories can be licensed for possession of nuclear substances. These inactive tailings disposal areas and facilities will remain under CNSC licence control in the absence of a suitable alternative. The Government of Saskatchewan, however, has developed such an alternative for decommissioned mining sites (not limited to uranium) on Crown land. (See section H.10.3.)

Current management practices for CNSC-licensed facilities use a lifecycle planning process. A preliminary decommissioning plan and financial guarantees for decommissioning are integral to the licence approval process and are required in the first stages of CNSC licensing – site preparation and construction (see section F.8). All phases in the lifecycle of a facility are subject to an environmental assessment process.

Section C – Scope of Application

C.1 Scope of the section

This section addresses article 3 (Scope of Application) of the Joint Convention. It provides Canada's position on reprocessing spent fuel, naturally occurring radioactive waste and military and defence programs.

C.2 Introduction

While neither the *Nuclear Safety and Control Act* (NSCA) nor its associated regulations define radioactive waste, regulatory policy P-290 *Managing Radioactive Waste* asserts that radioactive waste is:

Any liquid, gaseous or solid material that contains a nuclear substance, as defined in section 2 of the NSCA and for which the owner of the material foresees no further use and the owner had declared as waste. By definition, radioactive waste may contain non-radioactive constituents.

Radioactive waste is therefore regulated in the same manner as all other materials that contain a nuclear substance. All radioactive waste, whether from a large nuclear facility or a small-scale user, is subject to the Joint Convention, with the exception of:

- reprocessed spent fuel
- naturally occurring radioactive materials
- radioactive waste generated by military and defence programs

C.3 Reprocessed spent fuel

Given Canada's large natural resource of uranium, the nuclear industry has not deemed it necessary to reprocess spent fuel at this time. Therefore, pursuant to article 3(1) of the Joint Convention, Canada declares that reprocessing activities are not part of Canada's spent fuel management program and so are not included in this report. Note, however, that Chalk River Laboratories did reprocess spent fuel in the 1940s to 1960s to extract plutonium. The wastes from these activities are discussed later in annexes 7.5.2 and 7.5.3.

In accordance with article 3(1), medical isotope production fuel is also excluded from the report because it is processed to extract isotopes and so is outside the scope of the Joint Convention and protected from disclosure under article 36.

C.4 Naturally occurring nuclear substances

Naturally occurring nuclear substances, other than those that are or have been associated with the development, production or use of nuclear energy, are exempt from the application of all provisions of the NSCA and its associated regulations, except:

- provisions that pertain to the transport of radioactive materials
- in the case of naturally occurring radioactive material listed in the schedule to the *Nuclear Non-proliferation Import and Export Control Regulations*, provisions that govern the import and export of radioactive materials

In accordance with article 3(2) of the Joint Convention, only non-exempt naturally occurring radioactive substances are discussed in this report – namely, radium-bearing wastes resulting from the former radium industry, and tailings and waste rock from uranium mines and mills.

C.5 Department of National Defence programs

Although, under section 5 of the NSCA the Department of National Defence's programs are not subject to the NSCA or its associated regulations, the Royal Military College (RMC) of Canada's Safe Low-Power Critical Experiment (SLOWPOKE) reactor is, because it is operated as a research reactor (see section G.4.1). Therefore, in accordance with article 3(3) of the JC, the RMC SLOWPOKE reactor is the only military or defence program addressed in this report.

Section D – Inventories and Lists

D.1 Scope of the section

This section addresses article 32 (Reporting) (2) of the Joint Convention. It provides a list of the various spent fuel and radioactive waste management facilities in Canada and indicates the total inventory of each of the waste categories. Each licensee is required to develop and implement an accountability system, including the appropriate records. This system and associated records are subject to regulatory oversight. Figure D.1, a map showing the locations of radioactive waste management sites in eastern, central and western Canada, is exhibited in section D.4.

D.2 Inventory of spent fuel in Canada

D.2.1 Spent fuel wet storage inventory at nuclear reactor sites

Almost all nuclear generating stations and research reactor sites store spent fuel onsite in irradiated fuel bays (wet storage), pending transfer to a dedicated spent fuel dry storage centre. Table D.1 inventories the number of spent fuel bundles in wet storage in Canada, and table D.2 the spent fuel in dry storage.

Table D.1: Inventory of spent fuel in wet storage in Canada as of December 31, 2013

Site	Number of fuel bundles in wet storage	Kilograms of uranium ^[4]
Bruce A and Bruce B Nuclear Generating Stations	690,933	13,166,247
Darlington Nuclear Generating Station	335,150	6,422,369
Gentilly-2 Nuclear Generating Station	33,341	634,000
Pickering A and B Nuclear Generating Station	405,255	8,042,254
Point Lepreau Nuclear Generating Station	37,874	715,023
McMaster Nuclear Research Reactor	24 ^[1]	27
Chalk River Laboratories (CRL) – National Research Universal (NRU)	431 ^[1]	2,286 ^[2]

Table D.2: Inventory of spent fuel in dry storage facilities in Canada as of December 31, 2013

Site	Number of fuel bundles in dry storage	Kilograms of uranium ^[4]
CRL Waste Management Area (WMA) G	4,886	65,395 ^[2]
CRL WMA B (spent research reactor fuel)	7,349 ^[1]	33,313 ^[3]
Darlington Waste Management Facility	120,151	2,289,415
Douglas Point Waste Management Facility	22,256	299,827
Gentilly-1 Waste Management Facility	3,213	67,595
Gentilly-2 Waste Management Facility	96,600	1,835,000

Site	Number of fuel bundles in dry storage	Kilograms of uranium ^[4]
Pickering Waste Management Facility	270,804	5,379,586
Point Lepreau Waste Management Facility	87,480	1,651,535
Western Waste Management Facility (located at Bruce site)	360,182	6,833,453
Whiteshell Laboratories	2,268	21,540

^[1] Inventory is reported as the number of irradiated fuel rods, fuel assemblies, units and items.

^[2] Spent fuel material includes irradiated natural and depleted uranium, thorium and plutonium.

^[3] Area B includes natural thorium rods fuel.

^[4] Reported as spent fuel (depleted or enriched fuel), unless otherwise noted.

D.3 Radioactive waste inventory

D.3.1 Radioactive waste management facilities

Table D.3 describes the low- and intermediate-level waste being stored, the waste management methods and the inventory of low- and intermediate-level waste in storage at each facility in Canada. The table includes waste generated from normal operations, but does not include decommissioning waste; decommissioning waste is presented in table D.5.

Table D.3: Inventory of radioactive waste management for low-level radioactive waste (LLW) and intermediate-level radioactive waste (ILW) in Canada as of December 31, 2013

Radioactive waste management or nuclear fuel cycle facility	Company name or responsible party	Description of stored waste	Storage method	Onsite waste inventory as of December 31, 2013			
				ILW		LLW	
				Volume (m ³)	Activity (TBq)	Volume (m ³)	Activity (TBq)
Western Waste Management Facility (WWMF)	Ontario Power Generation (OPG)	Interim storage of low- and intermediate-level reactor waste generated from Bruce A and B, Darlington, and Pickering A and B	ILW: In-ground storage structures (trenches, tile holes, in-ground containers) and above-ground storage structures (retube waste storage building, quadricells) LLW: Above-ground storage structures (low-level storage buildings, steam generator storage buildings)	11,850 ^[7]	56,702	83,880 ^[7]	86

Radioactive waste management or nuclear fuel cycle facility	Company name or responsible party	Description of stored waste	Storage method	Onsite waste inventory as of December 31, 2013			
				ILW		LLW	
				Volume (m ³)	Activity (TBq)	Volume (m ³)	Activity (TBq)
Pickering Waste Management Facility	OPG	Interim storage of intermediate-level reactor refurbishment waste from Pickering A (Units 1 to 4)	ILW: Dry storage modules	2,210 ^[7]	127,155	N/A	N/A
Gentilly-2	Hydro-Québec	Operational reactor waste	ILW: ASDR and IGDRS (concrete cells) LLW: ASDR and IGDRS (concrete cells)	344	38	1,281	5.8
Point Lepreau	New Brunswick Power Corporation	Operational waste: Drums, filters, compactable	LLW: Concrete vault structures ILW: Concrete vault structures	162	789	2,911	178
Chalk River Laboratories	Atomic Energy of Canada Ltd. (AECL)	Research reactor and isotope production waste, external waste	ILW: Tile holes and bunkers LLW: Sand trenches, low-level storage buildings, above-ground stockpiles, MAGS, and Bulk Materials Landfill ILW/LLW: SMAGS	19,129 ^[5]	N/A	120,917 ^[5]	N/A
		Contaminated soils	Luggers, 205-litre steel drums, B-25 containers in SMAGS, sand trenches, above-ground stockpiles	nil	nil	382,841	N/A

Radioactive waste management or nuclear fuel cycle facility	Company name or responsible party	Description of stored waste	Storage method	Onsite waste inventory as of December 31, 2013			
				ILW		LLW	
				Volume (m ³)	Activity (TBq)	Volume (m ³)	Activity (TBq)
Whiteshell Laboratories	AECL	Research reactor waste and decommissioned reactor waste	ILW: In-ground concrete bunkers LLW: Above-ground concrete bunkers	863 ^[5]	2,942	19,885 ^[5]	333
Douglas Point Waste Management Facility	AECL	Contaminated soils	LLW: 205-litre drums	nil	nil	66	N/A
Gentilly-1 Waste Management Facility	AECL	Contaminated soils	LLW: 205-litre drums	nil	nil	1	N/A
Port Hope Conversion Facility	Cameco	Non-combustible process waste	LLW: 205-litre drums	nil	nil	7,000	N/A
Blind River Refinery	Cameco	Non-combustible process waste	LLW: 205-litre drums	nil	nil	6,300	N/A
Port Hope Fuel Manufacturing	Cameco	Non-combustible process waste	LLW: 205-litre drums	nil	nil	1,400	N/A
Radioactive Waste Operations Site 1	OPG	Interim storage of low- and intermediate-level reactor waste generated from Douglas Point and Pickering A (Units 1 to 4)	ILW: In-ground storage structures (trenches, tile holes) LLW: In-ground storage structures (trenches)	10 ^[7]	12 ^[6]	330 ^[7]	<1 ^[6]

^[5] Volumes are based on method of storage and do not necessarily represent the actual breakdown of waste into intermediate- and low-level categories.

^[6] Radioactive Waste Operations Site 1 activity estimated based on activity of waste stored at the Western Waste Management Facility.

^[7] Rounded up to nearest 10 m³.

Table D.4 describes the radioactive waste from past practices that is stored at each site and how it is managed.

Table D.4: Management of LLW from past practices

Site name or location	Licensee or responsible party	Description of stored waste	Storage method	LLW	
				Volume (m ³)	Activity (TBq)
Port Hope	AECL	Contaminated soils	<i>In situ</i> and consolidated storage	720,000	N/A
Welcome Waste Management Facility	AECL	Contaminated soils	Above-ground mound	454,380	N/A
Port Granby	AECL ^[8]	Waste and contaminated soils	Trench burial	438,200	N/A
Northern Transportation Route ^[9]	AECL (LLRWMO)	Contaminated soils	<i>In situ</i> and consolidated storage	54,403	N/A
Greater Toronto Area ^[10]	AECL-LLRWMO Regional Municipality of Peel, Ontario	Radium-contaminated soils, radium contamination fixed to structural elements in buildings	<i>In situ</i> and consolidated storage Above-ground consolidated mound	15,941	N/A
Deloro Mine Site	Ontario Ministry of the Environment	Contaminated soils and historical tailings	<i>In situ</i> (fenced-in area)	38,000	6.3
Chalk River Laboratories	AECL-LLRWMO	Packaged soils and artefacts	Area “D”: Buildings and luggers	1,000	0.02

^[8] In March 2012, the Government of Canada took possession from Cameco, and Atomic Energy of Canada Limited (AECL) assumed responsibility for the existing Port Granby waste management facility.

^[9] Includes 43,282 m³ of waste from Fort McMurray. The Fort McMurray and Fort Smith mounds were released from the requirement to license in 2009. The remaining sites are currently exempted from the requirement to license until 2016.

^[10] These sites are currently exempted from the requirement to license until 2016. The Passmore, Lakeshore Road and Peterborough sites were released from the requirement to license in 2009. Responsibility to find a long-term solution varies on a site-by-site basis.

Table D.5 inventories the low- and intermediate-level radioactive waste resulting from decommissioning activities at Canadian facilities, as of December 31, 2013.

Table D.5: ILW and LLW in Canada from decommissioning activities as of December 31, 2013

Site name or location	Company name or responsible party	Description of stored waste	Storage method	Onsite waste inventory as of December 31, 2013			
				ILW		LLW	
				Volume (m ³)	Activity (TBq)	Volume (m ³)	Activity (TBq)
Whiteshell Laboratories ^[11]	AECL	Decommissioning waste (January 1, 2005 to December 31, 2013)	ILW: In-ground, concrete bunkers LLW: Above-ground, concrete bunkers	22	0.018	738	0.080
Chalk River Laboratories ^[11]	AECL	Decommissioning waste (January 1, 2005 to December 31, 2013)	ILW: Tile holes and bunkers LLW: MAGS, SMAGS	92	N/A	2,162	N/A
Douglas Point Waste Management Facility	AECL	Decommissioned reactor waste	Reactor building	61	6.9	85	0.009
Nuclear Power Demonstration Waste Management Facility ^[12]	AECL	Decommissioned reactor waste	Reactor building	nil	nil	23.4 ^[13]	0.002
Gentilly-1 Waste Management Facility	AECL	Decommissioned reactor waste	Reactor building	27	0.3	927	0.09

^[11] Volumes are based on method of storage and do not necessarily represent the actual breakdown of waste into low- and intermediate-level radioactive waste.

^[12] Volume does not include reactor components, such as shielding and heat transport systems, in the reactor buildings.

^[13] Reduction in volume relative to 2010 inventory is due to repackaging of material.

D.4 Uranium mining and milling waste

Uranium mining and milling generates two main forms of waste: tailings and waste rock. Historically, waste rock has been either stockpiled above ground or used as backfill in underground mines. Today, mineralized special waste rock is segregated and managed with due consideration given to the hazards associated with mineralization and particular contaminants. Tailings are managed in engineered tailings management facilities (TMFs). The unit of measure used in this report for uranium mine and mill wastes is tonne of dry mass, as this is the same unit used in the mining industry to track and report materials.

D.4.1 Operational mine and mill sites

Table D.6 details the uranium tailings and waste rock in storage at operational mine sites in Canada.

Table D.6: Uranium tailings and waste rock at operational mine sites as of December 31, 2013

Operating tailings sites	Company name or responsible party	Storage method	Onsite waste inventory as of December 31, 2013		
			Tailings	Waste rock	
			Mass (tonnes)	Mineralized (tonnes)	Non-mineralized (tonnes)
Key Lake	Cameco	Deilmann TMF	5,213,815	4,562,831	62,033,000
Rabbit Lake	Cameco	Rabbit Lake in-pit TMF	8,308,554 ^[14]	2,161,600	24,381,800
McClean Lake Operations ^[15]	AREVA	In-pit TMF stores tailings from McClean Lake	1,828,500	10,200,000	51,700,000 ^[16]
McArthur River	Cameco	No tailings onsite; ore is transported to Key Lake for milling	nil	40,210	167,818
Cigar Lake	Cameco	No tailings onsite; not yet generating ore	nil	nil	429,907

^[14] Operational facility (see table D.7 for inactive, onsite tailing management facilities).

^[15] Mining did not occur at McClean Lake during this reporting period (2011–2013).

^[16] Mining from 2008–2010 occurred below a set cut-off elevation where segregation of mineralized and non-mineralized waste was not implemented. All waste material was classified as mineralized waste for in-pit disposal even though it was diluted with non-mineralized waste. Therefore, the non-mineralized total has not changed since reporting in 2007, while the mineralized total has increased.

D.4.2 Inventory of uranium mine and mill waste at inactive tailings sites

Table D.7 inventories waste rock and mill tailings at tailing sites that are no longer operational. As illustrated in table D.6, there are operational tailings facilities at Key Lake and Rabbit Lake. “Inactive”, in this context, refers to several different types of inventories described in section B.8. Note that although the waste rock inventory is provided for the Cluff Lake site and included in table D.6 for the Rabbit Lake and Key Lake sites, it is generally not available for the older sites.

Table D.7: Uranium tailings and waste rock at decommissioned and inactive tailings sites as of December 31, 2013

Site name or location	Company name or responsible party	Storage method	Onsite waste inventory as of December 31, 2013		
			Tailings	Waste rock ^[20]	
			Mass (tonnes)	Mineralized (tonnes)	Non-mineralized (tonnes)
Decommissioning tailings sites					
Cluff Lake	AREVA	Surface	3,230,000	N/A ^[17]	18,400,000
Inactive tailings sites					
Key Lake	Cameco	Above-ground TMF	3,549,781 ^[18]	N/A	N/A
Rabbit Lake	Cameco	Above-ground TMF	6,500,000	N/A	N/A
Beaverlodge	Cameco	Above-ground tailings and mine backfill	5,700,000 ^[19]	N/A	4,800,000
Gunnar	Saskatchewan Research Council	Above-ground tailings	4,400,000	N/A	N/A
Lorado	Saskatchewan Research Council	Above-ground tailings	360,000	N/A	N/A
Port Radium	Indian and Northern Affairs Canada	Above-ground tailings in four areas	907,000	N/A	N/A
Rayrock	Indian and Northern Affairs Canada	Above-ground tailings in north and south tailings piles	71,000	N/A	N/A
Quirke 1 and 2	Rio Algom Ltd.	Flooded, above-ground tailings	46,000,000	N/A	N/A
Panel	Rio Algom Ltd.	Flooded, above-ground tailings	16,000,000	N/A	N/A
Denison	Denison Mines Inc.	Flooded, above-ground tailings in two areas	63,800,000	N/A	N/A
Spanish American	Rio Algom Ltd.	Flooded, above-ground	450,000	N/A	N/A

Site name or location	Company name or responsible party	Storage method	Onsite waste inventory as of December 31, 2013		
			Tailings	Waste rock ^[20]	
			Mass (tonnes)	Mineralized (tonnes)	Non-mineralized (tonnes)
		tailings			
Stanrock/Can-Met	Denison Mines Inc.	Above-ground tailings	5,750,000	N/A	N/A
Stanleigh	Rio Algom Ltd.	Flooded, above-ground tailings	19,953,000	N/A	N/A
Lacnor	Rio Algom Ltd.	Above-ground tailings	2,700,000	N/A	N/A
Nordic	Rio Algom Ltd.	Above-ground tailings	12,000,000	N/A	N/A
Milliken	Rio Algom Ltd.	Tailings management area	150,000	N/A	N/A
Pronto	Rio Algom Ltd.	Above-ground tailings	2,100,000	N/A	N/A
Agnew Lake	Ontario Ministry of Northern Development and Mines	Lake-vegetated, above-ground tailings	510,000	N/A	N/A
Dyno	EnCana West Limited	Above-ground tailings	600,000	N/A	N/A
Bicroft	Barrick Gold Corp.	Above-ground tailings in two areas	2,000,000	N/A	N/A
Madawaska	EnCana West Limited	Above-ground tailings in two areas	4,000,000	N/A	N/A

^[17] Not available. Note that much of the mining at Cluff Lake predated current waste segregation practices.

^[18] Based on monthly production reports between 1983 and 1996. In 1996, tailings placement switched to the Deilmann TMF.

^[19] Tailings volume does not include 4,300,000 tonnes that have been used as backfill.

^[20] Decreases in waste rock inventories from previous reports may be due to milling or to the use of waste rock as backfill, on road surfaces or in construction projects.

Figure D.1: Map of radioactive waste management sites in Canada



Section E – Legislative and Regulatory Systems

E.1 Scope of the section

This section addresses articles 18 (Implementing Measures), 19 (Legislative and Regulatory Framework) and 20 (Regulatory Body) of the Joint Convention, as well as requirements set out in articles 19 and 20 of the International Atomic Energy Agency's (IAEA) General Safety Requirements (GSR) Part 1, *Governmental, Legal and Regulation Framework for Safety* (2010). Specifically, this section describes Canada's legislative and regulatory framework, regulatory body and approach to licensing radioactive material.

E.2 Establishment of the Canadian legislative and regulatory framework

In Canada, matters that relate to nuclear activities and substances are under the jurisdiction of the Government of Canada. Natural Resources Canada (NRCan) has been charged with setting Canada's nuclear policies, including those concerning radioactive wastes. The *Policy Framework for Radioactive Waste* establishes the roles and responsibilities of the Government of Canada and waste producers. In particular, the Government of Canada guides, oversees and regulates radioactive waste owners.

Section 9 of the *Nuclear Safety and Control Act* (NSCA) states the objects of the *Nuclear Safety and Control Act* (NSCA) and grants regulatory authority to the Commission over the use of nuclear materials. The Canadian Nuclear Safety Commission's (CNSC) responsibilities include issuing licences, making regulations and enforcing compliance.

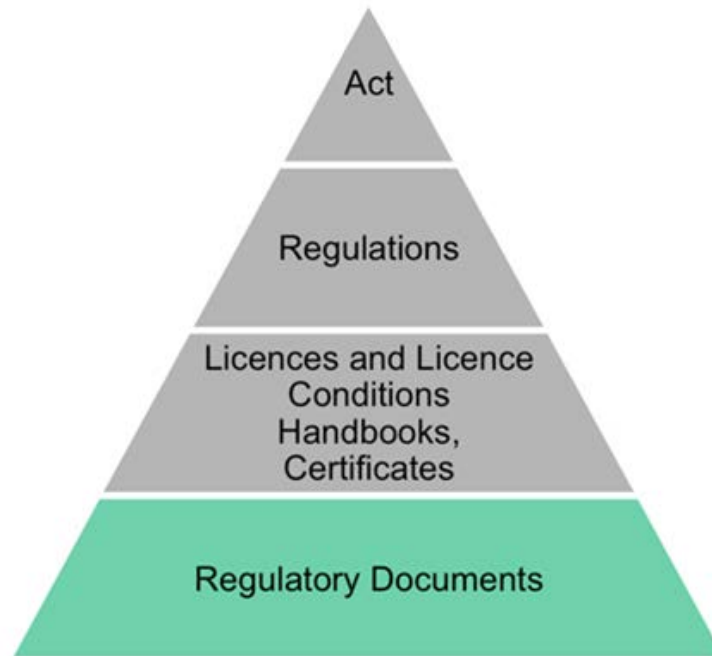
A list of the various federal organizations and acts that relate directly to Canada's nuclear industry are provided in annexes 1 and 2. A detailed description of the regulatory body – its structure, operations and regulatory activities – is provided in annex 3.

E.3 National safety requirements

The CNSC operates within a modern and robust legislative and regulatory framework. Figure E.1 depicts the main elements of Canada's nuclear regulatory framework. This framework consists of laws (acts) passed by the Parliament of Canada, which govern the regulation of Canada's nuclear industry, and instruments such as regulations, licences and documents that the CNSC uses to regulate the industry.

The NSCA is the enabling legislation for the regulatory framework. Regulatory instruments fall into two broad categories: those that set out requirements and those that provide guidance on requirements. Requirements are legally binding and mandatory elements and they include the regulations made under the NSCA, licences and orders. Regulatory documents also become legally binding requirements once they are referenced in licences. The NSCA, regulations, regulatory documents and licences are described in more detail in the sections below.

Figure E.1: Elements of the Canadian nuclear regulatory framework



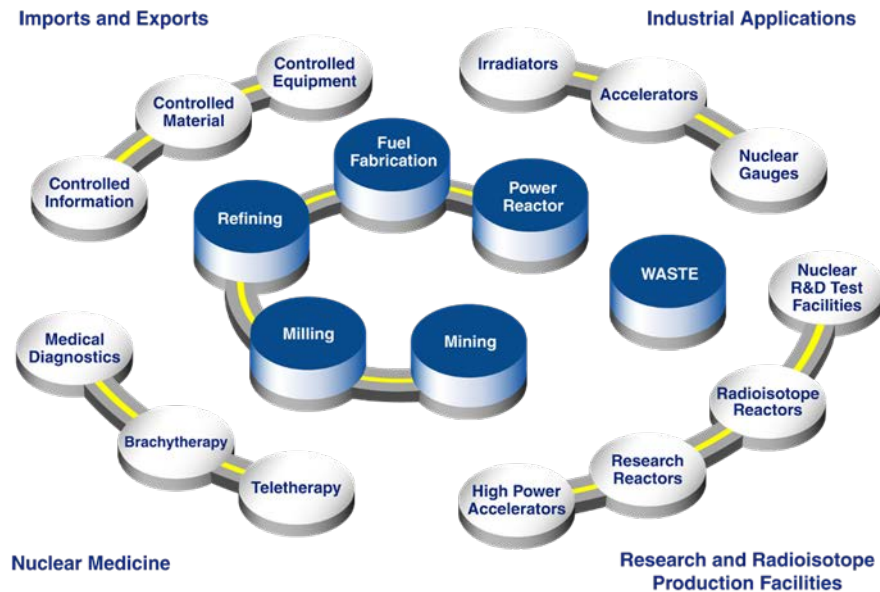
E.3.1 Nuclear Safety and Control Act

In the Canadian parliamentary system, the federal Cabinet – on the advice and recommendation of the appropriate Minister – makes the decision to introduce government legislation into Parliament. The NSCA was passed by Parliament on March 20, 1997 and became law in May 2000. This was the first major overhaul of Canada’s nuclear regime since the *Atomic Energy Control Act* and the creation of the Atomic Energy Control Board (AECB) in 1946. The NSCA provides legislative authority for all nuclear industry developments since 1946. These developments include health and safety standards for nuclear energy workers, environmental protection measures, security regarding nuclear facilities and public input into the licensing process. The NSCA can be viewed at nuclearsafety.gc.ca/eng/acts-and-regulations/regulatory-documents

The NSCA established the CNSC as an independent regulatory body responsible for regulating the use of nuclear material in Canada, including the nuclear fuel cycle. The CNSC comprises the Commission, which makes licensing decisions, and the CNSC’s staff organization, which prepares recommendations to the Commission, exercises delegated licensing and authorization powers, and assesses licensee compliance with the NSCA and its associated regulations and licence conditions. The NSCA gives the CNSC the power to make regulations, as shown in section E.3.2.

The CNSC’s regulatory framework consists of regulations, policies, standards and guides that apply to all nuclear industries, as depicted in figure E.2, including, but not limited to:

- nuclear power reactors
- non-power nuclear reactors, including research reactors
- nuclear substances and radiation devices used in industry, medicine and research
- the nuclear fuel cycle, from uranium mining through waste management
- the import and export of controlled nuclear and dual-use substances, equipment and technology identified as proliferation risks

Figure E.2: Nuclear industries regulated by the CNSC

The NSCA defines the CNSC's mandate to regulate the use of nuclear energy and materials to protect the health, safety and security of Canadians and the environment; to implement Canada's international commitments on the peaceful use of nuclear energy; and to disseminate objective scientific, technical and regulatory information to the public. The CNSC discharges these responsibilities through cooperative arrangements with federal and provincial regulators in other fields, such as those in environmental protection and occupational health and safety.

According to the Parliamentary Directive issued to the CNSC in December 2007, the CNSC now readily takes into account the health of Canadians in regulating the production, possession and use of nuclear substances in order to ensure the necessary protection of the health of Canadians at times when a serious shortage of medical isotopes in Canada or around the world puts the health of Canadians at risk.

In 2012, the NSCA was amended as part of the Government of Canada's Responsible Resource Development initiative. The amendments were:

- to provide the CNSC with a framework for an Administrative Monetary Penalties (AMPs) system. The purpose of AMPs was to provide the CNSC with an additional enforcement tool that could be used to strengthen environmental protection and to increase compliance with the NSCA and its regulations. To fully implement the AMPs system, the CNSC proposed regulations setting out the list of violations that will be subject to the AMPs program under the NSCA, the method and criteria by which the penalty amount will be determined, and the manner in which notices of violations must be served for legal purpose. The AMPs regulations came into force in 2013; see the following section for more details.
- to extend the maximum term of temporary Commission members from 6 months to 3 years. This will align the terms more closely with the expected timelines for regulatory licensing reviews and environmental assessments for major projects.
- to allow for licence transfers. Under certain circumstances, as per subsections 24(2) and 24(4), the CNSC may authorize the transfer of a licence from one licensee to another, or to a new licence applicant, provided there has been no significant change in the licensed activity. This process is

intended to simplify the regulatory process for licensees, while ensuring that all regulatory requirements are met.

The NSCA incorporates stringent regulations to ensure that public health and safety are protected. For example, the NSCA includes:

- radiation dose limits consistent with International Commission on Radiological Protection (ICRP) recommendations
- regulations that govern the transport and packaging of nuclear materials
- specifications for enhanced security at nuclear facilities, including spent fuel dry storage and radioactive waste management facilities
- the authority to issue an order for remedial action in hazardous situations
- the requirement for financial guarantees and the requirement for responsible parties to bear the costs of decontamination and other remedial actions

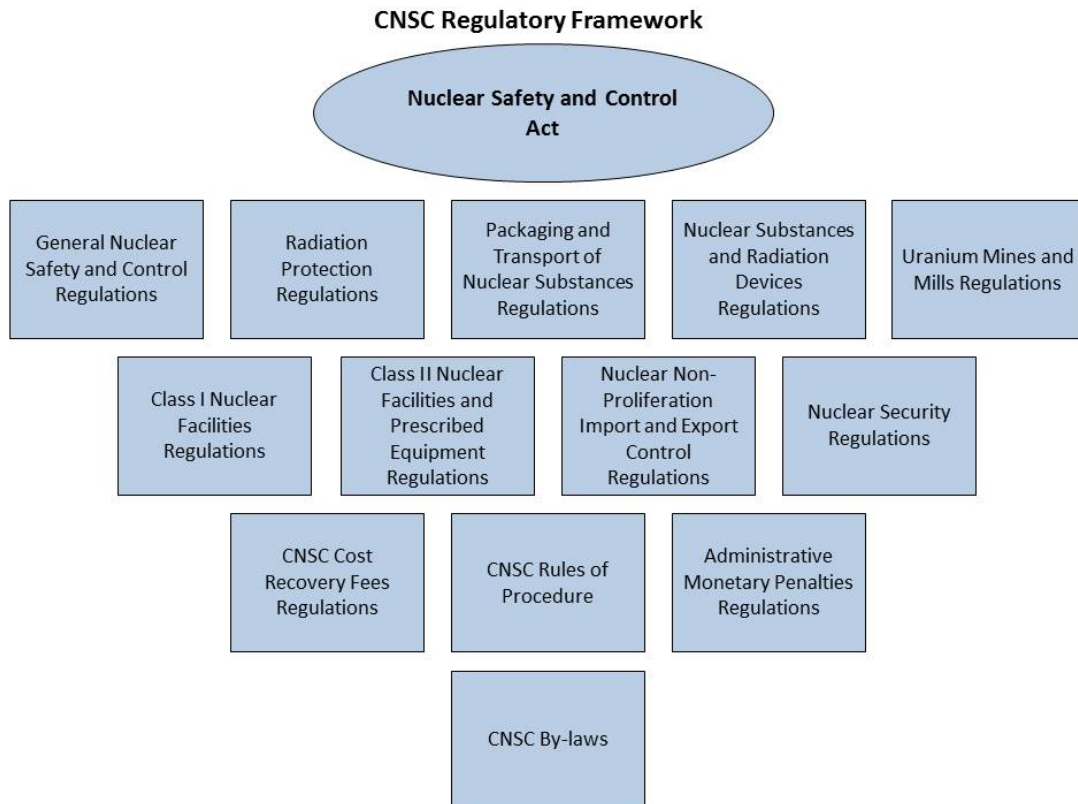
E.3.2 Regulations issued under the *Nuclear Safety and Control Act*

Under the NSCA, the CNSC has implemented regulations and by-laws. Regulations prescribe requirements for all types of licence applications and provide for exemptions from licensing. By-laws are in place to govern the management and conduct of the CNSC's affairs. The *Canadian Nuclear Safety Commission Rules of Procedure* set out rules of procedure for public hearings held by the Commission and for certain proceedings conducted by officers designated by the Commission.

As illustrated in figure E.3, the following regulations and by-laws are issued under the NSCA:

1. *General Nuclear Safety and Control Regulations*
2. *Administrative Monetary Penalties Regulations*
3. *Radiation Protection Regulations*
4. *Class I Nuclear Facilities Regulations*
5. *Class II Nuclear Facilities and Prescribed Equipment Regulations*
6. *Nuclear Substances and Radiation Devices Regulations*
7. *Packaging and Transport of Nuclear Substances Regulations*
8. *Uranium Mines and Mills Regulations*
9. *Nuclear Security Regulations*
10. *Nuclear Non-proliferation Import and Export Control Regulations*
11. *Canadian Nuclear Safety Commission Cost Recovery Fees Regulations*
12. *Canadian Nuclear Safety Commission Rules of Procedure*
13. *Canadian Nuclear Safety Commission By-laws*

Figure E.3: Regulations and by-laws issued under the NSCA



The CNSC regulation-making process includes extensive consultation with both internal and external stakeholders. In developing its consultation plan, the CNSC recognizes the multiplicity of stakeholders, with their different levels of interest, points of view and expectations concerning the nature and content of a proposed regulatory regime.

Generally, the CNSC's regulations allow the licensees some flexibility to define for their circumstances the means to comply with legislative requirements.

Following the March 2011 events at TEPCO's Fukushima Daiichi nuclear power station in Japan, the CNSC conducted a thorough review of its regulatory framework and processes. The CNSC Fukushima Task Force was established to review the capability of nuclear power plants – as well as all other nuclear facilities across Canada – to withstand conditions comparable to those that triggered the Fukushima accident. The task force reviewed the CNSC regulatory framework and processes, confirming that the Canadian regulatory framework is strong and comprehensive. At the same time, the task force identified and outlined a series of recommendations aimed at further enhancing the safety of nuclear facilities in Canada. The recommendations included specific proposals to amend certain regulations under the NSCA; the *CNSC Fukushima Task Force Report* can be found at nuclearsafety.gc.ca/eng/resources/fukushima

Brief descriptions of the regulations are provided below, including proposed amendments to the regulations that would be of interest to the Joint Convention. All CNSC regulations may be viewed in full at nuclearsafety.gc.ca/eng/acts-and-regulations/regulations

General Nuclear Safety and Control Regulations (GNSCR): The GNSCR outline the general information to be included in all licence applications; the obligations of licensees and their workers; definitions of prescribed nuclear facilities, equipment and information; and reporting and record keeping requirements. The GNSCR also detail the requirements for an application for a licence to abandon and obligations to provide information on any proposed financial guarantees. Note that these regulations apply to all licensees, including those holding licences for the management of spent fuel and radioactive waste and decommissioning activities. Naturally occurring nuclear substances that are not associated with the development, production or use of nuclear energy are exempt from these regulatory requirements.

As of November 2013, the CNSC is seeking feedback from licensees, the Canadian public and other stakeholders on proposed amendments to the GNSCR to include human performance and fitness for duty requirements.

Administrative Monetary Penalties Regulations (AMPR): The CNSC initiated the introduction of the AMPR during the reporting period, and the regulations came into force in May 2013. Administrative monetary penalties (AMPs) are monetary penalties imposed by the CNSC, without court involvement, for the violation of a CNSC regulatory requirement. They can be applied to any person or corporation subject to the NSCA. AMPs were proposed in order to enhance the robustness and effectiveness of the CNSC's enforcement regime and to serve as a credible deterrent, thereby achieving higher levels of compliance. AMPs are not part of the CNSC's cost-recovery mechanism – they are payable to the Government of Canada's Consolidated Revenue Fund. The AMPR contain three levels of violation for the purposes of AMPs – low, medium and high regulatory significance – with each having a corresponding monetary penalty range less than or equal to the maximum amount set by the NSCA. The maximum AMPs for individuals and corporations are \$25,000 and \$100,000 CDN, respectively.

Radiation Protection Regulations (RPR): The RPR contain radiation protection requirements that apply to all licensees and others who fall under the mandate of the CNSC. The RPR define the as low as reasonably achievable (ALARA) principle, contain limits on radiation doses to workers and members of the public, and require all CNSC licensees to implement radiation protection programs.

The CNSC published a discussion paper in August 2013 soliciting stakeholder feedback on proposals to amend the RPR in order to harmonize them with updated international standards, clarify requirements and address gaps based on lessons learned since the RPR came into force. In March 2014, the CNSC posted to its website feedback on the comments received regarding the discussion paper.

The current RPR, which were introduced in 2000, are based upon guidance from the ICRP and the IAEA. Both of these organizations have updated their guidance since the RPR came into force; therefore, there is a need to review the RPR, with the objective of aligning with current recommendations. The RPR reflect the ICRP's recommendations made in 1990 (ICRP 60). The ICRP recommendations have since been updated to ensure they remain relevant, useful and suitable for worldwide use, and new guidance was published in 2007. Similarly, the IAEA, in cooperation with co-sponsoring organizations, undertook a revision of its 1996 *Basic Safety Standards*, which were republished in 2011 as the IAEA's *General Safety Requirements*, GSR Part 3 (Interim). The IAEA-revised Basic Safety Standards provide updated requirements designed to be incorporated into future national and regional regulations.

The CNSC also proposed amendments to the RPR be more consistent with current international guidance and more fully describe requirements for addressing radiological hazards during the various phases of an emergency. As a result, the CNSC has also proposed amendments of the RPR in order to align with international benchmarks with respect to dose limits for persons during an emergency. The amendments would also clarify requirements for managing workers exposed to radiation while controlling an emergency.

It is anticipated that the amended RPR will come into force in the latter part of 2015.

Class I Nuclear Facilities Regulations (CINFR): The CINFR detail the information licensees need to supply when applying for different types of Class I nuclear facility licences. Licences are available for each stage in the lifecycle of a Class I nuclear facility, including site preparation, construction, operation, decommissioning and abandonment (release from CNSC licensing). The CINFR also address record keeping and the certification of reactor operators.

Note that under the NSCA, one of the definitions of a nuclear facility is “a facility for the disposal of a nuclear substance generated at another nuclear facility.” A nuclear facility also includes, where applicable, the land on which such a facility is located, a building that forms part of the facility, equipment used in conjunction with the facility and any system for the management, storage or disposal of a nuclear substance. As defined under subsection 19(a) of the GNSCR, a facility that manages, stores or disposes of radioactive waste and whose resident inventory of radioactive nuclear substances is greater than 10^{15} Bq is a prescribed Class I nuclear facility.

In January 2013, the CINFR were amended to establish 24-month timelines for projects requiring the CNSC’s regulatory review and decision on new applications for a licence to prepare a site for a Class I nuclear facility.

As of November 2013, the CNSC is seeking feedback from licensees, the Canadian public and other stakeholders on the inclusion of a regulatory requirement for the submission of provincial offsite emergency plans to the CNSC. The CNSC has also proposed an amendment to the CINFR to include a requirement for all licensees of Class IA nuclear power plants to carry out mandatory and comprehensive integrated safety reviews at least once every 10 years.

Class II Nuclear Facilities and Prescribed Equipment Regulations: These regulations specify the requirements for the licensing of Class II nuclear facilities and prescribed equipment, including low-energy accelerators, irradiators and radiation-therapy installations.

Nuclear Substances and Radiation Devices Regulations (NSRDR): The NSRDR provide requirements for the licensing and certification of nuclear substances and radiation devices, use of radiation devices and record keeping. The NSRDR apply to all licensees of nuclear substances, radioactive sealed sources and radiation devices not covered by other regulations.

As of November 2013, the CNSC is proposing to amend the NSRDR to require that all licensees in possession of aggregate quantities of Category I and II nuclear substances, or devices containing these substances, inform their local first responder of the presence of these materials on their site, including the hazards these materials could pose to emergency offsite personnel.

Packaging and Transport of Nuclear Substances Regulations (PTNSR): The PTNSR apply to the packaging and transport of nuclear substances, including the design, production, use, inspection, maintenance and repair of packaging and packages and the preparation, consigning, handling, loading, carriage, storage during transport, receipt at final destination and unloading of packages. They also cover certification of special-form radioactive material, low-dispersible radioactive material and certain types of packages.

The PTNSR are based on the IAEA Safety Standards Series TS-R-1, *Regulations for the Safe Transport of Radioactive Material*, 1996 edition, revised in 2000. To ensure Canadian requirements continue to be aligned with current international standards, the CNSC has been working toward amending the PTNSR to align with the 2012 edition of the IAEA *Regulations for the Safe Transport of Radioactive Material* (SSR-6). Additional changes to the PTNSR will be made to ensure continued alignment with Canada’s *Transportation of Dangerous Goods Regulations* (administered by Transport Canada) and to address specific transportation issues. It is anticipated that the amended PTNSR will come into force in 2015.

Nuclear Security Regulations (NSR): The NSR define security-related information requirements and general obligations. They also include information about security requirements for high-security sites and provide security-related requirements for licensing and operation of lower-risk facilities. The NSR are applicable to any CNSC licensee and applicant with respect to Categories I, II and III nuclear material and high-security sites.

Uranium Mines and Mills Regulations (UMMR): The UMMR detail the information needed for licence applications for uranium mines and mills, along with licensee obligations. Licences are required for each stage of a facility’s lifecycle, including site preparation, construction, operation, decommissioning and abandonment. The UMMR apply to all uranium mines and mills, including management of mill tailings, but not to uranium prospecting or surface-exploration activities.

Nuclear Non-proliferation Import and Export Control Regulations: These regulations govern the import and export of controlled nuclear substances, equipment and information.

Canadian Nuclear Safety Commission Cost Recovery Regulations: These regulations enable the CNSC to recover the actual cost of regulating the nuclear industry equitably through licence fees.

E.3.3 Regulatory documents

The NSCA and its associated regulations set the requirements while regulatory documents provide the basis for regulatory guidance, expectations and decisions.

The following explanatory text is included in all regulatory documents:

- The CNSC develops regulatory documents under the authority of paragraphs 9(b) and 21(1)(e) of the NSCA.
- Regulatory documents clarify NSCA requirements and associated regulations, and are an integral part of the regulatory framework for nuclear activities in Canada.
- Each regulatory document aims to disseminate objective regulatory information to stakeholders, including licensees, applicants, public interest groups and the public, and promote consistency in the interpretation and implementation of regulatory requirements.

Additional information on the CNSC’s regulatory documents program is available online at nuclearsafety.gc.ca/eng/acts-and-regulations/regulatory-documents

As outlined in the CNSC regulatory policy P-299, *Regulatory Fundamentals*, the CNSC bases its regulatory requirements on industry, national and international standards, and best practices, including those of the IAEA. Canada has actively helped the IAEA develop nuclear safety standards and create technical documents that outline more specific technical requirements and best practices for radioactive waste management and decommissioning.

Annex 3.6.2 includes a list of the CNSC’s regulatory documents. Two of these documents are specific to radioactive waste and spent fuel. For uranium mine and mill waste, the regulatory guidance document *Management of Uranium Mine Waste Rock and Mill Tailings* was published in March 2012. Other, more generic, regulatory documents relating to action levels, decommissioning, environmental protection and public information programs may also apply to waste management facilities. A complete list of regulatory documents is available at nuclearsafety.gc.ca; the CNSC’s regulatory documents for radioactive waste, decommissioning and public information/disclosure are described below.

Regulatory policy P-290, Managing Radioactive Waste: The CNSC issued this document in July 2004, following extensive consultation with the public, the nuclear industry and other stakeholders. The policy identifies the need for long-term management of radioactive waste and non-radioactive hazardous waste arising from licensed activities. P-290 is discussed in section B.5.

Regulatory guide G-320, *Assessing the Long Term Safety of Radioactive Waste Management*: In December 2006, the CNSC published this regulatory guide to assist licensees and applicants in assessing the long-term storage and disposal of radioactive waste. The guide (discussed in section B.6) was developed using provincial, federal and international documents, following a consultation with the nuclear industry in Canada.

Regulatory guide G-219, *Decommissioning Planning for Licensed Activities*: This document provides guidance on the preparation of plans for the decommissioning of activities licensed by the CNSC. G-219 is described in section F.8.

Regulatory document RD/GD-99.3, *Public Information and Disclosure Protocols*: This document provides guidance on the development and implementation of the requirements for public information programs and disclosure protocols. For more details, refer to section H.7.1.

Regulatory document RD/GD-370, *Management of Uranium Mine Waste Rock and Mill Tailings*: This document sets out the requirements of the CNSC for the sound management of mine waste rock and mill tailings resulting from site preparation, construction, operation and decommissioning of new uranium mine or mill projects in Canada, to ensure the protection of the environment and the health and safety of people. This regulatory document also provides guidance to applicants regarding the CNSC’s expectations for new mining projects throughout Canada on the management of waste rock and tailings generated by uranium mining and milling operations.

E.4 Comprehensive licensing system for spent fuel and radioactive waste management activities

E.4.1 Licensing procedure

The CNSC maintains the philosophy that a licensee is responsible for the safe operation of its own facilities. Licensees make safety-related decisions routinely; therefore, they must have a robust set of programs and processes in place to ensure adequate protection of the environment and the health and safety of workers and the public. The CNSC performs regulatory oversight and verifies that licensees and operators comply with the NSCA and its regulations.

Figure E.4: Process for obtaining a licence for a new Class I facility or uranium mine and mill

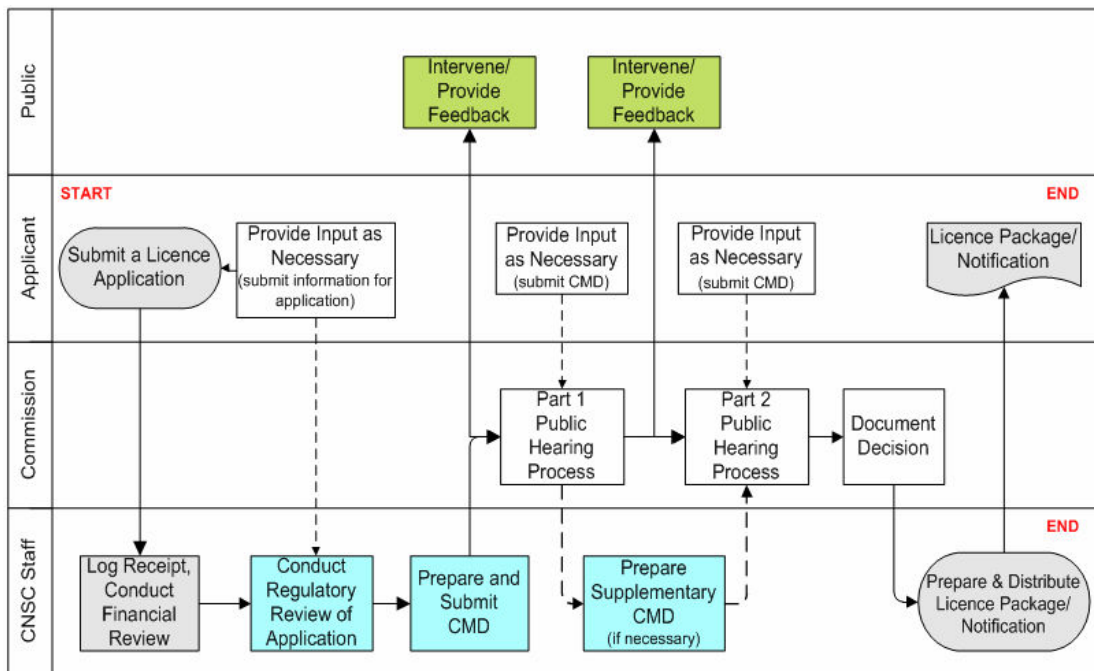


Figure E.4 illustrates how an applicant can obtain a licence under the NSCA. First, the applicant must submit to the CNSC an application for a licence. The applicant must meet general performance criteria, provide information and develop programs in accordance with the NSCA and regulations to be considered. CNSC staff publish regulatory documents including policies, guides, standards and notices, which help licensees meet regulatory requirements. Licensees are obligated to adhere to the terms and conditions of a licence, such as references to standards, decommissioning planning and financial guarantee requirements.

An application for a CNSC licence may be subject to other legislation and regulations. For example, an environmental assessment (EA) under the *Canadian Environmental Assessment Act, 2012* (CEAA 2012) may be required for a designated project regulated under the NSCA and described in the *Regulations Designating Physical Activities*. An EA is conducted to analyze potential environmental, physical and socio-economic impacts. Note that there are opportunities throughout the EA process for public consultations. The range of stakeholder consultations is determined by a criteria-based approach that takes into consideration public and Aboriginal interest, environmental characterization and potential impacts, and other factors.

Only after a positive decision is made on the EA (if one is required) may the Commission proceed with a licensing decision. The Commission holds public hearings to consider licence applications for major facilities (see section E.4.3). Under section 37 of the NSCA, the Commission can delegate responsibility for issuing certain types of licences – other than Class I licences and licences for uranium mines and mills – to persons who have been identified as designated officers (DOs) as defined under the legislation. This can include issuing various types of licences, such as licences for radioactive waste management facilities not defined as Class I nuclear facilities. When a DO is delegated this responsibility, no public hearing occurs unless the DO refers the decision back to the Commission using a risk-informed approach. In this case, the Commission will evaluate the need to conduct a public hearing as part of its decision-making process.

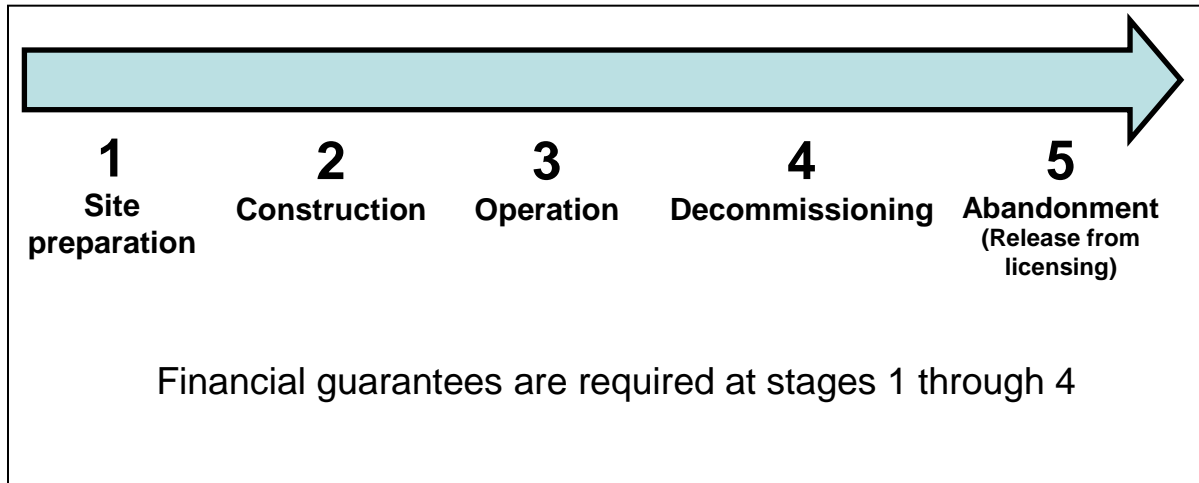
The CNSC administers its licensing system in cooperation with other federal and provincial government departments and agencies that work in areas such as health, the environment, transportation and labour.

Once a licence is issued, CNSC staff are responsible for administering the Commission's decision, including the requirement to develop and implement a compliance verification program (see section E.6.3) to ensure that licensees continue to meet their legislative and licence obligations.

E.4.2 Licence application assessment process

Early communication with the CNSC can help applicants develop a good understanding of the licensing process, regulatory requirements for spent fuel and radioactive waste management facilities and information to be submitted in support of a licence. Early communication also enables the CNSC to develop a regulatory review, which ensures that qualified staff are available to carry out the application review.

The management of spent fuel and radioactive waste is regulated through the entire lifecycle – from site preparation, construction and operation to decommissioning and, finally, abandonment (see figure E.5). Each phase of the lifecycle requires a separate licence, although a combined licence of site preparation and construction may be requested.

Figure E.5: The lifecycle of the CNSC’s licensing approach (step-wise approach/early planning)**E.4.2.1 Licence application**

For a new licence, the regulations require applicants to submit comprehensive information on their policies and programs, the design and components of the proposed facility, the manner in which the facility is expected to operate, facility operating manuals and procedures and any potential impacts on the site or surrounding environment. The design must be such that emissions from the facility meet strict limits under normal operating and upset conditions, as applicants are required to identify the manner by which a facility may fail to operate correctly, predict the potential consequences of such a failure and establish specific engineering measures to mitigate the consequences to tolerable levels. Those engineering measures may include, but are not limited to, multiple barriers to prevent the escape of noxious material. Many analyses of potential accidents are complex, covering a very wide range of possible occurrences.

CNSC staff rigorously review all submissions, using existing legislation and the best codes of practice and experience available in Canada and around the world to ensure regulatory requirements are met. The expertise of the CNSC’s staff covers a broad range of engineering and scientific disciplines. Considerable effort is also spent reviewing the analyses to ensure that predictions are based on well-established scientific evidence and that defences meet defined standards of performance and reliability.

In addition to reviewing the information described above, subsection 24(4) of the NSCA places the onus on the CNSC to ensure that:

...the applicant:

- is qualified to carry on the activity that the licence will authorize the licensee to carry on, and
- will, in carrying on that activity, make adequate provision for the protection of the environment, the health and safety of persons and the maintenance of national security and measures required to implement international obligations to which Canada has agreed.

The comprehensive assessment that takes place during the licensing process may result in defining additional programs and criteria as a condition(s) of the licence. Once satisfied that all of the requirements of the NSCA and its associated regulations are met and that the applicant’s documentation is complete and acceptable, CNSC staff prepare a licence recommendation for submission to the Commission – or to a DO – for a decision. The recommended licence may include any necessary conditions identified as required during the assessment, including the documentation references submitted in support of the application.

By referring to the applicant's documentation, the licence legally binds the applicant to comply with its own procedures and programs, making them subject to the CNSC's compliance, verification and enforcement program.

Licences may also contain other terms and conditions, such as references to standards, with which licensees must comply. For example, licensees may be required to observe occupational and public radiological exposure limits derived (or adopted) from internationally accepted standards, such as those of the ICRP. Limits for controlled release of gaseous or liquid effluents or solid materials are adopted from complementary regulatory regimes, such as Ontario's Provincial Water Quality Objectives or Metal Mining Limits for Liquid Effluent Releases, or derived from specific licence conditions, such as the derived release limits. Other standards, established by organizations such as the CSA Group and the American Society of Mechanical Engineers (ASME), may also be adopted by the CNSC.

E.4.2.2 Joint regulatory review process

Although the nuclear sector is subject to federal jurisdiction through the NSCA, the CNSC utilizes a harmonized or joint review approach with other federal, provincial or territorial departments in such areas as health, environment, transport and labour. The CNSC expects nuclear facilities to comply with all applicable federal and provincial regulations.

In recognition of this dual jurisdiction, the CNSC has established a joint regulatory process. As a lead agency, the CNSC invites other federal and provincial regulatory agencies to participate in the licensing process when their areas of responsibility could impact the proposed nuclear facility. Those that choose to participate become members of a site-specific joint regulatory group.

This process ensures that the legitimate concerns of federal, provincial and territorial agencies are considered in the regulatory process and are reflected, as appropriate, in the licence in the form of site-specific requirements. For example, the CNSC and the Saskatchewan departments of Environment and Labour have an administrative agreement that optimizes the participation of the Ministry of Environment (MoE) and the Ministry of Advanced Education, Employment and Labour (Labour) in the administration of the CNSC's regulatory regime. The involvement of Labour and the MoE in the regulation of Saskatchewan's uranium mines and mills helps to better

- protect the health, safety and security of Canadians and their environment
- harmonize the CNSC, MoE and Labour regulatory requirements and regulatory activities

E.4.2.3 Example of a new licence issued by the Commission

The following is an example of a licence that the Commission issued after the Fourth National Report was published. Following the September 2011 public Commission hearings, which were held in the local municipality, the CNSC issued a waste nuclear substance licence to Atomic Energy of Canada Limited for the Port Granby Long-Term Low-Level Radioactive Waste Management Project. The Commission received and considered submissions from 22 intervenors. This licence was granted for a 10-year period and is currently valid until December 31, 2021.

E.4.2.4 Licence periods

Typical licence periods for radioactive waste management facilities vary from five to 10 years.

In 2002, the CNSC introduced flexible licence periods to allow for more risk-informed regulation of spent fuel and radioactive waste management facilities. The CNSC may consider adjusting licence periods based on licensee performance, facility risks, and compliance and verification findings. Short licence periods will continue to be an option in case of unsatisfactory licensee performance or other considerations. Along with the assignment of longer licence periods, however, the Commission has requested mid-term or status updates to allow the Commission and the public to stay informed about the facilities' operations and

performance. In some cases, such as with Denison Mines Inc.'s licences to decommission a nuclear facility and to possess, manage and store nuclear substances, the licences have been granted for an indefinite period on the condition that CNSC staff present a status report at a public proceeding of the Commission every five years.

CNSC staff recommend licence periods using a set of consistent factors. These factors include facility-related hazards, the development and implementation of safety programs (see section E.6.3), the implementation of an effective monitoring and maintenance program, licensee experience and performance, the *Canadian Nuclear Safety Commission Cost Recovery Fees Regulations* and the facility's planning cycle.

Regardless of the specifics of the licence period or the schedule of mid-term or status reports, CNSC staff have an obligation to inform the Commission of any significant event at a nuclear facility licensed by the CNSC. Should such an event occur, all operational issues must be included in an emergency notification report to be presented to the Commission.

E.4.2.5 Licence renewals

Applications for a licence renewal or amendment require the CNSC to revisit the original documentation and assessment in light of licensee performance and compliance history (see section E.6.1). The CNSC bases its review on performance history, risk and expert judgment. The CNSC also may add, modify or remove licence conditions.

Since the last report, the CNSC renewed the waste facility operating licence for Ontario Power Generation's (OPG) Darlington Waste Management Facility following a one-day public hearing. This licence, issued in March 2013, is valid for a 10-year period and includes authorization for OPG to construct and operate two additional waste storage buildings after the completion and approval of an EA. In its decision, the Commission required CNSC staff to provide a performance report on facility operations in 2014.

E.4.2.6 Licence amendments

Amendments to spent fuel, radioactive waste management and uranium mine and mill licences can modify existing licence conditions, add new licensing requirements or approve revisions to the facility design, its operations or licensee programs referenced in the licence. Examples of documents to review before reaching a decision include operating policies and principles, station-shift complement, radiation protection requirements and emergency plans. DOs, when delegated by the Commission, can typically amend waste nuclear substance licences.

Licence conditions handbook amendments

A licence conditions handbook (LCH) is a separate document linked to the licence that outlines the CNSC's expectations and that contains compliance verification details for each specific licence condition. Compliance verification details include activities and reporting requirements. The LCH was developed as a tool that can more easily be updated as the licensees' programs are revised to align with operations. Amendments to the LCH, when delegated by the Commission, can be performed by a DO.

E.4.3 Public information and participation

E.4.3.1 Public hearings

As discussed in the CNSC licensing procedure (see section E.4.1), the NSCA requires that a public hearing be held before a major licensing decision is made or whenever it is in the public interest to do so. Public hearings, such as the hearing pictured in figure E. 6, give organizations and interested members of the public a reasonable opportunity to comment on matters before the Commission. The *Canadian Nuclear*

Safety Commission Rules of Procedure (Rules) apply to these proceedings and set forth the requirements for matters such as the notification of public hearings and publication of decisions from public hearings.

In accordance with the Rules, a public hearing may take place in one or two parts. Most major decisions are made following a two-part public hearing process.

Part 1 and Part 2 may be several months apart (the usual time frame is 60 days) to allow stakeholders enough time to review the application and recommendations. The CNSC's licensing process is described in annex 3.

E.4.3.2 Panels

The NSCA authorizes the president to establish, when needed, panels of the Commission consisting of one or more members. The panel, as directed by the president, may exercise any or all of the powers, duties and functions of the Commission, with only a few enumerated exceptions. An act of a panel is deemed to be an act of the Commission.

Figure E.6: Commission members during public hearing



E.4.3.3 Abridged hearings

The Commission is required to make all decisions with respect to applications to amend licences it has previously issued (i.e., for Class I nuclear facilities and uranium mines and mills). Many of these applications regard minor changes and updates that are of low safety significance to a facility's operations and reference documentation. The Commission, therefore, may decide that a full public hearing is not necessary when the amendments are more administrative in nature and there is less public interest in the matter being considered. These matters may be dealt with as an abridged hearing.

The process for an abridged hearing differs from that of a public hearing. This could mean shortened notification requirements, reduced time periods and/or limited participation. Abridged hearings may be held in a closed or public forum. A notice of hearing about upcoming matters to be dealt with through the abridged hearing process is published on the CNSC website. Following the deliberations of the Commission, a Record of Proceedings, including Reasons for Decision is published on the CNSC's website.

For example, on July 4, 2012, the Commission used an abridged hearing process to renew under the same terms and conditions, for a six-month period, the operating licence for the Darlington Waste Management Facility. On November 15, 2013 an abridged hearing process was used for the Commission's review and decision on a request by New Brunswick Power Corporation to modify the spent fuel and waste management funds investment strategy for the Point Lepreau Nuclear Generating Station.

E.4.3.4 Public Participation in the Hearing Process

The CNSC's outreach program is described in annex 3.11.

Public hearings and meetings are fundamental to the CNSC's outreach activities. The Commission publishes a Record of Proceedings, including Reasons for Decision to explain the basis for its licensing decisions. The Commission also publishes minutes to record the outcome of Commission meetings. These documents, along with other information about the Commission's proceedings and decisions, are available at nuclearsafety.gc.ca/eng/the-commission/hearings/documents/browse for public perusal. The Commission also posts the complete transcripts and webcasts of all public proceedings within days of a hearing or meeting – a best practice confirmed through benchmarking analysis.

Even when hearings are held in Ottawa, affected communities may use videoconferencing as a cost-effective way to participate. The Commission offers teleconference and videoconference services to facilitate access to public hearings and meetings. As part of the CNSC's ongoing efforts to provide easier access to the Commission's proceedings and enhance the visibility of the CNSC, the public can view live webcasts of all public hearings and meetings through the Commission's external website. Archived webcasts of past proceedings are also available online for a minimum of three months following the end of the proceedings.

Note that in an effort to encourage public participation, the Commission also holds licensing hearings and Commission meetings in the local communities. In September and October 2013, the Deep Geologic Repository Joint Review Panel held a total of 26 hearing days in two local communities, with 243 intervenors (including several government departments) participating through written and/or oral submissions. In 2011–2012, the Commission conducted 12 hearings, with a total of 322 intervenors participating through written and oral submissions, and held a total of nine days of public meetings. In 2012–2013, the Commission conducted nine hearings where it duly considered submissions from applicants and input from CNSC staff and stakeholders. A total of 301 intervenors participated through written and oral submissions in those hearings. In addition, the Commission held a total of 12 days of public meetings. In 2013–2014, the Commission conducted eight hearings. A total of 229 intervenors participated through written and oral submissions, and there was a total of 11 days of public meetings.

E.5 System of prohibition for the operation of spent fuel or radioactive waste facilities without a licence

Under section 26 of the *Nuclear Safety and Control Act* (NSCA), no person may possess, package, transport, manage, store or dispose of a nuclear substance, except in accordance with a licence issued by the CNSC or when exempted by the regulations. Since all spent fuel and radioactive waste contains nuclear substances, these are subject to the NSCA and its associated regulations.

E.6 System of institutional control, regulatory inspection, and documenting and reporting

E.6.1 General description of the Compliance Program

As stated in section E.4.1, only the Commission or a designated officer can issue licences to operate spent fuel and waste management facilities.

Section 30 of the NSCA authorizes CNSC staff who are designated inspectors to carry out inspections and verify licensee compliance with regulatory requirements, including licence conditions. Licensees must have

an approved set of programs and processes in place that adequately protect the environment and human health and safety.

The CNSC's regulatory policy *Compliance* (P-211) is implemented through a corporate-wide compliance program, the output of which is integral to the operating licence renewal process and which integrates all three compliance elements:

- promotion to encourage compliance
- verification activities to confirm that licensees are complying with safety provisions
- reactive control measures to enforce compliance

The CNSC rigorously enforces its regulatory requirement through a variety of measures such as inspections, reviews, audits and assessments. The CNSC's staff:

- apply regulatory requirements in a manner that is fair, predictable and consistent
- use rules, sanctions and processes securely founded in law and graded according to the seriousness of the violation, the compliance history of the licensee and the actions of the licensee once the violation is discovered
- establish and maintain a compliance verification program based upon the level of risk that the radioactive material or activity presents to human health, its authorized use and the environment
- ensure that its compliance activities are conducted by trained and qualified staff
- develop and implement a compliance promotion strategy and a compliance enforcement strategy
- implement an administrative monetary penalties (AMPs) system to increase compliance

E.6.2 Compliance promotion

The compliance program aims to inform the regulated community of the rationale behind the regulatory regime, disseminate information to regulated areas about regulatory requirements and standards, and design realistic and achievable requirements and standards. Promotional activities include communication and consultation.

The most common communication and consultation activity used to promote compliance consists of regularly scheduled meetings with the licensee, at which ongoing activities and developments, licensing and compliance issues, safety performance, outstanding commitments and emerging issues are discussed. Generally, compliance verification activities also result in follow-up meetings. The frequency of planned meetings varies by licensee, facility and risk level.

E.6.3 Compliance verification

To verify compliance with regulatory requirements and licence conditions, the CNSC:

- evaluates a licensee's operations and activities
- reviews, verifies and evaluates licensee-supplied information
- ensures that administrative controls are in place
- evaluates a licensee's remedial action and any actions taken to avoid future incidents

Programs cited in the licence or previously assessed during the licence application review process are evaluated. The CNSC checks that a licensee's activities meet acceptance criteria derived from:

- legal requirements

- the CNSC policies, standards or guides that clarify how the Commission intends to apply the legal requirements
- licensee-supplied information that expressly states the licensee’s intentions to meet the legal requirements in performing the licensed activity
- the CNSC staff’s expert judgment, including knowledge of industry best practices

CNSC staff assess licensee programs and their implementations according to the following four ratings:

- FS Fully satisfactory
- SA Satisfactory
- BE Below expectations
- UA Unacceptable

The following categories – commonly referred to by the CNSC as safety and control areas (SCAs) – are used to summarize all assessment and inspection results, as well as group licensee programs and performance in several safety areas being evaluated for licensing purposes. A standard list of programs or topics has been developed for each type of facility and may include:

- management system
- human performance management
- operating performance
- safety analysis
- physical design
- fitness for service
- radiation protection
- conventional health and safety
- environmental protection
- emergency management and fire protection
- waste management
- security
- safeguards
- packaging and transport

Compliance verification results are used in licence renewals and interim status reports.

E.6.3.1 Regulatory inspections

Type II inspections

A planned and documented activity to verify the results of licensee processes and not the processes themselves. They are typically routine (item-by-item) inspections and rounds, usually of specified equipment, facility material systems, or of discrete records, products or outputs from licensee processes.

Type I inspections

A systematic, planned and documented process to determine, through objective evidence, whether a licensee program, process or practice complies with the regulatory requirements as expressed in the compliance criteria associated with the inspection. Audits and evaluations are synonyms for Type I inspections.

E.6.3.2 Regulatory reporting

CNSC staff also assess the contents of submitted operating reports. Licensees are required to submit operating reports to the CNSC according to licence conditions. The frequency of these submissions varies by licensee, facility and risk level but generally ranges from quarterly to annually. The analysis of safety-significant events is another component in the safety performance evaluation of a facility. The objective of these analyses is not for the CNSC staff to duplicate reviews done by licensees, but to ensure that licensees have adequate processes in place to take corrective actions when needed and to integrate lessons learned from past events into day-to-day operations.

Figure E.7: Compliance verification taking place in a nuclear facility



E.6.4 Compliance enforcement

The CNSC uses a gradual approach to enforcement, commensurate with the risk or regulatory significance of the violation. The enforcement tools available to the CNSC are:

- discussion
- verbal or written notice
- warning
- increased regulatory scrutiny
- administrative monetary penalties (AMPs)
- issuance of an order
- licensing action (e.g., amendment or suspension of part of a licence)
- revocation of personal certification
- prosecution
- revocation or suspension of a licence

Depending on the effectiveness of the initial action, subsequent enforcement measures of increasing severity may be invoked.

The new AMP regulations authorize the use of financial penalties for violations of the NSCA. They are designed to address violations and instances of non-compliance with the NSCA early and effectively so that larger issues do not arise. As of March 31, 2014, three AMPs have been issued to CNSC licensees.

E.7 Considerations taken into account in deciding whether or not to regulate nuclear substances as radioactive waste

Section E.3.1 indicates that the CNSC is authorized under the NSCA to regulate nuclear substances so as to protect human health and the environment. The CNSC regulatory policy P-290, *Managing Radioactive Waste*, defines radioactive waste as any waste containing a nuclear substance, leaving no room for regulatory doubt, and promotes the following key principles with respect to radioactive waste:

- The generation of radioactive waste should be minimized to the extent practicable.
- Radioactive waste should be managed in a manner that is commensurate with its radiological, chemical and biological hazards.

For a full description of regulatory policy P-290, refer to section B.5.

E.8 Establishment of the regulatory body

E.8.1 Funding the CNSC

The CNSC is a departmental corporation listed in schedules II and V of the *Financial Administration Act*. The NSCA stipulates that the CNSC report to the Parliament of Canada through a member of the Privy Council for Canada who is designated by the Governor in Council. Currently, this designate is the Minister of Natural Resources Canada. The Commission requires the involvement and support of the Minister for special initiatives such as amendments to regulations and requests for funding.

The CNSC's operations are funded primarily from fees collected from industry (licensees), pursuant to the *CNSC Cost Recovery Fees Regulations*, and secondarily through an annual appropriation from Parliament. The CNSC has a revenue spending authority that allows it to spend the revenues collected to fund the cost of activities that are cost recoverable as per the *Cost Recovery Fees Regulations*. This authority provides a sustainable and timely funding regime to address rapid changes in the regulatory oversight workload associated with the Canadian nuclear industry.

E.8.2 Maintaining competent personnel

The CNSC has been successful in attracting qualified candidates and maintaining an optimal staff complement. To ensure our ability to effectively respond to changing industry requirements, the CNSC's human resource management efforts are increasingly focused on maximizing organizational flexibility while maintaining a competent and engaged workforce.

In support of this direction, the CNSC has developed a strategic HR plan for 2014 to 2017, which includes key initiatives related to workforce planning and renewal, talent management, leadership development and learning.

Concerning workforce planning, the CNSC is examining the capabilities and competencies that will be required to 2025, identifying potential risk areas and developing strategies to address them. Particular attention is also being paid to organizational renewal and, more specifically, to the CNSC's new graduate recruitment practices.

Talent management practices are being expanded to facilitate the earlier identification of leadership potential at lower levels within the organization. In addition, career maps are being developed to support career planning and ensure the development of competencies required for key technical and leadership roles.

Given the importance of employee development, the CNSC continues to encourage learning and development opportunities for managers and employees. The implementation of mandatory individual learning plans ensures that employees prepare for future careers within the CNSC while building the skills required for their current roles. In addition to more than 100 in-house courses offered each year, the CNSC encourages

employees to attend external training courses, as well as to consider assignments, independent study and on-the-job training. During the period 2010–2013, CNSC employees participated in an average of 14 days of training annually.

With regard to management and leadership development specifically, the CNSC completed the implementation of mandatory training that focuses on the fundamentals (e.g., financial management, human resource management, information management). Efforts are now underway to supplement this classroom training with action learning groups and targeted workshops.

The CNSC recently completed development and implementation of a comprehensive Inspector Training and Qualification Program. It is proving effective at ensuring consistent competency development to a high standard.

E.8.2.1 Aboriginal consultation

As an agent of the Government of Canada and as Canada’s nuclear regulator, the CNSC recognizes and understands the importance of consulting and building relationships with Canada’s Aboriginal peoples. The CNSC ensures that all its licensing decisions under the NSCA and environmental assessment (EA) decisions under the *Canadian Environmental Assessment Act, 2012* (CEAA 2012) uphold the honour of the Crown and consider Aboriginal peoples’ potential or established Aboriginal and/or treaty rights pursuant to section 35 of the *Constitution Act, 1982* (together, the “Aboriginal Interests”).

The CNSC is also mindful of its role as an independent administrative tribunal, which confers on it the duty to fairly treat all participants in its proceedings. When developing and implementing Aboriginal consultation processes, the CNSC takes into account the guiding principles that have emerged from Canada’s case law and best consultation practices as outlined in *Aboriginal Consultation and Accommodation – Updated Interim Guidelines for Federal Officials to Fulfill the Legal Duty to Consult* (2011).

Insofar as its statutory functions allow, the CNSC supports a whole-of-government approach to Aboriginal consultation, with an aim to coordinating consultative efforts, where feasible, with other federal, provincial and/or territorial regulatory departments and agencies through a one-window approach with respect to EAs and licensing activities.

Further information is available on the CNSC website at nuclearsafety.gc.ca/eng/resources/aboriginal-consultation

E.8.2.2 Management system

The CNSC is formally committed to aligning its management system in accordance with the requirements and guidance set out in both the IAEA’s safety standard for integrated management systems, *The Management System for Facilities and Activities* (GS-R-3), and the Government of Canada’s framework for management excellence, which is known as the Management Accountability Framework. To help drive and coordinate the continual strengthening of the management system, the Internal Quality Management Division has been given the responsibility of coordinating the management of all priority improvement initiatives and ensuring corporate-wide alignment and integration throughout the CNSC.

A stronger, more robust management system allows the CNSC to deliver on key goals and objectives across all areas (such as safety, health, environment, quality, finance, human resources and security) in a balanced, harmonious and optimal manner. In defining and applying a common set of principles, practices and/or processes across the entire organization, the management system provides the CNSC with overarching and uniform management structure by:

- coherently and consistently bringing together and managing all of the organization’s regulatory and business requirements

- mapping out and managing processes as part of a larger, single integrated system to minimize both gaps in direction/guidance and duplication of effort
- clarifying roles, responsibilities and authorities across all areas and all levels
- providing a consistent, robust platform for enabling continual improvements

As the top-tier document, the CNSC *Management System Manual* summarizes the integrated management system and provides a strong base for aligning management system-related documents such as policies, processes, procedures, criteria, forms and guides. These documents are developed on a priority basis and are driven by the need for additional guidance and direction for staff, management and/or licensees and other key stakeholders. This practical approach helps the CNSC to continually strengthen its management system such that it remains complete, documented and seamlessly implemented.

E.8.2.3 Integrated Regulatory Review Service mission to Canada

In 2005, the CNSC staff requested an IAEA Integrated Regulatory Review Service (IRRS) mission to Canada. The CNSC staff's initial preparation for the mission was a self-assessment covering three modules focusing on the regulation of nuclear power plants:

- general requirements
- regulatory activities
- management system

In the fall of 2007, following a review of IRRS missions conducted in other countries, the CNSC staff chose to broaden the scope of the CNSC's planned mission to also include the regulation of nuclear substances, medical and research facilities, waste management facilities, research reactors and fuel cycle facilities, including uranium mines and mills. In 2008, a complementary self-assessment was conducted for the regulatory activities of the Directorate of Nuclear Cycle and Facilities Regulation and the Directorate of Nuclear Substance Regulation. The results of this complementary self-assessment confirmed the direction of the previously identified improvement initiatives, but recommended that they be better coordinated with clearer priorities and shorter-term deliverables.

The need to improve coordination and strengthen the implementation of important improvement initiatives led to the development of the Harmonized Plan for Improvement Initiatives (referred to herein as the Harmonized Plan). The Harmonized Plan was initially populated with initiatives identified through prior assessments, audits and evaluations. As such, early versions of the Harmonized Plan were considered to be the corrective action plans addressing outstanding actions from the 2006 self-assessment and those identified in the 2009 and 2011 IRRS peer reviews. Currently, the Harmonized Plan is the primary vehicle for strengthening the CNSC management system and driving positive change throughout the CNSC. Key improvement opportunities are identified, prioritized and managed within the Harmonized Plan. Strong management oversight and engagement assures the successful implementation of planned improvements and realization of anticipated benefits.

The scope of the 2009 IRRS mission included all activities and facilities licensed by the CNSC, with the exception of import and export licences. All activities and facilities within scope were assessed with respect to the eight IRRS modules:

- Module I Legislative and Governmental Responsibilities
- Module II Responsibilities and Functions of the Regulatory Body
- Module III Organization of the Regulatory Body
- Module IV Authorization
- Module V Review and Assessment

- Module VI Inspection and Enforcement
- Module VII Regulations and Guides
- Module VIII Management System

Three technical areas were identified as out of scope for the IRRS mission to Canada: security, emergency preparedness and safeguards.

The thematic areas (specific facilities, activities or program areas) for the IRRS mission to Canada were as follows:

- regulation of nuclear power plant operations
- regulation of nuclear power plant refurbishment
- licensing of new nuclear power plants
- regulation of uranium mining
- radiation protection programs
- environmental protection programs
- implementation of IAEA *Code of Conduct on Safety and Security of Radioactive Sources* (2004)
- implementation of IAEA *Code of Conduct on Safety of Research Reactors* (2004)

Three policy issues were also addressed during the mission:

- research for safety and regulatory purposes
- roles and responsibilities of technical services in support of regulatory decision makers
- new build projects – regulatory transition from preoperational to operational phases

The 2009 peer-review team consisted of 21 members representing 13 Member States. The review was completed in June 2009. The final report, issued in November 2009, provided a comprehensive summary of the IRRS assessment and identified 19 good practices, 14 recommendations and 18 suggestions that collectively provided excellent feedback to the CNSC and helped inform the CNSC's ongoing improvement initiatives under the direction of the Harmonized Plan.

In response to one of the IRRS mission recommendations, CNSC staff developed an evergreen action plan – referred to as the *Regulatory Framework Plan* – for modernizing CNSC's regulatory framework with respect to the regulatory requirements for spent fuel and radioactive waste. As per the plan, CNSC staff have proposed to focus for the next five years on the following related documents:

- an information document on the licensing of geological repositories
- a regulatory guide for the siting of a geological repository
- a regulatory guide for the post-closure of a geological repository
- a regulatory guide for radioactive waste management programs
- a revision of regulatory guide G-320, *Assessing the Long Term Safety of Radioactive Waste Management*

CNSC staff are also conducting an analysis to determine whether or not there is a need to develop radioactive waste and decommissioning regulations. To address this potential need, CNSC staff continue to work toward a consolidated regulatory framework for waste and decommissioning consisting of a suite of updated regulatory documents and new waste regulations. A discussion paper on the proposed approach is planned for public consultation in late 2014 or early 2015, including seeking stakeholder feedback.

In 2011, a follow-up IRRS mission was conducted to review the progress on measures taken to date for addressing the recommendations and suggestions presented in the 2009 IRRS mission report. One new review area, the CNSC's role in regulating the transport of radioactive material, was added to the mission report at the request of the CNSC. Additionally, a new IRRS core module focusing on the regulatory implications of the TEPCO Fukushima Daiichi accident was included for review at the request of the CNSC. One policy issue regarding special arrangements for the transport of radioactive material was discussed during the mission.

The 2011 IRRS review team of 14 members from 8 Member States commended the CNSC for its systematic approach to successfully completing 13 of 14 recommendations and 17 of 18 suggestions. The review team concluded that the regulatory framework for the transport of radioactive material is well established and that the CNSC regulatory response to the TEPCO Fukushima Daiichi accident was prompt, robust and comprehensive. The review team also identified an additional eight recommendations and nine suggestions from the two new review areas included in this mission. As before, the Harmonized Plan has been leveraged in managing the completion of the associated improvement initiatives.

In May 2013, the CNSC confirmed the closure of all actions related to both the original 2009 IRRS mission and the 2011 follow-up mission. The CNSC continues to leverage the use of peer reviews, such as IRRS missions, as useful tools for assessing performance as a nuclear regulator, complementing other approaches used to evaluate regulatory effectiveness (e.g., self-assessments, evaluations and audits) and providing assurance that Canada's nuclear regulator is strong, transparent and independent. For more information on the IRRS mission and resulting reports, please visit nuclearsafety.gc.ca/eng/resources/international-cooperation

E.9 Supporting the separation of roles

E.9.1 Separation of the CNSC and organizations that promote and utilize nuclear energy

The NSCA is distinct and comprehensive legislation for the regulation of nuclear activities and the separation of functions of the regulatory body from organizations that promote or use nuclear energy. The CNSC's mandate (see section E.3.1) focuses clearly on the health and safety of persons and the protection of the environment and does not extend to economic matters. The CNSC operates at arm's length of, and reports directly to, the Canadian Parliament.

Section 19 of the NSCA authorizes "the Governor in Council [to], by order, issue to the Commission directives of general application on broad policy matters with respect to the objects of the Commission." Any political directives given to agencies (such as the CNSC), however, must be of a general nature and cannot fetter the Commission's decision-making authority in specific cases. In addition, all directives must be published in the *Canada Gazette* and placed before each House of Parliament.

E.9.2 Values and ethics

The CNSC has a firmly entrenched values and ethics regime, which serves to strengthen and support governance and ethical leadership. The CNSC's Office of Audit and Ethics administers three ethics-related programs. The programs are as follows:

- The Values and Ethics Program provides employees with guidance and techniques for strengthening relationships in the workplace and with stakeholders, as well as practical tools for ethical decision making.
- The Internal Disclosure Program is designed to help employees safely and constructively disclose wrongdoing and to protect them from reprisal.
- The Conflict of Interest and Post-employment Program gives the CNSC and employees tools to prevent and avoid situations that could create the appearance of conflicts of interest or result in a potential or actual conflict of interest.

A *CNSC Values and Ethics Code*, based on a new federal *Values and Ethics Code for the Public Sector*, came into effect on July 1, 2012. The CNSC has adopted six values – respect, integrity, service, excellence, responsibility, safety – complemented by corresponding expected behaviours. These values are printed on plaques and displayed across the CNSC. Over 45 information sessions were offered to staff in 2012 to explain the significant implication of these values. The sessions covered the expanded *CNSC Conflict of Interest and Post-employment Policy* (2012) and the new *CNSC Directive on Reporting and Managing Financial Conflicts of Interest* (2012), which includes a list of prohibited securities.

The dialogue established during these sessions maintains the CNSC’s practice of giving staff opportunities to discuss concerns and to explain the rationales of decisions made. This opportunity is regularly provided during annual events and town hall meetings where senior management meets with employees to conduct discussions on continuous improvements. The codes, the policy and the directive are posted on the CNSC website. In addition, ethical scenarios, annual values and ethics reports, and related literature are posted on the CNSC intranet.

Section F – Other General Safety Provisions

F.1 Scope of the section

This section addresses articles 21 (Responsibility of the Licence Holder) to 26 (Decommissioning) of the Joint Convention. It provides information about the steps Canada takes to meet its obligations for general safety at the national and facility levels. This section addresses requirements of several International Atomic Energy Agency (IAEA) standards. These include:

- Article 21: Responsibility of the Licence Holder – IAEA Safety Standard GS-R-1
- Article 22: Human and Financial Resources – IAEA Safety Standard GS-R-1
- Article 23: Quality Assurance – IAEA Safety Standards GS-R-1, WS-R-1 and Safety Series 50-C/SG-Q
- Article 24: Operational Radiation Protection – IAEA Safety Standard 115
- Article 25: Emergency Preparedness – IAEA Safety Standard GS-R-2
- Article 26: Decommissioning – IAEA Safety Standard WS-R-2 and Safety Guide WS-G-2.4

F.2 Responsibility of the licence holder

Each licensee in Canada has the prime responsibility for the safety of its spent fuel and radioactive waste management facilities. This responsibility includes providing adequate human and financial resources to support the safe management of the spent fuel and radioactive waste management facility over its lifespan.

F.3 Human resources

Adequate human resources are defined as the employment of enough qualified staff to carry out all normal activities without undue stress or delay, including the supervision of work done by external contractors. Paragraph 44(1)(k) of the *Nuclear Safety and Control Act* (NSCA) provides the legislative basis for the qualification, training and examination of staff. Paragraphs 12(1)(a) and 12(1)(b) of the *General Nuclear Safety and Control Regulations* specify that the licensee must ensure the presence of a sufficient number of trained, qualified workers.

As in the case of many countries with mature nuclear programs, the nuclear sector and the Canadian Nuclear Safety Commission (CNSC) have both faced challenges in recent years recruiting experienced staff, partly due to an aging Canadian population. The sections below outline initiatives the parties have taken to develop sufficient human resources to ensure the long-term sustainability of the workforce.

F.3.1 University Network of Excellence in Nuclear Engineering

Established in 2002, the University Network of Excellence in Nuclear Engineering (UNENE) is an alliance of Canadian universities, nuclear power utilities and research and regulatory agencies working to support and develop nuclear education and research and development capability in Canadian universities. Its purpose is to assure a sustainable supply of qualified nuclear engineers and scientists that can meet the current and future needs of the national nuclear sector. It accomplishes this through university education and university-based education, and by encouraging young people to choose a career in the nuclear sector. More information is available online at unene.ca

The alliance consists of a number of Canadian universities and industrial partners – including Ontario Power Generation (OPG), the CANDU Owners Group, Bruce Power, Atomic Energy of Canada Limited (AECL), the CNSC and Nuclear Safety Solutions.

With funding provided by all industry partners, the Natural Sciences and Engineering Research Council (NSERC) and the CNSC are committed to the support of education and research in nuclear science and engineering at the following universities:

- Queen’s University
- University of Toronto
- McMaster University
- University of Waterloo
- University of Western Ontario
- Royal Military College of Canada
- University of Ontario Institute of Technology

UNENE funding creates industrial research chairs in specialized areas at these universities, through which students in Masters and PhD programs are trained. In addition, UNENE sponsors collaborative research of topical interest to industry. It also supports a Master of Nuclear Engineering degree program delivered jointly by participating universities, which is intended for use by the employees of industry partners on a part-time basis.

Examples of current projects undertaken by UNENE and relevant to the CNSC include work in best-estimate and uncertainty-based nuclear safety analysis, corrosion and stress-corrosion research related to reactor materials such as Alloy 600, and seismic risk analysis for nuclear power plants.

F.3.2 CANTEACH

The CANTEACH program was established by Atomic Energy of Canada Limited (AECL), Ontario Power Generation (OPG), the CANDU Owners Group, Bruce Power, McMaster University, École Polytechnique and the Canadian Nuclear Society to meet succession-planning requirements. The aim of CANTEACH is to develop, maintain and electronically disseminate a comprehensive set of education and training documents. The CNSC and other industry members also contribute information to the program. More information is available online at canteach.candu.org

F.3.3 Ontario Power Generation

The Nuclear Waste Management Division (NWMD) of OPG currently comprises approximately 211 full-time employees. Staffing demand fluctuates, depending mostly upon attrition from retirements. The NWMD has recently been reorganized to align with OPG’s move to a centre-led model. As such, support groups such as Engineering, Health & Safety, Environment and Training have been moved to central reporting groups, rather than being directly managed within NWMD. These groups continue to provide dedicated support to NWMD. Staff for the skilled and semi-skilled trades are typically recruited from within OPG and, as required, acquired through the external labour marketplace.

The NWMD utilizes the following recruitment and retention strategies, wherever possible:

- succession management – assessment of leadership capabilities and succession replacement planning for all leadership positions
- advance hiring – critical positions in the organization are identified in its succession-management program
- Development and Co-op Student Program – recruitment of university or college students in technical and business streams for work terms
- participation in workforce planning within OPG to ensure adequate recruitment in advance of staffing needs – concentration on the skilled operator and maintenance positions, with an induction process to provide core skills training; the NWMD’s staffing demand is satisfied by the internal selection and placement processes

- semi-skilled labour – direct hire from community impact areas

With continued emphasis on succession management, workforce planning and staff development, the NWMO is positively positioned to meet its qualified staffing requirements for both the short and long term.

F.3.4 Nuclear Waste Management Organization

Following the Government of Canada’s selection of the Adaptive Phased Management (APM) approach in 2007, the Nuclear Waste Management Organization (NWMO) began its evolution from a small, study-based group to a sustainable corporation with full responsibility for implementing the plan. Work was undertaken to enhance the organization’s long-term viability and improve its capacity to recruit and retain personnel. Investments were made to ensure resource capacity, expertise and sound administrative and management policies and practices to provide a foundation for fulfilling the mandate.

On January 1, 2009 the NWMO became its own employer, with the necessary supporting infrastructure including finance, legal services and human resources. Staffing levels increased from 27 at the end of 2007 to 81 one year later, with further increases to 130 by year-end 2013. The initial large staff addition was due to the transfer to the NWMO of OPG personnel who had been working on both NWMO programs and the OPG’s Deep Geologic Repository project for its low- and intermediate-level radioactive waste. A significant benefit of this arrangement was the acquisition of the experience base of an established radioactive waste management and repository team.

Over the past three years, the NWMO has focused on hiring staff and contractors whose specialties match the complex social and technical requirements of the site selection process. The NWMO has reinforced its workforce with the addition of specialists in the fields of repository design and construction, safety assessment, environmental assessment, Aboriginal traditional knowledge, social research, ethics, law, finance, communications, public engagement, transportation and new media. Consistent with the increasing community focus of the site selection process, the NWMO opened 15 local offices in communities participating in preliminary assessments of site suitability.

NWMO employees are highly skilled professionals who regularly participate in specialized development and training to complement their technical, professional and academic backgrounds. All new staff are required to complete core business needs training. The NWMO continues to recruit staff in all key skill areas. The organization has also developed succession plans to ensure that a sustainable senior management team is in place for the future.

Research also helps to shape development of the site preparation process and continues to support its implementation. The NWMO’s research capability is supported through contracts with more than a dozen Canadian universities.

The organization works with an extended group of experts from across Canada and internationally to support its design, siting and confidence-building activities. The NWMO also has contacts with many international organizations and has exchange agreements with national radioactive waste management organizations in Sweden, Finland, Switzerland and France. This ensures that best international practices are incorporated.

F.4 Financial resources

F.4.1 General

Canada applies the polluter pays principle, by which the Government of Canada has clearly indicated that waste owners are financially responsible for the management of their radioactive waste and has set in place mechanisms to ensure that this financial responsibility does not fall on the Canadian public. This position was reaffirmed in the 1996 Government of Canada *Policy Framework for Radioactive Waste* (refer to section B).

In 2002, under the *Nuclear Fuel Waste Act*, the owners of spent fuel were specifically required to establish segregated funds to fully finance long-term waste management activities.

F.4.2 Historic waste

In some instances, remedial actions are required on properties not owned by the federal government but where the original polluter no longer exists. In these situations, the federal government may make a determination to accept responsibility for management of these wastes on a case-by-case basis. In March 2001, the Government of Canada and the local municipalities in Port Hope entered into an agreement on community-developed proposals to address the cleanup and long-term management of the bulk of Canada's historic wastes, thereby launching the Port Hope Area Initiative (PHAI). In 2012, the Government of Canada announced \$1.28 billion in funding to implement PHAI. Other historic wastes, located in Canada's North and in other discrete locations, are managed by AECL's Low-Level Radioactive Waste Management Office.

F.4.3 Financial guarantees

Licensees of spent fuel and radioactive waste management facilities and uranium mines and mills must provide guarantees that adequate financial resources are available for decommissioning of these facilities and managing the resulting radioactive wastes, including spent fuel.

Subsection 24(5) of the NSCA provides the legislative basis for this requirement. Paragraph 3(1)(l) of the *General Nuclear Safety and Control Regulations* (GNSCR) stipulates that, "an application for a licence must contain a description of any proposed financial guarantee related to the activity for which a licence application is submitted." Regulatory guide G-206, *Financial Guarantees for the Decommissioning of Licensed Activities*, covers the provision of financial guarantees for decommissioning activities. Regulatory guide G-219, *Decommissioning Planning for Licensed Activities*, provides guidance on the preparation of plans for the decommissioning of activities licensed by the CNSC. These guides can be viewed at cnsccn.gc.ca/eng/acts-and-regulations/regulatory-documents

Financial guarantees must be sufficient to fund all approved decommissioning activities. These activities include not only dismantling, decontamination and closure, but also any post-decommissioning monitoring or institutional control measures that may be required, as well as subsequent long-term management or disposal of all wastes, including spent fuel. To ensure that licensees are required to cover the costs of spent fuel only once, the money in the trust funds set up under the *Nuclear Fuel Waste Act* is considered part of the licensee's total financial guarantee to the CNSC.

The CNSC must be assured that it (or its agents) can access adequate funding measures upon demand if a licensee is not available to fulfill its obligations for decommissioning. Measures to fund decommissioning may involve various types of financial guarantees. Acceptable guarantees include cash, letters of credit, surety bonds, insurance and legally binding commitments from a government (either federal or provincial). The acceptability of any of the above measures will be determined ultimately by the CNSC according to the following general criteria:

- **Liquidity** – The proposed funding measures should be such that the financial vehicle can be drawn upon only with the approval of the CNSC and that payout for decommissioning purposes is not prevented, unduly delayed or compromised for any reason.
- **Certainty of value** – Licensees should select funding, security instruments and arrangements that provide full assurance of their value.
- **Adequacy of value** – Funding measures should be sufficient, at all or predetermined points in time, to fund the decommissioning plans for which they are intended.
- **Continuity** – The required funding measures for decommissioning should be maintained on a continuing basis. This may require periodic renewals, revisions and replacements of securities provided or issued for fixed terms. For example, during a licence renewal, the preliminary

decommissioning plan may be revised and the financial guarantee updated accordingly. Where necessary, to ensure that there is continuity of coverage, funding measures should include provisions for advance notice of termination or intent to not renew.

Since 2000, the CNSC has concentrated on financial guarantees for large complex facilities and has required all major licensees with Class I operating facilities and uranium mines and mills to have financial guarantees in place. Since the last reporting period, CNSC staff have continued to explore different approaches to broaden the financial guarantee program to require all sites and activities licensed by the CNSC to have financial guarantees.

F.5 Quality assurance

F.5.1 Quality assurance program requirements

NSCA regulations require licensees to prepare and implement quality assurance (QA) programs for nuclear facilities. The licensees of spent fuel and radioactive waste management facilities submit their overall QA programs to the CNSC before they begin their planned activity. The organization responsible for a facility must establish and implement a QA program for the items and services that the facility supplies. The overall QA program may cover the licensed spent fuel and radioactive waste management activities for more than one site. After a licence is granted, the involved organization must demonstrate the effectiveness of the QA programs.

In 2013, the Canadian Standards Association (CSA) Group issued CSA N286-12, *Management System Requirements for Nuclear Facilities*. The requirement for a management system to meet this standard emphasizes the paramount importance of safety in guiding decisions and actions. CSA N286-12 applies to all nuclear facilities, including spent fuel and waste management facilities at nuclear power plants. This standard also lists specific requirements for the lifecycle activities of radioactive waste management facilities. The QA programs for uranium mines and mills facilities must comply with the QA expectations of the NSCA and the *Uranium Mines and Mills Regulations*. The application for a licence must list the QA programs that are being reviewed by CNSC staff. The specific waste management activities are performed under accepted QA programs. Reviews conducted by CNSC staff during a licence application and QA program changes concentrate on an applicable QA program that satisfies CNSC-accepted QA requirements and on its ability to:

- consistently define roles and responsibilities for the facility
- implement the QA program in a structured manner
- demonstrate the control of changes and program interactions
- conduct self-assessments and corrective action

F.5.2 Quality assurance program assessment

To assess licensee QA programs or management system effectiveness, CNSC staff review the licensee's program documentation against the criteria established by the referenced requirement documents and standards. CNSC staff also examine the results from the licensee's internal reviews and assessments. After the QA program is accepted, the CNSC plans and carries out compliance audits, to ensure that the licensee complies with its provisions. When deficiencies are detected, the CNSC produces detailed reports of the audit findings and forwards them to the licensee for response and corrective actions. Based on the safety significance of the audit findings, the CNSC may decide an enforcement action is appropriate. Section E.6.4 provides further information on the CNSC's compliance enforcement.

F.6 Operational radiation protection

F.6.1 Keeping radiation exposures and doses ALARA

Operations at Canada's spent fuel and radioactive waste management facilities must be carried out in a manner that ensures radiation exposures and doses to workers, the public and the environment are below the CNSC regulatory dose limits and kept as low as reasonably achievable (ALARA), social and economic factors taken into account. This approach is legislated through the NSCA and the *Radiation Protection Regulations* (RPR). Radiation exposures and doses are kept ALARA through the implementation of a radiation protection program with the following elements:

- management control over work practices
- personnel qualification and training
- control of occupational and public exposure to radiation
- plans for unusual circumstances
- ascertainment of the quantity and concentration of any nuclear substance released as a result of a licensed activity

In addition, the RPR require that every licensee ensure the following effective dose limits are not exceeded:

- 50 millisieverts (mSv) in a year and 100 mSv over five years for a nuclear energy worker
- 4 mSv for a pregnant nuclear energy worker for the balance of pregnancy
- 1 mSv per year for a person who is not a nuclear energy worker (i.e., the public)

Details on proposed amendments to the RPR that will harmonize the RPR with updated international standards (i.e., International Commission on Radiological Protection (ICRP) 103) are discussed in E.3.2.

To ensure consistent application of the ALARA requirement by licensees, the CNSC has issued regulatory guide G-129 rev 1, *Keeping Radiation Exposures and Doses "As Low as Reasonably Achievable" (ALARA)* to provide further details on detailed regulatory expectations.

F.6.2 Derived release limits

Some nuclear facilities release small quantities of gaseous radioactive material in a controlled manner into the atmosphere (e.g., incineration of radioactive waste) and into adjoining water bodies as liquid effluents (e.g., treated waste water). Radioactive material released from nuclear facilities into the environment through gaseous and liquid effluents can result in radiation doses to members of the public through one or more of the following ways:

- direct irradiation
- inhalation of contaminated air
- ingestion of contaminated food or water

To ensure that the regulatory dose limit for members of the public is not exceeded, the RPR limit the amount of radioactive material released in effluents from nuclear facilities. These effluent limits are derived from the public dose limit and are referred to as derived release limits (DRLs). The nuclear sector sets operating targets or administrative limits that are typically a small percentage of the DRLs. These targets are based on the ALARA principle and are unique to each facility, depending on the factors that exist at each site.

When approving DRLs for nuclear facilities, the CNSC considers the environmental pathways through which radioactive material could reach the most exposed members of the public – also known as the “critical group” – after being released from the facility. Members of the critical group are those individuals expected to receive the highest dose of radiation because of their age, diet, lifestyle and location.

Doses received by members of the public through routine releases from Canadian nuclear facilities are very low and constitute a small fraction of the CNSC regulatory dose limits. Figure F.1 shows CNSC staff gathering an environmental sample during a routine inspection at a nuclear facility.

Figure F.1: Effluent monitoring



F.6.3 Action levels

Licensees may propose and establish action levels. An action level is defined in the RPR as a specific level that, if reached, may indicate a loss of control of part of the radiation protection program. When an action level is reached, the following actions must be taken:

- notify the CNSC
- conduct an investigation to establish the cause for reaching the action level
- take action to restore the effectiveness of the radiation protection program

Regulatory guide G-228, *Developing and Using Action Levels*, has been published by the CNSC to guide licensees in developing action levels in accordance with the RPR.

F.6.4 Ascertaining and recording radiation doses

The CNSC requires that every licensee ascertain and record the magnitude of radiation exposure to workers by direct measurement or monitoring or, in cases where this is not possible, by estimation. If a nuclear energy worker has a reasonable probability of receiving an effective dose of greater than five mSv in a one-year dosimetry period, the licensee is required to use a CNSC-licensed dosimetry service. Standards for licensed dosimetry services in Canada are found in regulatory document S-106 rev.1, *Technical and Quality Assurance Requirements for Dosimetry Services* (March 2006). Licensed dosimetry services must file the dose results of each nuclear energy worker to the Canadian National Dose Registry, which is maintained by Health Canada.

F.6.5 Preventing unplanned releases

The nuclear sector uses several means to reduce the risk of unplanned effluent releases of radioactive material into the environment: multiple barriers, reliable components and systems, competent staff and the detection and correction of failures.

Due to the robust design of storage facilities housing high-risk materials such as spent fuel, the potential for a significant release is present mainly when materials are handled. Such operations are closely monitored by the licensee, who would be available in the unlikely event of an accidental release. The process of transferring waste from the point of origin to a storage site is subject to stringent control and is only done in the safest possible manner. Some of these controls involve transporting the spent fuel at extremely low speeds and prohibiting the transfer of spent fuel during periods of rain or snow.

In the event of an uncontrolled release into the environment, competent licensee staff is available for an initial mop-up exercise, preventing further spread of radioactive contaminants. If necessary, the stored radioactive waste may be retrieved and held more securely. Depending on the magnitude and severity of the release, emergency procedures and emergency preparedness plans may be activated.

F.6.6 Protection of the environment

Regulatory policy P-223, *Protection of the Environment*, describes the philosophy, principles and fundamental factors that guide the Commission as it regulates the production and use of nuclear energy and the production, possession and use of nuclear substances, prescribed equipment and prescribed information. These are regulated in order to prevent unreasonable risk to the environment in a manner consistent with Canadian environmental policies, acts and regulations, and with Canada's international obligations. This policy applies to all regulatory decisions made by the Commission or CNSC staff. P-223 applies to all types of CNSC licences, including decommissioning.

Regulatory document, REGDOC-2.9.1, *Environmental Protection: Environmental Protection Policies, Programs and Procedures*, published in September 2013, combines the information from and supersedes two other CNSC regulatory documents: S-296, *Environmental Protection Policies, Programs and Procedures at Class I Nuclear Facilities and Uranium Mines and Mills*, and G-296, *Developing Environmental Protection Policies, Programs and Procedures at Class I Nuclear Facilities and Uranium Mines and Mills*. REGDOC-2.9.1 sets out the environmental protection policies, programs and procedures that licensees shall implement at Class I nuclear facilities and uranium mines and mills – which includes spent fuel management facilities and radioactive waste management facilities – when required by the applicable licence or other legally enforceable instrument.

The objective of REGDOC-2.9.1 is to establish adequate provision for protection of the environment at Class I nuclear facilities and uranium mines and mills. This shall be accomplished through an integrated set of documented activities typical of an environmental management system (EMS). The requirements of an EMS include the following tasks:

- An EMS meeting the requirements set by the Canadian Standards Association’s ISO 14001:2004, *Environmental Management Systems – Requirements with Guidance for Use*, must be established, implemented and maintained. Certification to ISO 14001 by an authorized registrar or other independent third party is not considered by the CNSC as meeting the requirements of this document. The CNSC, in exercising its responsibilities as outlined in the NSCA, will evaluate all licensees’ programs in relation to the requirements of this document.
- Licensees must ensure that the scope of the EMS is consistent with the definitions of “environment”, “environmental effect” and “pollution prevention”, as provided in this document.
- Licensees must conduct internal audits (clause 4.5.5 of ISO 14001:2004) at planned intervals so that all elements of the EMS are audited on at least a five-year cycle.
- Licensees must conduct a management review (clause 4.6 of ISO 14001:2004) annually.

The purpose of REGDOC-2.9.1 is to help applicants seeking a licence for Class I nuclear facilities and uranium mines and mills (other than a licence to abandon) to develop and implement environmental protection policies, programs and procedures in accordance with the NSCA and its associated regulations.

In a manner that is appropriate for the facility type and phase of licensing, the EMS should include the proposed measures to control the release of nuclear substances, hazardous substances, or both into the environment, along with the measures that will be taken to mitigate the effects.

In terms of releases, the EMS should be commensurate with overall regulatory requirements, the specific information provided on the proposed location of points of release, the proposed maximum quantities and concentrations, and the anticipated volume and flow rate of releases of nuclear substances and hazardous substances into the environment, including their physical, chemical and radiological characteristics.

In terms of wastes, the EMS should be commensurate with overall regulatory requirements and the specific information provided on the name, quantity, form, origin and volume of any radioactive waste or hazardous waste that may result from the activity to be licensed. This includes waste that may be stored, managed, processed or disposed of at the site of the activity to be licensed, and the proposed method(s) for managing and disposing of that waste. For uranium mines and mills, there is a further requirement to address management of the anticipated liquid and solid waste streams within the mine or mill, which includes attention to the following:

- ingress of fresh water and any diversion or control of uncontaminated surface and groundwater
- anticipated quantities, composition and characteristics of backfill
- the proposed waste management system

As a further consideration, the EMS should address environmental emergency preparedness and response by proposing measures to:

- prevent or mitigate the effects of accidental releases of nuclear substances and hazardous substances on the environment
- protect the health and safety of persons

Reporting requirements for certain emergency situations should also be included in the EMS. Lastly, additional elements relating to worker training or qualifications and the environmental protection obligations of workers should be included. Training programs should enable workers to meet their obligations with respect to environmental protection.

As specified in ISO14001:2004, clause 4.5.1 discusses monitoring and measurement. This is provided below to illustrate the correspondence between performance elements in ISO 14001:2004, certain CNSC regulations and CNSC guidance documents, and the CSA documents.

The Licence Conditions Handbook (LCH) is used as a vehicle to implement CSA standards such as N288.4 (environmental monitoring), N288.5 (effluent monitoring) and N288.6 (environmental risk assessment). The LCH references these standards as compliance verification criteria and provides a time schedule by which licensees shall become compliant with the standards.

Monitoring and measurement

Licensees should establish procedures to measure, monitor and evaluate environmental performance relative to the performance indicators and targets they have set to achieve their environmental objectives. Measurement and evaluation are the best way to verify whether the controls placed on contaminants are effective. For licensees to achieve their performance targets it is important that the overall monitoring process include continual feedback mechanisms. Such mechanisms enable licensees to take appropriate action when necessary. Monitoring should be conducted on a spatial and temporal scale and reflect the environmental effects predicted in an environmental assessment.

Environmental risk assessment

The environmental risk assessment (ERA) provides the basis for the scope and complexity of monitoring programs, including effluent and environmental monitoring programs. An ERA can provide input into an effluent monitoring program by identifying and prioritizing the specific radioactive and non-radioactive contaminants and physical stressors and the sources or release points from the nuclear facility or licensed activity. In this context, the CSA N288.6, published in 2012, addresses the design, implementation and management of an environmental risk assessment program. Similarly, an understanding of the environmental risk posed by the facility can develop the scope and complexity of an environmental monitoring program. The results of the ERA can be used to identify environmental monitoring requirements for normal operating conditions.

Effluent monitoring

The CSA N288.5 standard *Effluent Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills*, published in 2011, addresses the design, implementation and management of an effluent monitoring program that meets legal and business requirements.

Effluent monitoring should be the primary indicator of performance in terms of releases to air, surface waters, groundwater and soil from facility operations and waste management activities. Effluent monitoring addresses the nature and quantity of releases of nuclear and hazardous substances (including wastes). Monitoring schedules should be controlled administratively to help prevent situations that might lead to unreasonable risk for the environment. Targets should be designed that will prompt investigations – and thus lead to preventive measures – when situations are abnormal.

As part of a Code of Practice for uranium mines and mills, certain performance targets (action levels) must be developed to protect the environment. These should address how releases at the source are managed. All facilities require action levels for the radiation protection program. Although specific to radiation protection, regulatory guides G-218, *Preparing Codes of Practice to Control Radiation Doses at Uranium Mines and Mills*, and G-228, *Developing and Using Action Levels*, provide useful generic guidance on the principles underlying action levels. These principles, along with the ALARA principle (as outlined in *Keeping Radiation Exposures and Doses “As Low as Reasonably Achievable” (ALARA)*, regulatory guide G-129 rev 1), should be used to develop targets for environmental performance.

Class I nuclear facilities do not require a Code of Practice for environmental protection; however, licensees of Class I nuclear facilities should ensure their operations can control releases that are potentially harmful. The development of administrative controls typically requires modelling of environmental pathways in order to derive release targets that can be interpreted in terms of levels in environmental media. These levels are chosen to protect the environment as a whole, with adequate safety margins. The *Canadian Environmental Quality Guidelines* provide practical guidance on levels thought to be sufficiently

protective. Alternatively, levels can be derived from assessments performed under the *Canadian Environmental Assessment Act, 2012*, (CEAA 2012) the *Canadian Environmental Protection Act* (CEPA) or the NSCA.

Facilities that may potentially expose the public to releases are also expected to develop derived release limits (DRLs), historically referred to as derived emission limits. Facilities calculate DRLs through environmental transfer modelling; DRLs represent estimates of releases that could result in doses to the public that equal the prescribed public limit (effective dose of 1 mSv) or equivalent dose limits. DRLs may be incorporated separately as a licence condition.

Environmental monitoring

With the promulgation of the NSCA in 2000, protection of the environment (as opposed to the previous human-focused legislation) from both radionuclides and hazardous substances also became the responsibility of the CNSC. As mentioned in the previous reporting period, CSA document N-288 issued in 1990 had several identified gaps; therefore, it was recognized that a revised environmental monitoring standard/guide was required.

The CSA revised standard N288.4, *Environmental Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills*, published in 2010, involves significant changes and addresses both radiological and hazardous substances and their potential impacts to human and non-human biota.

F.6.7 Canadian Nuclear Safety Commission activities

To verify compliance with the requirements of a licence and regulations, CNSC staff:

- review documentation and operational reports submitted by licensees
- conduct radiation protection evaluations
- conduct evaluations of licensees' environmental protection programs and other programs as required

A detailed description of the compliance verification program is provided in section E.6.3.

F.7 Nuclear emergency management

Nuclear emergency preparedness and response in Canada is a multi-jurisdictional responsibility shared by all levels of government, and includes the CNSC and the licensed nuclear facilities. Licensees must respect Canada's international commitments on the peaceful use of nuclear energy and are responsible for protecting health, safety, security and the environment by preventing or mitigating the effects of accidental releases of nuclear or hazardous substances. The provinces and territories have primary responsibility to implement measures for civil protection and for offsite nuclear emergency preparedness and response, including designating municipalities to carry out nuclear emergency planning within their jurisdictions.

In accordance with IAEA guidance and requirements, responsibilities for nuclear emergency response are subdivided into two basic areas: onsite and offsite. Onsite nuclear emergency response pertains to all actions and measures taken within the boundary of the licensee site, whereas offsite nuclear emergency response pertains to actions and measures taken outside and beyond the licensee site boundary. The response activities and strategies in these two areas may involve and require different stakeholders; however, they are not independent of each other and therefore coordination must occur among all levels of government, the CNSC and the licensee to assure an effective and efficient response to a nuclear emergency.

All organizations playing a role in nuclear emergency response, including the CNSC and its licensees, must have nuclear emergency response plans in place, as well as operational facilities equipped and appropriately staffed to coordinate and direct the responses to the nuclear emergency. The CNSC has a dual

role in nuclear emergency response in that, under the mandate established by the NSCA, the CNSC maintains regulatory oversight of the onsite nuclear emergency response activities of the licensee, while as a federal agency, the CNSC also participates in the whole-of-government response to a nuclear emergency in accordance with the requirements of both the Federal Emergency Response Plan (FERP) and the Federal Nuclear Emergency Plan (FNEP).

The CNSC requires licence applicants to assess the impacts of their proposed activities on health, safety, security and the environment, and to propose and implement measures to prevent or mitigate the effects of accidental releases of nuclear or hazardous substances. Once the CNSC has reviewed, accepted and issued a licence, these measures become binding upon the licensee. Due to the variety of risk among CNSC-licensed facilities in Canada, some facilities require detailed emergency preparedness and response plans that must be coordinated with mutual aid organizations, while others may require only internal emergency procedures. Post-Fukushima, all major radiological and nuclear facilities in Canada were required to review their emergency planning basis, taking into account severe accidents and multi-event scenarios (loss of power coincident with a release of radioactive material, for example), to determine if their current preparedness measures were still appropriate or if additional measures needed to be incorporated into their plans.

The CNSC maintains its regulatory role and responsibilities during emergencies through direct oversight of the licensees' response actions, providing technical and advisory support to the provincial, territorial and federal authorities through the Government of Canada FERP and FNEP. These responsibilities encompass a wide range of contingency and response measures to prevent, correct or mitigate accidents, spills, abnormal situations and emergencies.

Because many of the major nuclear facilities in Canada are located in Ontario (i.e., the largest radioactive waste management facility and 20 of the 22 Canadian reactors), Emergency Management Ontario has been a key stakeholder in planning and preparedness with relation to the nuclear industry in Canada. In 2013, Emergency Management Ontario merged with the Office of the Fire Marshal to form the Office of the Fire Marshal and Emergency Management. The newly formed division provides leadership and expertise in the coordination, development and implementation of prevention, mitigation, preparedness, response and recovery strategies to keep Ontario communities safe and secure.

Until recently, Quebec had one operating nuclear reactor, located at Gentilly near Trois-Rivières on the St. Lawrence River. In 2013, the Gentilly-2 reactor was shut down and defuelled. Even though the reactor is no longer fuelled and producing electricity, there is a requirement for emergency preparedness plans until the site has been decommissioned. Consequently, l'Organisation de la sécurité civile du Québec (OSCQ) is still the lead provincial organization for the emergency management effort for all hazards, including offsite nuclear emergencies. The OSCQ nuclear emergency plan, le plan de mesures d'urgence nucléaire externe à Gentilly-2 (PMUNE-G2), is in accordance with Quebec provincial acts of legislation, such as *la Loi sur la sécurité civile* (L.R.Q., c. S-2.3), the *Loi sur la Santé publique* (L.R.Q., c. S-2-2) and others, which define the responsibilities of the government agency with specific objectives for minimizing consequences, protecting the public and providing support to the municipality.

New Brunswick has a single operating CANDU reactor located at Point Lepreau, approximately 40 kilometres southwest of St. John. The New Brunswick Emergency Measures Organization (NB EMO) coordinates emergency preparedness for the New Brunswick provincial and municipal governments. NB EMO works at the provincial and municipal levels through district coordinators to ensure that the province and its communities have appropriate and tested emergency plans. In addition, New Brunswick has invested significantly in provincial communications infrastructure to improve connectivity and harmonization with federal and provincial intervening organizations during a nuclear emergency.

Saskatchewan has several uranium mines and mills in the northern part of the province. The Saskatchewan Emergency Management Organization (SaskEMO) is the provincial government lead agency for emergency management. SaskEMO coordinates overall provincial emergency planning, training and response operations for the safety of residents and the protection of property and the environment before, during and after an emergency. Corrections and Public Safety, through SaskEMO, is the provincial

government lead agency for emergency management. Corrections and Public Safety is responsible for the *Emergency Planning Act* (November 1, 1989), which contains provisions for emergency planning, emergency powers and disaster relief. SaskEMO supports community preparedness by encouraging the formation of local government emergency measures organizations, assisting in the development of local emergency plans, and providing onsite consultation to municipal officials during government-declared states of emergency. SaskEMO also supports provincial preparedness by maintaining the provincial government emergency plan and related contingencies, coordinating provincial government resources during a state of emergency, assisting government departments, Crown corporations and agencies with emergency planning, and coordinating with Government of Canada emergency preparedness programs within Saskatchewan.

In Nova Scotia, many shipments containing radioactive substances pass through the dock at the Port of Halifax. The *Emergency Measures Act* is Nova Scotia's emergency-management and emergency-powers legislation. It establishes the rules for managing emergencies in Nova Scotia and requires municipal governments to have emergency plans. The Nova Scotia Emergency Management Office (NS EMO) is the lead agency to ensure the safety and security of residents of Nova Scotia, their property and the environment by providing for a prompt and coordinated provincial and municipal response to an emergency. This is accomplished through cooperative and consultative planning before emergencies occur and by coordinating the provision of provincial resources to assist with the response. The NS EMO facilitates and coordinates communication and emergency planning efforts between all levels of government.

F.7.1 CNSC assessment of licensee emergency management programs

Applicants, including those for spent fuel and radioactive waste management facilities, must submit their emergency plans as part of their licence application. CNSC staff review and evaluate those plans according to regulatory criteria and guidance documents. Once a licensee has been issued its licence, CNSC staff regularly review and perform audits of the licensee's emergency plans.

F.7.2 Types of nuclear emergencies

With respect to nuclear accident mitigation, emergency planning includes both onsite and offsite consequences, as described below:

- Onsite nuclear emergencies are described as those that occur within the physical boundaries of a CNSC-licensed nuclear facility. The operators of those nuclear facilities are responsible for their onsite emergency planning, preparedness and response, but must also have plans and procedures in place to assist with any potential offsite consequences as a result of an onsite emergency occurring at their facility.
- Offsite nuclear emergencies are events that occur outside licensed facilities, but may originate from, or be associated with, a licensed facility or activity, and may even originate outside Canada. Events of this type may require intervention from provincial, territorial or municipal authorities operating outside of the licensed facility or activity, likely requiring support from the licensee and possibly the Government of Canada through the FNEP.

F.7.3 Government of Canada responsibilities

In the event of a nuclear site or facility accident with potential offsite consequences, the offsite response would follow a tiered process involving the following parties:

- the licensee
- municipal government
- provincial/territorial governments

- federal government

The provincial governments are responsible for:

- overseeing public health and safety and protection of property and the environment
- enacting legislation to fulfill the province's lead responsibility for public safety
- preparing emergency plans and procedures and providing direction to municipalities that they designate to do the same
- managing the offsite response by supporting and coordinating the efforts of organizations with responsibility in a nuclear emergency
- coordinating support from the nuclear site or facility licensee and the Government of Canada during preparedness activities and response in a nuclear emergency

Federal government support and response for potential offsite impacts are required for addressing areas of federal responsibility, including an incident's effects that extend beyond provincial and/or national borders. Likewise, the coordination of federal assistance when requested by an affected province is also required. Some provinces have pre-agreements with the federal government for the provision of specific types of technical support. Federal responsibility also encompasses a wide range of contingency and response measures to prevent, correct or eliminate accidents, spills, abnormal situations and emergencies, and to support provinces and territories in their responses to a nuclear emergency. The Government of Canada is also responsible for:

- liaison with the international community
- liaison with diplomatic missions in Canada
- the assistance of Canadians abroad
- coordination of the national response to a nuclear emergency occurring in a foreign country

Public Safety Canada was created in 2003 to ensure coordination across all federal departments and agencies responsible for national security and the safety of Canadians. It is responsible for coordinating the overall federal government response to emergencies in support of provinces, including nuclear emergencies. In 2007, the Government of Canada replaced the former *Emergency Preparedness Act* with the modernized *Emergency Management Act* (EMA). The EMA provides the legislative basis and broad policy direction for federal government ministers and their respective departments/agencies, broadening the scope of emergency preparedness at the federal level to include the four pillars of emergency management: mitigation, preparedness, response and recovery.

Public Safety Canada is the lead authority for the FERP. Health Canada is the lead authority for the FNEP and also has responsibilities related to radiation protection. Health Canada administers a federal interdepartmental and a federal-provincial nuclear emergency management committee.

Other federal organizations with responsibilities in nuclear emergency preparedness and response include the CNSC, Transport Canada, Environment Canada and Natural Resources Canada (NRCan). NRCan is responsible for providing emergency radiation mapping and surveying services, providing policy advice and coordinating federal actions in relation to nuclear liability. Transport Canada is responsible for the Canadian Transport Emergency Centre. Internationally, Health Canada and the CNSC serve as national competent authorities to the IAEA. Environment Canada is a Regional Specialized Meteorological Centre under the World Meteorological Organization and provides atmospheric modelling services to the IAEA as part of its emergency response functions. The Public Health Agency of Canada is the national authority for reporting to the World Health Organization under the *International Health Regulations*.

Health Canada led a review and update of the FNEP, which was endorsed in October 2012 by federal deputy ministers on the condition that the revised FNEP be tested in a national-level exercise, currently planned for May 2014 and involving all jurisdictions, including the licensee and the municipal, provincial and federal organizations.

The Government of Canada is also responsible for establishing and managing a nuclear civil liability regime that addresses civil liability and compensation for injury and damage arising from nuclear incidents. This regime is established under the *Nuclear Liability Act* (NLA), and the CNSC designates certain nuclear facilities as coming within its scope. Typically, these are facilities where there is a risk of criticality. An operator of such an installation is absolutely and exclusively liable for any civil damages caused by an incident at that installation and carries mandatory insurance. In the event of a serious incident, the NLA provides special compensation measures that may be imposed by government to replace the normal court process. NRCan is the lead department for ensuring the process of compensation is well coordinated and administered in Canada.

Proposed legislation (the *Nuclear Liability and Compensation Act*) to replace the NLA was introduced in the Canadian Parliament in January 2014, as part of the *Energy Safety and Security Act* bill. Annex 2.4 provides details on the proposed legislation.

F.7.4 International arrangements

Canada has signed and ratified the following three international emergency response conventions:

Canada–U.S. Joint Radiological Emergency Response Plan (1996) – This plan focuses on emergency response measures of a radiological nature rather than generic civil emergency measures. It is the basis for cooperative measures to deal with peacetime radiological events involving Canada, the United States or both countries. Cooperative measures contained in the FNEP are consistent with this plan.

Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (1986) – This international assistance agreement, which was developed under the auspices of the IAEA, promotes cooperation between signatories and facilitates prompt assistance in the event of a nuclear accident or radiological emergency. Its purpose is to minimize the consequences of such an accident; practical steps include taking measures to protect life, property and the environment. The agreement sets out how assistance is requested, provided, directed, controlled and terminated.

Convention on Early Notification of a Nuclear Accident (1987) – This international convention, which was developed under the auspices of the IAEA, defines when and how the IAEA would notify the signatories associated with an international event that could have an impact on their respective countries.

F.8 Decommissioning

In accordance with regulatory guide G-219, *Decommissioning Planning for Licensed Activities*, the CNSC requires Class I nuclear facilities and uranium mines and mills licensees to keep decommissioning plans up to date throughout the lifecycle of a licensed activity. The CNSC also requires licensees to prepare a preliminary decommissioning plan (PDP) and detailed decommissioning plan (DDP) for approval.

The PDP must be filed with the CNSC as early as possible in the lifecycle of the activity or facility and must be reviewed and updated in the following situations:

- every five years
- when operational experience is gained or technological advancements are made
- when requested by the Commission or person authorized by the Commission

In the case of nuclear facilities, specific requirements for decommissioning planning are set out in the CNSC regulations for Class I and Class II nuclear facilities and for uranium mines and mills.

The PDP documents the preferred decommissioning strategy, whether it is prompt decommissioning, deferred decommissioning or *in situ* confinement, along with objectives at the end of decommissioning. The plan should be sufficiently detailed to assure that the proposed approach is technically and financially feasible. It must also be in the interests of health, safety, security and protection of the environment. The plan defines areas to be decommissioned and the general structure and sequence of the principal decommissioning work packages envisioned.

The DDP is filed with the CNSC prior to decommissioning and is required for appropriate licensing action, i.e., licence to decommission. The DDP refines and adds procedural and organizational detail to the PDP.

CSA standard N294-09, *Decommissioning of Facilities Containing Nuclear Substances* was published in July 2009. The CNSC is working with the CSA committee on amendments to the document, which is planned for release in 2014.

The applicable regulations and regulatory guide can be viewed on the CNSC website at nuclearsafety.gc.ca

Decommissioning activities are listed in annex 7. Decommissioning waste generated in the last reporting period is listed in section D.

F.8.1 Qualified staff and adequate financial resources

Subsection 24(5) of the NSCA legislates that licensees of nuclear facilities must guarantee that adequate financing and human resources will be available for the decommissioning of facilities and the management of resulting radioactive wastes, including spent fuel. Paragraph 3(1)(l) of the GNSCR states: “An application for a licence shall contain a description of any proposed financial guarantee relating to the activity to be licensed.” Section F.4.3 describes the financial guarantees applicable to the decommissioning process. Paragraph 44(1)(k) of the NSCA provides the legislative basis for the qualification, training and examination of personnel. Paragraphs 12(1)(a) and 12(1)(b) of the GNSCR specify that the licensee must ensure the presence of a sufficient number of trained, qualified workers.

F.8.2 Operational radiation protection, discharges, unplanned and uncontrolled releases

During the entire lifecycle of a facility, including decommissioning, the licensee is required to implement and maintain a radiation protection program that ensures radiation exposures and doses to persons are below CNSC regulatory dose limits and kept ALARA through the implementation of:

- management control over work practices
- personnel qualification and training
- control of occupational and public exposure to radiation
- planning for unusual situations

Additionally, licensees are required to ascertain the quantity and concentration of any nuclear substance released as a result of a licensed activity and to implement measures to protect the environment and prevent or mitigate the effects of unplanned releases.

F.8.3 Emergency preparedness

For nuclear emergency management during the decommissioning phase, an emergency response plan is still required; however, the plan will be based on the risk associated with the facility at the time of decommissioning.

F.8.4 Records

As part of the decommissioning planning process, records are reviewed. Relevant aspects are incorporated into the documentation required for formal approval of both preliminary and detailed decommissioning plans. A preliminary plan serves as the basis for the decommissioning financial guarantees provided by the licensee. The CNSC requires that the PDP and financial guarantee be in place prior to the start of construction and operations. A detailed decommissioning plan must be developed while operations approach completion; this serves as the basis for subsequent licensing of the decommissioning activities. The detailed plan must include a description of the records and information that will be permanently retained and of the reports that are to be submitted to the CNSC.

The licensee must retain specified records and information, typically through the corporate office, as the need for onsite staff diminishes. Reports submitted to regulatory agencies will be retained in accordance with the respective agencies' procedures.

For example, the *Class I Nuclear Facility Regulations* require that every licensee who operates a nuclear facility keep a record of the following:

- operating and maintenance procedures
- the results of the commissioning program
- the results of the inspection and maintenance programs
- the nature and amount of radiation, nuclear substances and hazardous substances within the nuclear facility
- the status of each worker's qualifications, re-qualifications and training

Also, every licensee who decommissions a Class I nuclear facility must keep a record of the following:

- the progress achieved in meeting the schedule
- the implementation and results of the decommissioning
- the manner in which, and the location at which, any nuclear or hazardous waste is managed, stored, disposed of or transferred
- the name and quantity of any radioactive nuclear substances, hazardous substances and radiation that remain at the nuclear facility after completion of the decommissioning
- the status of each worker's qualifications, re-qualifications and training

These *Class I nuclear facility Regulations* can be viewed at the CNSC's website nuclearsafety.gc.ca/eng/acts-and-regulations

Section G – Safety of Spent Fuel Management

G.1 Scope of the section

This section addresses article 4 (General Safety Requirements) to article 10 (Disposal of Spent Fuel) of the Joint Convention. It provides a comprehensive description of spent fuel management in Canada. At every stage of spent fuel management, there are effective defences against potential hazards. These defences protect individuals, society and the environment from the harmful effects of ionizing radiation.

In addition to describing facilities and their normal operation, this section discusses the steps and controls in place to prevent accidents with radiological consequences and to mitigate the consequences should such accidents occur. The information contained in this section demonstrates that the requirements of the following applicable International Atomic Energy Agency (IAEA) Safety Standards have been addressed:

- Article 4: General Safety Requirements – IAEA Safety Requirements SSR-2/1, SSR-5 and GSR Part 5
- Article 6: Siting of Proposed Facilities – IAEA Safety Requirement NS-R-3
- Article 7: Design and Construction of Facilities – IAEA Safety Requirements SSR-2/1 and SSR-5
- Article 8: Assessment of Safety of Facilities – IAEA Safety Requirements SSR-2/1, SSR-5 and GSR Part 3
- Article 9: Operation of Facilities – IAEA Safety Standards SSR-2/1, SSR-5, GSR Part 5 and GSR Part 3
- Article 10: Disposal of Spent Fuel – IAEA Safety Standard SSR-5

G.2 Nuclear power plants

In Canada, spent fuel is stored in wet and dry states at the locations where it is produced. When the fuel first exits a power reactor, it is placed in water-filled bays. Water cools the fuel and shields the radiation. After several years in the bays – seven to 10 years, depending on site-specific needs and organizational administrative controls – and when the associated heat generation has diminished, the spent fuel can be transferred to an onsite dry storage facility. These dry storage facilities are large, reinforced concrete cylinders or containers. Each nuclear power plant in Canada has enough storage space to store all the spent fuel produced during the operating life of the station. A 600-megawatt CANDU nuclear reactor produces approximately 90 tonnes of heavy metal spent fuel annually.

G.3 CANDU fuel

All CANDU fuel bundles are fabricated from natural uranium oxide pellets contained in a zirconium-alloy (zircaloy-4) tube (cladding). There are normally 30 uranium oxide pellets per element. The maximum nominal bundle diameter is 102 millimetres, with an overall bundle length of 495 millimetres. The weight of a nominal bundle is 23.6 kilograms, of which 21.3 kilograms are uranium oxide. Approximately 19.2 kilograms can be attributed to the uranium (without the oxygen component). These numbers are averages and may vary depending on the type and age of the CANDU bundle. Each year, 4,500 to 6,000 fuel bundles per reactor are added to the wet storage bays, based on 80 percent to 95 percent full power reactor operation.

G.4 Research reactors

G.4.1 General

In support of the international regime, Canada contributed its expertise and perspective to the development of two IAEA documents, the *Code of Conduct on the Safety of Research Reactors* and *Safety Requirements for Research Reactors*. These documents will help strengthen the regulatory framework governing the safe operation of research reactors in Canada.

As of March 2014, there were seven operating research reactors in Canada. Four of these are Safe Low-Power Critical Experiment (SLOWPOKE)-2 reactors, designed by Atomic Energy of Canada Limited (AECL). These are located across Canada as follows:

- Royal Military College of Canada (Kingston, Ontario)
- École Polytechnique (Montréal, Quebec)
- University of Alberta (Edmonton, Alberta)
- Saskatchewan Research Council (Saskatoon, Saskatchewan)

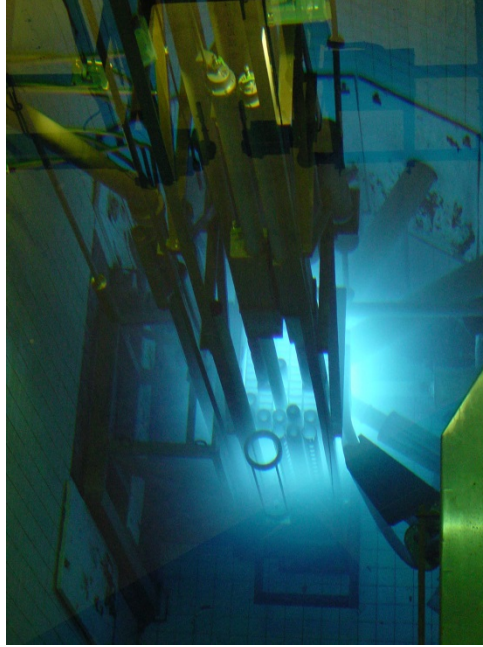
Of the three remaining research reactors, one is a five-megawatt pool-type reactor at McMaster University, while the final two reactors, namely, National Research Universal (NRU) and Zero Energy Deuterium-2 (ZED-2), are located at AECL's Chalk River Laboratories (CRL). In the past, research reactors have typically used highly enriched uranium (HEU) for the fuel cores, but within the last decade some of them have been converted to low-enriched uranium (LEU) fuel. This conversion to an LEU operation is in line with the United States Department of Energy's Reduced Enrichment for Research and Test Reactors Program. The program aims to convert all HEU research reactors to LEU fuel. The HEU fuel used in Canadian reactors comes from the United States.

G.4.2 Nuclear fuel waste from research reactors

Two of the four SLOWPOKE-2 reactors in Canada use LEU (below 20 percent uranium-235); the others use HEU. All SLOWPOKE-2 cores are preassembled and cannot be modified by the licensee. The cores last many years, with the addition of beryllium reflector shims compensating for reactivity decreases in fuel. Once the addition of the shims can no longer compensate for the decreased reactivity of the spent fuel (usually after 20 to 30 years, depending on usage), the complete core is removed and the spent fuel is sent either to AECL's CRL for storage or to the United States. The fuel may also be removed if the facility is being decommissioned or converted to an LEU core.

The waste and spent fuel for CRL reactors is stored onsite. The spent fuel from NRU is stored in fuel storage pools until it can be transferred to Waste Management Area B, which is described in annex 4. The ZED-2 reactor is operated occasionally and is mainly used for testing of prototype fuel to determine fuel characteristics.

The McMaster Nuclear Reactor (MNR) (see figure G.1) was recently fully converted to LEU. Some of the LEU comes from France. All MNR-used HEU fuel was sent to Savannah River in the United States.

Figure G.1: McMaster Nuclear Reactor**G.5 Medical isotope production fuel**

This type of fuel is not included in the report because, once spent, the fuel is reprocessed for extraction of medical isotopes and is therefore outside the scope of the Joint Convention, according to Article 3(1).

G.6 Storage of spent fuel

In Canada, all spent fuel is stored at the site where it was produced, with the following exceptions:

- small quantities that are transported to research facilities for experimental or examination purposes, and which are stored at those facilities
- the fuel from the Nuclear Power Demonstration (NPD) reactor, which is stored at the nearby AECL CRL site

All Canadian nuclear power reactors were constructed with onsite spent fuel storage bays or water pools. Spent fuel is stored in either storage bays or in dry storage facilities at the location where it was produced. The only exception is the spent fuel produced at the now-closed NPD nuclear facility. The spent fuel from this facility was transferred to AECL CRL, where it was placed in a dry storage facility. Refer to section D.4 for a map of the locations.

Secondary or auxiliary bays have also been constructed at Pickering A (Units 1 to 4), Bruce A and Bruce B for additional storage. Since 1990, dry storage technology has been chosen for additional onsite interim storage. In addition, the spent fuel from the earlier decommissioned prototype reactors is stored onsite in dry storage facilities. The spent research reactor fuel rods are stored in dry storage facilities in tile holes and in silos at the CRL and Whiteshell Laboratories waste management facilities.

The engineered structures, canisters, Modular Air-Cooled Storage (MACSTOR) and Ontario Power Generation (OPG) dry storage containers were originally designed for a 50-year lifetime. The actual life of the structures could be much longer. These structures are vigorously monitored; in the event of a structure failure, the spent fuel can be retrieved and transferred to a new structure.

Dry storage facilities are licensed for a limited period. Licences issued by the Canadian Nuclear Safety Commission (CNSC) are generally valid for a five- to 10-year period. At the time of licence renewal, the CNSC examines the operational performance of the dry storage facility to determine whether it can continue to operate safely for another licensing term – again, typically for a five- to 10-year period. This situation may continue until a long-term management facility becomes available.

G.7 Spent fuel management methods and requirements for spent fuel storage

The fuel cycle in Canada is a once-through process (currently, there is no reprocessing or intent to reprocess spent fuel for recycling of its uranium and plutonium content). The development and selection of an approach for long-term management of spent fuel is discussed in section G.16.

Spent fuel handling and storage facilities are required to provide the following:

- containment
- shielding
- dissipation of decay heat
- prevention of criticality
- assurance of fuel integrity for the required time of storage
- allowance for loading, handling and retrieval
- mechanical protection during handling and storage
- allowance for safeguards and security provisions
- physical stability and resistance to extreme site conditions

The Canadian Standards Association (CSA) Group has developed a standard consisting of best practices for the safe site preparation (siting), design, construction, commissioning, operation and decommissioning of facilities and associated equipment for the dry storage of spent fuel, known as CSA N292.2-13, *Interim Dry Storage of Irradiated Fuel*. The Canadian nuclear sector uses this standard as a guide to facilitate the licensing process.

G.8 Safety of spent fuel and radioactive waste management

In Canada, spent fuel and radioactive waste management and associated facilities are regulated in a similar fashion. Safety and licensing issues are regulated according to *Nuclear Safety and Control Act* (NSCA) requirements and associated regulations.

G.8.1 General safety requirements

Canada ensures that individuals, society and the environment are adequately protected at all stages of spent fuel and radioactive waste management. This is accomplished through the Canadian regulatory regime. Canada's approach to the safety of spent fuel and radioactive waste management is in line with the guidelines provided by the IAEA *Safety Guides and Practices*.

G.8.2 Canadian licensing process

The Canadian licensing process covers site preparation, construction, operation, decommissioning and abandonment. No phase may proceed without the required applications, documentation, assessments and approvals. A full description of Canada's comprehensive licensing system is provided in section E.4.

G.8.3 Protection and safety fundamentals

The main objective in the regulation of spent fuel and radioactive waste management is to ensure that facilities and activities do not pose unreasonable risks to health, safety, security and the environment. The regulation of spent fuel and radioactive waste can be divided into:

- generic performance requirements
- generic design and operational principles
- performance criteria

G.8.3.1 Generic performance requirements

There are three main generic performance requirements:

- The applicant must make adequate provision for the protection of the environment, the health and safety of persons and the maintenance of security.
- The applicant must comply with all applicable laws, regulations and limits (e.g., dose limits, ALARA principle).
- The applicant must assure or demonstrate compliance with tests, analyses, monitoring programs, records, data and relevant reports.

G.8.3.2 Generic design and operational principles

There are two main principles for generic design and operations:

- Multiple engineered barriers are used to ensure spent fuel and radioactive waste are adequately contained and isolated from humans and the environment during normal and abnormal conditions.
- Administrative controls and procedures are used to augment and monitor the performance of the engineered barriers.

G.8.3.3 Performance criteria

The performance criteria accepted by the CNSC are as follows:

- Structural integrity must be maintained over the design life of the structure.
- Radiation fields at one metre from the storage structure and at the facility perimeter must not exceed regulatory limits for the public and for workers.
- There must be no loss of effective shielding during the design life of the storage container.
- There must be no significant release of radioactive or hazardous contaminants over the design life of the storage container.
- There must be no significant tilt or upset of the storage containers under normal conditions.
- Physical security systems of the contents and facility components must be maintained.

G.8.4 Safety requirements

Spent fuel and radioactive waste management facilities must be operated in a safe manner that protects the environment and the health and safety of workers and the public. System components that may require periodic maintenance must be readily accessible and designed to permit safe and efficient maintenance.

Safety requirements at spent fuel and radioactive waste facilities include the following:

- nuclear criticality safety
- radiation safety
- physical security and safeguards
- industrial safety

G.8.4.1 Nuclear criticality safety

As per CNSC regulatory document RD-327, *Nuclear Criticality Safety*, criticality safety requirements must address both normal and abnormal conditions. This document applies to operations with fissionable materials outside nuclear reactors, except for the assembly of these materials under controlled conditions (such as in critical experiments). Criticality safety analyses must be performed when significant quantities of fissionable materials are stored or handled. Each analysis must clearly demonstrate that the storage and handling of the radioactive waste is safe, which means that an inadvertent criticality cannot occur under normal (or credible abnormal) conditions. The analysis of a facility must consider the offsite consequences of improbable or inadvertent criticality events and demonstrate that these consequences do not violate the public evacuation criteria established by international standards (IAEA Safety Standards Series GS-R-2) and national guidelines (*Health Canada Guidelines for Intervention During a Nuclear Emergency*).

G.8.4.2 Facility design

Spent fuel storage and radioactive waste systems must be designed to ensure that radiation exposures to persons and radioactive emissions to the environment are kept as low as reasonably achievable (ALARA). It is a CNSC regulatory requirement for dose rates at storage area boundaries and at any accessible points within storage areas to be monitored, controlled and maintained at levels that would not result in an exposure to a person that would exceed the corresponding CNSC regulatory dose limit for workers and members of the public.

Spent fuel and radioactive waste management facilities in Canada operate at a small fraction of the CNSC regulatory dose limits for workers and members of the public.

G.8.4.3 Security and safeguards

The CNSC monitors and assesses the effectiveness of the security of nuclear facilities and nuclear materials and provides guidance to licensees on how to apply the *Nuclear Security Regulations* and other applicable regulatory requirements. The CNSC is the designated competent authority for Canada responsible for implementing the requirements of the Canada/IAEA safeguards agreements within the regulatory framework established through the NSCA and the associated regulations. As a result of these agreements, much of the nuclear material and many of the facilities identified in this report are also subject to verification undertaken by the IAEA.

G.8.4.4 Industrial safety

At every stage in the lifecycle of a spent fuel and radioactive waste management facility, the licensee must take into consideration the occupational health and safety of workers. The handling of hazardous materials must meet all federal and provincial legislation.

G.9 Protection of existing facilities

Canadian regulations ensured the safety of the spent fuel management facilities that existed when the Joint Convention entered into force, as all facilities were under a CNSC licence. Consequently, the operation of spent fuel management facilities must be conducted according to NSCA requirements, associated regulations and licence conditions.

Storage facilities for spent fuel and radioactive waste have been designed to ensure there are no effluent discharges to the environment. Effluent discharges from the processing of spent fuel or radioactive waste (e.g., incineration of combustible radioactive waste) are monitored to ensure they do not exceed regulatory guidelines. All discharges from nuclear facilities must conform to the NSCA, its associated regulations and, if applicable, conditions specified in the licence.

G.10 Protection in the siting of proposed facilities

As discussed in section E.3.2, spent fuel storage facilities are considered to be Class I nuclear facilities in accordance with the definition provided in the *Class I Nuclear Facilities Regulations*. The regulations stipulate several licensing steps for these types of facilities:

- a site preparation licence
- a construction licence
- an operating licence
- a decommissioning licence
- an abandonment licence

The requirements for a licence to prepare a site for a Class I nuclear facility are listed in section 4 of these regulations. Other requirements are indicated in section 3 of the *General Nuclear Safety and Control Regulations* and section 3 of the *Class I Nuclear Facilities Regulations*.

G.10.1 Public information programs

It is a regulatory requirement for licence applicants and licensed operators of Class I nuclear facilities and uranium mines and mills to have public information programs about their facilities and activities. The CNSC has issued regulatory requirements regarding licensee public information programs. This document, *Public Information and Disclosure* (regulatory document RD/GD-99.3), is available on the CNSC website at nuclearsafety.gc.ca/eng/acts-and-regulations/regulatory-documents (also see section E.3.3 for more information). A key component of the public information program is the proactive disclosure of information to the public by the licensed operator.

For example, at the Bruce site, OPG operates the Western Waste Management Facility (WWMF), which accommodates all the low- and intermediate-level radioactive waste for the 20 OPG-owned or operated nuclear units. In addition, the WWMF has a spent fuel dry storage facility for the interim management of spent fuel from the Bruce reactors. Similar processing and storage facilities for interim storage of spent fuel are also in operation at OPG's Darlington and Pickering stations. OPG has an extensive public information program for the Bruce site, as described in section H.7.1.1. The public information programs for these sites are integrated and include many of the same communication strategies used for the Bruce site, such as brochures, newsletters, tours, media and key stakeholder briefings, and the Internet. In addition, the information centres at the Darlington and Pickering sites feature displays on spent fuel dry storage.

G.10.2 International arrangements with neighbouring countries that could be affected

The Canadian regulatory regime does not obligate the proponents of domestic nuclear facilities that may affect the United States to consult with foreign jurisdictions or with the public about the proposed siting of such facilities.

Canada and the United States, however, are signatories to the *International Convention on Environmental Impact Assessment in a Transboundary Context* (Espoo, Finland, February 25, 1991). The Convention entered into force on September 10, 1997 and obliges signatories to:

- “take all appropriate and effective measures to prevent, reduce, and control significant adverse transboundary environmental impacts of proposed activities” (including the site preparation, construction and operation of nuclear installations)
- “ensure that affected Parties are notified” of the proposed installation
- “provide an opportunity to the public in the areas likely to be affected to participate in relevant environmental impact assessment procedures regarding proposed activities, and to ensure that the opportunity provided to the public of the affected Party is equivalent to that provided to the public of the Party of origin”
- include in the notification “information on the proposed activity, including any available information on its possible transboundary impact”

The governments of Canada and the United States, in cooperation with state and provincial governments, are also obligated to have programs in place for the abatement, control and prevention of pollution from industrial sources. This includes measures to control the discharges of radioactive materials into the Great Lakes system. These obligations are contained within the *Great Lakes Water Quality Agreement* (1978), as amended by the protocol signed September 7, 2012.

Since the 1950s, the CNSC and the United States Nuclear Regulatory Commission have practised cooperation and consultation. On August 15, 1996, the two countries entered into a bilateral administrative arrangement for “cooperation and the exchange of information on nuclear regulatory matters.” This commitment includes the exchange of certain technical information that “relates to the regulation of health, safety, security, safeguards, waste management and environmental protection aspects of the siting, construction, commissioning, operation and decommissioning of any designated nuclear facility” in Canada or the United States. The administrative arrangement was updated and renewed in April 2012 for an additional five-year period.

G.11 Design, construction and safety assessment of facilities

After the granting of a licence to prepare site, the second formal licensing step for nuclear facilities is the construction licence. Sometimes, a site preparation and construction licence application is submitted to the CNSC for approval concurrently.

The requirements for a licence to construct a Class I nuclear facility are listed in section 5 of the *Class I Nuclear Facilities Regulations*. Information listed in section 3 of the *General Nuclear Safety and Control Regulations* (GNSCR) and section 3 of the *Class I Nuclear Facilities Regulations* is also required. It includes items such as the proposed design (including systems and components), the quality assessment program, the possible effects on the environment and the proposed measures to control releases to the environment, a waste management strategy, and a preliminary decommissioning plan (refer to section F.8).

Prior to preparing the site and construction of a new nuclear facility to manage spent fuel, an application to the CNSC for a licence may require the CNSC to conduct an environment assessment (EA) under the *Canadian Environmental Assessment Act, 2012* (CEAA 2012) before making a licensing decision. Regulatory guide G-320, *Assessing the Long Term Safety of Radioactive Waste Management* (see section B.6), assists licensees and applicants as they assess the long-term safety of storage and disposal of spent fuel and radioactive waste.

G.12 Operation of facilities

The third step in the licensing process is obtaining an operating licence.

Requirements to operate a Class I nuclear facility are listed in section 6 of the *Class I Nuclear Facilities Regulations*. Information listed in section 3 of the GNSCR and section 3 of the *Class I Nuclear Facilities Regulations* is also required. It includes such items as a safety analysis report, commissioning program, the

measures to prevent or mitigate releases of nuclear substances and hazardous substances to the environment, and a preliminary decommissioning plan.

Also, as a requirement of a licence to operate, the licensee must keep a record of the results of:

- effluent and environmental monitoring programs
- operating and maintenance procedures
- commissioning programs
- inspection and maintenance programs
- the nature and amount of radiation, nuclear substances and hazardous substances within the nuclear facility
- the status of each worker's qualifications, re-qualifications and training

G.13 Monitoring of spent fuel dry storage facilities

Dry storage facilities are required if a nuclear facility is to have an operational monitoring performance assessment program. The program is the means by which the performance of individual barriers – as well as the entire containment system – is evaluated with respect to:

- established safety criteria
- standards related to potential impacts on human health and safety, as well as to non-human biota and the physical environment

A monitoring program for a dry storage facility must be able to detect any unsafe condition or the degradation of structures, systems and components (SSCs). A typical monitoring program for a spent fuel dry storage facility may include the following elements:

- gamma radiation monitoring
- canister monitoring for leaks, and tightness verification of the baskets and canister liners
- effluent monitoring (including airborne emissions and liquid emissions)
- an environmental monitoring program

G.13.1 Gamma radiation monitoring experience

Routine gamma radiation surveys are performed by using a handheld monitor at appropriate points inside the dry storage facility fence and on all sides of the dry storage containers, or by using thermoluminescent dosimeter (TLD) mounted devices to monitor cumulative fields. Experience has demonstrated that gamma radiation at dry storage facilities is significantly less than predicted during the design phase.

G.13.2 Leak tightness verification experience

Leak tightness verification of the AECL-type fuel baskets and concrete canisters consists of connecting a pump to the liner cavity and recirculating the air through filters. Excessive humidity indicates either a liner leak or water holdup in the canister from operations carried out before sealing. The presence of radioactivity indicates a basket leak. For the OPG-type dry storage containers, leak tightness is verified through helium leak testing before containers are placed in storage. Subsequent aging management activities provide assurance that the container condition and weld integrity are not compromised and that helium cannot leak out.

Experience indicates that the various dry storage structures and components currently used in Canada effectively contain the fission products in the fuel bundles.

G.13.3 Environmental monitoring experience

Every nuclear power plant, and AECL's research facilities, has an environmental monitoring program. Spent fuel dry storage facilities at these sites are addressed in the site environmental monitoring programs, which:

- provide an early indication of the appearance or accumulation of radioactive material in the environment
- verify the adequacy and proper functioning of effluent controls and monitoring programs
- provide an estimate of actual radiation exposure to the surrounding population
- provide assurance that the environmental impact is known and within anticipated limits
- provide standby monitoring capability for rapid assessment of risk to the general public in the event of accidental releases of radioactive material

Experience shows that spent fuel dry storage facilities in Canada operate safely and within prescribed regulatory limits.

G.13.4 Effluent monitoring experience

G.13.4.1 Atomic Energy of Canada Limited

AECL fuel baskets are wet-loaded in the generating station's fuel bay area. The loaded fuel basket is raised into the shielded workstation. While being raised, an annular ring with spray nozzles sprays the chain and loaded fuel basket with demineralized water to clean them. All liquids are returned to the spent fuel storage bay. Once in the shielded workstation, the loaded fuel basket is air-dried and weld-sealed. The air-drying system consists of:

- two air heaters
- blowers with high-efficiency particulate air (HEPA) filters
- associated ductwork
- dampers

The hot air is blown in via a swan neck duct and removed via a plenum formed by the basket cover and the rotating table. The return air is filtered before being exhausted into the spent fuel bay active ventilation system. Monitoring results have shown no significant levels of particulates in the ventilation system resulting from the dry storage operations. Because the fuel baskets are processed in the fuel bay area where active ventilation is provided, and any liquids generated by the drying of the spent fuel are returned to the storage pool, no airborne or liquid emissions are encountered during the transfer of the loaded basket to the dry storage facility. At the dry storage facility, the cylinders are filled with loaded baskets and a cover plate is then welded in place. Monitoring results have shown that the loaded baskets in the sealed storage cylinders generate no significant levels of airborne or liquid effluents.

G.13.4.2 Ontario Power Generation

OPG dry storage containers are wet-loaded in the fuel bay, decontaminated, drained and dried, and a transfer clamp and seal are installed to secure and seal the lid during onsite transfer. The fuel bay area is equipped with an active ventilation system, and most of the liquids resulting from the draining and vacuum drying are returned to the fuel bay. Other liquids from the draining and vacuum drying are directed to the station's active liquid waste system. At the dry storage facility, a special workshop houses the following dedicated systems for dry storage container processing:

- closure welding and welding-related systems

- non-destructive examination of welds
- vacuum drying system
- helium backfilling system
- helium leak detection system

Airborne contamination hazards may present a danger if any loose surface contamination on the dry storage container becomes airborne or if there is leakage of the dry storage container internal gas (such gas may contain krypton-85, as well as radioactive particulates). The processes that could give rise to these airborne hazards are:

- dry storage container draining and drying
- transfer clamp and seal removal
- dry storage container backfilling with helium

Airborne particulate monitors and gamma radiation monitors are used to detect any abnormally high levels. Re-suspension of loose surface contamination is a low-probability event, and experience from the used fuel dry storage facilities supports this. The workshop also has active ventilation, which consists of exhaust fans, radioactive filter assemblies and a discharge stack. Any airborne radioactive particulate contamination, if present in the ventilation exhaust, is effectively removed by high-efficiency particulate air (HEPA) filters in the active ventilation system. Monitoring results to date from the Pickering Used Fuel Dry Storage Facility, the Darlington Waste Management Facility and the Western Used Fuel Dry Storage Facility have shown no significant levels of particulates in the active ventilation exhaust.

Because the dry storage containers are fully drained and vacuum dried at the generating station fuel bay area, there are no liquid emissions from the dry storage container during onsite transfer to the dry storage workshop. The exterior surfaces of dry storage containers are decontaminated prior to their transfer from the fuel bay area to the dry storage workshop. Spot decontamination operations do not generate liquids, and liquids are not normally used in the storage areas. Because of this, and because loose contamination is not permitted on dry storage containers or facility surfaces, no contaminated liquid effluents are expected from the dry storage operations; however, some liquid effluents may originate in the processing area as a result of maintenance. Such liquids are sampled and placed in appropriate containers for proper disposal or, when acceptable, pumped into the generating station's active liquid waste management system at the Pickering Used Fuel Dry Storage Facility. Monitoring results at the Pickering Used Fuel Dry Storage Facility have shown no significant levels of radioactivity in the drainage effluent transferred to the generating station system. As a result, the Darlington Waste Management Facility and the Western Used Fuel Dry Storage Facility do not have active liquid waste management systems.

G.14 Disposal of spent fuel

Currently, Canada does not have a disposal facility for spent fuel. Any proposal for the siting, construction, operation, decommissioning (closure and post-closure) and abandonment (release from CNSC licensing) of a disposal facility, such as a deep geological repository, must satisfy the requirements of the NSCA, along with its associated regulations. The CNSC can make a licensing decision on a deep geological repository only after the completion of a positive EA process.

G.15 New facilities

Spent fuel from the operation of research reactors at AECL's CRL is currently stored below ground in vertical cylindrical concrete structures called "tile holes". These are situated in Waste Management Area B. The fuel initially loaded into these storage structures from 1963 to 1983 was research reactor prototype fuel and included uranium metal fuel that has less corrosion resistance than modern-day alloy fuels. These fuels consist of about 700 prototype and research reactor fuel rods, with a total mass of approximately 22 tonnes. Although these fuels are safety stored, monitoring and inspection have shown that some of the fuel containers and fuels are corroding.

The CNSC has granted operational approval for this project with a regulatory hold point. AECL has constructed, and is commissioning, a new above-ground dry storage facility to store this selected spent legacy research fuel. The new dry storage system is located in a Fuel Packaging and Storage (FPS) building. This building will contain a packaging and vacuum drying station and a monitored storage structure. The existing storage container will be placed – with the spent fuel remaining inside it – in a new stainless steel container and dried before being placed in the monitored storage structure. The storage structure is engineered to last at least 50 years and will provide safe interim storage for the packaged fuel until a long-term management facility is available.

G.16 Long-term management of spent fuel

Since the early days of the CANDU program, several concepts for long-term management of spent fuel have been under consideration. The options for long-term management in Canada were reviewed by a royal commission in 1977. Subsequently, Canada's spent fuel waste management program was formally initiated by the governments of Canada and Ontario. AECL was assigned responsibility to develop a concept for placing spent fuel in a deep underground repository within the plutonic rock of the Canadian Shield. Ontario Hydro (now OPG) was assigned responsibility to study and develop technology to store and transport spent fuel. It was also designated to provide technical assistance to AECL in the area of repository development. In 1981, the governments of Canada and Ontario announced that site selection for a repository would not be undertaken until after the disposal concept had been accepted.

In 1994, AECL submitted for review to a federal environmental assessment panel – the Seaborn Panel – its environmental impact statement (EIS) for the deep geological repository concept. This review included input from government agencies, non-governmental organizations and the general public. Public hearings conducted by the Seaborn Panel associated with the review took place during 1996 and 1997. The report of the Seaborn Panel, entitled *Report of the Nuclear Fuel Waste Management and Disposal Concept Environmental Assessment Panel*, was submitted to the Government of Canada in 1998. The report concluded that a deep geological repository in crystalline rock was technically feasible but “until broad public acceptance of a nuclear fuel waste management approach has been achieved, the search for a specific site should not proceed.”

It also made recommendations to help the Government of Canada reach a decision on the acceptability of the disposal concept and the steps to be taken to ensure the safe long-term management of spent fuel in Canada (as per the Canadian Environmental Assessment Agency (CEA Agency), 1998).

The Government of Canada responded to the Seaborn Panel report later in 1998 and announced the steps it would require the producers and owners of spent fuel in Canada to take, including the formation of the Nuclear Waste Management Organization (NWMO) by the nuclear utilities. In 2002, the Canadian Parliament passed the *Nuclear Fuel Waste Act* (NFWA), which indicates that the Governor in Council will select one approach for the long-term management of nuclear fuel waste from those examined by the NWMO. Under the NFWA, the following actions were to take place:

- The nuclear energy corporations were to establish a waste management organization, the purpose of which would be to study and propose approaches for the management of nuclear fuel waste and to implement the approach selected by the Governor in Council. The study was to include a technical description and a comparison of the benefits, risks and costs and ethical, social and economic considerations associated with each approach, together with specification of economic regions for implementation and plans for implementation of each approach in the study. The waste management organization was to consult the general public and, in particular, Aboriginal peoples on each approach.
- The waste management organization was to create an advisory council, which would reflect a broad range of scientific and technical disciplines. Its expertise should include public affairs, other social sciences as needed and traditional Aboriginal knowledge. It was also to include representatives of the local and regional governments and Aboriginal organizations affected by the selected approach because of their geographic locations.

- The waste management organization was to submit, within three years of the NFWA coming into force, a study setting out proposed approaches for the management of nuclear fuel waste, as well as its final recommendation. The study would need to include approaches based on the following methods:
 - a modified AECL concept for deep geological disposal in the Canadian Shield
 - storage at nuclear reactor sites
 - centralized storage, either above or below ground

Under the NFWA, the Government of Canada was tasked with reviewing the study prepared by the waste management organization, selecting a long-term management option from those proposed and providing oversight during implementation. Natural Resources Canada (NRCan) was tasked with overseeing how the waste management organization implements the management approach and ensuring compliance with the NFWA. The waste management organization was to report annually to the Minister of Natural Resources. Every third year – following the selection of an approach by the Governor in Council – this report would include a summary of activities and a strategic plan for the subsequent five years.

Canada's plan has now moved forward in conjunction with this legislative framework.

Pursuant to the NFWA, the waste management organization – the NWMO – was established in 2002 by the nuclear energy corporations of OPG, Hydro-Québec, and New Brunswick Power. Upon its establishment in 2002, the NWMO's first mandate was to develop collaboratively with Canadians a management approach for the long-term care of Canada's spent fuel that is socially acceptable, technically sound, environmentally responsible and economically feasible. From 2002 to 2005, the NWMO studied various approaches to the long-term management of Canada's spent fuel.

In 2005, the NWMO recommended the Adaptive Phased Management (APM) approach to the Minister of Natural Resources. APM includes a technical method based on an end point of centralized containment and isolation of the spent fuel in a deep geological repository in a suitable rock formation. It provides for continuous monitoring of the spent fuel and the potential to retrieve it for an extended time. There is provision for contingencies, such as the optional step of shallow storage at the selected central site if circumstances favour early centralization of the spent fuel before the repository is ready.

The management system is based on phased and adaptive decision making. Flexibility in the pace and manner in which the project is implemented allows for phased decision making, with each step supported by continuous learning, research and development, and public engagement. An informed, willing community will be sought to host the centralized facilities. Sustained engagement of people and communities is a key element of the plan, as the NWMO continues to work with citizens, communities, municipalities, all levels of government, Aboriginal organizations, non-governmental organizations, industry and others.

On June 14, 2007, following a review of the NWMO's study *Choosing a Way Forward*, the Government of Canada announced it had selected the APM approach for the long-term management of spent fuel in Canada.

With this government decision, the NWMO assumed responsibility for implementing the APM approach. Governance and organization staffing have evolved to provide the oversight, skills and capabilities required to implement APM. The advisory council continues to provide advice as required by the NFWA and the NWMO issues its reports annually to the Minister of Natural Resources and to the public. In March 2014, the NWMO submitted its second Triennial Report to the Minister, as required by the NFWA.

To support financing of the plan, waste owners continue to make regular deposits into the segregated trust funds established in 2002. In 2008, the NWMO had submitted to the Minister of Natural Resources a funding formula and schedule for trust fund deposits. The Minister approved this funding formula in 2009.

Implementation of APM will be regulated at all stages, with the CNSC responsible for regulatory matters pursuant to the NSCA. The NWMO will be required to obtain licences from the CNSC for site preparation, construction, operation, decommissioning and abandonment (release from CNSC licensing) of the repository facilities.

Refer to Section K.4 for further information on plans for the long-term management of spent fuel and on the public consultation process.

Refer to Section K.5 for more information on the CNSC's role and early involvement in the APM project for the long-term management of Canada's spent fuel.

Section H – Safety of Radioactive Waste Management

H.1 Scope of the section

This section addresses article 11 (General Safety Requirements) to article 17 (Institutional Measures after Closure) and provides a comprehensive description of radioactive waste management in Canada.

At every stage of radioactive waste management, there are effective defences that protect individuals, society and the environment against potential hazards and the harmful effects of ionizing radiation, now and into the future. In addition to describing facilities and their normal operations, this section describes the steps or controls that are in place, with the dual purpose of preventing accidents with radiological consequences and mitigating their consequences should accidents occur.

The information contained in this section demonstrates that the requirements of the following applicable International Atomic Energy Agency (IAEA) Safety Standards have been addressed:

- Article 11: General Safety Requirements – IAEA Safety Requirements SSR-2/1, SSR-5 and GSR Part 5
- Article 13: Siting of Proposed Facilities – IAEA Safety Requirement NS-R-3
- Article 14: Design and Construction of Facilities – IAEA Safety Requirements SSR-2/1 and SSR-5
- Article 15: Assessment of Safety of Facilities – IAEA Safety Requirements SSR-2/1, SSR-5 and GSR Part 3
- Article 16: Operation of Facilities – IAEA Safety Standards SSR-2/1, SSR-5, GSR Part 5 and GSR Part 3

H.2 Radioactive waste in Canada

Nuclear facilities and users of certain prescribed substances produce radioactive waste. The Government of Canada establishes the policy framework for the management of these wastes. The Canadian Nuclear Safety Commission (CNSC) regulates the management of radioactive waste to ensure it causes no undue radiological hazard to the health and safety of persons or to the environment. The radioactive content of the waste varies with the source; therefore, management techniques depend on the characteristics of the waste (see section H.3).

Certain types of radioactive waste, such as from hospitals, universities and industry, contain only small amounts of radioactive materials, with short half-lives. This means that radioactivity decays within hours or days. After holding the waste until the radioactivity has decayed to the acceptable levels authorized by the CNSC, the waste can be disposed of by conventional means (in local landfill or sewer systems).

With the notable exception of waste from nuclear power plants – which is contaminated with long-lived radioisotopes – radioactive waste is generally shipped directly or via a waste broker to the waste management facility operated by Atomic Energy of Canada Limited (AECL) at its Chalk River Laboratories (CRL) site. The typical storage facilities at CRL include shielded above-ground storage buildings, concrete bunkers and concrete tile holes. In some cases, radioactive waste is shipped to waste treatment and disposal facilities in the United States. For information on the amount shipped to the United States, refer to annex 5.1.8.

Canadian methods for the management of radioactive waste are similar to those of other countries. Primary emphasis is placed on minimization, volume reduction, conditioning and long-term storage of the waste, since long-term management facilities are not yet available. Radioactive waste is stored onsite or offsite, in above- or below-ground engineered structures. Some of the waste may be reduced in volume by compaction or incineration prior to storage. All radioactive waste currently generated is stored in such a way that it can be retrieved when necessary. Operators have instituted methods to recover storage space by

cascading the waste after sufficient radioactive decay or reclaiming existing storage space through further compaction (super compaction), segregation or both.

As is the case for all nuclear activities, the facilities for handling radioactive waste must be licensed by the CNSC and conform to all pertinent regulations and licence conditions. The waste management objective throughout the industry – from mines to reactors – is the same: to control and limit the release of potentially harmful substances into the environment.

H.3 Characteristics of radioactive waste in Canada

H.3.1 Fuel manufacturing waste

In the past, wastes from refineries and conversion facilities were managed by means of direct in-ground burial. This practice was discontinued in 1988 after the closure of the Port Granby Waste Management Facility. The volume of low-level radioactive waste (LLW) produced from these operations has been greatly reduced through recovery and reuse of feedstock materials, the conversion of waste materials into by-products and the decontamination of wastes for disposal with non-radioactive wastes. The residual volume of LLW now being produced is drummed and stored in warehouses pending the establishment of an appropriate long-term waste management facility. The seepage and runoff from the waste management facilities where direct in-ground burial was practised continues to be collected and treated prior to discharge.

Fuel manufacturing waste consists of a variety of potentially uranium-contaminated wastes, including the following:

- uncontaminated and contaminated zirconium dioxide
- graphite crucibles used to cast billets
- filters
- scrap lumber
- pallets
- rags
- paper
- cardboard
- rubber
- plastic
- oils
- solvents

H.3.2 Electricity generation waste

Radioactive wastes resulting from nuclear reactor operations are stored in a variety of structures located in radioactive waste management facilities at nuclear reactor sites. Prior to storage, the volume of the radioactive waste may be reduced by incineration, compaction or shredding. In addition, within the nuclear power plant there are facilities for the decontamination of parts and tools, laundering of protective clothing and the refurbishment and rehabilitation of equipment. Electricity generation waste consists of varying types of low- and intermediate-level activity radioactive waste such as:

- filters
- light bulbs
- cable

- used equipment
- metals
- construction debris
- absorbents (sand, vermiculite, sweeping compound)
- ion exchange resins
- reactor core components
- retube materials
- paper
- plastic
- rubber
- wood
- organic liquids

See figure H.1 for an example of how retube waste is being stored at a nuclear power plant’s radioactive waste management facility.

Figure H.1: Dry storage modules containing Pickering A (Units 1 to 4) retube waste at the Ontario Power Generation’s Pickering Waste Management Facility



H.3.3 Historic waste

Historic LLW in Canada refers to LLW that was managed in the past in a manner no longer considered acceptable, but for which the current owner cannot reasonably be held responsible and for which the Government of Canada has accepted the long-term responsibility. In 1982, the Government of Canada established the Low-Level Radioactive Waste Management Office (LLRWMO) within AECL as the federal agent for the cleanup and management of historic LLW in Canada. Natural Resources Canada (NRCan) provides the mandate, policy direction and funding to the LLRWMO. The LLRWMO has completed historic LLW cleanups across Canada and continues to monitor several sites with historic radium or uranium contamination. At some sites, materials have been placed in interim storage pending the development of a long-term management approach. Ongoing site monitoring, inspection and maintenance are conducted at these sites.

In keeping with the 1996 *Policy Framework for Radioactive Waste*, Canada has taken different approaches for the management of spent fuel, low- and intermediate-level radioactive waste (L&ILW) and uranium mine and mill tailings. These different approaches reflect not only the different scientific and technical characteristics of the wastes, but also the economics and the geographic dimensions of Canada and the locations of the waste. Long-term strategies and solutions for historic LLW are evolving for the various regions of the country. The LLRWMO helps develop and implement the Government of Canada's strategic approach to historic low-level radioactive waste management by working with communities and federal stakeholders to develop solutions to safely and cost-effectively reduce liabilities and associated risks. These community-based solutions apply sound waste management and environmental principles in the best interests of Canadians.

H.3.4 Radioisotope production and use waste

Radioisotope production and use generate a variety of radionuclides for commercial use, such as cobalt-60 for sterilization and cancer therapy units, and molybdenum-99 or other isotopes for use as tracers for medical research, diagnoses and therapy. A number of waste management facilities process and manage the wastes that result from the use of radioisotopes for research and medicine. In general, these facilities collect and package waste for shipment to approved storage sites. In some cases, the waste is incinerated or allowed to decay to insignificant radioactivity levels and then discharged into the municipal sewer system or municipal garbage system.

H.3.5 Uranium mining and milling waste

Uranium mining and milling waste comprises three major waste streams: mill tailings, waste rock and waste water.

After ore is removed from the ground, either by underground mining or from an open pit, it is milled. The milling process, in which the ore is crushed and treated with chemicals, extracts the ore's uranium content, leaving a waste product known as mill tailings.

The method used to manage tailings from uranium mine operations varies from mine to mine. Much depends on where the mine is located. The quantity of tailings produced at any uranium mine is determined by the grade of the ore, as well as the size of the deposit. Canada's operating mines (all in northern Saskatchewan) have high-grade ore deposits in comparison to past mining operations in Canada; therefore, smaller volumes of tailings are being produced.

Due to varying mineralogy, different mines use different chemicals, concentrates or mixtures of chemicals in the milling process. As a result, tailings vary in composition from mine to mine.

Tailings management facilities (TMFs) have evolved over the decades, from simple deposition into natural landforms and lakes or into abandoned underground mine workings, to the construction of engineered surface storage facilities, complete with seepage collection systems, to the current practice of placing the tailings in engineered mined-out open pits converted to TMFs. Tailings in modern facilities are covered with water (subaqueous deposition) to enhance radiation protection and avoid oxidization and winter freezing of the tailings.

Waste rock ranges from benign material, devoid of the metal or mineral being sought, to mineralized material that contains sub-economical concentrations of the metal or mineral that was being extracted. Waste rock characteristics are highly variable. Some waste rock contains sufficient concentrations of sulphide to generate moderate levels of acidity. This can mobilize potential contaminants from secondary minerals. In Saskatchewan, some waste rock contains secondary arsenic and nickel minerals, often to the point where the long-term care and control of these non-radioactive contaminants – not the waste rock's radioactivity – drive the level of care needed to manage it.

The waste water (effluent) generated from mining and milling processes is treated as required, and the treated water discharged to the environment is monitored to ensure it meets regulatory standards prescribed by the provincial and federal governments. These limits ensure that the impact on the environment is minimal.

H.3.6 Radioactive waste at research reactors

At all research reactors, radioactive waste materials are segregated by licensees into short-lived and long-lived radioactive waste. Short-lived radioactive wastes are stored onsite to allow for decay until they can be disposed of in a conventional manner. Long-lived radioactive wastes are kept onsite temporarily until a certain amount or volume is accumulated; thereafter they are generally transported to AECL's CRL for storage. This is also the case for TriUniversity Meson Facility's (TRIUMF) radioactive waste.

Liquid wastes from research reactors mostly consist of water that contains radioactive contamination. Typically, the water is cleaned up through a water purification system, which includes filtration and ion exchange. Once ion exchange resins are used up, they are stored with the long-lived radioactive waste that is eventually sent to AECL's CRL. At the TRIUMF, the accelerator's vacuum pumps produce a small amount of contaminated oil. All of this slightly contaminated oil (approximately two litres per year) is presently stored onsite. Waste management at AECL's CRL is described in detail in annex 5.

H.4 Waste minimization

Canada has adopted IAEA waste minimization practices as described in CNSC policy document P-290, *Managing Radioactive Waste*, which expects that the "generation of radioactive waste is minimized to the extent practicable." (Regulatory policy P-290 is described in section B.5.) Waste minimization is also a key principle espoused in the CSA Group industry standard CSA N292.3-14, *Management of low- and intermediate-level waste* and CSA N292.0-14, *General principles for the management of radioactive waste and irradiated fuel*.

In addition, CNSC regulatory guide G-219, *Decommissioning Planning for Licensed Activities*, indicates that waste management plans should include "specific plans for the reuse, recycling, storage or disposal of that waste" [G-219, section 6.2.2 (9)]. Canada has also developed the industry standard CSA N294-09, *Decommissioning of Facilities Containing Nuclear Substances*, which indicates that strategies for waste management must consider and prioritize "the potential for recycling or reuse of equipment and materials" [N294-09, clause 6.1.3 (e)].

The Canadian nuclear sector actively promotes and practises waste minimization. For example, Ontario Power Generation (OPG) policy is to minimize the production of radioactive waste at the source by preventing materials from unnecessarily becoming radioactive. The Canadian nuclear sector practises waste minimization by:

- implementing material control procedures to prevent materials from unnecessarily entering into radioactive areas
- implementing enhanced waste monitoring capabilities to reduce the inclusion of non-radioactive wastes in radioactive wastes
- implementing improvements to waste handling facilities
- enhancing employee training and awareness

Canadian licensees follow various forms of waste minimization, depending upon site and operational specifics. OPG has an overall waste management procedure that derives its authority from OPG's environmental waste management program. This provides the overall framework by which waste is managed. Integrated into this program is the implementation of a number of waste minimization activities. Specific initiatives include the following:

- communication and awareness strategies for maintaining a waste minimization culture
- establishment of a clean zone area for de-packaging materials
- controls to minimize the transfer of unnecessary materials in zoned areas
- use of reusable equipment and materials as much as possible
- segregation of waste into radioactive and “likely clean” at many collection points, for further monitoring and characterization of likely clean waste
- separation of recyclable materials at collection points
- use of washable protective equipment to replace disposable protective equipment such as gloves and booties
- use of washable bags, cloths and mops
- use of industry best practices related to free release standards and segregation
- development of five-year radioactive waste minimization plans for each nuclear generating station
- development of suitable fleet-wide metrics to drive improvements and monitor performance
- benchmarking of other radioactive waste management facilities, both domestically and internationally, for implementation of best practices
- diversion of waste to external third-party contractors, where possible, to further process specific waste streams (such as diversion of metal waste to metal melting)

AECL is undertaking similar activities, and has operated waste clearance facilities at CRL and Whiteshell Laboratories to enhance its capability to effectively utilize free-release standards and segregation.

The CNSC supports the internationally adopted and environmentally friendly principles of good waste management practices in the nuclear industry to reduce the volume of radioactive waste requiring storage.

H.5 General safety requirements

The main objective in the regulation of either a spent fuel dry storage facility or a radioactive waste management facility is to ensure that such facilities and their activities do not pose unreasonable risks to health, safety, security and the environment. Canada’s comprehensive licensing system, described in detail in section E.4, does not differentiate between a spent fuel management facility and a radioactive waste management facility. The design, construction and operation of either type of facility must ensure the safety of human health and the environment.

H.5.1 Protection and safety fundamentals

The regulation of spent fuel and radioactive waste can be divided into generic performance requirements, generic design, and operational principles and performance criteria. These criteria are described in sections G.8.4 to G.8.6.

Uranium mines and mills are governed by the same principles as those for spent fuel or radioactive waste and are also governed by the *Uranium Mines and Mills Regulations*.

H.5.2 Safety requirements

Safety requirements for the management of spent fuel and radioactive waste must provide for the protection of the environment and the health and safety of workers and the public. During normal operations, spent fuel and radioactive waste management facilities must be operated in a safe manner. System components that may require periodic maintenance must be readily accessible and designed to permit safe and efficient maintenance. The safety requirements are described in detail in section G.8.7.

H.6 Protection of existing facilities

The safety of radioactive waste management facilities that existed when the Joint Convention entered into force was ensured through the Canadian regulatory regime. The operation of radioactive waste management facilities must be conducted in accordance with the *Nuclear Safety and Control Act* (NSCA), along with its associated regulations and the licence conditions. The CNSC compliance program activities verify that operators comply with the requirements for safe operation of radioactive waste management facilities. A list of facilities is included in section D.

H.6.1 Past practices

Legacy radioactive wastes at AECL sites date back to the Cold War and the birth of nuclear technologies in Canada. These include contaminated buildings that have been shut down and contaminated lands that are managed by AECL on behalf of the Government of Canada. The liabilities include high-level waste – in particular, spent research reactor fuel and high-level liquid waste from the production of medical isotopes and fuel processing experiments conducted in the Cold War era. In 2006, the Government of Canada initiated the Nuclear Legacy Liabilities Program (as described in section K.6.2) to deal with the liabilities at AECL sites. A description of AECL waste management facilities is included in annex 5.

In 1982, the Government of Canada established the LLRWMO within AECL as the federal agent for the cleanup and management of historic LLW in Canada. Canada's historic low-level radioactive waste inventory consists largely of radium- and uranium-contaminated soils. The Government of Canada has accepted responsibility for the long-term management of this waste.

NRCan provides policy direction and funding to the LLRWMO, enabling it to carry out its work. The LLRWMO has completed historic low-level radioactive waste cleanups across Canada and continues to monitor several sites with historic radium or uranium contamination. The bulk of Canada's historic LLW is located in the southern Ontario communities of Port Hope and Clarington. In March 2001, the Government of Canada and the local municipalities partnered on community-developed proposals to address the cleanup and long-term management of these wastes. This partnership launched the Port Hope Area Initiative (PHAI). The PHAI and other initiatives dealing with historic waste are described in section K.6.3.

As already shown in section F.4, when remedial actions are required at uranium mine and mill tailings facilities where the owner no longer exists, the federal and provincial governments ensure that the sites are safely decommissioned. In Ontario, home of the former Elliot Lake uranium mining complex, the governments of Canada and Ontario entered into a Memorandum of Agreement in 1996 that outlined their respective roles in the management of abandoned uranium mine and mill tailings. In keeping with the *Policy Framework for Radioactive Waste*, best efforts are made to identify the uranium producer or property owner of a site. Where such an owner cannot be identified, the governments have agreed to share costs, including an equal sharing of costs associated with any necessary remediation. To date, these arrangements have not been necessary, as all Ontario sites have owners who are complying with their responsibilities.

In a similar vein, the governments of Canada and Saskatchewan entered into a Memorandum of Agreement that defines roles and responsibilities for the remediation of certain Cold War era uranium mine sites, principally the Gunnar mine and mill site in northern Saskatchewan. On April 2, 2007 the two governments announced the first phase of the cleanup. The total cost, which the governments will share, will be \$24.6 million. NRCan advanced \$1.13 million as its share of Phase 1. A comprehensive environmental assessment of the project began on June 15, 2007. In October 2007, the Government of Saskatchewan and Encana Corporation entered into an agreement for the decommissioning and reclamation of the nearby Lorado uranium mill site. The Gunnar and Lorado mine sites are described in annexes 8.1.1.2 and 8.1.1.3.

H.7 Protection in the siting of proposed facilities

The *Class I Nuclear Facilities Regulations* stipulate a lifecycle licensing approach for radioactive waste management facilities. Required are:

- a site preparation licence
- a construction licence
- an operating licence
- a decommissioning licence
- an abandonment licence

The *General Nuclear Safety and Control Regulations* (GNSCR), *Nuclear Security Regulations*, *Radiation Protection Regulations*, and *Nuclear Substances and Radiation Devices Regulations* also have requirements that must be met.

The requirements for a licence to prepare site for a Class I radioactive waste management facility are listed in sections 3 and 4 of the *Class I Nuclear Facilities Regulations*. Note that section 3 of the GNSCR requires additional information.

At the time this report was written, no contracting parties could be affected by the siting of a radioactive waste facility in Canada. The United States and Canada, however, originated a *Nuclear Cooperation Agreement* in 1955. Article 2 of that agreement provides for the exchange of “classified and unclassified information, etc., with respect to the application of atomic energy for peaceful uses, including research and development relating thereto, and including problems of health and safety.” Article 2 also covers the entire field of health and safety as it relates to the Joint Convention.

H.7.1 Public information programs

The CNSC’s regulatory document on public information programs is addressed in annex 3.6.2. A description of OPG’s public information program for spent fuel is addressed in section G.10.1. Information on OPG’s existing public information program for its L&ILW storage (section H.7.1.1) and an example of public information for a new uranium mine or mill (section H.7.1.2) are described below.

H.7.1.1 Public information program for L&ILW storage

The following is an example of an existing public information program where radioactive waste facilities for spent fuel and radioactive waste are located. This section also includes an example where radioactive waste facilities are proposed to be located

OPG operates an extensive public information program in the Municipality of Kincardine and surrounding communities, home to OPG facilities that store L&ILW and spent fuel. Information is communicated in a number of ways, based on interests and concerns people may have about OPG’s operations and projects. OPG provides many avenues to learn about its nuclear operations and is committed to sharing information on performance and nuclear operations and projects through open and transparent communication.

Since 2002, OPG, in partnership with the host Municipality of Kincardine and surrounding communities, has proposed a deep geological repository for the long-term management of its L&ILW.

In support of current operations and this project, OPG operates a broad community engagement program designed to inform and engage the public in dialogue and discussion on radioactive waste issues. Communication strategies include the use of advertising, brochures, videos, tours, briefings for key community stakeholders with media and elected officials, open houses, transportation seminars for first responders, newsletters, direct mailings, speaking engagements, exhibits at many community events, and sponsorships. To reach beyond the local communities, strategies include extensive use of the Internet and

social media, where reports, brochures, videos and newsletters can be obtained. OPG strives to be open and transparent in all its operations.

H.7.1.2 Public information for a new uranium mine or mill

During the reporting period, the CNSC continued to review applications from three mining companies that expressed interest in establishing new uranium projects: Strateco Resources for the Matoush Underground Exploration Project (Quebec), AREVA Resources Canada for its Midwest (Saskatchewan) and Kiggavik (Nunavut) mining projects, and Cameco Corporation for the Millennium Mine Project (Saskatchewan).

Sub-paragraph 3(c)(i) and paragraph 8(a) of the *Uranium Mines and Mills Regulations* state that an application for a new uranium mine or mill shall include a: "...program to inform persons living in the vicinity of the mine or mill of the general nature and characteristics of the anticipated effects of the activity to be licensed on the environment and the health and safety of persons" and "...a program to inform persons living in the vicinity of the site of the mine or mill of the general nature and characteristics of the anticipated effects of the abandonment on the environment and the health and safety of persons."

Proponents are expected to consult with the public about their plans for new uranium mines and mills. In the case of Cameco's proposed Millennium Mine Project, the licensee undertook comprehensive and on-going engagement activities with the residents of Saskatchewan's north, and maintains open communications with the interested local communities and Aboriginal groups.

Cameco holds meetings with the Northern Saskatchewan Environmental Quality Committee, the Athabasca Working Group, community leadership groups and other stakeholders with a direct interest in the project. Cameco uses a variety of communication tools: videos, a website, factsheets, print media, local radio and ongoing community engagement activities, such as its annual northern tour.

H.8 Design, construction and assessment of facilities

The second formal licensing step for nuclear facilities, including radioactive waste management facilities, is the construction licence. Requirements for a licence to construct a Class I nuclear facility are listed in sections 3 and 5 of the *Class I Nuclear Facilities Regulations*. Note that section 3 of the GNSCR requires additional information.

Before the CNSC can make a decision about whether to grant a licence to a party that has applied to construct a Class I radioactive waste management facility, the CNSC may have to initiate an environmental assessment in accordance with the *Canadian Environmental Assessment Act, 2012*. Regulatory guide G-320, *Assessing the Long Term Safety of Radioactive Waste Management* (see section B.6), assists licensees and applicants as they assess the long-term safety of storage and disposal of spent fuel and radioactive waste.

Regulatory guide G-320, *Assessing the Long Term Safety of Radioactive Waste Management* (see section B.6 of this report), helps licensees and applicants assess the long-term safety of storage and disposal of radioactive waste.

H.9 Operation of facilities

The third step in the licensing process is the operating licence. Requirements to operate a Class I nuclear facility are listed in sections 3 and 6 of the *Class I Nuclear Facilities Regulations*. Section 3 of the GNSCR and section 3 of the *Class I Nuclear Facilities Regulation* require additional information. The information includes such items as a safety analysis report, commissioning program, measures to prevent or mitigate releases of nuclear substances and hazardous substances to the environment, and a preliminary decommissioning plan.

H.9.1 Records

As a requirement of a licence to operate, the licensee must also keep a record of:

- the results of effluent and environmental monitoring programs
- operating and maintenance procedures
- the results of the commissioning program
- the results of the inspection and maintenance programs
- the nature and amount of radiation, nuclear substances and hazardous substances within the nuclear facility
- the status of each worker's qualifications, re-qualifications and training

H.9.2 Criticality safety

As per CNSC regulatory document RD-327, *Nuclear Criticality Safety*, criticality safety requirements must address both normal and abnormal conditions. A criticality safety analysis must be performed when significant quantities of fissionable materials are stored or handled. The analysis must clearly demonstrate that the storage and handling of the radioactive waste is safe and, therefore, an inadvertent criticality cannot occur under normal (or credible abnormal) conditions. The analysis must consider the offsite consequences for low-probability, high-consequence inadvertent criticality events and demonstrate that the consequences of such events do not violate the public evacuation criteria established by international standards (IAEA Safety Standards Series GS-R-2) and national guidelines (*Canadian Guidelines for Intervention During a Nuclear Emergency*).

H.10 Institutional measures after closure

H.10.1 Introduction

Article 17 applies to institutional measures that must be taken after a disposal facility has been closed. Disposal means that the radioactive waste is disposed of in a manner where there is no intent to retrieve it and that surveillance and monitoring is not required. Canada does not currently have a disposal facility. Examples of institutional controls for proposed future radioactive waste repositories are discussed in sections H.10.2(i) and (ii). Decommissioned TMFs require long-term institutional controls. These will vary from minimal – after the closure of the current generation of in-pit TMFs, which were designed for future decommissioning – to ongoing monitoring and maintenance programs at older sites where tailings have been deposited in surface facilities. Section H.10.3 describes the institutional control program developed by the Government of Saskatchewan for decommissioned mine sites, including former uranium mining and milling sites situated on Crown lands in that province.

H.10.1.1 Regulatory body requirements

Any licence application for the siting, construction, operation, decommissioning (closure and post-closure) and abandonment (release from CNSC licensing) of a disposal facility, such as a deep geological repository, must satisfy the requirements of the NSCA, along with its associated regulations. The CNSC can make a licensing decision on a disposal facility only after the completion of a positive environmental assessment process.

If a licence application is received for a disposal facility, current nuclear regulations in Canada require that the CNSC oversee the nuclear inventory there. This implies perpetual licensing from the CNSC unless the risks are very minimal and oversight by another regulatory or governmental body allows the Commission to exempt the site indefinitely from pursuing a CNSC licence, something that is determined on a case-by-case basis.

Several requirements are imposed by the NSCA and its associated regulations, including the following;

- A licence from the CNSC must be held in order for anyone to possess and use nuclear substances.
- Persons and the environment must be protected from unreasonable risk arising from the production, possession and use of nuclear substances and the development, production and use of nuclear energy.
- A licensee must conform with international obligations to which Canada has agreed (such as the commitments in the Joint Convention report).

Regulatory guide G-320, *Assessing the Long Term Safety of Radioactive Waste Management*, helps licensees and applicants assess the long-term safety of storage and disposal of radioactive waste, including institutional controls (see section B.5). The guide describes typical ways to assess the impacts that radioactive waste storage and disposal methods have on the environment and on the health and safety of people. It addresses topics that include the use of institutional controls.

After post-closure of a disposal facility, institutional controls may be a part of an abandonment licence application. Current Canadian regulations do not allow removal from licence control (abandonment) without an explicit exemption by the CNSC. Such an exemption would require the licensee to present a safety case demonstrating long-term safety. The case would have to cite engineering design and barriers and/or other forms of institutional controls, including periodic site verification. The CNSC would examine on a case-by-case basis the proposed institutional controls for long-term safety, cost, consequences of failure of the institutional controls and reliability of the institutional controls. The CNSC must be satisfied that the abandonment of the nuclear substance and the prescribed equipment or information do not pose an unreasonable risk to the environment, the health and safety of persons, or national security nor result in a failure to achieve conformity with measures of control and Canada's international obligations. Annex 7.8 of this report provides further information on the abandonment licence issued to the Dalhousie University SLOWPOKE-2 reactor.

Pursuant to section 8 of the CNSC *Class I Nuclear Facilities Regulations*, an application for a licence to abandon a Class I nuclear facility that includes spent fuel management facilities shall contain the following information:

- the name and location of the land, buildings, structures, components and equipment that are to be abandoned
- the proposed time and location of the abandonment
- the proposed method of, and procedure for, abandonment
- the effects on the environment and the health and safety of persons that may result from the abandonment and the measures that will be taken to prevent or mitigate those effects
- the results of the decommissioning
- the results of the environmental monitoring

H.10.1.2 Records

According to the GNSCR, the NSCA requires every person to keep records for the period specified in the regulations or, if no such period is specified, until one year after the expiry of the licence that authorizes the activity in respect of which the records are kept. No person may dispose of a record unless the NSCA no longer requires him or her to keep that record or unless he or she has notified the regulatory body of the date of disposal and the nature of the record at least 90 days before disposing of it.

Records relating to an abandonment licence or an exemption from licensing may also need to be archived or stored indefinitely under the oversight of another government or regulatory body.

H.10.2 Examples of the use of institutional controls for proposed spent fuel and radioactive waste repositories

The following are examples of Canadian initiatives for repositories:

- (i) The Nuclear Waste Management Organization's (NWMO's) proposed deep geological repository for the long-term management of spent fuel

On November 3, 2005 the NWMO submitted to the Government of Canada a final study, *Choosing a Way Forward – The Future Management of Canada's Used Nuclear Fuel*, along with a recommendation. The recommended approach, Adaptive Phased Management (APM), includes centralized containment and isolation of spent fuel in a deep geological repository in a suitable rock formation. In June 2007, the Government of Canada issued its decision, accepting the APM as Canada's plan.

After a decision is made to close the deep repository sometime in the future, a provision will come into play for post-closure monitoring of the facility. The precise nature and duration of post-closure monitoring and any requirements to restrict public access to the area will be developed collaboratively during implementation and will take advantage of the most modern technology at the time. This is a decision to be made by a future society.

- (ii) Ontario Power Generation's Deep Geologic Repository (DGR) for its low- and intermediate-level radioactive waste

OPG's licence application to prepare and construct a DGR for its L&ILW proposed the use of institutional controls for a 300-year period to prevent the public from inappropriate use of the site following the closure and dismantling of the surface facilities. For OPG's proposed DGR, all activities might be permitted during the institutional period except drilling, deep excavation, or disruption of the shaft seals, subject to any ongoing use of the site for nuclear activities during the same period. The controls currently proposed are passive in nature and include zoning and land use restrictions. At the current stage of the DGR program, specific details of these and any additional activities are yet to be defined.

H.10.3 Example of the development of institutional control for decommissioned uranium mines and mills in Saskatchewan

In December of 2009, the Government of Saskatchewan published its *Institutional Control Program – Post Closure Management of Decommissioned Mine/Mill Properties on Crown Land in Saskatchewan*, under the auspices of the provincial Ministry of Energy and Resources.

In 2005, Saskatchewan initiated the formal development of an institutional control framework for the long-term management of decommissioned mine and mill sites on provincial Crown land. The development of the framework was to ensure the health, safety and well-being of future generations, provide certainty and closure for the mining industry and recognize obligations by the province and national and international obligations for storage of radioactive materials. The Ministry of Energy and Resources was assigned responsibility for the Institutional Control Registry. An interdepartmental Institutional Control Working Group (ICWG) of senior representatives from the Ministries of Environment, Energy and Resources, Northern Affairs, Justice, and Finance, along with the Executive Council, developed a framework and consulted with stakeholders from the Government of Canada, industry, Aboriginal peoples and northern residents, special interest groups, and the general public.

In May 2006, the provincial legislature promulgated the *Reclaimed Industrial Sites Act* to implement and enforce a recognized need for institutional control. With the *Reclaimed Industrial Sites Act* in place, the ICWG proceeded with the development of the *Reclaimed Industrial Sites Regulations*, which were subsequently approved in March 2007. The *Reclaimed Industrial Sites Act* and *Reclaimed Industrial Sites Regulations* legislate the establishment of the Institutional Control Program (ICP). In the case of a former uranium mining or milling site, the ICP recognizes the jurisdictional authority of the NSCA as enforced by the CNSC.

The two primary components of the ICP are:

- the Institutional Control Registry and the Institutional Control Funds
- the Monitoring and Maintenance Fund and the Unforeseen Events Fund

The Institutional Control Registry will maintain a formal record of closed sites, manage the funding, and perform any required monitoring and maintenance work. Registry records will include the location and former operator, site description and historical records of activities, site maintenance, monitoring and inspection documentation, and future allowable land use for the site. In the case of a decommissioned uranium mining or milling site, it will reference the related CNSC documentation and decisions.

The Monitoring and Maintenance Fund will pay for long-term monitoring and maintenance. The Unforeseen Events Fund will pay for unforeseen future events. Examples of unforeseen events include damage resulting from floods, tornadoes or earthquakes. To reduce the province's risk when it accepts custodial responsibility for sites, and to offset the cost of future monitoring, maintenance and unforeseen events, dedicated site-specific funding will be established by the site holder. The funds will be managed by the province but are legislated and stand alone from provincial revenue.

The ICP completes the regulatory framework for the province, helping the province respond to industry's requirement for clarity in the investment climate and accepting responsibility for safety and environmental concerns. This helps create a sustainable mining industry and protect future generations. For more information on the ICP, visit economy.gov.sk.ca/Institutional_Control-Decommissioned_Mines/Mills

H.11 Monitoring programs

Each radioactive waste management facility in Canada must have in place an approved monitoring program. The monitoring program for a waste management facility must detect unsafe conditions and degradation of structures, systems and components that could result in an unsafe condition. This is how the performance of the individual storage structures – and the entire waste storage system – is evaluated. It helps ensure standards will create a safe environment for humans, non-human biota and the physical environment. For more information on environmental monitoring programs, refer to section F.6.6. Radiological effluent discharge levels for radioactive waste management facilities are listed throughout annexes 5, 6, 7 and 8.

A typical monitoring program for a radioactive waste management facility, including a uranium mine tailings area, may include the following elements:

- gamma radiation monitoring
- effluent monitoring, including airborne and liquid emissions
- an environmental monitoring program, which may include water quality, soil sampling, sediment sampling and fish sampling
- surface water and groundwater monitoring

Section I – Transboundary Movement

I.1 Scope of the section

This section addresses article 27 (Transboundary Movement) of the Joint Convention and provides information on Canada’s experience and practices pertaining to the transboundary movement of radioactive material. The information in this section demonstrates that such movements are undertaken in a manner consistent with the provisions of the Joint Convention and relevant binding international instruments.

I.2 Introduction

The Canadian laws and regulations used to control the import and export of nuclear substances in accordance with Canada’s bilateral and multilateral agreements are:

- the *Nuclear Safety and Control Act* (NSCA) and the associated *Nuclear Non-proliferation Import and Export Control Regulations*
- the *Canadian Environmental Protection Act* (CEPA) and the associated *Export and Import of Hazardous Wastes Regulations*
- the *Export and Import Permits Act*
- the *United Nations Act*

I.3 Controlled substances

Under the NSCA, the Canadian Nuclear Safety Commission (CNSC) regulates the import and export of nuclear substances. The schedule to the *Nuclear Non-proliferation Import and Export Control Regulations* identifies the “controlled nuclear substances” that require export and import authorization from the CNSC.

The following are considered controlled nuclear substances and require transaction-specific export authorizations from the CNSC:

- plutonium
- uranium
- thorium
- deuterium
- tritium
- radium-226 (greater than 370 MBq)
- alpha-emitting radioisotopes with a half-life of 10 days or greater, but less than 200 years, with a total alpha activity of 37 GBq/kilogram or greater (with the exception of material with less than 3.7 GBq of total alpha activity)

The Department of Foreign Affairs, Trade and Development Canada (DFATD) regulates the export of certain types of nuclear substances under the *Export and Import Permits Act*.

The export of a radioactive sealed source of the first 16 radionuclides identified by the International Atomic Energy Agency (IAEA) as a Category 1 or Category 2 radioactive sealed source under table 1 of annex 1 of the IAEA’s *Code of Conduct on the Safety and Security of Radioactive Sources* requires authorization by the CNSC under the NSCA.

I.4 Exporting state

As stated above, the CNSC and DFATD both regulate the export of nuclear substances listed in section I.3. Although the regulations that both organizations use are based upon Nuclear Suppliers Group guidelines Parts 1 and 2, the regulations administered by the CNSC are slightly broader in scope and coverage, pursuant to its mandate.

Finally, in keeping with Canadian nuclear non-proliferation policy, nuclear exports can go forward only to countries with which Canada has established a *Nuclear Cooperation Agreement (NCA)*. NCAs establish reciprocal obligations to ensure, among other things, that nuclear materials will only be used for peaceful, non-explosive purposes. Exports of nuclear substances may still go forward to countries with which Canada does not have an NCA, provided they are of small quantities and/or for non-nuclear use. Canada may also import nuclear substances from countries with which it does not currently have an NCA.

I.5 State of destination

Possession licences issued by the CNSC specify the nuclear substances that the licensee is authorized to hold. These possession licences may also authorize certain types and maximum quantities of nuclear substances to be imported without further authorization. When substances (as defined in section I.3) are imported, transaction-specific authorization must be obtained. This authorization verifies that the applicant holds the necessary possession licences for receiving and properly handling the nuclear substances. If the applicant does not hold the necessary licence, the applicant is notified of the requirements for holding the substance shown in the application.

The Canada Border Services Agency assists the CNSC in administering export and import controls under the NSCA. An importer/exporter must present a valid CNSC licence to a customs officer when importing or exporting a nuclear substance. If a valid licence is not presented upon import or export, the licence holder may be in violation of the conditions of the import or export licence.

I.6 Destination south of latitude 60 degrees

Antarctica is the only land mass south of 60 degrees latitude in the southern hemisphere, as defined under the *Antarctic Treaty* (1959). Seven states currently claim unofficial sovereignty rights to portions of Antarctica. Canada is not one of the seven states. The procedures for ensuring that radioactive material is not transferred to Antarctica are the same as for other destinations. In addition, this international obligation was incorporated under Canadian national law through the CEPA.

Section J – Disused Sealed Sources

J.1 Scope of the section

This section addresses article 28 (Disused Sealed Sources) of the Joint Convention, which requires that:

1. Each contracting body shall, in the framework of its national law, take appropriate steps to ensure that the possession, re-manufacturing or disposal of disused sealed sources is done safely.
2. A contracting party shall allow for the re-entry into its territory of disused sealed sources if, in the framework of its national laws, it has accepted that the sealed sources can be returned to a manufacturer qualified to receive and possess the disused sealed sources.

J.2 Introduction

In Canada, the *Nuclear Safety and Control Act* (NSCA) establishes requirements for the protection of health, safety, security and the environment, as well as the fulfillment of Canada's international obligations and commitments on the peaceful use of nuclear energy. The Canadian Nuclear Safety Commission (CNSC) is the regulatory authority responsible for controlling the export and import of risk-significant radioactive sealed sources in Canada. It is mandated by the NSCA to:

- regulate the development, production and use of nuclear energy in Canada
- regulate the production, possession, use and transport of nuclear substances, along with the production, possession and use of prescribed equipment and information
- implement measures that respect international control of the development, production, transport and use of nuclear energy and nuclear substances, including the non-proliferation of nuclear weapons and explosive devices
- disseminate objective scientific, technical and regulatory information that concerns the CNSC's activities, and their effects on the environment and the health and safety of persons, of the development, production, possession, transport and use of nuclear substances referred to above

Radioactive nuclear substances, whether in sealed or unsealed source form, have many industrial, medical and commercial, as well as academic and research, applications. A wide variety of organizations, including universities, hospitals, industrial facilities and government departments, are typical users of nuclear substances.

Most radioactive sealed sources are physically small (see figure J.1), but their radioactivity may range from tens to billions of becquerels (Bq). When radioactive sealed sources are no longer required or have decayed beyond their useful life and are not intended to be used for the practice for which authorizations have been granted, they become disused radioactive sealed sources. They may then be returned to the manufacturer in Canada or to their country of origin. They may also be sent to a licensed waste management facility. If a radioactive sealed source has decayed below its exemption quantity or its clearance level – as defined in the *Nuclear Substances and Radiation Devices Regulations* (NSRDR) – it may be released from the CNSC's regulatory control, pursuant to subsection 5.1 of these regulations. Nuclear substances that remain within regulatory control must be managed in consideration of all existing regulations.

Figure J.1: Cesium-137 radioactive sealed source



J.3 Regulatory framework for radioactive sealed sources

In accordance with section 26 of the NSCA and subject to regulatory requirements, no person shall possess, transfer, import, export, use, abandon, produce or service a sealed source, except in accordance with a licence.

As defined in the NSRDR, “sealed source” refers to a radioactive nuclear substance in a sealed capsule or bonded to a cover. The capsule or cover must be strong enough to prevent contact with – or dispersion of – the substance, under the conditions for which the capsule or cover is designed.

The export of Category 1 and Category 2 radioactive sources as identified in table 1 of annex 1 of the International Atomic Energy Agency’s (IAEA) *Code of Conduct on the Safety and Security of Radioactive Sealed Sources* requires a transaction-specific authorization issued pursuant to the NSCA. For authorization to export Category 3 and below radioactive sealed sources and authorization to import, use, abandon, produce, manage, store or dispose of a radioactive sealed source, applicants must provide the information required under section 3 of the *General Nuclear and Safety Control Regulations* and section 3 of the NSRDR. For the import and export of controlled nuclear substances, separate licence requirements are prescribed by the *Nuclear Non-proliferation Import and Export Control Regulations*. Additional requirements for persons wishing to apply for a licence to transport nuclear substances are prescribed by the *Packaging and Transport of Nuclear Substances Regulations*.

J.4 Radioactive sealed sources used in Canada

Through Canada’s regulatory control program, the CNSC regulates activities involving radioactive sealed sources. Each licence specifies the isotope and the maximum activity (in Bq) of each radioactive nuclear substance and the maximum activity per sealed source.

J.4.1 Disposal of radioactive sealed sources in Canada

A radioactive sealed source may only be transferred in accordance with the conditions of a licence issued by the CNSC. For long-term management, radioactive sealed sources may be returned to the manufacturer in Canada or to their country of origin. In Canada, certain source manufacturers are recycling radioactive sealed sources at the end of their useful life by either reusing decayed sources for other applications, re-encapsulating them or reprocessing them for other useful applications. The radioactive sealed sources may also be sent to a licensed radioactive waste management facility such as the Atomic Energy of Canada Limited facility in Chalk River, Ontario, or transferred to a person licensed by the CNSC to possess the radioactive sealed sources. If a radioactive sealed source has decayed below its exemption quantity or its clearance levels – as identified in schedule 1 and schedule 2 of the NSRDR – it may also be released from CNSC regulatory control, pursuant to subsection 5.1 of these regulations. Even though the radioactive sealed sources may no longer be under CNSC regulatory control, persons possessing them must still follow applicable federal, provincial and/or municipal regulations.

J.4.2 The National Sealed Source Registry and the Sealed Source Tracking System

The Sealed Source Tracking System (SSTS) is a secure information management computer program used to populate the National Sealed Source Registry (NSSR); it allows licensees to report the movements of radioactive sealed sources online throughout their complete lifecycle. The NSSR enables the CNSC to build an accurate and secure inventory of radioactive sealed sources in Canada, starting with those that are classified as high risk. The information is as current as the reporting time frames required by the licence (e.g., reporting within two days of receipt and seven days in advance of any transfer). These systems have been efficient and effective since their establishment in 2006.

Licensees may report their transactions via the online interface or by other means (such as fax, email and written submissions by regular mail). Since the initial launch of the online interface, the CNSC has redesigned it twice to keep up-to-date with the Government of Canada’s secure system for online services: Access Key in December 2010 and GCKey in December 2012. While doing so, the system was also modified to comply with the Government of Canada’s *Standard on Web Accessibility*. For more information on the standard, visit tbs-sct.gc.ca

By the end of December 2013, the NSSR contained information on 66,139 radioactive sealed sources of all categories in Canada. This represented an increase of 53 percent over the number of sources in the NSSR at the end of December 2011. This increase is a result of various contributing factors, such as an increase in the number of radioactive sealed sources manufactured over the time period or returned to Canadian manufacturers, as well as more licensees adding Category 3, 4 and 5 sources as an integral part of their overall inventory. As of December 2013, the SSTS was tracking 3,993 sources of Category 1 and 32,466 sources of Category 2. The remaining 29,680 sources in the NSSR were of Category 3, 4 and 5, which are subject to mandatory reporting and tracking on an annual basis.

Each change in inventory is called a “transaction” for SSTS purposes, and is the result of a radioactive sealed source being imported, exported, created, transferred or received. In 2013, the SSTS registered 88,904 transactions of all types, representing a 67 percent increase over the number of transactions registered in 2011. CNSC staff conducted 612 inspections between January 1, 2011 and December 31, 2013 related to the SSTS requirements. Of the 612 inspections conducted, 96.9 percent of these confirmed that licensees were compliant with the CNSC requirements, demonstrating a high degree of compliance by the licensed community. The remaining 3.1 percent, or 19 of these inspections, were deemed as not meeting all of the requirements. Examples of non-compliances included licensees not providing notifications of a transaction within the required timeframe or inconsistencies such as errors in source serial numbers or reference dates. In all cases, the CNSC ensured that all non-compliances were adequately addressed by licensees and corrections were made in the NSSR. The aforementioned information indicates a strong commitment by licensees and the CNSC to the NSSR and SSTS and reflects the system’s effectiveness, ensuring the safe and secure management of radioactive sealed sources in Canada.

International collaborations

In addition, the CNSC has held discussions with the United States Nuclear Regulatory Commission (US NRC) regarding the feasibility of an electronic exchange of radioactive sealed source information between countries (the CNSC's SSTS and the US NRC's National Source Tracking System). This exchange of data would provide essential information on authorized radioactive sealed source import and export transactions between the countries, allowing for a continued tracking of sources in their respective systems. In 2012, the CNSC and the US NRC successfully conducted data exchange testing.

J.4.3 Import and export of radioactive sealed sources

The enhancement of Canada's import and export control program for radioactive sealed sources is the result of the government's commitment to two key IAEA documents: the *Code of Conduct on the Safety and Security of Radioactive Sources* (the Code) and its supplementary *Guidance on the Import and Export of Radioactive Sources* (the Guidance). Under the leadership of the IAEA, the Code and the Guidance were developed to improve the safety and security of radioactive sealed sources around the world. In support of the IAEA and its efforts to develop a global regime for the control and secure management of Category 1 and Category 2 radioactive sealed sources, the Government of Canada committed to meet the provisions contained within the Code and implement an import and export control program as outlined in the Guidance.

As Canada's nuclear regulatory authority, the CNSC is responsible for controlling the import and export of radioactive sealed sources under the NSCA. Category 1 and 2 radioactive sealed sources reflect IAEA-TECDOC-1344 *Categorization of Radioactive Sources*, which is based on the D-values that define how dangerous a source is. Category 1 and Category 2 radioactive sealed sources are defined as risk-significant radioactive sealed sources for the purpose of the CNSC import and export control program.

By implementing import and export control measures as outlined in the Code and Guidance, the CNSC enhances national and international safety and security. These measures ensure that only authorized persons can receive Category 1 and Category 2 radioactive sealed sources. The CNSC's import and export control program is consistent with the Code and Guidance and aims to:

- achieve a high level of safety and security regarding Category 1 and 2 radioactive sources
- reduce the likelihood of accidental harmful exposure to Category 1 and 2 radioactive sealed sources or the malicious use of such sources intended to harm individuals, society and the environment
- mitigate or minimize the radiological consequences of any accident or malicious act involving Category 1 and 2 radioactive sources

Prior to implementation of the enhanced import and export controls, the CNSC amended operating licences to remove general authorization for the export of Category 1 and 2 radioactive sources through the use of an export limitation condition. A CNSC licensee authorized to use or possess a Category 1 or 2 radioactive sealed source must apply for and be issued an export licence before exporting that source.

In considering an application to export Category 1 and 2 radioactive sealed sources, the CNSC must satisfy itself that the importing state meets the expectations specified in paragraph 7 of the Guidance, regarding Category 1 sources, and paragraph 11, with respect to Category 2 sources. Where such assurances cannot be obtained and the CNSC determines that the importing state lacks the appropriate regulatory infrastructure to effectively manage the source in a safe and secure manner, the CNSC may consider denying the authorization of the export.

The enhanced CNSC import and export control program for Category 1 and 2 radioactive sealed sources is fully consistent with the provisions of the Code and Guidance. Canadian exporters are required to apply for and obtain an export licence from the CNSC prior to exporting Category 1 and 2 sources. The program encompasses licensing, compliance, prior shipment notifications to importing states, post shipment verifications, state-to-state requests for import consent to import Category 1 sources, the establishment of bilateral administrative arrangements, and the confirmation of receipt of radioactive sources as negotiated in several bilateral administrative arrangements.

To assist licensees and other states, the CNSC has published INFO-0791, *Control of the Export and Import of Risk-Significant Sealed Sources*, which provides information on the CNSC import and export control program for Category 1 and 2 radioactive sealed sources. An application form and accompanying instructions for obtaining a licence to export Category 1 and 2 radioactive sealed sources are also available at nuclearsafety.gc.ca

Since implementation of the program on April 1, 2007, the CNSC has received more than 1,438 applications to export Category 1 and 2 sources to over 85 countries and has controlled the export of greater than 8.5 TBq. Canada remains a global leader in the production and export of Category 1 Co-60 radioactive sealed sources, supplying 75 percent of the global demand.

International harmonization through bilateral administrative arrangements

To assist the international implementation of the Code and Guidance in a harmonized manner, the CNSC has developed a model bilateral administrative arrangement with a core set of terms, definitions and procedures. The CNSC continues to enter into bilateral administrative arrangements with its international counterparts to ensure that imports and exports of Category 1 and 2 radioactive sealed sources between Canada and these countries are conducted in a manner consistent with the Code and Guidance. These arrangements assist in harmonizing regulatory approaches for authorizing imports and exports and facilitate the sharing of regulatory information related to such imports and exports. To date, the CNSC has established 12 bilateral administrative arrangements for the import and export of radioactive sources.

The importance of bilateral arrangements for facilitating greater international harmonization of controls was regarded as a good practice by the IAEA's Integrated Regulatory Review Service (IRRS) review of the CNSC regulatory program in June 2009. For more information on the IRRS review, refer to section E.8.2.3. The practice is also highly regarded internationally, as it assists other states in implementation of the Code and Guidance. The CNSC encourages the establishment and use of bilateral arrangements to assist in harmonizing regulatory approaches for authorizing imports and exports.

J.4.4 Records

Paragraph 36(1)(c) of the NSRDR requires every licensee to keep a record of any transfer, receipt, disposal or abandonment of a nuclear substance. Requirements include:

- the date of the transfer, receipt, disposal or abandonment
- the name and address of the supplier or the recipient
- the number of the licence of the recipient
- the name, quantity and form of the nuclear substance transferred, received, disposed of, or abandoned
- when the nuclear substance is a radioactive sealed source, the model and serial number of the source
- when the nuclear substance is contained in a radiation device, the model and serial number of the device

J.4.5 Safety of radioactive sealed sources

In Canada, radioactive sealed sources are referenced in a licence (pursuant to the NSRDR) to ensure that, throughout its lifecycle, a radioactive sealed source is possessed, transferred, imported, exported, used, abandoned, produced or serviced in accordance with regulatory requirements.

J.5 Radioactive sealed sources in the international community

The re-entry of previously exported radioactive sealed sources is permitted either by an import licence (with respect to controlled nuclear substances) or in accordance with a general import authorization licence issued by the CNSC.

Section K – Planned Activities

K.1 Scope of the section

This section provides a summary of key activities and programs mentioned throughout this report, including planned next steps. Where appropriate, these include measures of international cooperation.

K.2 Introduction

Canada is currently pursuing several initiatives in order to better manage the spent fuel and radioactive waste produced inside its borders and to ensure the protection of health, safety, security and the environment. These initiatives include:

- improving the regulatory framework
- updating, revising and developing new regulatory documents that provide guidance to licensees
- developing long-term management options for spent fuel and radioactive waste
- addressing historic and legacy issues

K.3 Regulatory framework initiatives

The Canadian Nuclear Safety Commission (CNSC) is continually making improvements to the framework to make it more robust and more responsive to current and emerging needs. For example,

- international standards (such as those developed by the International Atomic Energy Agency (IAEA) and the International Organization for Standardization (ISO)) are being adapted or adopted as appropriate
- external consultations are being aligned with the Treasury Board of Canada's *Guidelines for Effective Regulatory Consultations*
- an online consultation form has been launched to encourage people to participate in the development of regulatory documents
- CNSC staff are participating in the development of CSA Group standards
- the CNSC is developing of an evergreen five-year Regulatory Framework Plan

A regulatory framework analysis was prepared for regulations and related documents to identify any gaps and to help develop long-term plans for the framework, referred to as the Regulatory Framework Plan. The Regulatory Framework Steering Committee provides strategic direction to coordinate the identification, development and implementation of the framework. This plan can be found on the CNSC website at nuclearsafety.gc.ca/eng/acts-and-regulations

Coinciding with this, CNSC staff are conducting an analysis to determine whether or not there is a need to develop radioactive waste and decommissioning regulations. To address this potential need, CNSC staff continue to work toward a consolidated regulatory framework for waste and decommissioning, consisting of a suite of updated regulatory documents and new waste regulations. A discussion paper on the proposed approach is planned for public consultation in the winter of 2014, including seeking stakeholder feedback. For more information, refer to section E.8.2.3.

This discussion paper will also include a proposed plan forward for updating the information contained in regulatory guide G-206, *Financial Guarantees for Decommissioning of Licensed Activities* (for information on this regulatory guide, refer to section F.4.3). As a related activity, CNSC staff are proposing a financial guarantee program for CNSC licenses issued in respect of nuclear substances, prescribed equipment and Class II nuclear facilities. Based on the Commission's decision to approve the program, all licences will be amended to include a condition requiring a financial guarantee based on this proposed program.

For the development and revision of regulatory documents, emphasis has been placed on providing more efficient documents for stakeholders. This includes providing further guidance in relation to regulations and licence conditions and licence application guides for potential licensees of various facility types. As an example regulatory document REGDOC-1.3.1, *Licence Application Guide: Uranium Mines and Mills* is currently under development.

CNSC staff are currently developing a position paper on decommissioning strategies. The purpose of this position paper is to document, based on international benchmark and best practices, the required elements for the selected decommissioning strategies for nuclear facilities. The information presented in this document will then be used as a seed document in support to the drafting of the *Radioactive Waste Regulations* and possibly also in support to the development of a CNSC regulatory document on decommissioning strategies for nuclear facilities. Similarly, the information presented may be used to update CNSC regulatory guide G-219, *Decommissioning Planning for Licensed Activities*.

In addition, future planned initiatives for regulatory documents, specific to spent fuel and radioactive waste, include reviewing P-290, *Managing Radioactive Waste*, G-320, *Assessing the Long Term Safety of Radioactive Waste Management*, and RD/GD-370, *Management of Uranium Mine Waste Rock and Mill Tailings* to ensure these documents remain relevant to licences.

Lastly, CNSC staff are currently developing a regulatory document for siting a deep geological repository for the long-term management of radioactive waste in Canada.

K.4 Long-term management of spent fuel

K.4.1 Assessment of options for long-term management of spent fuel

From 2002 to 2005, the Nuclear Waste Management Organization (NWMO) studied approaches for long-term management of Canada's spent fuel.

The NWMO began by analyzing management options that have been considered internationally. Following this review and screening, the NWMO selected as the basis for its initial assessment the three methods specified in the *Nuclear Fuel Waste Act* (NFWA): deep geological disposal in the Canadian Shield, storage at nuclear reactor sites, and centralized, above- or below-ground storage. From the insights gained through the NWMO analysis and public consultation, the NWMO proposed a fourth option, Adaptive Phased Management (APM).

The management options were subject to multiple assessment processes. The NWMO developed an assessment framework for evaluating the options according to citizen values, ethical principles and eight objectives:

- fairness
- public health and safety
- worker health and safety
- community well-being
- security
- environmental integrity
- economic viability
- adaptability

The analysis included ethical and social considerations. A preliminary assessment of the three options in the NFWA examined the strengths and limitations of each approach, through an application of multi-attribute utility analysis. Extensive comparative analysis of the costs, benefits and risks of the three options in the NFWA and the NWMO's fourth option provided quantitative and qualitative assessments.

The assessment processes were supported by multi-disciplinary research contributions, workshops, submissions from Canadians, guidance on values and ethical principles from citizens, Aboriginal traditional knowledge and the NWMO's Roundtable on Ethics.

The NWMO developed its recommendation, APM, following the input of technical specialists, the public and Aboriginal peoples. The NWMO engaged Canadians in a wide-ranging dialogue on the values, principles and objectives they believe are required of a spent fuel waste management approach in order for the approach to be socially acceptable, environmentally responsible, technically sound and economically feasible. In studying these options, the NWMO held 120 public consultations and numerous full-day dialogues on values, covering a cross-section of the population in every province and territory. Approximately 18,000 citizens contributed to the study. More than 60,000 people expressed their interest by visiting the NWMO website. The final study report, *Choosing a Way Forward*, which contains the detailed recommendation and the NWMO's supporting assessment findings and research, is available at nwmo.ca for download.

K.4.2 Adaptive Phased Management: The Nuclear Waste Management Organization's proposal to government

In November 2005, the NWMO submitted its study and recommended the APM approach to the Minister of Natural Resources. On June 14, 2007, following a government-wide review, the Government of Canada announced it had selected the APM approach, as proposed by the NWMO.

APM is composed of:

1. a technical method that:
 - is based on centralized containment and isolation of the spent fuel in a deep geological repository of suitable rock formations, such as the crystalline rock of the Canadian Shield or formations such as sedimentary rock
 - is flexible in the pace and manner of implementation, through a phased decision-making process that will be supported by a program of continuous learning, research and development
 - provides for an interim step in the implementation process, in the form of shallow underground storage of spent fuel at the central site, prior to final placement in a deep repository
 - monitors the spent fuel to support data collection and confirmation of the safety and performance of the repository
 - is able to retrieve the spent fuel over a long period, until such time as a future society makes a determination on the final closure and the appropriate form and duration of post-closure monitoring

and

2. a management approach, whose key characteristics include:
 - responsiveness to advances in technology, natural and social science research, Aboriginal traditional knowledge and societal values and expectations
 - sustained engagement of people and communities while making and implementing decisions
 - financial stability, through funding by the nuclear energy corporations – currently Ontario Power Generation (OPG), Hydro-Québec (HQ) and New Brunswick Power Corporation (NB Power) – and Atomic Energy of Canada Limited (AECL), according to a financial formula required by the NFWA
 - site selection, focused on provinces that currently benefit from the nuclear fuel cycle: Saskatchewan, Ontario, Quebec and New Brunswick, although communities in other regions will also be considered

- selection of a site in an informed, willing community to host the central facilities; the site must meet the scientific and technical criteria to ensure that multiple engineered and natural barriers will protect human beings, other life forms and the biosphere

APM was designed to build upon the advantages of each of the other three approaches and in order to provide safety and fairness to this and future generations.

In proposing the APM, the NWMO tried to provide a risk-management approach that comprises deliberate stages and periodic decision points. The APM plan:

- commits this generation of Canadians to take the first steps to manage the spent fuel it has created
- includes a design and process that ensure that APM meets rigorous safety and security standards
- features a step-by-step decision-making process that will provide the flexibility to adapt to experience and societal change
- provides genuine choice by taking a financially conservative approach and by allowing capacity to be transferred from one generation to the next
- promotes continuous learning – improvements in operations and design can be made to enhance performance and reduce uncertainties
- provides a viable, safe and secure long-term storage capability, with the potential for retrieving waste, which can be exercised until future generations have confidence to close the facility
- is rooted in values and ethics and engages citizens, allowing for societal judgments as to whether there is sufficient certainty to proceed with each step

K.4.3 Implementing the long-term management plan (2011–2014)

Following the Government of Canada’s decision in 2007, the NWMO developed and confirmed, through public review, seven strategic objectives that would serve as the foundation of strategic plans for the important first phase of work to implement the approach. It is against these seven strategic areas that the NWMO presents its progress for 2011 to 2014.

The NWMO has grown into a broader implementing agency and activities are underway in all seven key areas of its five-year plan. The NWMO’s current plan, *Implementing Adaptive Phased Management 2014 – 2018*, can be found on the NWMO website at nwm.ca/implementationplan. These activities are described in the following sections.

K.4.3.1 Relationship building

Throughout the reporting period, building and nurturing relationships with those potentially affected by the NWMO’s work has remained an important focus, with the ongoing invitation to interested organizations and individuals to contribute to shaping implementation plans for the APM project. In 2008–2009, important foundations for the APM site selection process were laid through the collaborative development of a process to identify a safe site in an informed and willing host community. Since that time, engagement activities continued to seek input on NWMO plans and policies and strategic objectives for APM.

Activities have included:

- working closely with communities involved in the site selection process
- convening meetings of the Municipal Forum and strengthening liaisons with municipal associations for guidance on needs and processes of municipalities involved in the site selection process
- expanding work and collaboration with national, provincial and regional Aboriginal organizations and the NWMO Council of Elders to involve Aboriginal people in program design and implementation

- expanding relationships with all levels of government
- expanding a suite of communication supports to keep communities and the general public informed about NWMO’s work and the site selection process, including APM exhibits on the repository concept and transportation, a virtual exhibit, multi-media exhibits for local offices, backgrounders, fact sheets, and newsletters
- introducing in 2012 the regular issuance of “Ask the NWMO” advertising columns featured in local and regional newspapers to address topics of interest to communities in the siting process
- introducing in 2013 a custom-built mobile transportation exhibit featuring a full-size spent fuel transport package that has been certified by the CNSC, and which comes with touch screens and panels for a hands-on opportunity to learn more about plans for the safe and secure transportation of Canada’s spent fuel (see figure K.1)
- establishing in 2012 a “Learn More Centre” at the organization’s Toronto headquarters, as a fully equipped meeting space featuring exhibits and panels explaining APM; the venue is used for meetings and briefings with a wide range of groups and individuals
- continuing to deliver Learn More tours for the media to build understanding of the APM approach
- continuing outreach to youth at the local community level, support for youth in science programs, outreach to universities and support for doctoral students

Figure K.1: Mobile transportation exhibit



K.4.3.2 Site selection

In 2008 and 2009, NWMO led the collaborative development of a community-driven process for identifying a safe, secure location in an informed and willing community to host the deep geological repository. The site selection process was initiated in 2010 with the invitation to communities to learn more about the APM project.

Between 2011 and 2014, significant progress was made as NWMO worked with interested communities. Activities during this period included:

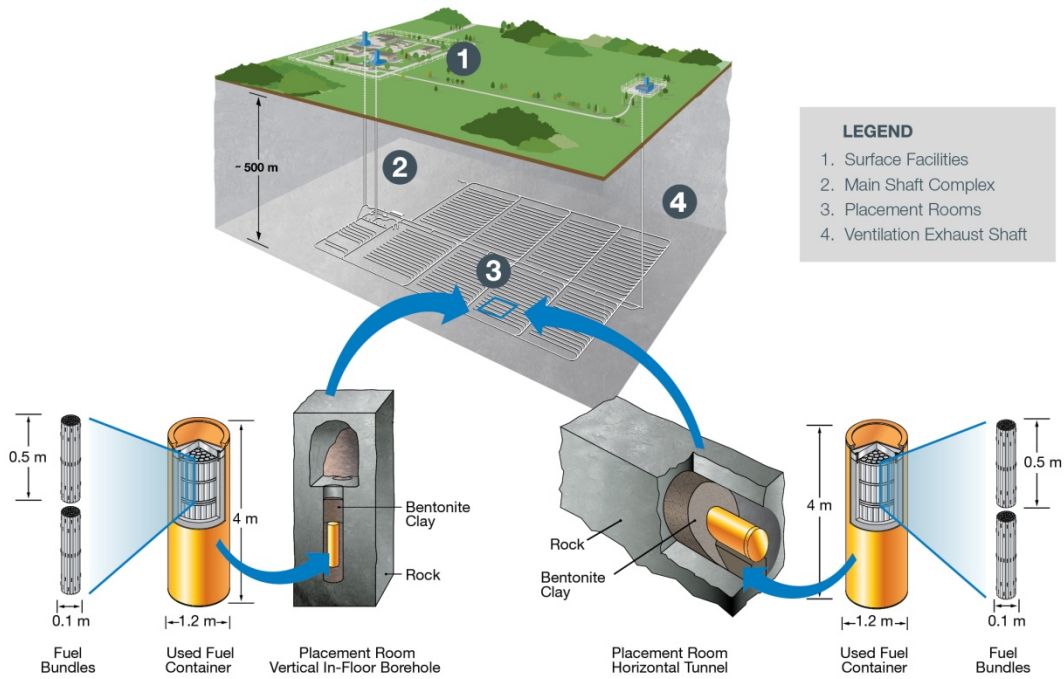
- concluding Step 1 of the site selection process, as NWMO delivered a broad-based program of activities to raise awareness of the APM project and responded to early interest from communities in learning about APM
- concluding Step 2 of the site selection process with 22 communities, involving delivery of programs to build community understanding of APM with initial desktop screenings requested by communities as part of this period of learning more about APM and the siting process
- suspending the expressions of interest phase in September 2012, to enable NWMO to focus its support and resources on the 21 communities that had entered the siting process, in order to explore their interest and suitability for hosting the APM project
- initiating Step 3, Phase 1 desktop assessments with 20 requesting communities that passed initial screenings; supporting the establishment of community liaison committees and delivery of Learn More resource programs to communities; providing resources to communities to meet separately with CNSC staff to get a better understanding of the CNSC's independent role in regulating Canada's nuclear sector and its early involvement with the APM project
- completing Step 3, Phase 1 for the first 11 communities in 2013–2014:
 - identifying four communities with strong potential for Step 3, Phase 2 field work assessments
- continuing with Step 3, Phase 1 desktop assessments for another nine communities, scheduled for completion later in 2014 or early in 2015
- in January 2014, initiating Step 3, Phase 2 assessments with the four communities through collaborative planning and community dialogue for airborne surveys and expanded outreach to Aboriginal peoples and surrounding municipalities
- reviewing with each of the Step 3, Phase 2 interested communities, local Aboriginal people and surrounding communities the opportunities to work together during this multi-year period of study, including the expanded resource program and opportunities available to communities for more learning about APM, expanded local offices and exhibits, and support from NWMO staff

K.4.3.3 Design and safety case for the APM deep geological repository

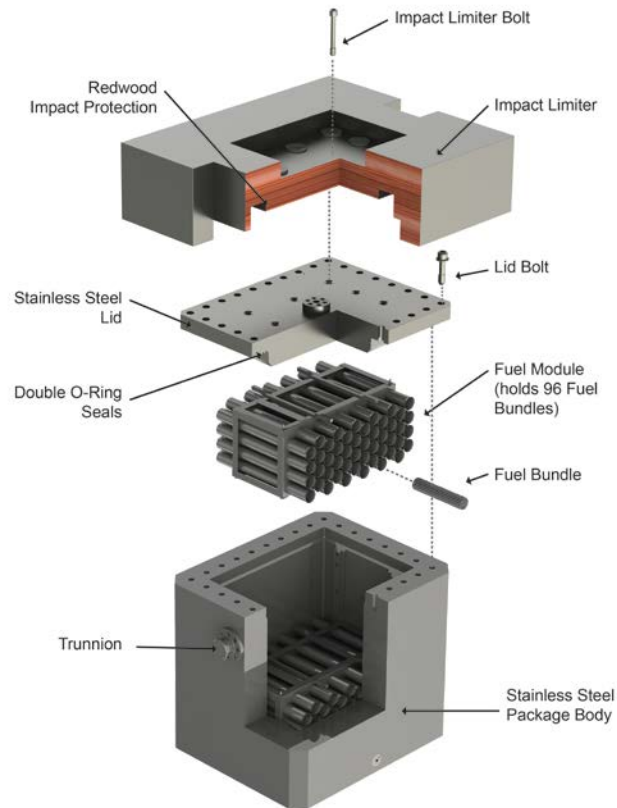
In parallel, refinements to elements of the technical reference designs and safety cases for the deep geological repository for spent fuel continued, supported by a breadth of design and development work in collaboration with international partners. Activities included:

- completing an update of conceptual designs and cost estimates for a deep geological repository (see figure K.2) and transportation system
- preparing conceptual designs for the handling, transfer, loading and sealing of spent fuel containers
- completing two illustrative post-closure safety assessments – one in crystalline rock, the other in sedimentary rock – for pre-project review by the CNSC

Figure K.2: Deep geological repository



- developing copper coatings for repository containers using Canadian technologies developed by the National Research Council and the Canadian universities of Ottawa, Windsor and Toronto, and collaborating on these efforts with Nagra, Switzerland’s nuclear waste management organization
- conducting analyses specific to the safe and secure transportation of spent fuel
- acquiring a used fuel transportation package, preparing a safety analysis report and obtaining a Canadian Nuclear Safety Commission certificate for that package to current regulations for a spent fuel transport package (see figure K.3)
- advancing geo-scientific research for both crystalline and sedimentary bedrock settings
- collaborating on a technical research program with Canadian universities and international partners in Sweden, Finland, Switzerland and France

Figure K.3: Used fuel transport package

K.4.3.4 Funding of Nuclear Waste Management Organization activities

The NFWA requires that Canada's nuclear energy corporations – OPG, HQ, NB Power and AECL – ensure there is enough money to pay for the full costs of implementing the plan. Since 2002, waste owners have been contributing to individual trust funds, which total more than \$2.9 billion as of the end of 2013. The NFWA built in explicit provisions to ensure that the trust funds are maintained securely and used only for their intended purposes. The NWMO cannot access the NFWA trust fund until the NWMO has been issued a construction licence from the CNSC.

The NFWA trust fund money is in addition to other segregated funds and financial guarantees the companies have set aside for spent fuel and radioactive waste management and decommissioning. These funds and financial guarantees are used to satisfy the financial guarantees requirements that all NWMO members – OPG, HQ and NB Power – have provided to the CNSC. These guarantees for the year 2014 total \$16.9 billion and equal the total cost (in terms of present value) of managing the decommissioning of all reactors and permanently managing all radioactive waste (including spent fuel) produced to date. A large portion of these guarantees, approximately \$14.8 billion (as of year-end 2013), exists in segregated funds dedicated to spent fuel and radioactive waste management and decommissioning, with the remainder in the form of provincial guarantees. These guarantees include the NFWA trust fund contributions made by NWMO members.

In addition to making financial provision for work required after the construction licence is issued, the cost of the NWMO's activities up to receipt of this licence is covered by contributions made by the nuclear energy corporations.

Activities related to the funding of NWMO activities over the last three years have included:

- completing in 2011 a full update of the lifecycle cost estimate for the APM deep geological repository and related transportation of spent fuel
- updating annual trust fund contributions required of waste owners to reflect the latest lifecycle cost estimates and trust fund balances

K.4.3.5 Plan adaptation

All work has progressed through the important lens of adaptive management, as the organization seeks to stay abreast of evolving developments and expectations that may impact future activities. Activities have included:

- inviting public input so that evolving societal expectations of Canadians can be reflected in implementation plans for the APM project
- tracking emerging technologies, spent fuel inventory projections and potential impacts of energy policy decisions on the APM project
- partnering with universities, radioactive waste organizations and international agencies to keep abreast of the latest technical advances and best practices in engagement and assessing social considerations
- hosting the 2012 International Conference on Geological Repositories in cooperation with Natural Resources Canada (NRCan), the Nuclear Energy Agency of the Organisation of Economic Co-operation and Development, the IAEA, the European Commission, and the International Association for Environmentally Safe Disposal of Radioactive Materials, to discuss progress with national programs and discuss the topic of “National Commitment – Local and Regional Involvement”
- participating in the Nuclear Energy Agency’s Radioactive Waste Management Bureau and Committee, Integration Group for the Safety Case, Forum for Stakeholder Confidence and working group on the Preservation of Records, Knowledge and Memory Across Generations
- reviewing the social and ethical framework for APM in 2011 to ensure its appropriateness to guide the site selection phase of work
- continuing work to understand opportunities to interweave Aboriginal traditional knowledge

K.4.3.6 Accountability and governance

The integrity of the NWMO’s work is advanced by multiple layers of oversight and peer review. Internally, the NWMO is governed by its board of directors. Over the reporting period, NWMO’s accountability and governance was also provided through a broad framework comprising such activities as:

- continued independent reviews by the Independent Technical Review Group (ITRG) to review the APM technical program; annual ITRG reviews confirming that the full range of relevant scientific topics is covered by the NWMO
- issuance of five-year strategic plans for APM implementation
- independent review of the organization’s work through the NWMO Advisory Council, Municipal Forum and a forum of Aboriginal Elders
- providing updates to the CNSC and seeking feedback as part of the service arrangement between the CNSC and the NWMO; activities include CNSC staff conducting a review of APM technical components of siting, design development and safety assessment to identify any regulatory concerns with meeting regulatory requirements, such as pre-project reviews of reports that the

- NWMO submits on the conceptual design and illustrative post-closure safety assessments for a spent fuel repository in both crystalline and sedimentary rock formations
- ensuring that the NWMO’s management system meets the highest standards by adding two new certifications to its existing Quality Management (ISO 9001:2008) certification: Occupational Health and Safety Management (CSA Z1000:2006) and Environmental Management Systems (ISO 14001:2004)
 - implementation of a Memorandum of Understanding with NRCan on consultation with Aboriginal peoples
 - annual reports to the Minister of Natural Resources, as required by the NFWA

K.4.3.7 Organization building

The NWMO itself developed and expanded in recent years, as it transitioned into a larger implementing organization with the range of skills, oversight and governance required to capably deliver on the NWMO’s mandate and earn the confidence of Canadians.

Activities included the continued strengthening of its capabilities through recruitment of a highly qualified, experienced multi-disciplinary team; the NWMO grew from 27 employees in 2007 to 130 employees by the end of 2013.

The NWMO’s staffing priorities and policies reflect the fact that the management of spent fuel is a long-term responsibility involving a wide range of disciplines. All are critical to responding to the needs and concerns of interested and potentially affected communities, developing collaborative partnerships with those communities, and ensuring that evaluations of potential sites meet the highest technical standards, as does the eventual site itself. Because it will take several generations to implement APM, succession planning is an important priority for the NWMO. To preserve and transfer institutional memory, the NWMO implemented systematic procedures for archiving and retrieving policies, technical reports, field notes and briefings. The goal of equipping a new generation to assume responsibility for APM was also advanced through a number of youth-based science initiatives including, most notably, the NWMO’s ongoing support to graduate students through the Natural Sciences and Engineering Research Council’s Industrial R&D scholarship and fellowship programs.

K.5 The CNSC’s role and early involvement in the APM project for the long-term management of Canada’s spent fuel

As a best practice, the CNSC gets involved early in proposed new nuclear projects to ensure that licence applicants and affected communities have a comprehensive understanding of the CNSC’s role in regulating Canada’s nuclear sector.

Future applicants are provided with CNSC information and guidance on the regulatory requirements and licensing process prior to the submission of a licence application and the initiation of the environmental assessment process. The CNSC engages affected communities to provide factual and unbiased information about how its mandate is fulfilled: to regulate the use of nuclear energy and materials to protect health, safety, security and the environment, and to implement Canada’s international commitments on the peaceful use of nuclear energy. More information is available at the CNSC website, nuclearsafety.gc.ca/eng/waste

K.5.1 Service arrangement between the CNSC and NWMO

In March 2014, the CNSC renewed the service arrangement with the NWMO to provide regulatory guidance and support for implementing the NWMO’s APM project. The service arrangement identifies the terms under which the CNSC provides services to the NWMO prior to the submission of a licence application. Services include providing pre-project reviews of the APM deep geological repository

concepts, identifying regulatory requirements for a geological repository and participating in public meetings to provide information on the CNSC's involvement. Additionally, the service arrangement is valid for a five-year period, unless a licence application is submitted, at which point the agreement would no longer be in effect. For more information about the service arrangement, refer to the CNSC website at nuclearsafety.gc.ca/eng/waste/high-level-waste/index.cfm#Long-term

As part of this arrangement, the CNSC will conduct [pre-project reviews](#) of reports that the NWMO has submitted on the conceptual design and illustrative post-closure safety assessment for the APM deep geological repository for spent fuel.

A design review is an assessment of a proposed design based on the concepts presented by a future licence applicant. The term “pre-project” signifies that a design review takes place before a licence application is submitted to the CNSC.

At this time, it is not known where the repository will be located in Canada; therefore, the NWMO is developing conceptual designs – these are draft designs (i.e., models) – for two hypothetical sites. The NWMO is also looking at methods to assess the safety of these two hypothetical sites after a decision is made to close the sites (i.e., post-closure). The CNSC is currently reviewing the conceptual design and illustrative post-closure safety assessment reports for the two hypothetical, but realistic, sites in representative rock formations – one in crystalline rock and one in sedimentary rock.

The CNSC provides reviews as an optional service when requested by a future licence applicant. This service does not certify a concept design or involve issuing a licence under the NSCA and it is not required as part of the licensing process for the deep geological repository. The conclusions of any reviews do not bind or otherwise influence decisions that the Commission makes.

K.5.2 CNSC independent research and assessment on the safe long-term management of radioactive waste and spent fuel in geological repositories

Since 1978, the CNSC has been involved in independent research and assessment, including international collaboration, on the safe long-term management of spent fuel in geological repositories. These activities looked at the Canadian Shield's granitic rock because it was the only type of rock formation being considered for the long-term management of spent fuel in Canada.

The NWMO is currently looking for a voluntary community, with a site that is technically acceptable, in either granitic rock formations of the Canadian Shield, or in sedimentary rock formations. At the same time, OPG is proposing a deep geological repository for its low- and intermediate-level radioactive waste (L&ILW), at approximately 680 metres deep in a sedimentary formation. In response to the above two initiatives, the CNSC identified the need to expand its technical expertise from granitic rock to include knowledge and understanding of geological disposal in sedimentary rock. Therefore, the CNSC is conducting a research program to evaluate long-term safety issues related to the deep geological disposal of radioactive waste and spent fuel in sedimentary rock. This program consists of independent scientific research conducted by CNSC staff in collaboration with national and international institutions. It also includes monitoring and review of state-of-the-art scientific advancements, and participation in international forums to exchange information and knowledge related to geological repositories.

K.5.3 CNSC outreach activities

Throughout the reporting period, the CNSC continued to meet with the communities that have formally entered the NWMO's siting process. Outreach activities have focused on relationship building with the communities. At the request of community representatives, additional outreach activities, including information sessions, have been undertaken.

These information sessions take place at the request of the community representatives (usually the community liaison committees (CLCs)), and take place as follows:

- an initial conference call between community/CLC representative and CNSC staff
- a day-long meeting at the CNSC's Ottawa offices with community representatives (typically the mayor and council, but often a separate meeting is held for the CLC)
- presentations by the CNSC at CLC meetings in the community
- information sessions, such as an open house in the communities

The outreach activities are designed to provide information on the CNSC's role as Canada's nuclear regulator and to elaborate the organization's early role in the APM project. Topics addressed during the sessions include:

- overview of the CNSC's independent regulatory role and its early involvement in the APM approach
- regulatory considerations, including CNSC licensing process
- public participation in the Commission hearing process, Aboriginal consultation, environmental assessment
- public information programs
- geotechnical aspects of a deep geological repository
- the transportation and safety of spent fuel
- other regulatory bodies the CNSC works with to fulfill its mandate in licensing nuclear facilities and activities
- CNSC independent research program
- CNSC's international collaboration
- pre-project design reviews of geological repository concepts

The exchange of information between communities and the CNSC has been lively, and feedback from communities has been positive: they feel sure that the CNSC is a neutral, independent body, and are confident CNSC has the right people to evaluate repositories for spent fuel and who are concerned with safety first and foremost. Figure K.4 provides a screen shot of the information found on the CNSC website at nuclearsafety.gc.ca/eng/waste/high-level-waste/index.cfm#Long-term

Figure K.4: Example of information available on the CNSC website

The screenshot shows the Canadian Nuclear Safety Commission website. The header includes the Government of Canada logo and navigation links for Canada.ca, Services, Departments, and Français. The main navigation menu includes: The Commission, Uranium, Reactors, Nuclear Substances, Waste, Acts and Regulations, and Resources. The current page is titled 'Talking to Communities about the APM Approach' under the 'Waste' section. A sidebar on the left lists categories: High Level Waste, Low and Intermediate Waste, Uranium Mines and Mills Waste, Historic Nuclear Waste, and Ontario Power Generation Deep Geologic Repository. The main content area contains the following text:

On August 8 and 9, 2014, the Canadian Nuclear Safety Commission (CNSC) will hold three open-house events in Huron-Kinloss, Ontario, explaining our regulatory role and our early involvement in a deep geological repository for used nuclear fuel. [Learn more.](#)

In May 2010, as part of the Adaptive Phased Management (APM) approach, the NWMO launched its [Site Selection Process](#) to select a community to host a geological repository for the long-term management of Canada's used nuclear fuel

In this early stage of the APM approach, the Canadian Nuclear Safety Commission (CNSC)'s has been meeting with communities involved in the NWMO's site selection process to help them better understand the safety and regulatory matters that would be examined for a deep geological repository for used nuclear fuel.

These sessions take place at the request of the community representatives (usually the Community Liaison Committees), and take place as follows:

- an initial conference call between community/CLC representative and CNSC staff
- a day-long meeting at the CNSC's Ottawa offices with community representatives (typically the mayor and council, but often a separate meeting is held for the CLC).
- presentations by the CNSC at CLC meetings in the community
- information sessions, such as an Open House in the communities

CNSC staff presentations typically cover one or more the following topics:

- overview of the CNSC's independent regulatory role and its early involvement in the APM approach
- regulatory considerations, including our licensing process

K.6 Long-term management of low- and intermediate-level radioactive waste

All Canadian L&ILW is currently in safe storage. Canada's two major L&ILW owners, OPG and AECL (who are responsible for about 98 percent of the non-historic L&ILW), have initiatives underway to develop and implement long-term solutions.

The Port Hope Area Initiative (PHAI) involves the cleanup and long-term management of historic low-level radioactive waste (LLW) in Port Hope, Ontario, which accounts for the bulk of Canada's historic LLW. For more information on the PHAI, refer to section K.6.3.1.

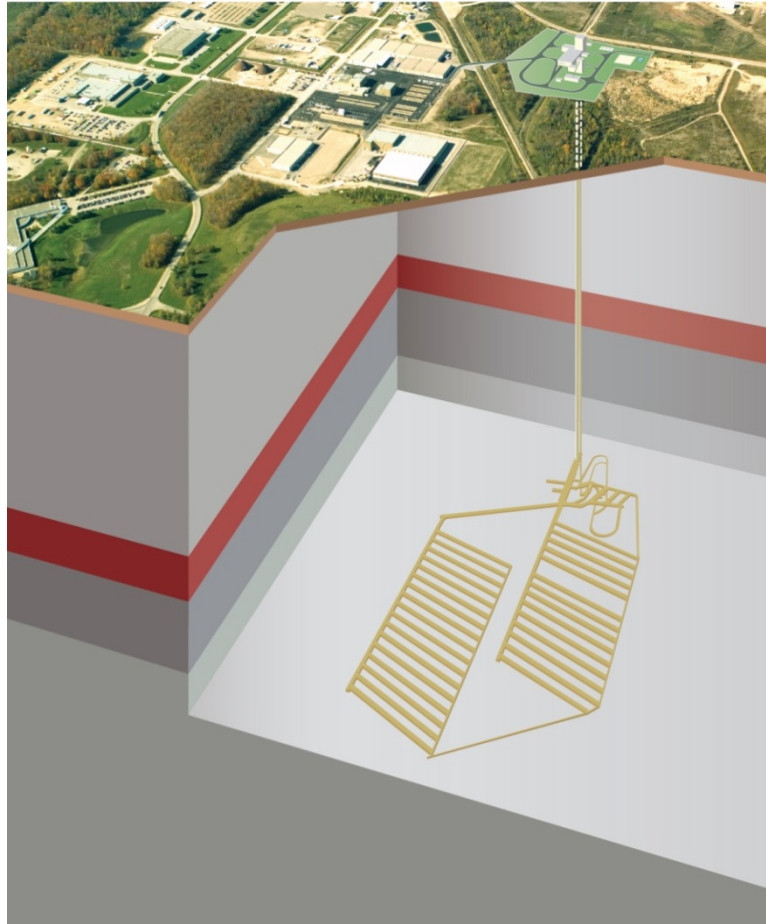
Ongoing initiatives to address the long-term management of L&ILW in Canada are described in the following sections.

K.6.1 Proposed low- and intermediate-level waste deep geological repository at the Bruce nuclear site

OPG has recognized that, while its current approach to radioactive waste storage is safe, secure and environmentally responsible, a safe and permanent solution is required to dispose of the waste safely where it cannot pose a threat to the public or the environment for the long term. A long-term management approach will ensure that radioactive waste can be kept safely isolated from the environment without burdening future generations.

The current project proposed by OPG is to prepare the site and construct a deep geological disposal facility on the secure Bruce nuclear site within the Municipality of Kincardine (see figure K.5). The purpose of the proposed repository is to safely isolate and contain L&ILW deep underground, ensuring protection of water and the environment. It will be buried 680 metres deep, in stable rock formations that are over 450 million years old. The deep geological repository site is adjacent to the existing Western Waste Management Facility that is owned by OPG and provides centralized storage for L&ILW from the operation of OPG-owned or operated reactors in Ontario. OPG has safely managed L&ILW for the Pickering, Darlington and Bruce reactors at the Bruce site for over 40 years. Currently, an estimated 94,000 cubic metres of L&ILW is stored onsite on an interim basis. Throughout the life of the facility, emissions have been less than one percent of the regulatory limit.

Figure K.5: Artist's concept of the OPG Deep Geologic Repository

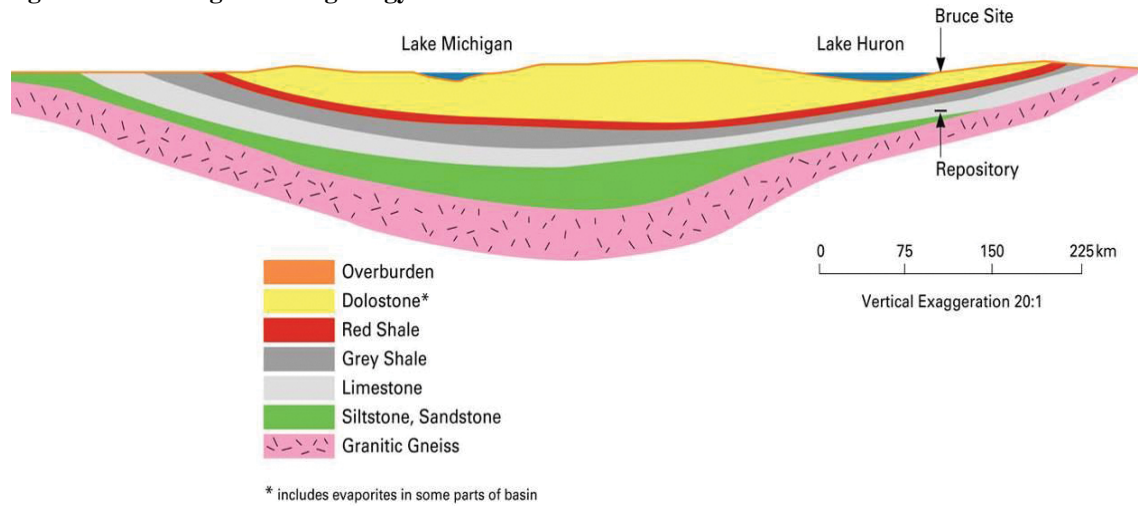


Following a request by the Municipality of Kincardine to explore, jointly with OPG, the options for a long-term management of L&ILW within the municipality, the concept for the DGR at the Bruce nuclear site was developed.

A geotechnical feasibility study, a preliminary safety assessment, a social and economic assessment, a community attitude survey, interviews with local residents, businesses and tourists and an environmental review led to the creation of the independent assessment study (IAS). Another component of the IAS was a public consultation program, conducted in Kincardine and surrounding municipalities.

The IAS concluded that a number of options were feasible. The options, including enhanced processing and storage, covered above-ground concrete vault, and a DGR, could be constructed to meet international and Canadian safety standards with a high margin of safety, and would not have significant residual environmental or socio-economic effects. The geology of the Bruce site was considered ideal for the DGR option (see figure K.6). The study report can be accessed at opgdgr.com

In April 2004, the Kincardine Council passed a resolution to endorse the Deep Rock Vault option as the preferred course of study with regard to the management of L&ILW. The Deep Rock Vault (i.e., deep geologic repository) has the highest margin of safety and is consistent with best international practices.

Figure K.6: Michigan basin geology and the Bruce site

Following the Council resolution, Kincardine and OPG began to negotiate terms for a hosting agreement. Hosting agreements have been implemented in a number of jurisdictions in Canada and internationally by communities that support the location of a long-term waste management facility.

The Kincardine Hosting Agreement was signed on October 13, 2004. It set out the terms and conditions under which the project would proceed.

From mid-October 2004 to mid-January 2005, OPG assisted Kincardine to undertake a public dialogue on the DGR proposal and to determine the level of community support. Each residence in Kincardine was telephoned or followed up with a mail-out, as required. The results of the poll were announced at the Kincardine Council meeting on February 16, 2005 and were as follows:

- 60 percent in favour
- 22 percent against
- 13 percent neutral
- 5 percent didn't know/refused to answer

Of the eligible residents, 72 percent participated in the telephone poll. In December 2005, OPG submitted a letter of intent to prepare the site and construct the DGR to the CNSC, thus initiating the environmental assessment (EA) process. The EA process is still currently underway and has involved detailed geoscientific investigations, preliminary design work and environmental and safety assessments.

Six deep boreholes were drilled at the site from 2007 to 2010, with two additional boreholes at the main and ventilation shaft sites in 2012. These boreholes have confirmed the expected stratigraphy at the site. More than 200 metres of low-permeability shale form a protective cap over the low-permeability limestone formation where the repository would be constructed. Hydraulic conductivity measurements, in both the limestone and shale formations, have shown values of 10^{-13} m/s and below. These values indicate that any solute movement away from the repository will be diffusion controlled (i.e., there will be little chance of water seeping into the repository).

The DGR model is composed of horizontally excavated emplacement rooms, which will be arranged in two panels with access provided via two vertical, concrete-lined shafts. The proposed depth of the repository is 680 metres below ground.

K.6.1.1 Joint Review Panel – regulatory review

The Environmental Impact Statement (EIS), Preliminary Safety Report (PSR) and supporting reports were submitted to the CNSC in March 2011. A Joint Review Panel (JRP) was established in 2012 by the Minister of Environment and the CNSC (the submission package documents can be viewed at opgdgr.com). Under the JRP agreement, the panel's main role is to conduct an examination of potential environmental effects of the DGR project to meet the requirements of the *Canadian Environmental Assessment Act*, 2012 (CEAA 2012) and to obtain the information necessary for the consideration of OPG's application under the NSCA for a site preparation and construction licence. The agreement, along with more information on the project, is available on the Canadian Environmental Assessment (CEA) Registry at ceaa-acee.gc.ca/050/details-eng.cfm?evaluation=17520

Following its appointment, the JRP announced a six-month public review period in February 2012 for the DGR's EIS, licensing and supporting documents. This important public participation step provided an opportunity for federal and other government agencies, the public, and First Nations and Métis communities to submit comments. The public review period was subsequently extended by the JRP until May 2013, where a total of 575 information requests (IRs) were responded to by OPG.

The JRP scheduled a 25-day public hearing for the DGR project in the host communities supporting the project, from September 16 to October 11 and from October 28 to 30 (see figure K.7). The public hearing provided an opportunity for participants to hear about the DGR project and the results of the EIS, and to provide their views to the JRP. All documents and hearing transcripts can be found on the CEA Agency website, ceaa-acee.gc.ca

Subsequent to the public hearing, OPG received from the JRP two additional IR packages. Responses to the questions in these packages have been completed by OPG which brings the total number of IRs from the JRP to 585. The JRP has also announced additional public hearing days pertaining only to the information received from OPG following the initial hearing days in September and October 2013. The additional hearing days commence September 9, 2014 and will last for approximately two weeks.

Figure K.7: OPG's Deep Geologic Repository Joint Review Panel, 2013



Once the JRP concludes it has sufficient information, it will issue a notice for submission of written closing remarks. The JRP will then take up to 90 days to prepare a report and recommendations for the federal Minister of the Environment who, in turn, will render a decision within 120 days on the EA. Assuming the EA is approved, the JRP can then deliberate on the approval of the site preparation and construction licence for up to 90 days. A decision is expected in 2015.

K.6.2 Nuclear Legacy Liabilities Program

The Government of Canada's legacy radioactive waste and decommissioning liabilities at AECL sites have resulted from more than 60 years of nuclear research and development carried out on behalf of Canada by the National Research Council (1944 to 1952) and AECL (1952 to present). Nuclear facilities were constructed at sites in Ontario, Manitoba and Quebec. Chalk River Laboratories (CRL) in Chalk River, Ontario is the only facility that remains operational. Whiteshell Laboratories (WL) in Pinawa, Manitoba, which was AECL's other major research centre, is being decommissioned. Further, AECL's three prototype reactors – namely, Nuclear Power Demonstration (NPD) in Rolphton, Ontario; Douglas Point in Kincardine, Ontario; and Gentilly-1 in Bécancour, Quebec – were all shut down between 1979 and 1987 and are being maintained in a safe storage state. The liabilities also include the site of a former heavy water plant near Glace Bay, Nova Scotia, which does not contain any radioactive waste or contamination. The environmental remediation of this former industrial site will be completed in 2014, and it will be subsequently transferred to Enterprise Cape Breton Corporation, a federal Crown corporation, thereby fully addressing this liability.

The nuclear legacy liabilities include outdated and unused research facilities and associated infrastructure, accumulated radioactive waste, and contaminated lands. AECL's waste inventory includes spent fuel, low- and intermediate-level solid and liquid radioactive waste, and historic radioactive waste at CRL (largely contaminated soils) from site cleanup work across Canada. Most of the waste is in an unconditioned form, and limited characterization information is available for the waste generated in past decades.

In June 2006, the Government of Canada adopted a new long-term strategy to deal with the nuclear legacy liabilities over a 70-year period and initiated a five-year, \$520 million start-up phase, thereby creating the Nuclear Legacy Liabilities Program (NLLP). The objective of the long-term strategy is to safely and cost-effectively reduce the risks and liabilities based on sound waste management and environmental principles, in the best interests of Canadians. Under the strategy, disused infrastructure will be safely decommissioned, contaminated lands restored to meet federal regulatory requirements, and long-term solutions developed and implemented for managing the waste. The estimated cost to implement the strategy over 70 years is about \$10 billion (current Canadian dollars).

Strategy development was based on two key assumptions:

- CRL will continue to operate the site with the majority of legacy liabilities for the foreseeable future.
- A range of additional waste management facilities will be required.

Implementation of the strategy at CRL is coordinated with ongoing site operations. The strategy deals with operational facilities and other infrastructure over time as they are shut down and taken out of service. Further waste characterization, processing, conditioning, treatment, packaging, storage and long-term waste management facilities are being designed and constructed to deal effectively with the existing legacy waste inventory, as well as the waste that will be generated by decommissioning and cleanup activities.

The Government of Canada renewed the NLLP in February 2011 for three years with \$439.1 million in additional funding, which extended the program to March 31, 2014. The undertakings and activities carried out under the NLLP focus on infrastructure decommissioning, environmental restoration, improving the management of legacy radioactive waste, and advancing the long-term strategy. Also, ongoing care and maintenance activities will continue to ensure that waste materials and facilities remain in a safe state until

they are fully addressed in later stages of the long-term strategy, and that regulatory requirements continue to be satisfied.

The program is being implemented through a Memorandum of Understanding between NRCan and AECL, whereby NRCan is responsible for policy direction and oversight, including control of funding, and AECL is responsible for carrying out the work and holds and administers the licences, facilities, land, materials and other asset responsibilities.

Good progress has been made in achieving planned outcomes in the NLLP's first eight years. Liabilities and risks have been reduced through the decontamination and dismantling of buildings, the recovery of buried waste, the construction of a fourth groundwater treatment system at CRL, and the shipment of certain wastes to the United States for treatment. To date, decommissioning activities have removed more than 15,000 square metres of building floor area at CRL and WL, and more than 7,000 square metres at the site of the former heavy water production plant at Glace Bay, Nova Scotia. Cleanup has been completed or environmental risks have been reduced at more than 20 discrete contaminated areas, and approximately 180,000 litres of mixed liquid waste (oils or solvents with radioactive contamination) have been shipped to offsite commercial facilities for treatment or destruction. Further, new facilities and capabilities have been established to characterize process and store legacy radioactive waste, and large volumes of "likely clean" waste have been cleared for release with conventional waste, which promotes recycling and significantly reduces waste management costs. The volume of waste "cleared" for release to date has totalled more than 60,000 cubic metres.

K.6.2.1 Progress against current decommissioning strategy

At the CRL, as buildings are released from operations, they are turned over for decommissioning. Prompt decommissioning is favoured so that ongoing care and maintenance costs are minimized. Buildings are prioritized based on health, safety, security and environmental criteria. Environmental remediation of legacy waste management areas is conducted to remove contaminating sources contributing to plumes or for stabilizing areas that are candidates for *in situ* disposal. Progress at CRL since 2011 includes:

- decommissioning and removal of a Pool Test Reactor, and release of the room housing the former reactor for reuse
- repatriation of United States origin-highly enriched uranium (HEU) as part of the Global Threat Reduction Initiative (see section K.6.2.2)
- removal of active liquids from a high-risk, single-walled buried tank
- decommissioning of the previous Heavy Water Upgrading Plant (initiated); the first phases of removal of equipment have been completed
- complete removal of the NRX stack duct, 1.2 metres in diameter and 500 metres in length of carbon steel, recycled through metal melt for reuse in the industry
- removal of the older administration building, fire hall and associated structures
- inauguration of concrete crushing from decommissioned buildings; the crushed concrete is cleared at the Waste Analysis Facility and the cleared rubble is re-used onsite for road grading and backfill
- installation of an impermeable geo-membrane cover on a historic low level radioactive waste area known as Waste Management Area (WMA) C, to minimize the infiltration of atmospheric water into the stored waste
- installation of a permeable reactive barrier at the historic (closed) WMA A to intercept a groundwater plume travelling to a nearby swamp

The Whiteshell Laboratories have been under a decommissioning licence since 2003. The present strategy is to have the majority of the main campus buildings removed by 2028. Currently 30 percent of the main site has been decommissioned. Accomplishments include:

- all required heating system conversions (completed in 2013)
- closure and sealing of the previous Underground Research Laboratory
- removal of the active ventilation system in the WL B300 Radiochemical Laboratories
- decommissioning of the Irradiated Fuel Test Facility (IFTF) warm cells and the Thorium Fuel Waste Processing (TFRE) tanks and piping in the Shielded Facilities

Three prototype reactor sites and two former heavy water plants remain under care and maintenance. Over the reporting period, the following was accomplished:

- extensive repairs to the roofing of auxiliary buildings and the reactor building dome at Douglas Point
- repairs to the reactor building dome ring beam at Gentilly-1
- initiation of planning to advance the decommissioning of the NPD reactor to start in 2016
- decommissioning of the remaining buildings at the heavy water production site at Glace Bay and remediation of the site

K.6.2.2 Waste management and strategic progress for subsequent phases

AECL owns an inventory of high-level radioactive waste and low- and intermediate- level radioactive waste. The high-level waste consists of spent fuel from its research reactors at CRL and WL, spent fuel from the three prototype reactors, and fuel waste from fuel development experiments and examination of spent fuel from third parties. The spent fuel will be safely stored at the AECL sites until a national deep geological repository becomes available. The process to manage Canada's spent fuel in the future is currently undertaken by the NWMO. AECL maintains a working relationship with the NWMO, documented in a Memorandum of Understanding, and contributes funds to current NWMO operations and to the NWMO nuclear fuel waste fund. AECL is seeking to repatriate much of the irradiated HEU fuel from its research reactors and target residual material (TRM) from medical isotope production to the United States through agreements with the United States Department of Energy and as part of the Global Threat Reduction Initiative), a broad international effort to consolidate HEU inventories in fewer locations around the world.

As is typical with the nuclear industry, the largest component of the legacy waste is L&ILW, which contains a wide variety of materials including typical laboratory waste such as rubber, plastic and cellulose materials, and soil, concrete and rubble. L&ILW is currently stored in historic facilities, including sand trenches and operating facilities and in ground structures known as tile holes and bunkers for intermediate-level waste (ILW), and above-ground facilities, known as shielded modular above-ground storage (SMAGS) facilities for low-level waste (LLW).

Key activities that have been undertaken to manage the L&ILW liability include:

- Construction and operation of SMAGS facilities at CRL and WL. The CNSC has granted approval for the construction and operation of six new SMAGS facilities at CRL. CRL currently has two operational SMAGS facilities and WL has one. Each building provides 4,000 cubic metres of long-term, safe and usable LLW storage volume. A third SMAGS facility is planned to be constructed at CRL in 2014–15.
- Construction of a soil storage compound at WL for the long-term safe storage of up to 2,000 cubic metres of slightly contaminated soils and ground materials.
- A third party review of the Geologic Waste Management Facility (GWMF) suitability study. The study, carried out from 2006–11, assessed the feasibility of the CRL site to host a deep geological repository located at a nominal depth of 500 to 700 metres in the site's bedrock. The review was cautiously optimistic that the CRL site offered a suitable subsurface environment for a GWMF. AECL is implementing a short-term program of additional site investigations and assessments to

complete the site feasibility study and inform decision making. This work is planned to be completed in 2016. For more information on the third party review, visit geofirma.com/Projects_Main

- Production of a concept design for a very-low-level radioactive waste (VLLW) facility to be located at CRL. This facility would accept large volumes of material such as soil, concrete, rubble and vegetation and provide a more cost-effective solution for managing these typical decommissioning project wastes. Production of a detailed design is underway for two proposed sites at CRL and is scheduled to be completed in 2014–2015. Also in 2014–2015, AECL will update its project business case to inform decisions on whether to construct a VLLW at CRL.

A key achievement of the NLLP was the comprehensive review of the long-term decommissioning strategy and the costing methodologies used to derive the associated liability cost estimate. This review enabled new technical approaches and cost models to be applied, based on AECL's experience and that of others internationally, and also to optimize the scheduling of activities against current knowledge. As a result of this review, AECL has now included a near-surface, LLW facility and a decommissioning landfill located at the CRL site in its reference strategy for the CRL site. The feasibility of such facilities will now be studied. Planning documents for both the short (2014–2017) and long terms (2017–2026) have also been produced. The current decommissioning and waste management reference strategies for CRL, WL and the prototype reactor sites have been documented in reports.

A number of studies are underway to better define the waste processing, treatment and long-term radioactive waste management facilities required to deal with the wide variety of legacy radioactive waste types at AECL sites. This will help to define, for example, the volume reduction and waste immobilization technologies to be used, the extent to which buried waste can be managed in place over the long-term, and the available options for the long-term management of the waste that needs to be recovered.

A communication program has been developed to support the NLLP efforts. The goal of the program is to inform decision making and to build understanding among individuals, groups and organizations that have a stake in the NLLP. At CRL, information on the program is regularly communicated to local stakeholders through forums such as an Environmental Stewardship Council and local council member briefings. Regular communication with the general public in the Chalk River area continues via AECL's *Contact* publication and as required to support NLLP project-specific environmental assessments or re-licensing. At WL, information on the program is regularly communicated to the Public Liaison Committee (every six months), and a local *Contact* publication is distributed to the communities. More information about the NLLP can be found at nuclearlegacyprogram.ca

K.6.2.3 AECL Stored Liquid Waste Cementation project

Over a 60-year period, liquid radioactive waste has accumulated from various sources: AECL's medical radioisotope program, the fuel processing program, decontamination of test loops in CRL's research reactors, and regeneration of ion exchange resins used to purify water in fuel storage bays at CRL's research reactors. Except for radioactive waste streams from the radioisotope program, the generation of such wastes has stopped. At the time of the last Joint Convention report in 2011, these liquid wastes were stored in 21 monitored storage tanks at CRL. Since that time, liquid waste contained in seven tanks has been removed and managed through the CRL Waste Treatment Centre. The contents of 13 of the remaining 14 tanks, together with the sludge residue from the seven emptied tanks, are to be retrieved and cemented by the Stored Liquid Waste Cementation (SLWC) project using a field cementation system. Regarding the final tank, the TRM held in the Fissile Solution Storage Tank (FISST) is to be repatriated and a discrete project is underway to manage this inventory.

Significant pre-project development work has been undertaken to confirm the strategic direction and the optimum tactical approach for cementing the non-TRM stored liquid waste. This includes engineering studies, development of waste product performance criteria, radiation dose evaluations and cement formulation and testing. SLWC project design activities will begin in 2014.

The scope of the SLWC project includes:

- design, construction and commissioning of waste retrieval equipment and a cementation plant
- processing operations to retrieve and process the stored liquid waste to a solid cemented product
- emplacement of the cemented waste in interim storage facilities
- placement of the remaining redundant storage facilities in a safe shutdown state

The Tank 40D leak avoidance project deals with a single-walled, direct-buried tank from the 1950s Tank 40D, located in the Waste Tank Farm (B538), contains concentrated ion exchange resins waste. If a leak from this tank were to occur, it would have a detrimental effect on the environment and require costly and challenging remediation. Therefore, AECL expedited the project to reduce this risk utilizing existing equipment, facilities and experienced resources. To date, AECL has removed 75 percent of the contents (i.e., about 30 cubic meters of the liquid waste) and processed it in the Waste Treatment Centre.

K.6.2.4 The Fuel Packaging and Storage Project

The Fuel Packaging and Storage (FPS) Project is being implemented to improve the storage of selected spent legacy research reactor fuel rods. The project addresses the older, experimental fuels from approximately 100 tile holes (in-ground vertical structures that are used to store all spent research reactor fuel at CRL) with problematic and degraded fuel and storage conditions. The project involves the design, licensing, construction and commissioning of a modern, above-ground facility to dry, repackage and store the spent fuel. Construction of the facility is complete and all major equipment has been installed. The CNSC has granted operational approval for this project with a regulatory hold point. AECL has constructed, and is commissioning, a new above-ground dry storage facility to store this selected spent legacy research fuel. Related activities that are either complete or ongoing include investigations and studies to prepare for spent fuel recovery, sludge removal, remediation of the tile holes that have become flooded over time, and treatment of the water recovered.

K.6.3 Management of historic low-level radioactive waste

In 1982, the Government of Canada established the Low-Level Radioactive Waste Management Office (LLRWMO) within AECL to carry out Canada's responsibilities for the management of historic LLW in Canada. The LLRWMO delivers two major programs – a historic radioactive waste program involving the cleanup and management of historic low-level radioactive waste across Canada, and an information program on radioactive wastes in Canada. Over the course of its existence, the LLRWMO has completed historic radioactive waste cleanups across Canada and continues to monitor several sites with historic radium or uranium contamination.

During the planning stage for the PHAI it was determined that due to the size and complexity of the two PHAI projects (described below), a dedicated entity should be established for their management. In August 2009, AECL, NRCan, and Public Works and Government Services Canada formed the PHAI Management Office, a tripartite organization with a mandate to plan, manage and implement the PHAI.

K.6.3.1 Port Hope Area Initiative

The bulk of Canada's historic LLW is located in the southern Ontario municipalities of Port Hope and Clarington. These wastes and contaminated soils amount to roughly 1.7 million cubic metres. They originate from the operations of a radium and uranium refinery in the Municipality of Port Hope dating back to the 1930s. While recognizing that there are no urgent risks from a health or environmental standpoint, the Government of Canada determined that intervention measures are required in order to implement more appropriate long-term management measures for these materials.

In March 2001, the Government of Canada and the local municipalities entered into an agreement on community-developed proposals to address the cleanup and long-term management of these wastes, thereby launching the PHAI. The PHAI will result in the long-term management of the historic LLW in two above-ground mounds that will be constructed in the local communities. The initiative comprises two projects – the Port Hope Project (see figure K.8) and the Port Granby Project.

This \$1.28-billion initiative includes a planning phase, an implementation phase and a long-term monitoring phase. In 2008, the Government of Canada approved a transition phase to bridge the completion of the regulatory review and the commencement of the implementation phase. In September 2011, the CNSC granted AECL a licence to initiate the implementation phase of the PHAI.

The Port Hope Project entails the cleanup of the urban area and 13 major sites and the consolidation of all of the wastes (approximately 1.2 million cubic metres, including the current Welcome Waste Management Facility (WMF) waste) in the Municipality of Port Hope at one long-term radioactive waste management facility (LTWMF). This facility is to be located at the present site of the existing Welcome WMF. In October 2009, the CNSC issued a five-year licence to AECL to undertake the cleanup and the interim operation of the Welcome WMF. In November 2012, the CNSC issued an amendment to the licence, with a duration of 10 years. Additionally, a number of enabling activities have been initiated to prepare for the remediation and consolidation of the LLW, including construction of a Waste Water Treatment Plant (WWTP) (see figure K.9) and radiological investigations of residential properties in Port Hope to identify occurrences of LLW not included in the major sites (see figure K.10).

The Port Granby Project involves the relocation of the existing Port Granby wastes (approximately 500,000 cubic metres) to a new above-ground, long-term WMF. The WMF is to be located at a nearby site approximately 700 metres north of the current site and away from the Lake Ontario shoreline. In the fall of 2011, AECL received a licence to complete the cleanup in Port Granby from the CNSC and, in March 2012, AECL assumed responsibility for the existing Port Granby WMF. Since this time, a number of enabling activities have been initiated to prepare for the remediation and consolidation of the LLW, including rehabilitation of an access road to the location of new WWTP that is currently under construction. Programs committed to in the 2001 agreement are ongoing. These programs include Interim Waste Management (IWM), Property Value Protection (PVP) and community consultation. Regular dialogue occurs with Aboriginal groups and members of the community stakeholders. Information for the public at large is transmitted through newsletters, open house events, direct contact with communications specialists in the Project Information Exchange, and via phai.ca

Figure K.8: Visualization of proposed waste management facility, Port Hope Project



Figure K.9: Port Hope WWTP under construction**Figure K.10: Radiological investigation at residential property**

Procurement activities to hire contractors to complete the cleanup and associated works have begun. The cleanups in Port Hope and Port Granby are anticipated to be completed by 2023. Following the emplacement of wastes and the closure of the new WMFs, the long-term monitoring and maintenance phase will commence and continue for hundreds of years.

K6.3.2 Other historic radioactive waste sites

Key priorities for the LLRWMO are the management of sites along the Northern Transportation Route in the Northwest Territories and northern Alberta, which are contaminated with low concentrations of uranium ore, and also properties in the Greater Toronto Area that are contaminated with radium. The LLRWMO also has ongoing responsibilities to deliver a number of property compliance and environmental monitoring programs in the Municipality of Port Hope in southeastern Ontario.

K.6.4 Management of uranium tailings

Since 1995, the CNSC has required that all operating uranium mines have an approved preliminary decommissioning plans as well as a financial assurance to ensure funds will be available for decommissioning. For uranium mines that were closed before these requirements were put into place, the federal and provincial governments have made provisions to ensure that the sites are properly decommissioned.

Uranium mines that operated in Ontario between 1955 and 1996 represent more than 80 percent of the uranium tailings in Canada. Before 1977, the regulation of uranium mining was primarily the responsibility of the province. In 1996, the governments of Canada and Ontario entered into a Memorandum of Agreement that outlined their respective roles in the management of uranium mine and mill tailings in Ontario. In the event that an owner is unable to finance the costs for decommissioning a uranium mine site, the costs will be shared by the two governments equally. To date, these arrangements have not been necessary, as all Ontario sites have now been substantively decommissioned and the owners are continuing to comply with their responsibilities.

In northern Saskatchewan during the late 1950s to early 1960s, the Gunnar mine and mill, the Lorado mine and mill, and several small mines produced uranium to supply Canada's allies during the Cold War. At the time, these mines operated under provincial regulations that did not require that the sites be decommissioned to the level that would be expected today. As a result, there have been environmental impacts to local soils and lakes that must be addressed. The private sector companies that operated these mines no longer exist and, as a result, these abandoned sites have become the responsibility of the provincial government. In September 2006, the governments of Canada and Saskatchewan entered into a Memorandum of Agreement to share the estimated \$24.6-million cost to remediate these sites. The EA of the project to remediate the Gunnar uranium mine and mill site began on June 15, 2007 and an EIS was submitted for review to the CNSC in January 2011. A revised EIS was submitted for review in March 2013 and a CNSC licence was issued in May 2013 for a 10-year period. The Lorado uranium mill site is being remediated by the Government of Saskatchewan, through the Saskatchewan Research Council (SRC). A licence application has been submitted to the CNSC by the SRC, and a licensing decision is anticipated by the end of 2014.

K.7 Other contaminated lands

The CNSC established the Contaminated Lands Evaluation and Assessment Network (CLEAN) program to deal with sites previously not licensed under the *Atomic Energy Control Act* but that required regulatory control under the NSCA. The CLEAN program effectively ended during the 2006–2007 period, as all of the identified contaminated land sites across Canada had been assessed and their regulatory oversight requirements evaluated in accordance with the NSCA.

K.8 Shutdown of Gentilly-2 Nuclear Generating Station

On December 28, 2012, the Gentilly-2 Nuclear Generating Station was permanently shut down. The generating station was placed in a guaranteed shutdown state and decommissioning activities are being undertaken. Hydro Québec has adopted a deferred decommissioning strategy approach. These activities under this strategy are divided in several phases, the first three of which are:

- 2013–14 stabilization phase
- 2015–20 dormancy and transfer of fuel phase
- 2021–59 dormancy and site monitoring phase

Further details of each phase and a schedule for the major decommissioning activities are found in annex 7.9.

Annex 1 – Federal Structure

1.0 Introduction

Canada is a confederation of ten provinces and three territories, administered by the Government of Canada. The provinces and territories are self-governing in the areas of legislative power assigned to them by the Canadian constitution, as expressed in the *Constitution Acts* of 1867 and 1982. These areas include local commerce, working conditions, education, direct health care, energy and resources in general.

The constitution gives the Parliament of Canada legislative power over works declared by it to be for the general advantage of the country. The Parliament of Canada used this declaratory power in the *Atomic Energy Control Act* of 1946 and again in the *Nuclear Energy Act* of 2000. It declared certain works and undertakings to be for the general advantage of Canada and therefore subject to federal legislative control. Such works and undertakings are constructed for the following purposes:

- production, use and application of nuclear energy
- research or investigation of nuclear energy
- production, refinement or treatment of nuclear substances

This means that the Government of Canada is responsible for certain aspects of nuclear energy applications that would otherwise have been under provincial jurisdiction, including:

- occupational health and safety
- regulation of boilers and pressure vessels
- coordination of federal response to nuclear emergencies
- environmental protection

Under the Canadian constitution, provincial laws may also apply in these areas when they are not directly related to nuclear energy and do not conflict with federal law. Because both federal and provincial laws may apply in some regulated areas, the approach taken has been to avoid redundant regulations by seeking cooperative arrangements between the federal and provincial departments and agencies that have responsibilities or expertise in these areas.

Although these cooperative arrangements have been successful in achieving industry compliance, they need a firmer legal basis. The *Nuclear Safety and Control Act* (NSCA) binds both the federal and provincial governments and the private sector. Like private companies, government departments and agencies must hold licences from the regulatory body – the Canadian Nuclear Safety Commission (CNSC) – to perform any of the nuclear-related activities otherwise prohibited by the NSCA. In addition, the NSCA provides authority for the regulatory body and the Governor in Council to incorporate provincial laws by reference and to delegate powers to the provinces in areas better regulated by them or where licensees would otherwise be subject to overlapping regulatory provisions. The major Government of Canada organizations involved in the Canadian nuclear sector are as follows.

1.1 Natural Resources Canada

Natural Resources Canada (NRCan) is responsible for developing Canadian policy concerning energy sources. NRCan provides federal policy leadership concerning uranium, nuclear energy and radioactive waste management. NRCan provides expert technical, policy and economic information and advice to the Minister and the Government of Canada on issues affecting:

- Canadian uranium exploration and development
- environmental protection
- production and supply capability

- foreign ownership
- domestic and international markets
- exports
- international trade
- end uses

The Government of Canada, through NRCan, is responsible for ensuring that the long-term management of radioactive waste is carried out in a safe, environmentally sound, comprehensive, cost-effective and integrated manner. Canada's approach to radioactive waste management is that the producers and owners of radioactive waste are responsible for the funding, organization, management and operation of long-term waste management and other facilities required for their wastes.

NRCan is also responsible for administering the *Nuclear Fuel Waste Act* (NFWA) on behalf of the Minister. The organizational unit responsible for carrying out this function is the Nuclear Fuel Waste Bureau. The Bureau's mandate is to support the Minister of Natural Resources in discharging the Minister's responsibilities under the NFWA by overseeing, monitoring, reviewing and commenting on relevant activities of the waste owners and ensuring all NFWA requirements are met. The Bureau's website address is nfwbureau.gc.ca

NRCan is responsible for policy direction and oversight, including control of funding, for the Government of Canada's Nuclear Legacy Liabilities Program. This program deals with legacy waste and contamination at Atomic Energy of Canada Limited (AECL) research sites. AECL carries out the work under the program to ensure compliance with regulatory requirements and the protection of health, safety and the environment.

NRCan also provides policy direction and funding to the Low-Level Radioactive Waste Management Office (LLRWMO). In 2009, NRCan established the Port Hope Area Initiative Management Office, a tripartite organization to implement the Port Hope Area Initiative (PHAI). The PHAI is an undertaking to cleanup historic low-level radioactive wastes and contaminated soils in the Port Hope area of southern Ontario and to consolidate the material in two new long-term waste management facilities.

1.2 Canadian Nuclear Safety Commission

The CNSC is Canada's nuclear regulatory body, created by the Governor in Council under the NSCA. The CNSC reports to the Canadian Parliament through the Minister of Natural Resources. It is not part of the Department of Natural Resources; however, the Minister of Natural Resources can seek information from the CNSC on its activities. Under the NSCA, the Governor in Council may issue directives to the Commission of general application on broad policy matters. The Governor in Council cannot give direction to the Commission on specific licensing matters.

The CNSC is a federal regulatory agency and an independent administrative tribunal set up at arm's length from the government, with no ties to the nuclear industry. To serve Canadians, the ultimate outcome of the CNSC's work must be the establishment of safe and secure nuclear installations and processes solely for peaceful purposes and of public confidence in the nuclear regulatory regime's effectiveness. Consistent with the Government of Canada's SMART Regulation initiative to improve regulatory performance and reduce the administrative burden on business, the CNSC engages in extensive consultation and sharing of information to ensure that the desired results are understood and accepted by stakeholders and licensees.

The CNSC reports to Parliament through the Minister of Natural Resources, but is an independent entity. This independence is critical for the CNSC to maintain an arm's length relationship with government when making legally binding regulatory decisions. The CNSC is not an advocate of nuclear science or technology. Its mandate and responsibility is to regulate users of nuclear energy or materials to ensure their operations will not pose unreasonable risks to Canadians. The people of Canada are the sole clients of the CNSC.

The CNSC’s mandate is to “regulate the use of nuclear energy and materials to protect health, safety, security, and the environment and to implement Canada’s international commitments on the peaceful use of nuclear energy.” In pursuing its mandate, the CNSC is working to become one of the best nuclear regulators in the world. To achieve that, it encourages its employees to comply with the CNSC’s values: respect, integrity, service, excellence, responsibility and safety.

The CNSC is responsible for conducting and making decisions on environmental assessments (EAs) of nuclear projects under the *Canadian Environmental Assessment Act, 2012* (CEAA 2012), which is the primary EA legislation in most regions of Canada. The other regions are administered by land claim agreements (e.g., lands north of 60 degrees latitude). Under these land claim agreements, the CNSC has an advisory role during the EA.

The CNSC’s Regulatory Policy P-299, *Regulatory Fundamentals Policy*, which was adopted in January 2005, states that persons and organizations subject to the NSCA and its associated regulations are directly responsible for managing regulated activities in a manner that protects health, safety, security and the environment, while respecting Canada’s international obligations. Through Parliament, the CNSC is responsible to the public for assuring that these responsibilities are properly discharged.

1.3 Atomic Energy of Canada Limited

AECL is a Crown corporation wholly owned by the Government of Canada. AECL is Canada’s premier nuclear science and technology organization. For over 60 years, AECL has been a world leader in developing peaceful and innovative applications from nuclear technology through its expertise in physics, metallurgy, chemistry, biology and engineering. Highly skilled employees deliver a range of nuclear services – ranging from research and development, design and engineering to specialized technology, waste management and decommissioning. AECL is responsible for the operations of the Chalk River Laboratories (CRL), the Whiteshell Laboratories and the decommissioning of shutdown facilities on those sites and three prototype reactor sites. AECL provides a national service for safely storing radioactive waste at the CRL site from institutions across Canada, including hospitals and universities, on a fee-for-service basis.

After the sale of the assets of AECL’s former CANDU Reactor Division to Candu Energy Inc., a wholly owned subsidiary of SNC-Lavalin Group Inc., in October 2011, the Government of Canada formally turned its attention to the restructuring of AECL’s nuclear laboratories in 2012, with an announcement that it would engage in a competitive procurement process to restructure the management and operations of AECL. The government is seeking to implement a government-owned, contractor-operated (GoCo) model, as is done in other jurisdictions, such as in the United States and the United Kingdom. Under the new management model, the nuclear laboratories will focus on three key objectives:

- managing their radioactive waste and decommissioning responsibilities accumulated during the more than 60 years of nuclear research and development at CRL and at Whiteshell Laboratories
- ensuring that Canada's world-class nuclear science and technology capabilities and knowledge continue to support the federal government in its nuclear roles and responsibilities – from health protection and public safety to security and environmental protection
- providing access to industry to address its need for in-depth nuclear science and technology expertise

1.4 Low-Level Radioactive Waste Management Office

The Government of Canada established the LLRWMO to carry out the relevant federal responsibilities for historic low-level radioactive waste (LLW) management in Canada. The LLRWMO operates under a Memorandum of Understanding between NRCAN and AECL. Although the LLRWMO receives its funding and policy direction from NRCAN, it was organizationally established as a separate division of AECL.

Through its mandate, the LLRWMO operates to:

- resolve historic LLW issues that are a federal responsibility
- establish LLW temporary and permanent management facilities
- analyze issues associated with specific types and occurrences of LLW as requested
- address public information needs concerning LLW, specifically related to waste that the Government of Canada has taken ownership of that are of general public interest

1.5 Department of Foreign Affairs, Trade and Development Canada

The Department of Foreign Affairs, Trade and Development Canada (DFATD), formerly known as Foreign Affairs and International Trade Canada (DFAIT), is charged with promoting nuclear cooperation and safety both bilaterally and multilaterally. DFATD also implements key non-proliferation and disarmament agreements in Canada and abroad.

Implementation of these agreements requires Canadian domestic law to be consistent with Canada's responsibilities under the agreements. It also requires the capacity to ensure effective monitoring to verify that treaty obligations and commitments are being honoured. DFATD is responsible for the implementation of the *Chemical Weapons Convention* and the *Comprehensive Nuclear-Test-Ban Treaty*. In addition, DFATD oversees foreign policy, including global security issues, and is a required interlocutor for dealings with other governments.

1.6 Health Canada

Health Canada (HC) is the federal department responsible for helping the people of Canada maintain and improve their health. In the area of radiation protection, HC contributes to maintaining and improving the health of Canadians by investigating and managing the risks from natural and artificial sources of radiation. It accomplishes this mission through:

- maintaining the National Radioactivity Monitoring Network
- developing guidelines for exposure to radioactivity in water, food and air following a nuclear emergency
- providing advice and assistance to environmental assessments and reviews, as required by the CEAA 2012
- providing a full range of dosimetry services to workers through the National Dosimetry Services, the National Dose Registry, the National Calibration Reference Centre and biological dosimetry services
- contributing to the control of the design, construction and function of radiation emitting devices imported, sold or leased in Canada, under the *Radiation Emitting Devices Act*
- administering the Federal Nuclear Emergency Plan

The Canadian Radiological Monitoring Network is a national network that routinely collects air particulate, precipitation, external gamma dose, drinking water, atmospheric water vapour, and milk samples for radioactivity analysis. These surveillance activities of the network serve to establish background radiation levels in Canada.

The National Dosimetry Services (NDS), operated through HC, provides occupational monitoring for ionizing radiation to Canadians everywhere. Among the services offered are whole body and extremity thermoluminescent dosimetry services, as well as neutron dosimetry services and dosimetry for uranium miners. The NDS is licensed by the CNSC.

The National Dose Registry is a centralized radiation dose record system managed by HC. The Registry contains occupational radiation dose records for all monitored radiation workers in Canada, dating back to the 1940s.

1.7 Environment Canada

Environment Canada's mandate is to:

- preserve and enhance the quality of the natural environment, including water, air, soil, flora and fauna
- conserve Canada's renewable resources
- conserve and protect Canada's water resources
- carry out meteorology
- enforce the rules made by the Canada–United States International Joint Commission relating to boundary waters
- coordinate environmental policies and programs for the Government of Canada

Environment Canada administers the *Canadian Environmental Protection Act*.

1.8 Transport Canada

Transport Canada's mission is to develop and administer policies, regulations and services for a national transportation system that is safe and secure, efficient, affordable, integrated and environmentally friendly. Transport Canada sets policies, regulations and standards to protect the safety, security and efficiency of Canada's rail, marine, road and air transportation systems. This oversight includes the transportation of dangerous goods, such as nuclear substances, and ensuring that related developments can be sustained.

Annex 2 – Canadian Legislative System and Institutional Framework

2.0 Introduction

Five pieces of legislation currently govern the nuclear sector in Canada: the *Nuclear Safety and Control Act* (NSCA), the *Nuclear Energy Act* (NEA), the *Nuclear Fuel Waste Act* (NWFA), the *Nuclear Liability Act* (NLA) and the *Canadian Environmental Assessment Act, 2012* (CEAA 2012). The NSCA is the main legislation dealing with safety considerations.

2.1 *Nuclear Safety and Control Act*

The NSCA was passed by Parliament on March 20, 1997. This was the first major overhaul of Canada's nuclear regulatory regime since the *Atomic Energy Control Act* (AECA) and the creation of the Atomic Energy Control Board (AECB) in 1946. The NSCA provides legislative authority that covers the nuclear sector regulatory developments. These developments include health and safety standards for nuclear energy workers, environmental protection measures, security regarding nuclear facilities and public input into the licensing process.

The NSCA established the Canadian Nuclear Safety Commission (CNSC), which comprises the Commission and the CNSC staff. The Commission makes licensing decisions, while CNSC staff make recommendations to the Commission, exercise delegated licensing and authorization powers and assess licensee compliance with the NSCA, its associated regulations, and licence conditions.

Section 26 of the NSCA states that,

Subject to the regulations, no person shall, except in accordance with a licence

- possess, transfer, import, export, use or abandon a nuclear substance, prescribed equipment or prescribed information
- mine, produce, refine, convert, enrich, process, reprocess, package, transport, manage, store or dispose of a nuclear substance
- produce or service prescribed equipment
- operate a dosimetry service for the purposes of this Act
- prepare a site for, construct, operate, modify, decommission or abandon a nuclear facility, or
- construct, operate, decommission or abandon a nuclear-powered vehicle or bring a nuclear-powered vehicle into Canada.

The NSCA authorizes the CNSC to make regulations. Regulations had to be developed before the NSCA could be fully implemented, and include:

- *General Nuclear Safety and Control Regulations*
- *Administrative Monetary Penalties Regulations*
- *Radiation Protection Regulations*
- *Class I Nuclear Facilities Regulations*
- *Class II Nuclear Facilities and Prescribed Equipment Regulations*
- *Uranium Mines and Mill Regulations*
- *Nuclear Substances and Radiation Devices Regulations*
- *Packaging and Transport of Nuclear Substances Regulations*
- *Nuclear Security Regulations*
- *Nuclear Non-proliferation Import and Export Control Regulations*

Canada is a signatory of the *Treaty on the Non-Proliferation of Nuclear Weapons*. Pursuant to that treaty, Canada signed the *Agreement Between Canada and the Agency for the Application of Safeguards in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons*, as well as a protocol additional to that agreement. Pursuant to these legal instruments, Canada must account for and maintain control of all uranium, thorium and plutonium, which is subject to measures implemented by the International Atomic Energy Agency (IAEA) to verify that all declared nuclear material is in peaceful use and that there are no undeclared nuclear materials or activities in Canada. As a result of these commitments, much of the nuclear material and many of the facilities identified in this report, in accordance with the *Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*, are also subject to the terms and conditions of the safeguards agreements. The CNSC is the designated governmental authority responsible for implementing the requirements of the safeguards agreements under the regulatory framework established through the NSCA and the associated regulations.

2.2 Nuclear Energy Act

Concurrent with the NSCA, the NEA came into force in 2000. It is a revision of the AECA (1946) to address the development and utilization of nuclear energy (with the regulatory aspects of the AECA having been removed to the NSCA). AECL is authorized under the NEA. The NEA gives the designated government minister the authority to:

- undertake or cause to be undertaken research and investigations with respect to nuclear energy
- with the approval of the Governor in Council, utilize, cause to be utilized and prepare for the utilization of nuclear energy
- with the approval of the Governor in Council, acquire or cause to be acquired, by purchase, lease, requisition or expropriation, nuclear substances and any mines, deposits or claims of nuclear substances and patent rights relating to nuclear energy and any works or property for production or preparation for production of, or for research or investigations with respect to, nuclear energy
- with the approval of the Governor in Council, license or otherwise make available or sell or otherwise dispose of discoveries and inventions relating to, and improvements in processes, apparatus or machines used in connection with nuclear energy and patent rights acquired under this Act and collect royalties and fees on and payments for those licences, discoveries, inventions, improvements and patent rights

2.3 Nuclear Fuel Waste Act

Three provincial nuclear utilities, Ontario Power Generation (OPG), Hydro-Québec and New Brunswick Power (NB Power), own 98 percent of the nuclear fuel waste in Canada. AECL owns most of the remainder. Following a decade-long environmental assessment for a deep geological disposal concept for spent fuel, which ended in 1998, it became clear that the Government of Canada needed to put in place a process to ensure that a long-term management approach for Canada's spent fuel would be developed and implemented. Given the relatively small volume of spent fuel in Canada, it was determined that a national solution would be in the best interest of Canadians.

On November 15, 2002 Parliament passed the NFWA, which made the owners of spent fuel clearly responsible for the development of long-term waste management approaches. The legislation required nuclear energy corporations to establish a waste management organization as a separate legal entity to manage the full range of long-term spent fuel management activities. It also required waste owners to establish trust funds with independent financial institutions so as to finance their long-term waste management responsibilities. Through the waste management organization, the owners of spent fuel were required to prepare and submit a study to the Government of Canada of proposed approaches for the long-term management of the waste, along with a recommendation on which of the proposed approaches should be adopted. The NFWA required this analysis to include feedback from comprehensive public consultations that included Aboriginal peoples and to be evaluated in terms of social and ethical considerations.

Under the NFWA, the Government of Canada is responsible for reviewing the study prepared by the waste management organization, selecting a long-term management option from those proposed and providing oversight during its implementation.

Shortly after the NFWA came into force, and as required by the NFWA, the nuclear energy corporations established the Nuclear Waste Management Organization (NWMO) and the trust funds necessary to finance the implementation of long-term waste management activities. Following extensive studies and public consultation, the NWMO submitted its study of options to the Government of Canada on November 3, 2005. The NWMO presented four options, including those listed in the NFWA:

- long-term storage at the reactor sites
- central shallow or below-ground storage
- deep geological disposal
- a fourth option called the Adaptive Phased Management (APM) approach, which combines the three previous options within a flexible, adaptive management decision-making process

On June 14, 2007 the Government of Canada announced that it had selected the APM approach for the long-term management of spent fuel in Canada. The APM approach recognizes that people benefiting from nuclear energy produced today must take steps to ensure that the wastes are dealt with responsibly and without unduly burdening future generations. At the same time, it is sufficiently flexible to adjust to changing social and technological developments. The NWMO is required to implement the government's decision according to the NFWA, using funds provided by the nuclear energy corporations.

Over the past several years, a number of key government decisions contributed toward the implementation of the APM approach. First, in April 2009 the Minister of Natural Resources approved the funding formula that ensures there is sufficient money set aside in trust to pay for the full lifecycle cost of this approach. Second, on August 14, 2009 the Minister of Natural Resources entered into a Memorandum of Understanding (MOU) with the NWMO regarding Aboriginal engagement. The MOU clarifies the roles and responsibilities of the Crown and the NWMO, with respect to their obligation for consultations with Aboriginal peoples regarding this project and in relation to the NFWA.

Since early 2010, the NWMO has been moving forward with its siting process to identify a safe, secure and suitable site for a deep geological repository for managing nuclear fuel waste in an informed and willing host community. A number of communities have inquired about the project and are exploring their interest with the NWMO. It is expected to take a number of years before a suitable site within an informed and willing host community is confirmed.

2.4 Nuclear Liability Act

The NLA establishes the legal regime that would apply in the event of a Canadian nuclear incident resulting in civil damages. The NLA is administered by the CNSC, while Natural Resources Canada (NRCAN) has responsibility for policy direction. The NLA can be viewed at laws.justice.gc.ca

The NLA places total responsibility for civil nuclear damage on the operator of a nuclear installation. It requires the operator to carry \$75 million in insurance and also provides for the establishment of a Nuclear Damage Claims Commission in the event of a serious nuclear incident. This commission would deal with claims for compensation when the Government of Canada deems a special tribunal is necessary (for example, if claims are likely to exceed \$75 million).

On January 30, 2014 the Minister of Natural Resources introduced in Parliament the omnibus bill *An Act respecting Canada's offshore oil and gas operation, enacting the Nuclear Liability and Compensation Act, repealing the Nuclear Liability Act and making consequential amendments to other Acts* (Bill C-22).

The *Nuclear Liability and Compensation Act* (NLCA) component of the bill increases the liability limit of the operator of a nuclear power plant to \$1 billion to be phased in over a three-year period from an amount of \$650 million set at proclamation. The operator's liability limit under the proposed legislation will be reviewed at least once every five years and can be increased by the government through a regulation.

Other features of the proposed legislation are the expanded categories of compensable damage to address environmental damage, economic loss and costs related to preventive measures; a longer limitation period for submitting compensation claims for bodily injury (30 years versus the current 10 years); and the elaboration of the process for a quasi-judicial claims tribunal to be established to replace the court system if necessary in order to accelerate claims payments and provide an efficient and equitable forum.

The bill also contains provisions to implement the *Convention on Supplementary Compensation for Nuclear Damage* (Convention), an international treaty under the auspices of the IAEA, which provides a liability and compensation regime to address damages, including those arising from transboundary and transportation incidents.

The bill must be considered by the Canadian Parliament, including both the House of Commons and the Senate. The bill will enter into force once critical regulations have been enacted and negotiations with insurers are complete. Once the NLCA has entered into force, Canada will be able to ratify the correlating Convention.

2.5 Canadian Environmental Assessment Act

The CEAA 2012 establishes the legislative basis for the federal practice of environmental assessment in most regions of Canada. The CEAA 2012 can be viewed online at laws.justice.gc.ca

An environmental assessment (EA) offers a systematic approach to documenting the environmental effects of a proposed project and determining the need to eliminate or minimize the adverse effects, if any, to modify the project plan or to recommend further action.

The purpose of the CEAA 2012 is to:

- protect components of the environment that are within federal legislative authority from significant adverse environmental effects caused by a designated project
- ensure that designated projects are considered and carried out in a careful and precautionary manner when the exercise of a power or performance of a duty or function by a federal authority is required for the project to proceed
- promote cooperation and coordination between federal and provincial governments
- promote communication and cooperation with Aboriginal peoples
- ensure that opportunities are provided for meaningful public participation
- ensure that environmental assessments are completed in a timely manner
- ensure that projects proposed to be carried out on federal lands and projects that are outside of Canada that the federal government intends to carry out or fund, are considered in a careful and precautionary manner in order to avoid significant adverse environmental effects
- encourage federal authorities to take action in a manner that promotes sustainable development
- encourage further studies of the cumulative effects of physical activities in a region and the consideration of the study results in environmental assessments

The Canadian Environmental Assessment Agency (CEA Agency) was historically involved in panel reviews for nuclear projects and remains involved in the ongoing OPG's Deep Geologic Repository EA (see section K.6.1). Under the CEAA 2012, however, the CEA Agency no longer has a role in new proposed nuclear projects entering the EA phase; the CNSC is the responsible authority for assessing proposed nuclear projects. The CNSC is responsible for managing the EA process, including ensuring that an EA report is prepared and making a decision on the EA. In practice, the project proponent may be delegated to conduct technical studies for the EA or to ensure that mitigation measures and/or a follow-up program are implemented; however, the CNSC is the federal decision maker when determining if a project is likely to cause significant adverse environmental effects.

Annex 3 – The Canadian Nuclear Safety Commission and the Regulatory Process

3.0 Introduction

The Canadian nuclear sector is diverse. From radioisotopes to electricity generation, to radiation devices and non-proliferation of nuclear substances – all are regulated by the Canadian Nuclear Safety Commission (CNSC), which replaced the former Atomic Energy Control Board with the implementation of the *Nuclear Safety and Control Act* (NSCA) on May 31, 2000.

3.1 Nuclear Safety and Control Act

A description of the NSCA is provided in annex 2.1.

3.2 Canadian Nuclear Safety Commission

The CNSC's regulatory regime covers the entire nuclear substance lifecycle from production, to use, to final disposition of any nuclear substances. Its mandate, derived from the NSCA, is as follows:

- to regulate the development, production and use of nuclear energy and materials to protect health, safety, security and the environment
- to regulate production, possession and use of nuclear substances, prescribed equipment, and prescribed information
- to implement measures respecting international commitments on the peaceful use of nuclear energy and substances
- to disseminate scientific, technical and regulatory information concerning the CNSC's activities

3.3 The Canadian Nuclear Safety Commission in the government structure

In accordance with the Canadian system of parliamentary government, the decision to introduce government legislation such as the NSCA into Parliament is made by the federal Cabinet, on the advice and recommendation of the appropriate minister. The NSCA established the CNSC as a departmental corporation, named in schedule II of the Government of Canada's *Financial Administration Act*. The CNSC reports to the Parliament of Canada through a member of the Queen's Privy Council for Canada, designated by the Governor in Council as the minister for purposes of the NSCA. This designate is currently the Minister of Natural Resources. The CNSC is a departmental corporation, an independent agency and not part of any government department.

The NSCA requires the Commission to comply with any directives of general application on broad policy matters, with respect to the objects of the Commission issued by order of the Governor in Council. It is an accepted constitutional convention in Canada that any political directives given to agencies such as the CNSC are general and cannot interfere with Commission decisions in specific cases. An example of such a directive might be the government-wide commitment to the SMART Regulation initiative.

CNSC staff routinely interact with the management and staff of Natural Resources Canada (NRCan) in areas of mutual interest. NRCan has a general interest in various matters relating to nuclear energy and natural resources. Further information on this is provided in annex 1.1.

In keeping with federal policies on public consultation and regulatory fairness, the CNSC routinely consults with parties and organizations that have an interest in its regulatory activities. These include:

- licensees
- the nuclear sector
- federal, provincial and municipal departments and agencies

- special interest groups
- individual members of the public

As required by federal policies on access to information and in accordance with Canada's SMART Regulation principles, formal consultations are conducted in an open and transparent manner.

The CNSC licensees include publicly funded institutions or agents of the federal and provincial governments, including:

- Atomic Energy of Canada Limited (AECL), the federal nuclear research and development company
- nuclear operations of provincially owned electrical utilities (Ontario Power Generation, New Brunswick Power, and Hydro-Québec)
- Canadian universities
- hospitals and research institutions

The CNSC regulates the health, safety, security and environmental impacts of the nuclear activities of these organizations in the same manner and according to the same standards as required from privately owned companies or operations.

3.4 Organizational structure

The mandate of the CNSC is to regulate the use of nuclear energy and materials to protect health, safety, security and the environment and to respect Canada's international commitments on the peaceful use of nuclear energy. The CNSC consists of a president, the federally appointed members of the Commission, and approximately 800 staff members as of the end of March 2014. The organization's general structure is defined by the NSCA. The CNSC consists of two components:

- the Commission – the agency's tribunal component
- the CNSC – refers to the organization and its staff in general

3.4.1 The Commission

The Commission is an independent administrative tribunal and court of record. It can consist of up to seven permanent members. Commission members are appointed by the Governor in Council (Cabinet) of Canada for terms not exceeding five years and may be reappointed. In addition, the Governor in Council may appoint temporary members for a renewable term not exceeding six months. The members are to be independent of all influences, whether political, governmental, special interest or private sector. Commission members commit to the highest standards of ethics and conflict-of-interest guidelines, and carry out their duties impartially. The president of the CNSC is a full-time Commission member. Other members generally serve on a part-time basis.

The Commission's key roles are to:

- establish regulatory policy on matters relating to health, safety, security and the environment
- make legally binding regulations
- make independent decisions on the licensing of nuclear-related activities in Canada

The Commission makes its decisions transparently, guided by clear rules of procedure. The Commission takes into account the views, concerns and opinions of interested parties and intervenors when establishing regulatory policy, making licensing decisions and implementing programs.

The CNSC public hearings are the public's primary opportunity to participate in the regulatory process. CNSC staff attend these hearings to advise the Commission. Subsection 17(1) of the NSCA stipulates that the Commission can also hire external staff members to advise it independently of the CNSC's staff, although this is not currently done.

The Commission Secretariat supports the Commission by planning its business, publishing notices and decisions and offering technical and administrative support to the president and other members. The Secretariat is also the official registrar of Commission documentation.

The Commission administers the NSCA and its associated regulations. Among these regulations are the CNSC *Rules of Procedure*, which outlines the public hearing process, and the CNSC *By-laws*, which outline the Commission's meeting process. Decisions on the licensing of major nuclear facilities are made through public hearings. Commission meetings are held to consider a wide range of topics related to the nuclear regulatory process and, in certain cases, to make legislative, policy or administrative decisions on matters.

3.4.2 Canadian Nuclear Safety Commission staff

CNSC staff are primarily located at headquarters in Ottawa. The Uranium Mines and Mills Division is located in Saskatoon, close to Canada's major uranium mining operations. The CNSC satellite offices are located at each of the four nuclear power plants in Canada, and at AECL's Chalk River Laboratories. Regional offices located in Quebec, Ontario and Alberta conduct compliance activities for nuclear substances, transportation, radiation devices and equipment containing nuclear substances. They also respond to unusual events involving nuclear substances.

CNSC staff support the Commission by:

- developing proposals for regulatory development and recommending regulatory policies
- carrying out licensing, certification, compliance inspections and enforcement actions
- coordinating the CNSC's international undertakings
- developing the CNSC-wide programs in support of regulatory effectiveness
- maintaining relations with stakeholders
- providing administrative support to the organization

In addition, CNSC staff prepare recommendations on licensing decisions, present them to the Commission for consideration during public hearings and subsequently administer the Commission's decisions. Where so designated, CNSC staff also render licensing decisions.

In terms of organizational structure, the president's office provides administrative support services to the president. Other groups in the CNSC organizational structure include the Secretariat, Legal Services, and the Office of Audit and Ethics.

There are four major branches of the CNSC staff: Regulatory Operations, Technical Support, Regulatory Affairs and Corporate Services.

1. The Regulatory Operations Branch is responsible for the licensing, certification and regulation of nuclear power plants, uranium mines and mills, uranium fuel fabricators and processing facilities, waste management facilities, nuclear substance processing and transport, industrial and medical applications, in accordance with the requirements of the NSCA and its associated regulations. The Regulatory Operations Branch comprises the Directorate of Power Reactor Regulation, the Directorate of Nuclear Cycle and Facilities Regulation, the Directorate of Nuclear Substance Regulation, and the Directorate of Regulatory Improvement and Major Projects Management.

These four directorates are responsible for licensees in matters of licensing, compliance and enforcement.

2. The Technical Support Branch provides specialized expertise in the areas of nuclear science and engineering, safety analysis, safety management, human factors, personnel training and certification, environmental and radiation protection, security, nuclear emergency management, safeguards, and nuclear non-proliferation. The Technical Support Branch comprises the Directorate of Assessment and Analysis, the Directorate of Safety Management, the Directorate of Security and Safeguards, and the Directorate of Environmental and Radiation Protection Assessment. These four directorates also support the CNSC's regulatory mandate.
3. The Regulatory Affairs Branch is responsible for providing strategic direction and implementation of the CNSC's regulatory policy, communications and stakeholder engagement, strategic planning, international relations and Executive Committee services. The Regulatory Affairs Branch comprises the Strategic Planning Directorate, the Regulatory Policy Directorate, and the Strategic Communications Directorate.
4. The Corporate Services Branch is responsible for policies and programs related to the management of the CNSC's finances and administration, human resources, information technology and information management. The Corporate Services Branch consists of the Human Resources Directorate, Finance and Administration Directorate, and Information Management Technology Directorate.

3.4.3 The CNSC's Research and Support Program

The CNSC's Research and Support Program is managed within the Regulatory Affairs Branch. The program provides staff with access to independent advice: expertise, experience, information and other resources, via contracts or contribution agreements placed with other agencies and organizations in Canada and internationally. The work undertaken through the Research and Support Program is intended to support staff in meeting the CNSC's regulatory mission. Each year, the program is reviewed and evaluated, the need for research and support in the following year is identified, and a commensurate budget is allotted. The CNSC Research and Support Program is independent of research and development programs conducted by industry.

The program supports an increasing number of activities associated with the handling of spent fuel and management of radioactive waste. Among recent activities supported is a project to characterize the mechanical behaviour of sedimentary rock and a study of international regulation practices for decommissioning. See section K.5.2 for more information on the CNSC's research program.

3.5 Regulatory philosophy and activities

The CNSC's regulatory philosophy is based on two principles, as outlined in the CNSC regulatory policy P-299, *Regulatory Fundamentals*:

- Persons and organizations subject to the NSCA and its associated regulations are directly responsible for ensuring that the regulated activities that they engage in are managed so as to protect health, safety, security and the environment and to respect Canada's international commitments on the peaceful use of nuclear energy.
- The CNSC is responsible to the public for regulating persons and organizations subject to the NSCA and its associated regulations, to ensure that they are properly discharging their obligations.

The CNSC establishes a strategic framework, which encompasses the following:

- a clear and practical regulatory framework
- individuals and organizations that operate safely and conform to safeguards and non-proliferation requirements
- high levels of compliance with the regulatory framework
- cooperation and integration of CNSC activities in national and international nuclear programs
- stakeholders' understanding of the regulatory program

The following activities are delineated to achieve the above outcomes:

- regulatory framework
- licensing and certification
- compliance
- cooperative undertakings, both domestic and international
- stakeholder relations

The CNSC establishes and requires compliance with regulatory requirements and makes independent, objective decisions based on regulatory action on the level of risk and seeks public input.

In carrying out its responsibilities, the CNSC issues licences (after assessing whether regulatory requirements and international obligations are met), verifies compliance with the licences that have been issued, sets standards for meeting regulatory requirements and communicates the work of the CNSC to its licensees and other stakeholders.

3.6 Regulatory framework

3.6.1 General framework

The CNSC's mandate, regulatory responsibilities, and powers are set forth in:

- the NSCA
- the *Safeguards Agreement and Additional Protocol* between Canada and the International Atomic Energy Agency (IAEA)
- Canada's bilateral and multilateral nuclear cooperation agreements

The CNSC also conducts environmental assessments under the *Canadian Environmental Assessment Act, 2012* and administers the *Nuclear Liability Act*.

To carry out these responsibilities, the CNSC uses the following regulatory tools:

- regulations
- licences, with licence conditions and the licence conditions handbook
- regulatory documents that provide guidance to the CNSC licensees on meeting criteria set out in the regulations

In line with the *Cabinet Directive on Regulatory Management*, the CNSC has taken steps to enhance stakeholder consultation by holding information sessions on key regulatory documents, posting public comments related to key documents on its website, and initiating an online public input form. Also in line with this directive, the CNSC continues to adopt or adapt national and international standards in regulatory documents.

3.6.2 The CNSC’s regulatory documents

Regulatory documents support the CNSC’s regulatory framework by expanding on expectations set out in the NSCA, its associated regulations, and legal instruments such as licences and orders. These documents provide instruction, assistance and information to the licensees.

The CNSC has developed a five-year Regulatory Framework Plan extending until 2018. This plan notes that regulatory documents will present both requirements and guidance in a single document. CNSC staff are transitioning towards organizing regulatory documents into the following categories:

- regulated facilities and activities
- safety and control areas
- other regulatory areas

A listing of CNSC regulatory documents published since the last review meeting can be found in table 3.1. Additional information on the CNSC’s regulatory documents program and full access to all of CNSC regulatory documents is available on the CNSC website, nuclearsafety.gc.ca under the “Acts and Regulations” tab.

Table 3.1: Regulatory documents published by the CNSC since the Fourth Review Meeting

Document number	Document title	Date of publication
REGDOC-2.2.2	<i>Personnel Training</i>	July 2014
REGDOC-2.2.3	<i>Personnel Certification: Radiation Safety Officers</i>	July 2014
REGDOC-2.4.1	<i>Deterministic Safety Analysis</i>	May 2014
REGDOC-2.4.2	<i>Probabilistic Safety Assessment for Nuclear Power Plants</i>	May 2014
REGDOC-2.5.2	<i>Design of Reactor Facilities: Nuclear Power Plants</i>	May 2014
REGDOC-3.1.1	<i>Reporting Requirements for Nuclear Power Plants</i>	May 2014
REGDOC-2.6.3	<i>Aging Management</i>	March 2014
REGDOC-3.5.2	<i>Compliance and Enforcement: Administrative Monetary Penalties</i>	March 2014
REGDOC-2.12.1	<i>High-Security Sites: Nuclear Response Force</i>	October 2013
REGDOC-2.3.2	<i>Accident Management Severe Accident Management Programs for Nuclear Reactors</i>	September 2013
REGDOC-2.9.1	<i>Environmental Protection: Policies, Programs and Procedures</i>	September 2013
REGDOC-2.12.3	<i>Security of Nuclear Substances: Sealed Sources</i>	May 2013
REGDOC-2.12.2	<i>Site Access Security Clearance</i>	April 2013
RD/GD-210	<i>Maintenance Programs for Nuclear Power Plants</i>	December 2012
RD/GD-98	<i>Reliability Programs for Nuclear Power Plants</i>	June 2012

Document number	Document title	Date of publication
GD-385	<i>Pre-licensing Review of a Vendor's Reactor Design</i>	May 2012
RD/GD-289, version 2	<i>Licence Application Guide - Class II Non-radiotherapy Accelerator Facilities</i>	May 2012
GD-379	<i>Guide for Applicants and Intervenors: Writing CNSC Commission Member Documents</i>	March 2012
RD/GD-99.3	<i>Public Information and Disclosure</i>	March 2012
RD/GD-370	<i>Management of Uranium Mine Waste Rock and Mill Tailings</i>	March 2012
GD-310	<i>Guidance on Deterministic Safety Analysis for Nuclear Power Plants</i>	March 2012
GD-314	<i>Radiation Protection Programs for the Transport of Nuclear Substances</i>	February 2012
RD/GD-352	<i>Design, Testing and Performance of Exposure Devices</i>	January 2012
RD/GD-371	<i>Licence Application Guide: Nuclear Substances and Radiation Devices</i>	November 2011
RD/GD-369	<i>Licence Application Guide: Licence to Construct a Nuclear Power Plant</i>	August 2011
RD/GD-254	<i>Licence Application Guide : Certification of Radiation Devices or Class II Prescribed Equipment</i>	June 2011
RD/GD-207	<i>Licence Application Guide : Servicing Class II Prescribed Equipment</i>	June 2011
RD-308	<i>Deterministic Safety Analysis for Small Reactor Facilities</i>	June 2011
RD-367	<i>Design of Small Reactor Facilities</i>	June 2011

The draft regulatory documents as of July 2014 are listed in table 3.2. Draft documents either currently in development by CNSC staff, issued for external stakeholder comment, or under revision to incorporate the comments received during consultation. For a complete list of regulatory documents and the current status on the below draft regulatory document, visit the CNSC website, nuclearsafety.gc.ca under the “Acts and Regulations” tab.

Table 3.2: Draft regulatory documents as of July 2014

Document number	Document title	Status
REGDOC-1.3.1	<i>Licence Application Guide: Uranium Mines and Mills</i>	Currently under development
REGDOC-2.2.1	<i>Human Performance: Managing Worker Fatigue and Hours of Work</i>	Document under revision
REGDOC-2.2.2	<i>Personnel Training</i>	Document under revision
REGDOC-2.3.1	<i>Conduct of Licensed Activities: Commissioning of Reactor Facilities</i>	Document under revision
REGDOC-2.3.1	<i>Conduct of Licensed Activities: Construction of Reactor Facilities</i>	Public consultation period

Document number	Document title	Status
REGDOC-2.3.2	<i>Accident Management</i>	Document under revision
RD/GD-360 version 2	<i>Long-term Operation Management of Nuclear Power Plants</i>	Document under revision
REGDOC-2.9.1	<i>Environmental Protection: Environmental Assessments</i>	Public consultation period
REGDOC-2.10.1	<i>Emergency Management and Fire Protection: Nuclear Emergency Preparedness and Response</i>	Document under revision
REGDOC-2.13.2	<i>Import and Export</i>	Document under revision
REGDOC-3.1.2	<i>Reporting Requirements for Non-Power Reactor Class I Facilities and Uranium Mines and Mills</i>	Currently under development

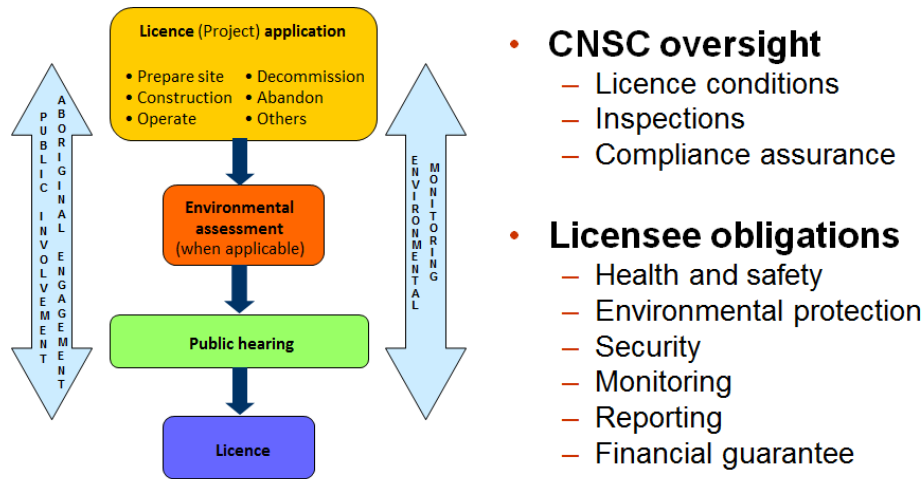
3.7 Licensing process

The CNSC licenses about 3,500 operations across Canada, including uranium mines, fuel fabrication facilities, radioisotope production, waste management facilities, nuclear power plants in Ontario, Quebec and New Brunswick, and AECL facilities in Chalk River, Ontario and Whiteshell, Manitoba. Information about the CNSC’s licensing process is available at nuclearsafety.gc.ca; a diagram of the licensing process is seen in figure 3.1.

Several types of licences are issued. A facility (Class I, II, uranium mines or mills) is licensed during its lifecycle. Licences are required for site preparation, construction, operations, decommissioning and abandonment. An application for a licence, renewal or amendment may trigger other legislation and regulations. For example, an environmental assessment (EA) under the *Canadian Environmental Assessment Act, 2012* (CEAA 2012) may be a prerequisite to proceeding with a licence application. The CEAA 2012 may require an EA of a project to analyze potential environmental impacts and their severity, possible mitigation measures and any residual impacts. Both the physical and socio-economic environments must be considered in the EA. The range of stakeholder consultations is determined by the severity of the potential environmental impacts.

In addition, the CNSC also licenses the import and export of controlled nuclear substances, equipment, information and nuclear-related dual-use items. Proposed imports and exports are evaluated by CNSC staff to ensure compliance with Canada’s nuclear non-proliferation and export policies, and international agreements related to safeguards, health, safety and security, as well as to the NSCA and its associated regulations.

Figure 3.1: CNSC licensing process



3.8 Licensing hearings

The NSCA establishes a legislative requirement for the Commission to hold public hearings, with respect to exercising its power to license. The *CNSC Rules of Procedure* allow the Commission to vary the public hearing requirement to ensure that a matter before it is dealt with as informally and expeditiously as the circumstances and the considerations of fairness permit. The NSCA also requires that applicants, licensees and anyone named in or subject to an order have the opportunity to be heard. The *CNSC Rules of Procedure* sets out the requirements for notification of public hearings and publication of decisions from public hearings, as described earlier.

During a public hearing, simultaneous interpretation in one or the other of Canada’s official languages (English and French) is provided. The CNSC produces and publishes verbatim transcripts on its website and webcasts public hearings. The webcast is archived on the CNSC website for a minimum of three months following the proceeding.

Public hearings usually take place in one or two parts; most decisions involving major nuclear facilities are made through the two-part public hearing process. For a one-part hearing, the Commission hears all of the evidence from the applicant, CNSC staff and intervenors in a single hearing session, generally completed over one or more consecutive days. For a two-part hearing, the first part is reserved to hear the applicant and the CNSC staff recommendations. The second part is reserved to hear interventions and is typically held 60 days after the first part to permit stakeholders time to review the application and recommendations. Commission hearings are normally open to the public, but some are also held “in-camera” (closed session) in whole or in part. For example, certain protected information may not be discussed in a public forum.

Abridged hearings are held for less significant licence amendments. They deal with Commission decisions that are more administrative in nature and when there is less public interest in the matter being considered. Procedural changes made for abridged hearings could include shortened public notice requirements, reduced time periods and/or limited participation. Abridged hearings may be held in a closed or public forum and are presided over by one or more Commission member.

3.9 The CNSC Compliance Program

Administering licensing decisions of the Commission entails planned and continuous oversight. Whether based onsite or offsite, CNSC staff work on a daily basis to carry out regular inspections, audits and reviews to provide a comprehensive overall and day-to-day picture of operations. This process ensures that the operations are safe and in compliance with the licence and regulatory documentation, as described in section E.6.1.

Confirmation of compliance with licences is managed within the CNSC Compliance Program. The program is a formal compliance verification program that includes promotion, verification and enforcement. These elements of the program are described in section E.6.1.

3.10 Cooperative undertakings

The CNSC works cooperatively with a number of other national and international organizations. At the national level, the CNSC's mandate is clearly outlined by the NSCA, which specifies that nuclear regulatory activities are a federal responsibility. Areas such as security, emergency preparedness and mining, however, are examples of areas where provincial departments or other federal departments have legislated parallel or complementary responsibilities.

In addition, to fulfill Canada's international obligations, the CNSC collaborates with various agencies (such as its counterparts in other countries and with the Department of Foreign Affairs, Trade and Development Canada) to ensure that the conducting of nuclear cooperation is consistent with international agreements and the non-proliferation regime.

The CNSC's cooperation and involvement with international nuclear organizations includes the IAEA and the Organisation of Economic Co-operation and Development's (OECD) Nuclear Energy Agency. The CNSC's role is to promote Canadian interests and evaluate international recommendations, standards and guides for adoption into the CNSC's regulatory framework.

3.11 Outreach at the CNSC

The dissemination of technical, scientific and regulatory information related to nuclear activities is part of CNSC's mandate. These outreach activities are meant to demystify nuclear science, describe CNSC's role as Canada's nuclear regulator, and bring a CNSC face into communities across the country (see figure 3.2). The outreach activities also mean to bring openness, transparency and timely communication to the work and management of Canada's nuclear regulatory regime.

Because the CNSC has a reputation as an unbiased scientific expert in the nuclear field, it has been urged, now more than ever, to take part in outreach and engagement activities and events. The organization also strives to involve stakeholders, the public and Aboriginal groups in the regulatory process through a variety of appropriate consultation opportunities.

3.11.1 Definition of "outreach"

Outreach is the delivery of awareness activities through targeted interactive forums to interested parties. These activities are designed to educate the public, licensees and other stakeholders about a particular issue or topic. Outreach is a way to deliver on CNSC's mandate to disseminate objective scientific, technical and regulatory information to the public. It includes:

- meetings with municipal officials and community groups
- interactions with the public
- public hearings of the Commission, particularly when they are held in a local community

- meetings with licensees on non-licence specific issues (e.g., quarterly meetings with the Canadian Nuclear Association or the Cost Recovery Advisory Group)
- presentations by the president, executives and staff at various seminars and stakeholder meetings
- participation in international and national conferences and events
- proactive media relations events
- consultations on environmental assessments
- social media

3.11.2 Definition of “engagement”

Engagement is a means of involving stakeholders in key issues. It includes providing information, understanding concerns, and identifying solutions in collaborations between the CNSC and stakeholders. Engagement requires ongoing and sustained two-way dialogue.

3.11.3 Definition of “consultation”

Consultation is a means of involving stakeholders in the regulatory process. Through consultation, the CNSC receives feedback from individuals or groups on specific projects, policies or programs that may affect them directly or in which they have a significant interest. (For information on specific initiatives relating to Aboriginal consultation, refer to section E.8.2.1.)

Figure 3.2: CNSC outreach



3.12 CNSC requirement for public information programs

Introduced in March 2012, RD/GD-99.3, *Public Information and Disclosure Protocols*, replaces guidance document G-217 and defines the CNSC's requirements for public information and disclosure protocols for licensees and applicants. The regulatory document applies to uranium mines and mills, Class I and some Class II nuclear facilities, as defined in the regulations. It provides guidance on the development and implementation of the requirements for public information programs and disclosure protocols.

The primary goal of a public information program, as it relates to the licensed activities, is to ensure that information related to the health, safety and security of persons and the environment, along with other issues associated with the lifecycle of nuclear facilities, is effectively communicated to the public. As a component, where the public has indicated an interest in knowing, RD/GD-99.3 requires that a licensee's public information program shall include a commitment to and protocol for ongoing, timely communication of information related to the licensed facility during the course of the licence period.

The CNSC expects a licensee's public information program and disclosure protocol to be commensurate with the public's perception of risk and the level of public interest in the licensed activities, which may be influenced by the complexity of the nuclear facility's lifecycle and activities, along with the risks to public health and safety and the environment perceived to be associated with the facility and activities.

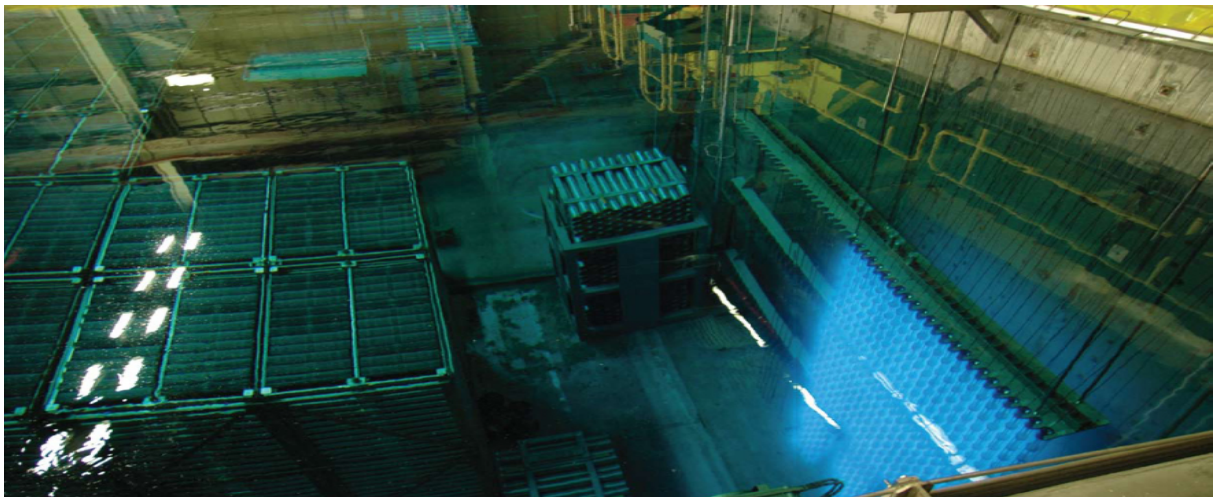
Annex 4 – Spent Fuel Storage Technologies in Canada

4.1 Wet storage technology

Spent fuel discharged from a nuclear reactor is stored initially in wet bays or water pools (see figure 4.1). The wet bays, together with the cooling and purification systems, provide containment of the spent fuel and associated radioactivity and provide good heat transfer to control fuel temperatures. The water also provides shielding and allows access to the fuel, via remotely operated and automated systems, for handling and examination. The bay structure and structural elements (such as fuel containers and stacking frames) provide mechanical protection.

The walls and floors of CANDU reactor water pools are constructed of carbon steel reinforced concrete that is approximately two metres thick. Inner walls and floors are lined with a watertight liner consisting of stainless steel, a fibreglass-reinforced epoxy compound, or a combination of the two. The bay structure is seismically qualified, so that the structures and bay components maintain their structural form and support function both during and following a design basis event (i.e., an accident such as an earthquake). Other structural design considerations include load factors and load combinations (including thermal loads), for which upper and lower temperature limits have been established.

Figure 4.1: Pool storage at Bruce Nuclear Generating Station



4.1.1 Bay liners

The bays are designed to prevent bay water leaking into the environment through any possible defects in the concrete. The bay's inner liner is the primary barrier against outward leakage. The bays also have a leakage collection system to ensure that any leakage that does occur is captured and conducted to a controlled drainage system. The design has provisions for leak detection and tracing.

4.1.2 Storage in wet bays

A number of designs are used to hold spent fuel for storage in wet bays. Ontario Power Generation (OPG) has a standardized site-specific, storage-transportation module that stores the fuel compactly. To reduce handling, the storage-transportation module is also suitable for holding the fuel during transportation. Baskets, trays and modules are stacked vertically in the bays, in seismically qualified stacking frames.

4.1.3 Water pool chemical control

In all storage bays, water is circulated through cooling and purification circuits. A combination of ion exchange columns, filters and surface skimmers is used to control water purity within design limits. A typical purification system also includes resin traps, sample points and instrumentation to indicate when filters and ion exchange columns are exhausted, as well as when resin traps must be cleaned out. Water-pool chemical control has the following objectives:

- minimize corrosion of metal surfaces
- minimize the level of radioisotopes in the water and reduce radiation fields and radioiodine levels in the bay area
- maintain clarity of the bay water for ease of bay operation

To ensure purity, demineralized water is used.

4.2 Experiences with wet storage

Early operating experiences at both the Atomic Energy of Canada Limited (AECL) research reactor spent fuel bays (which have been in operation since 1947) and at the Nuclear Power Demonstration (NPD) and Douglas Point reactors have provided a basis for the successful operation of the spent fuel bays in the current generation of power reactors. Those experiences, along with the development of high-density storage containers, inter-bay fuel transfers and remote handling mechanisms, have contributed to the establishment of current safe storage techniques.

Good chemical control has been achieved in Canadian spent fuel bays. Radioactivity in the water has been kept to very low or non-detectable levels, resulting in low radiation levels in the bay area. Overall fuel bundle defect rates are low. During early operations, defective fuel was canned (stored in a sealed cylinder). With more operating experience, canning has been found to be generally unnecessary, due to minimal release of fission products from most defective bundles. In some cases, known defective fuel is held temporarily in the fuel handling system before being passed to the bay. Known defective fuel is generally stored in a designated part of the fuel bay.

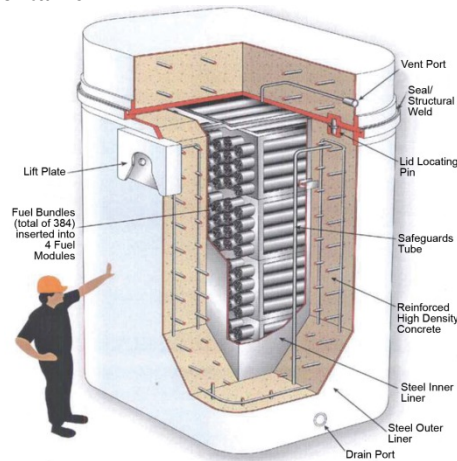
As noted above, an epoxy polymer liner is in place at a number of the stations. With extended operating lifetimes and continual exposure to radiation, some radiation-induced deterioration of the liner occurred at the Pickering A (Units 1 to 4) Nuclear Generating Station (Pickering A NGS) primary bay (where the first epoxy liner was used).

Potential leaks were located and repaired before Pickering A NGS was returned to service after an extended shutdown. Techniques have been developed for underwater repairs that use an underwater-curing epoxy. Extensive repairs were completed in 2002–2003 at various locations in the Pickering A NGS primary bay.

4.3 Dry storage technology

There are currently three basic designs used for the dry storage of spent fuel in Canada:

- AECL concrete canister
- AECL Modular Air-Cooled Storage (MACSTOR™) system
- OPG dry storage container (figure 4.2)

Figure 4.2: OPG dry storage container

4.3.1 AECL concrete canisters

The AECL Concrete Canister Fuel Storage program was developed at the Whiteshell Laboratories in the early 1970s to demonstrate that dry storage for spent reactor fuel was a feasible alternative to water pool storage. Owing to the success of the demonstration program, concrete canisters were used to store Whiteshell Reactor-1 spent fuel. Thanks to the success of the program, the AECL concrete canister design was used at the Chalk River Laboratories (CRL), the Point Lepreau Nuclear Generating Station and the partially decommissioned Douglas Point and Gentilly-1 nuclear generating stations.

The main components of the canister system are:

- the fuel basket
- the shielded workstation
- the transfer flask
- the concrete canister itself

The fuel basket is constructed of stainless steel and comes in three designs:

- designed to hold 54 bundles (used for fuel from Douglas Point and NPD)
- designed to hold 38 bundles, each of which is placed over a basket pin (used for fuel from Gentilly-1)
- designed to hold 60 bundles (in use at Point Lepreau)

A shielded workstation is equipped to dry a loaded fuel basket and to weld the basket cover to the basket base plate and central post assembly. It is composed of a number of subassemblies used for lifting, washing, drying, seal welding and inspecting the spent fuel baskets. The shielding provided by the workstation is sufficient to reduce the radiation fields and ensure the safety of the workers.

The fuel basket transfer flask is used to shield the basket when it is moved from the shielded workstation at the nuclear generating station to the dry storage canister at the waste management facility.

The concrete canister is a cylindrical, reinforced concrete shell with an internal liner. To provide additional shielding, a two-piece loading plug is used until the canister is filled. Provision is made for International Atomic Energy Agency (IAEA) safeguard seals to be placed on top of the canister plug, so that it cannot be removed without breaking the seals.

Two small-diameter pipes allow the air between the liner and the fuel baskets to be monitored in order to confirm the integrity of the confinement barriers. The concrete canisters are supported on reinforced concrete foundations above the water table. Each canister holds six, eight, nine or 10 baskets, depending on the specific needs of the station.

The transfer of spent fuel from the storage bays to dry storage canisters always begins with the oldest fuel. Therefore, the nominal age of the spent fuel in dry storage is usually older than seven years, which adds a measure of conservatism to the assumptions and overall safety of the dry storage of spent fuel.

Three barriers (defence in depth) ensure the containment of the radioactive products:

- the fuel sheath
- the fuel basket
- the internal liner

4.3.2 AECL MACSTOR™ module

The MACSTOR system is a variant of the canister storage technique. MACSTOR modules are currently installed and being operated at the Gentilly-2 site in Quebec, at the Cernavoda site in Romania and at the Qinshan site in China.

The original design of MACSTOR (MACSTOR-200) is a secure, reinforced concrete structure housing 20 vertical steel cylinders, each of which holds 10 sealed baskets of 60 spent fuel bundles. Each module can store 12,000 bundles of spent fuel. Each cylinder is secured to the top slab of the module, and two sampling pipes, which extend to the outside of the MACSTOR module, are provided at its base. These pipes allow confirmation of the integrity of confinement. The MACSTOR-200 is used at the Gentilly-2 site (see figure 4.3) and the Cernavoda site.

The newer design, MACSTOR-400, can store twice as much fuel with a marginal increase in construction costs when compared to MACSTOR-200. The MACSTOR-400 houses 40 vertical steel cylinders, each of which will hold 10 sealed baskets of 60 fuel bundles. In total, the module can store 24,000 bundles of spent fuel. The MACSTOR-400 is used at the Qinshan site and will be used at the Cernavoda site.

The heat of the spent fuel is dissipated primarily by natural convection, through ventilation ports that extend through the concrete walls. The ventilation is provided by 10 large air inlets in each longitudinal wall near the base of the module (five on each side), and by 12 large air outlets located slightly below the top of the module (six on each side). The air inlets and outlets are arranged in a series of baffles to avoid direct gamma radiation.

To enhance cooling, the storage cylinders of the MACSTOR module are in direct contact with the air circulating in the module. All the surfaces of the storage cylinders are hot galvanized to protect the storage cylinders from ambient air.

The loading operations for the MACSTOR module are identical to those for the concrete canister. Both use the fuel basket, shielded workstation and transfer flask concept. The only essential difference between the two is the storage structure itself.

Figure 4.3: MACSTOR™ at Gentilly-2

4.3.3 OPG dry storage containers

OPG currently operates three spent fuel dry storage facilities – at the Pickering Waste Management Facility (PWMF), the Western Waste Management Facility (WWMF) and the Darlington Waste Management Facility.

OPG dry storage facilities employ dry storage containers (DSCs) (see figure 4.4). These are massive, transportable containers with an inner cavity for fuel containment. Each one is designed to hold 384 fuel bundles and weighs approximately 60 tonnes when empty and 70 tonnes when loaded.

The containers are rectangular, with walls of reinforced, high-density concrete sandwiched between interior and exterior shells made of carbon steel. The inner liner is an integral part of the containment boundary, while the outer liner is intended to enhance structural integrity and facilitate decontamination of the surface of the dry storage container. Helium is used as a cover gas in the dry storage container cavity, to protect the fuel bundles from potential oxidation. OPG dry storage facilities are located indoors, while the AECL storage facilities are located outdoors. For both, there are no anticipated radiological releases under normal operating conditions.

Figure 4.4: Dry storage containers at an OPG waste management facility

4.4 Experiences with dry storage

Research programs have assessed the behaviour of spent fuel when stored in dry and moist air conditions and in a helium environment. The programs have concluded that CANDU fuel bundles, whether intact or with defects, can be stored in dry storage conditions for up to 100 years or more without losing integrity. Additional research is ongoing.

The experience gained at licensed dry storage facilities provides a high level of confidence that CANDU dry storage facilities can be operated safely and without undue risk to workers, the general public and the environment. Dry storage containers have been used successfully and safely at the PWMF since 1996. The safety performance of the facility has been excellent over the entire period. Dose rates have remained below regulatory limits. Collective occupational radiation exposures have been below the predicted amounts by 30 percent or more. Emissions from the processing area have also remained below regulatory limits. All three OPG dry storage facilities operate contamination-free, and there have been no effluent releases resulting from dry storage containers.

Thermal and shielding analyses, carried out for design and safety assessment purposes, have been found to be conservative. Analysis and measurements carried out at the PWMF indicate that the maximum fuel cladding temperature does not exceed 175°C in dry storage. In addition, results of neutron dose rate calculations have demonstrated that, as expected, the dose rates produced by neutrons are negligible compared to those generated by gamma radiation. This result is due to the heavy concrete used as shielding in the dry storage containers.

To verify the results of the thermal analysis, an experimental thermal performance verification program was carried out in the summer of 1998. A dry storage container, instrumented with 24 thermocouples at various locations on the inner and outer liners, was loaded with six-year cooled fuel and placed within an array of dry storage containers containing 10-year cooled fuel. Temperatures were also measured at the interspaces between the dry storage containers, in addition to indoor and outdoor ambient temperature measurements. The results demonstrated the conservatism of the temperatures predicted analytically.

4.5 Spent fuel storage facilities

After a cooling period of six to 10 years in the storage bay (the exact cooling period is site-specific), spent fuel is then transferred to an interim dry storage facility. All transfers of spent fuel to dry storage are conducted under IAEA surveillance. All loaded dry storage containers in interim storage are also under the surveillance of the IAEA and through the application of a dual sealing system.

4.5.1 Pickering Nuclear Generating Station

Pickering hosts two NGSs (Pickering A and B (Units 5 to 8)). Each station consists of four CANDU pressurized heavy-water reactors. Pickering A commenced operation in 1971 and continued to operate safely until 1997, when it was placed in voluntary layup as part of what was then Ontario Hydro's nuclear improvement program. In September 2003, Unit 4 was returned to commercial operation. Unit 1 was returned to commercial operation in November 2005. Units 2 and 3 were defuelled, dewatered and placed in safe storage by September 2010.

Pickering B commenced operation in 1982 and continues to operate today. OPG plans for continued operation of some of the Pickering B units until 2020.

The spent fuel generated at both Pickering A and B is stored in the spent fuel bays for a minimum of 10 years before it is transferred to the PWMF.

4.5.2 Pickering Waste Management Facility – spent fuel dry storage

OPG's PWF is located within the protected area of the Pickering NGS. In operation since 1996, the primary purpose of the PWF is to store spent fuel from the reactors at the Pickering NGSs. It is expected that the PWF will be in operation until at least 10 years after the shutdown of the last Pickering reactor unit.

The spent fuel dry storage area of the PWF comprises a dry storage container processing building and three storage buildings. The Pickering spent fuel dry storage system is designed to transfer spent fuel from wet storage in the Pickering spent fuel bays into a concrete dry storage container designed by OPG. Prior to transfer to the PWF, each loaded dry storage container is drained, its cavity is vacuum dried, and the container surface is surveyed for loose contamination. If necessary, decontamination is carried out.

Once the dry storage container loaded with spent fuel is received at the PWF processing building, the transfer clamp and the seal are removed, and the lid is seal-welded to the dry storage container body. The lid weld is subsequently inspected for defects. The dry storage container undergoes final vacuum drying and helium backfilling. Subsequently, the drain port is welded and inspected, and helium leak testing is performed. The dry storage container is surveyed to ensure that no loose contamination is present; in the unlikely event contamination is found, the container and the affected area are decontaminated.

Finally, touch-up paint is applied to scuffs or scrapes on the container's exterior. Following processing, IAEA seals are applied to each container and placed in storage. The PWF can process approximately 50 dry storage containers (or 19,200 spent fuel bundles) per year.

The PWF can store up to 650 dry storage containers or 249,600 fuel bundles in the two existing storage buildings in the PWF Phase I. A PWF Phase II area has been constructed in the east complex, as shown in figure 4.5. The PWF Phase II complex currently contains one spent fuel dry storage building (Storage Building 3), with space for one additional storage building. The two storage buildings in the PWF Phase II area will eventually have a combined capacity of 1,000 dry storage containers. The PWF Phase II area operates within its own established protected area.

In 2012, the PWF (spent fuel dry storage area and retube components storage area combined) reported releases of 0.00022 GBq to air and 0.14 GBq to water. It is important to note, however, that activity released from the PWF is included in the total releases reported for the Pickering NGS.

Figure 4.5: PWF I (Processing Building, storage buildings 1 and 2 and Retube Components Storage Building) and PWF II (Storage Building 3 and future storage building 4) area



4.5.3 Bruce Nuclear Generating Stations A and B

The Municipality of Kincardine, Ontario, hosts the Bruce nuclear site, which contains two NGSs (Bruce NGS-A and NGS-B). Bruce NGS-A consists of four CANDU pressurized heavy-water reactors. Currently, all four units are in operation.

Bruce NGS-B consists of four CANDU heavy-water reactors. This station commenced operation in 1984 and continues to operate today. Bruce Power Inc. leases and operates both Bruce NGS-A and Bruce NGS-B.

4.5.4 Western Waste Management Facility – spent fuel dry storage

OPG’s Western Used Fuel Dry Storage Facility, which is part of the WWMF, began operations in February 2003. The Western Used Fuel Dry Storage Facility was designed to provide safe storage for the Bruce NGS-A or NGS-B spent fuel until all of it is transported to an alternative long-term spent fuel storage or disposal facility. It can provide dry storage for about 750,000 fuel bundles produced at Bruce NGS-A and Bruce NGS-B. The spent fuel is stored in dual-purpose concrete dry storage containers, identical to those currently in use at the PWF. The processing of dry storage containers is carried out in a manner similar to that at the PWF.

The WWMF can process approximately 130 dry storage containers (or 49,920 spent fuel bundles) per year. OPG is authorized to store up to 750,000 spent fuel bundles, or approximately 2,000 dry storage containers, at the facility.

4.5.5 Darlington Nuclear Generating Station

The Darlington NGS, operated by OPG, consists of four CANDU pressurized heavy-water reactors. The station commenced operation in 1989 and continues to operate today. OPG has announced a reinvestment plan that sets the course for refurbishment of the existing Darlington facility to extend its lifetime to approximately 2050. OPG is proceeding with detailed planning for refurbishment.

The spent fuel generated at the Darlington NGS is stored in the spent fuel bays for a minimum of 10 years before the spent fuel is transferred to the Darlington Waste Management Facility (DWMF).

4.5.6 Darlington Waste Management Facility

The DWMF is located at the Darlington NGS site (figure 4.6). It provides safe storage for the Darlington NGS spent fuel until this fuel is transported to an alternative long-term spent fuel storage or disposal facility.

The DWMF is made up of a processing building and storage building designed to house up to 500 dry storage containers. The facility, however, is designed to provide a storage capacity for up to 576,000 fuel bundles produced at the Darlington NGS after two additional storage buildings are constructed in the future. The spent fuel is stored in dual-purpose concrete dry storage containers, identical to those currently in use at the PWMF and WWMF. The processing of dry storage containers is also identical to the operations at the PWMF and the WWMF. The DWMF can process approximately 60 dry storage containers (or 23,040 spent fuel bundles) per year.

Figure 4.6: Darlington reactor site, with DWMF in the foreground



4.5.7 Gently-2 Nuclear Generating Station

The Gently-2 Nuclear Generating Station (figure 4.7), which is operated by Hydro-Québec, houses a CANDU pressurized heavy water reactor. The station went into service in 1982 and began commercial operation in 1983. At the end of 2012, Hydro-Québec ended its operation in order to proceed with its decommissioning.

Because the station has ended operations, the total number of spent fuel bundles will not increase. There are 129,941 spent fuel bundles in safe storage at the station. The spent fuel is first stored in a pool and then, after an appropriate cooling period, transferred to the dry storage facility. The transfer of spent fuel in baskets is performed directly at the pool. The loaded baskets are then transferred to a shielded workstation, in which the contents are dried and the basket lids welded on. Once the work on the baskets has been completed, the baskets are transported to Hydro-Québec’s spent fuel dry storage facility.

Figure 4.7: Gently-2 Nuclear Generating Station



4.5.8 Hydro-Québec spent fuel dry storage facility

In operation since 1995, the Gently-2 Used Fuel Dry Storage Facility (figure 4.8) stores fuel used during station operation. Hydro-Québec was authorized to build all of the CANSTOR (CANDU Storage) modules required for the storage of its spent fuel. At the end of 2010, nine CANSTOR modules were in service. The final, permanent shutdown of the nuclear generating station requires the construction and commissioning of two additional CANSTOR modules to store 132,000 spent fuel bundles.

The storage baskets are transferred on an as-needed basis in accordance with decommissioning planning requirements, with transfers normally held between April and December each year, until 2020. At all times, the licensee must ensure that dose rates at the fence line of these facilities stays within the authorized limit of 2.5 $\mu\text{Sv/h}$.

Figure 4.8: Gently-2 used fuel dry storage facility

4.5.9 Point Lepreau Nuclear Generating Station

The Point Lepreau Nuclear Generating Station (PLGS), operated by New Brunswick Power, consists of one CANDU pressurized heavy-water reactor. The station commenced operation in 1982. It is currently in full power operation, having completed a major refurbishment outage in the fall of 2012 that will enable the station to operate for another 25 to 30 years. In May 2014, the station will be taken offline for a planned shutdown that will involve fuel channel inspections, feeder inspections and other activities.

4.5.10 Point Lepreau spent fuel dry storage facility

The spent fuel generated at PLGS is initially stored in the spent fuel bay and then transferred to the spent fuel dry storage facility (figure 4.9) or the Phase II area of the Solid Radioactive Waste Management Facility (SRWMF). In operation since 1990, the spent fuel dry storage facility provides additional storage capacity for PLGS in above-ground concrete canisters. The facility is authorized to construct 300 canisters, which can house a total of 180,000 spent fuel bundles. By the end of the reporting period, March 31, 2014, the facility had constructed 180 canisters. Approximately 5,000 spent fuel bundles are transferred to dry storage each year that the station operates, depending on the power output of the Point Lepreau nuclear reactor.

During the aforementioned refurbishment outage, all of the fuel in the reactor core was emptied into the station's spent fuel bay, but no spent fuel was transferred to Phase II. To handle the spent fuel resulting from the extended operational life of the station on account of the refurbishment outage, land was prepared to permit the construction of up to 300 additional canisters, depending on upcoming needs.

Spent fuel transfers commenced again in May 2013, and 12 additional canisters were filled between this time and the end of that year. A total of 162 canisters had been filled and sealed as of the end of the reporting period.

Samples of surface runoff from the Phase II area, collected and analyzed over the reporting period, have had an average tritium concentration of 66 Bq/litre. The average dose rate for the reporting period at the spent fuel storage facility perimeter fence, as read from thermoluminescent dosimeters, was 0.11 μ Sv/h.

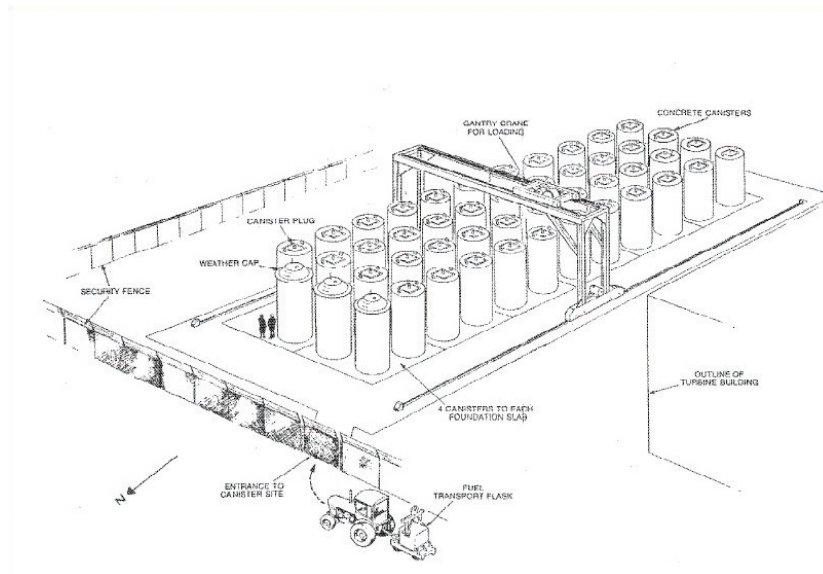
Figure 4.9: Point Lepreau spent fuel dry storage area



4.5.11 Douglas Point spent fuel dry storage facility

The AECL Douglas Point spent fuel dry storage facility (figure 4.10) is located at the Bruce NGS. The prototype CANDU power reactor at Douglas Point became operational in 1968 and was shut down permanently after 17 years of operation. Decommissioning began in 1986, and approximately 22,256 spent fuel bundles were transported to concrete canisters in late 1987. The concrete canisters are currently in storage-with-surveillance mode. The Dry Fuel Storage Canister Air Sampling program showed gross beta activity levels below 0.32 Bq/canister, gross alpha levels below 0.04 Bq/canister and gross gamma levels below 9.28 Bq/canister in 2013. These measurements confirm that the facility is in a safe storage-with-surveillance state.

Figure 4.10: Douglas Point spent fuel dry storage facility



4.5.12 Gentilly-1 spent fuel dry storage facility

The AECL Gentilly-1 Nuclear Power Station became operational in May 1972. It attained full power for two short periods in 1972 and was then operated intermittently for a total of 183 effective full-power days until 1978. In 1984, AECL began a two-year decommissioning program, during which a total of 3,213 spent fuel bundles were transferred to concrete canisters. The concrete canisters are currently in storage-with-surveillance mode. The Dry Fuel Storage Canister Air Sampling program showed that gross beta activity levels were below 0.12 Bq/canister, gross alpha levels were less than 0.02 Bq/canister, and gross gamma levels were less than 2.01 Bq/canister in 2013. These measurements confirm that the facility is in a safe storage-with-surveillance state.

4.5.13 Chalk River Laboratories – Area G – spent fuel dry storage area

The Waste Management Area G at AECL's CRL is a spent fuel dry storage area that contains concrete canisters, as described in section 4.3.1. The NPD was a demonstration reactor operated by Ontario Hydro (now OPG) from 1962 until 1987, when it was decommissioned. As part of the decommissioning program, the spent fuel was transferred to concrete canisters located at the AECL CRL spent fuel dry storage area. At this site, AECL has stored 68 full and partial spent fuel bundles from Bruce, Pickering and Douglas Point, as well as 4,886 fuel bundles from the NPD reactor, in 12 dry storage concrete canisters. The concrete canisters are currently in storage-with-surveillance mode.

Two concrete canisters were constructed on the existing concrete support pad to store calcined waste from the processing of radioisotopes separated in the new processing facility at CRL. These canisters are in the extended shutdown state, matching the other dedicated isotope facility systems. Construction of the canisters is not completed.

4.5.14 Whiteshell Laboratories spent fuel storage facility

Whiteshell Laboratories (WL) was established at Pinawa, Manitoba, in the early 1960s to carry out nuclear research and development activities for higher-temperature versions of the CANDU reactor. The initial focus of research was the Whiteshell Reactor-1 (WR-1) organic cooled reactor, which began operation in 1965. WR-1 continued to operate until 1985.

The Concrete Canister Storage Facility program, or Whiteshell spent fuel storage facility, was developed in the early 1970s to demonstrate that dry storage was a feasible alternative to water pool storage for spent reactor fuel.

Because of the success of the demonstration program, the Concrete Canister Storage Facility (see figure 4.11) was built to store all remaining WR-1 spent fuel. In addition, a number of spent fuel bundles from CANDU stations are stored in the WL facility after undergoing post-irradiation examinations in the WL shielded facilities. The facility provides storage for 2,268 spent fuel bundles originating from both the WR-1 operation and CANDU reactors. Some spent fuel from operations prior to the 1975 canister development program is stored in standpipes in the waste management area. (Further details on the Whiteshell decommissioning program can be found in annex 7.1.)

Figure 4.11: Whiteshell Laboratories Concrete Canister Storage Facility



4.5.15 National Research Universal research reactor

The National Research Universal (NRU) research reactor is a thermal neutron, heterogeneous, heavy-water moderated and cooled reactor. It was designed for operation with natural uranium metal fuel rods and converted to operation with enriched driver fuel rods in 1964. Gradual conversion to low-enriched uranium (LEU) fuel began in 1991.

Initial storage of the spent fuel rods takes place in water-filled bays located within NRU. After an appropriate time to allow for radioactive decay and cooling, the spent fuel is generally transferred to tile holes at Waste Management Area B at CRL. The tile holes are also used to store the spent fuel from the National Research Experimental reactor, which was shut down in 1992.

4.5.16 McMaster Nuclear Reactor

The McMaster Nuclear Reactor (MNR) is a pool-type reactor, with a core of enriched uranium fuel moderated and cooled by light water. The reactor operates at powers up to 5 MW. The MNR was converted from highly enriched uranium (HEU) fuel to LEU fuel during 2006–07. The original HEU fuel was returned to Savannah River in the United States. The LEU fuel was manufactured in France. The MNR is the only Canadian medium-flux reactor in a university environment. The MNR's neutrons are used in nuclear physics, biology, chemistry, earth sciences, medicine and nuclear medicine. Any spent fuel at the MNR can be stored in a water environment.

Annex 5 – Radioactive Waste Management Facilities

5.1 Radioactive waste management methods

All radioactive waste produced in Canada is placed into storage with surveillance, pending the establishment of long-term waste management facilities (WMFs). At existing WMFs, various storage structures are currently in use, such as:

- in-ground burial
- low-level and intermediate-level waste storage buildings
- intermediate-level waste storage buildings
- shielded modular above-ground storage buildings
- Quonset huts
- above-ground or in-ground containers or tile holes
- concrete bunkers

5.1.1 Pickering Waste Management Facility – retube components storage

The Pickering WMF (see figure 5.1) consists of the spent fuel dry storage area (see annex 4.5.2) and a storage area, called the retube components storage area (RCSA), which stores reactor core component waste from retube activities at the Pickering A. The RCSA is located within the protected area of the Pickering NGSs and is operating in storage-with-surveillance mode, meaning that it is closed to new waste unless it receives prior written approval from the Canadian Nuclear Safety Commission (CNSC).

The RCSA uses dry storage modules (DSMs) to store the retube components. The RCSA was designed to accommodate 38 DSMs, cylindrical casks made from reinforced heavy concrete. The design of the DSMs provides adequate shielding to meet dose rate requirements outside the facility and keep worker dose rates as low as reasonably achievable (ALARA). At present, the RCSA consists of 34 loaded DSMs, two empty DSMs and empty space for two additional DSMs.

The RCSA is covered in an impermeable membrane and provides a low-maintenance surface. A drainage system directs the runoff water from the storage area to the Pickering B outfall. Catch basins permit the periodic sampling of the water.

Figure 5.1: Pickering WMF, with RCSA (left) and spent fuel dry storage area (right)



5.1.2 Western Waste Management Facility – low- and intermediate-level waste storage

The Western Waste Management Facility (WWMF) is owned and operated by Ontario Power Generation (OPG) at the Bruce Power site near Kincardine, Ontario. The WWMF consists of two distinct areas (see figure 5.2):

- a low- and intermediate-level radioactive waste storage area
- a spent fuel dry storage area (refer to annex 4.5.4)

The low- and intermediate-level radioactive waste storage area provides safe handling, processing and storage of radioactive materials produced at NGSs (Pickering, Darlington, Bruce A and B) and other facilities currently or previously operated by OPG or its predecessor, Ontario Hydro. The low- and intermediate-level radioactive waste storage area consists of various buildings, such as the Waste Volume Reduction Building (WVRB) and the Transportation Package Maintenance Building (TPMB). The storage structures used in this facility consist of above-ground low-level waste storage buildings, refurbishment waste storage buildings, quadricells, in-ground containers, in-ground trenches and tile holes.

The WVRB can receive low-level radioactive wastes and sort them into processable and non-processable streams. It can further process some of the waste by using compaction or incineration prior to storage. The WVRB consists of the following main areas:

- The radioactive waste incinerator area contains the radioactive waste incinerator, auxiliary systems and equipment and an active drainage sump.
- The compaction area contains a box compactor and a civil maintenance shop. Control and mechanical maintenance shops are located at the TPMB to carry out repairs and equipment maintenance.
- The material handling, storage and sorting area provides for material movement, sorting and temporary storage of incoming and processed wastes. Access to the incinerator and compaction areas is included.
- The control room houses the main work control centre. All low- and intermediate-waste storage area systems and services alarms are monitored in this room.
- Truck bays establish a weather-protected area for the receipt and unloading of low-level wastes.
- Ventilation equipment areas contain air intake filters, intake fans, heating coils, air exhaust filters and exhaust fans. Radioactive airborne effluent monitors, for the building ventilation and radioactive incinerator exhaust, are also located in this area.
- Electrical and storage rooms provide housing for electrical switchgear and motor control centres, as well as storage for non-waste products.

OPG has developed derived release limits (DRLs) for airborne radioactive releases from the radioactive incinerator and active ventilation in the WVRB and TPMB and for releases to surface and subsurface drainage at the site. The non-radioactive effluents must conform to the Certificate of Approval (Air) for the WWMF site issued by the Ontario Ministry of Environment. Currently and historically, radioactive and non-radioactive effluents are all below regulatory requirements.

The safe handling, processing and storage of radioactive waste at the WWMF requires a combination of design features, procedures, policies and monitoring programs. Required programs focus on radiation protection, occupational health and safety, environmental protection and monitoring for individual areas, as well as the overall facility.

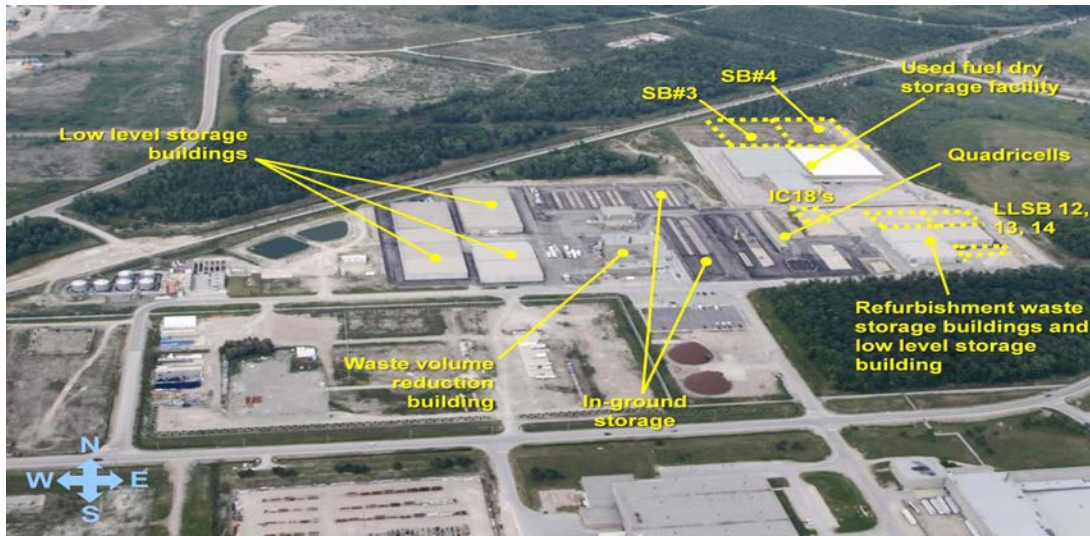
The low- and intermediate-level waste storage area of the WWMF typically receives about 450 cubic metres of radioactive waste per month. The actual amount can vary widely, depending on maintenance

activities at the various nuclear power plants. The waste is subsequently processed, when possible, and placed into the appropriate storage structure.

There are two refurbishment waste storage buildings located within the low- and intermediate-level waste storage area. These buildings store the waste that arose from the refurbishment of Bruce NGS-A Units 1 and 2. One of these buildings contains the retube components in specially designed concrete and steel boxes, and the other houses the steam generators. The construction schedule for the future refurbishment waste storage structures will be based on need and, therefore, on the refurbishment plans developed for the nuclear power plants by the power reactor licensee.

In 2013, the WWMF (spent fuel dry storage area and the low- and intermediate-level radioactive waste storage area combined) released $1.43\text{E}+13$ Bq of tritium, $3.78\text{E}+05$ Bq particulate beta/gamma, $6.38\text{E}+04$ Bq iodine-131 and $1.96\text{E}+09$ Bq carbon-14 to air. Releases to water were $1.42\text{E}+11$ Bq tritium and $1.30\text{E}+08$ Bq gross beta.

Figure 5.2: Western Waste Management Facility



5.1.3 Radioactive Waste Operations Site 1

Radioactive Waste Operations Site 1 (RWOS 1) is owned and maintained by OPG at the Bruce nuclear site. The facility provides for the storage of low- and intermediate-level waste produced at the Douglas Point NGS and from the early operating life at the Pickering A. The majority of the original wastes from this facility were retrieved and relocated to the WWMF in the late 1990s and early 2000s. Some small volume of wastes remains stored in reinforced concrete trenches with concrete covers and in in-ground monoliths and lined tile holes.

The facility is currently operated in caretaking mode and no longer receives new wastes. OPG monitors and maintains the site and structures, and no new waste can be added without the prior written approval of the CNSC.

5.1.4 Hydro-Québec Waste Management Facility

Hydro-Québec's Gentilly-2 Solid Radioactive Waste Management Facilities (SRWMFs) provide for the safe storage of radioactive materials produced at the Gentilly-2 Nuclear Generating Station (see figure 5.3). These facilities consist of several types of reinforced concrete bunkers.

Intermediate-level radioactive waste (ILW) with a high dose-rate, such as filters, is stored in type A bunkers. Type B bunkers are also used to store ILW, but with a lower dose-rate than type A bunkers, while type C bunkers are used to store low-level radioactive waste (LLW).

Commissioning of Phase II of the SRWMF was authorized in 2013. Phase II was originally built for storage of refurbishment waste; however, this installation will be used to store radioactive resins and either intermediate- or low-level radioactive wastes.

The volume of LLW is approximately 25 cubic metres per year. Samples of surface water run-off from the SRWMF collected and analyzed in 2013 have shown that tritium concentrations varied between 84 Bq/litre and 2,018 Bq/litre. The average dose rate for 2013 at the SRWMF perimeter fence was 0.57 $\mu\text{Sv/h}$.

Figure 5.3: Gentilly-2 Solid Radioactive Waste Management Facility



5.1.5 Point Lepreau Solid Radioactive Waste Management Facility

The SRWMF includes a Phase I area for the storage of radioactive materials produced at the Point Lepreau NGS, a Phase II Area for the storage of spent fuel (described in annex 4.5.10), and a Phase III Area for the storage of waste from the refurbishment outage.

The Phase I area contains the following storage structures:

- Vaults are concrete structures, of which there are six with four equal compartments. They are used to store the bulk of LLW (see figure 5.4). Almost all the waste stored in the vaults is expected to decay to an insignificant level by the end of the design life of these structures. There was approximately 2,047 m³ of storage in the six vault structures as of the end of the reporting period.
- Quadricell structures are designed to house ILW, such as spent ion exchange resins and filters from reactor systems and contaminated system components. Currently, there is approximately 144 m³ of quadricell storage available in a total of nine quadricells. As of the end of the reporting period, however, these structures were empty.
- Filter storage structures are used for storing filters from heat transport purification, active drainage, gland seal supply, moderator purification, and spent fuel bay and fuelling machine systems. These structures are contained within one of the vaults mentioned above. As of the end of the reporting period, a total of 11 m³ were stored within these storage structures.

A total of 322 m³ were transferred to Phase I over the reporting period. The volume reduction strategy, whereby incinerable radioactive waste is sent to EnergySolutions' Radioactive WMF in Oak Ridge, Tennessee, was implemented in December 2010. An approximate volume reduction of 100:1 is realized via this process in terms of the shipped waste and the returned ash. Maintenance Manual MM-79100-SP06, *Waste Shipment To EnergySolutions*, was drafted to document the process followed in terms of these offsite shipments. A total of 292.32 m³ were transferred from Phase I to EnergySolutions over the reporting period.

Samples of surface runoff from Phase I, collected and analyzed over the reporting period, have had an average tritium concentration of 259 Bq/litre. The average dose rate for the reporting period at the Phase I perimeter fence, as read from thermoluminescent dosimeters, was 0.15 µSv/h.

Figure 5.4: Point Lepreau vault storage structure



The Phase III area contains the following storage structures:

- Vaults are concrete structures identical to those in Phase I. They are used to store the bulk of LLW from the refurbishment outage. There is approximately 890 m³ of storage space in the two vault structures. As of March 31, 2014 there were approximately 869 m³ of vault storage being occupied.
- Retube canisters are concrete structures used to store ILW from the refurbishment of the Point Lepreau Nuclear Generating Station reactor, which consists primarily of reactor components (see figure 5.5). There are approximately 165 m³ of storage in the five structures. There was approximately 140 m³ of retube canister storage being occupied as of the end of the reporting period.

A total of 96 m³ were transferred to this facility over the reporting period. In March 2013, a 2.27 m³ coffin box housing 164 closure plugs was removed from vault storage in Phase III to assess the plugs' applicability with regard to closure plug challenges at the station.

Samples of surface runoff from the Phase III area, collected and analyzed over the reporting period, have had an average tritium concentration of 101 Bq/litre. The average dose rate for the reporting period at the Phase III perimeter fence, as read from thermoluminescent dosimeters, was 0.19 µSv/h.

Figure 5.5: Point Lepreau retube waste canisters



5.1.6 Radioactive waste management at decommissioned reactor sites

The Douglas Point, Gentilly-1 and Nuclear Power Demonstration (NPD) reactors are shut down, partially decommissioned and in the storage-with-surveillance phase (see figure 5.6). As these facilities contain radioactive materials, including radioactive wastes from decommissioning activities, they are presently licensed as WMFs. The storage-with-surveillance phase is currently envisaged to be 30 years or longer. A major factor influencing the length of the phase is the availability of long-term WMFs. (Annex 7 provides further information on the decommissioning activities at each of these sites.)

5.1.6.1 Douglas Point Waste Management Facility

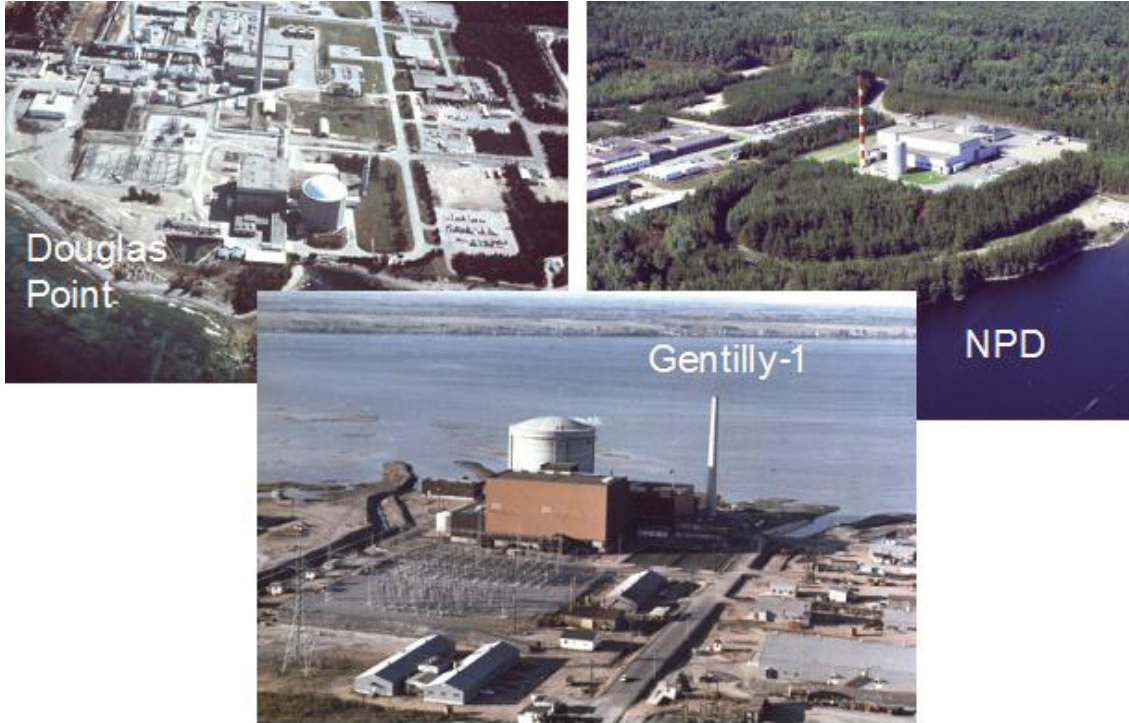
The Atomic Energy of Canada Limited (AECL) Douglas Point Waste Management Facility (DPWMF) is located on the Bruce nuclear site in Kincardine, Ontario. The prototype CANDU power reactor was shut down permanently in 1984 after 17 years of operation. Decommissioning began in 1986, and the spent fuel bundles were transported to concrete canisters in late 1987.

Stored waste consists of activated corrosion products and fission products. The waste is stored in the reactor and service buildings. The sources of each waste type are as follows:

- induced radioactivity in reactor components and the biological shield
- radioactive corrosion products and fission products deposited on the drained heat transport and moderator surfaces
- ion exchange resin from both the heat transport and moderator systems stored in underground tanks
- contaminated soil stored in the service building
- drums of contaminated steel from fuel storage trays
- intermediate-level waste stored in the fuel transfer tunnel leading from the reactor building to the receiving bay

In 2013, the DPWMF released $2.37\text{E}+11$ Bq of tritium and $1.31\text{E}+09$ Bq of carbon-14 from the HEPA-filtered ventilation system for the reactor building during 889 hours of operation. The total liquid tritium release was $4.49\text{E}+10$ Bq. The total liquid carbon-14 release was $3.11\text{E}+09$ Bq from the facility. These measurements indicate that the facility is operating safely.

Figure 5.6: Douglas Point, NPD and Gentilly-1 facilities



5.1.6.2 Gentilly-1 Waste Management Facility

The AECL Gentilly-1 Waste Management Facility (G1WMF) is situated within Hydro-Québec's Gentilly-2 nuclear power plant boundary. The CANDU-BLW-250 Gentilly-1 nuclear power station began operation in May 1972 and attained full power for two short periods during that same year. It was operated intermittently for a total of 183 effective full-power days until 1978, when it was determined that some modifications and considerable repairs would be required. Consequently, it was in a layup state from 1980 to 1984, when a decommissioning program was initiated to bring the Gentilly-1 station to a safe sustainable shutdown state that permitted storage-with-surveillance.

The G1WMF consists of specified areas within the turbine and service buildings, the whole reactor building, the resin storage area and the spent fuel storage canister room.

Stored waste consists of activated corrosion products and fission products. The sources of each waste type area are as follows:

- induced radioactivity in reactor components and the biological shield
- radioactive corrosion products and fission products deposited on the drained heat transport and moderator system surfaces
- contaminated soil
- ion exchange resin from the heat transport and moderator systems

- containers of dry low-level contaminated equipment and material that resulted from operation and earlier decommissioning activities

There are no airborne releases from the G1WMF. In 2013, $2.96\text{E}+04$ Bq of activity beta/gamma were released from the facility liquid sump to the Hydro-Québec power reactor active liquid discharge system. The measurement confirms that the facility is operating safely.

5.1.6.3 Nuclear Power Demonstration Waste Management Facility

Located in Rolphton, Ontario, the AECL Nuclear Power Demonstration Waste Management Facility (NPDWMF) contains the decommissioned NPD NGS. The station operated from 1962 until 1987, when Ontario Hydro (now OPG), with assistance from AECL, decommissioned it to a static state interim storage condition. After the static state was achieved, Ontario Hydro turned over control of the NPDWMF to AECL in September 1988. Since then, various non-nuclear ancillary facilities, such as the administration wing, training centre, pump house and two large warehouses, were demolished and the refuse was removed from the site for reuse, recycling or waste. The fuel bundles were transferred to the Chalk River Laboratories (CRL) waste management area (WMA) for storage.

The NPDWMF is divided into nuclear and non-nuclear areas. Stored waste consists of induced radioactive products, activated corrosion products and some fission products. The confined residual radioactivity in the NPD after removal of the spent fuel and heavy water consists of:

- induced radioactivity in the reactor components and biological shield (i.e., the concrete walls surrounding the reactor)
- radioactive corrosion products in the drained heat transports and moderator systems
- small amounts of radioactivity in auxiliary systems, components and materials stored in the nuclear area of the facility

In 2013, the airborne emissions were $6.86\text{E}+10$ Bq for tritium and $6.60\text{E}+01$ Bq for gross beta. Liquid effluent releases during 2013 were $1.41\text{E}+11$ Bq for tritium, $8.69\text{E}+07$ Bq for carbon-14 and $9.76\text{E}+05$ Bq for gross beta. These measurements confirm that the facility is operating safely.

5.1.7 AECL nuclear research and test establishment facilities

AECL currently has two research facilities in Canada – one at AECL CRL in Ontario, which is operational, and the other at the AECL Whiteshell Laboratories (WL) in Manitoba, which is currently undergoing decommissioning. (Annex 7 provides further information on decommissioning activities.) The radioactive wastes produced at these two sites are stored in WMFs at each site.

5.1.7.1 Chalk River Laboratories

The CRL site is located in Renfrew County, Ontario, on the shore of the Ottawa River, 160 kilometres northwest of Ottawa. The site, which has a total area of about 4,000 hectares, is situated within the boundaries of the Corporation of the Town of Deep River. The Ottawa River, which flows northwest to southeast, forms the northeastern boundary of the site. The Petawawa Military Reserve abuts the CRL property to the southeast. The Village of Chalk River, in the Municipality of Laurentian Hills, lies immediately to the southwest of the site.

The CRL site was established in the mid-1940s and has a history of various nuclear operations and facilities, primarily related to research. Most of the nuclear and associated support facilities and buildings on the site are located within a relatively small industrial plant site area, adjacent to the Ottawa River near the southeast end of the property. Various WMAs for radioactive and non-radioactive wastes are located within the CRL property, along the southwest to northeast corridor. The CRL WMAs provide some fee-

based waste management for institutions such as universities, hospitals and industrial users that have no other means to manage their wastes.

The CRL WMAs manage eight types of waste:

- nuclear reactor operation wastes, which include fuel and reactor components, reactor fluid cleanup materials (e.g., resins and filters), trash and other materials contaminated with radioactivity as a result of routine operations
- fuel fabrication facility wastes, which include zirconium dioxide and graphite crucibles used to cast billets, filters and other trash such as gloves, coveralls and wipes
- isotope production wastes, which include general radioactive wastes contaminated primarily with cobalt-60 and molybdenum-99
- isotope usage wastes, which include general radioactive wastes contaminated primarily with cobalt-60 and molybdenum-99
- hot cell operations wastes, which include cleaning materials, contaminated air filters, contaminated equipment and discarded irradiated samples
- decontamination and decommissioning wastes, which include a variety of contaminated wastes with variable physical and chemical, as well as radiological properties
- remediation wastes, which include solidified waste arising from the treatment of contaminated soil and groundwater
- CRL and offsite miscellaneous wastes, which include radioactive wastes that do not readily fall within the other classes of wastes described above (e.g., wastes from radioisotope laboratories and workshops, and other materials such as contaminated soil)

Liquid wastes, such as scintillation cocktails, radiological-contaminated lubricating oils, wastes contaminated by polychlorinated biphenyl and isotope production wastes are also handled by the CRL waste management operations. Approximately 15 to 20 m³ of these types of waste are received into the WMAs per year, including wastes received from offsite waste generators, and are disposed of using commercial disposal services.

In addition, active aqueous wastes generated at the CRL site are treated at the Waste Treatment Centre. After treatment through a liquid waste evaporator, the treated effluent is released to the process sewer, which eventually discharges to the Ottawa River.

5.1.7.1.1 Waste Management Area A

The first emplacement of radioactive waste at the CRL site took place in 1946, into what is now referred to as WMA A. These emplacements took the form of direct disposal of solids and liquids into excavated sand trenches. The scale of operations was modest and unrecorded until 1952, when the cleanup from the NRX accident generated large quantities of radioactive waste (which included the NRX calandria) that had to be managed quickly and safely. At that time, approximately 4,500 m³ of aqueous waste, containing 330 TBq (9,000 Ci) of mixed fission products, was poured into excavated trenches. This action was followed by smaller dispersals (6.3 TBq and 34 TBq of mixed fission products) in 1954 and 1955, respectively. Waste is no longer accepted for emplacement in WMA A.

The two active liquid waste tanks in this area received bottled liquids and, based on recorded observations, it is assumed the bottles were intentionally broken at the time of emplacement. The active liquid disposal tank was estimated to have received about 3.7×10^{13} Bq of strontium-90 and about 100 grams of plutonium. The radioactive liquids inside the tanks were recovered in 2013 and sent to an offsite service provider for processing. Retrieval of liquids from these tanks minimizes the potential and consequence of contaminant release from the tanks.

WMA A is on the western flank of a sand ridge. Three aquifers have been identified in the vicinity of WMA A: lower sand, middle sand and upper sand (see figure 5.7). Groundwater flow is initially to the south. As the aquifer sands thicken, the flow direction bends to the south-southeast. The wastes are believed to be above the water table in WMA A, but infiltration has transported contaminants into the groundwater, which creates a contaminated plume with an area extent of 38,000 m². Groundwater monitoring data collected to date have encountered total beta (10 Bq/litre to 7,740 Bq/litre), gross alpha (0.13 Bq/litre to 2.5 Bq/litre) and strontium-90 (5 Bq/litre to 3,800 Bq/litre) in some of the sample wells. The groundwater plume is subject to periodic investigations to monitor migration of the plume and identify any deviations from expected conditions. Routine groundwater monitoring around the perimeter of WMA A (i.e., near the source of the plume) indicates stable or improving conditions, in that the contamination levels in the groundwater around the perimeter are generally either remaining at similar concentrations or gradually declining with time. Construction of a permeable reactive barrier, known as the South Swamp Groundwater Treatment System, at WMA A was completed in 2013. The treatment system is intended to intercept the strontium-90 plume emanating from WMA A via the upper sand aquifer that flows into South Swamp located in the vicinity of WMA A. Work related to the implementation of the South Swamp Groundwater Treatment System will continue in 2014.

5.1.7.1.2 Waste Management Area B

WMA B was established in 1953 to succeed WMA A as the site for solid waste management. The site is located on a sand-covered upland, approximately 750 metres west of WMA A (see figure 5.7). Early waste storage practices for LLW were the same as those used in WMA A – namely, emplacement in unlined trenches and capped with sandy fill, in what is now the northern portion of the site. Additionally, numerous special burials of components and materials occurred.

Asphalt-lined and capped trenches were used for solid ILW from 1955 to 1959, when they were superseded by concrete bunkers constructed below grade but above the water table in the site's sand. The use of sand trenches in WMA B for LLW was discontinued in 1963 in favour of concrete bunkers and WMA C.

Concrete structures were used to store solid waste packages that did not meet sand trench acceptance criteria, but did not require a significant amount of shielding either. Early concrete bunkers were rectangular. These were superseded in 1979 by cylindrical structures, which are still used.

Cylindrical bunkers are formed by using removable metal forms to create corrugated reinforced concrete walls on a concrete pad. The maximum volume of a cylindrical concrete bunker is 110 m³, but typical volumes of stored waste average about 60 m³.

High-level wastes are also stored in WMA B, in engineered facilities known as tile holes. Tile holes are used to store radioactive material that requires more shielding than can be provided in concrete bunkers. Stored materials include irradiated fuel, hot cell waste, experimental fuel bundles, unusable radioisotopes, spent resin columns, active exhaust system filters and fission product waste from the molybdenum-99 production process. A new tilehole array at WMA B was constructed in 2010 and made available for use in 2011.

There are several groundwater contaminant plumes extending from WMA B. One plume, on the east side, contains organic compounds (e.g., 1,1,1-trichloroethane, chloroform, trichloroethylene) that emanate from the unlined sand trenches at the north end of the site. Referred to as the “solvent plume”, this plume is subject to periodic investigations to monitor contaminant migration and identify any deviations from expected conditions. Routine groundwater monitoring around the northeast perimeter of WMA B (i.e., near the source of the plume) indicates stable conditions, in that the contamination levels in the groundwater at the perimeter remain at similar concentrations over time.

The second plume emanates from the northwest corner of the WMA B and is dominated by strontium-90. The source of this plume is the western section of the unlined sand trenches. Routine groundwater monitoring around the northwest perimeter of WMA B (i.e., near the source of the plume) indicates improving conditions, in that the contamination levels in the groundwater at the perimeter decrease over time. The effects of this contaminant migration are mitigated by a plume treatment system known as the

Spring B Treatment Plant. This automated treatment facility removes strontium-90 from surface water and groundwater, where the plume flow path discharges to the biosphere in a series of springs. This treatment system removes a significant fraction of the strontium-90 activity in the influent. In 2013, the Spring B Treatment Plant treated 1,308 m³ of groundwater, removing 1.60 GBq of strontium-90 and reducing input concentrations from 1,258 Bq/litre (average) to 2.0 Bq/litre (average). Since the Spring B Treatment Plant is close to the end of its design life, a conceptual design of a new treatment system was finalized in 2013.

Tritium is another contaminant observed in the groundwater at WMA B. Routine groundwater monitoring around the WMA indicates that the tritium contamination levels remain stable over time. A number of different types of waste storage structures within WMA B are considered the source of this contamination.

Figure 5.7: Waste Management Area B at the CRL site



5.1.7.1.3 Waste Management Area C

WMA C was established in 1963 to receive LLWs with hazardous half-lives less than 150 years, and wastes that could not be confirmed to be uncontaminated. Early operations consisted of emplacements in parallel trenches separated by intervening wedge-shaped stripes of undisturbed sand. In 1982, this system was changed to a “continuous trench” method to make more efficient use of the available space. In 1983, part of the original parallel trenches was covered with an impermeable membrane of high-density polyethylene.

The WMA C extension was constructed adjacent to the south end of WMA C in 1993 and began accepting wastes in 1995. As the continuous trench and/or its extension was backfilled and landscaped, material from the suspect soil stockpile was used for grading purposes to ensure that the surface of WMA C was suitable for travel by heavy equipment. Material placed in the soil stockpile satisfied specific acceptance criteria.

Besides the sand trench waste, inactive acid, solvent and organic liquid waste were also placed in specific sections of the trenches or in special pits located along the western edge of the area – although this practice was discontinued. Contaminated sewage sludge was also emplaced in the sand trenches until late 2004.

Since 2006, additional WMA C waste inventory, including sewage sludge, has been restricted to interim above-ground storage of sealed containers. The new Bulk Materials Landfill (BML) was completed in 2010, and the sewage sludge in containers on the surface of WMA C was transferred to WMA J in late 2010. In 2012 and 2013, materials stored on the surface of WMA C, namely the NRX stack pieces, were removed in preparation for installation of an engineered cover over WMA C. The NRX stack pieces were

re-packed in specially designed Pactec bags and transferred to WMA H for surface storage. In 2013, the engineered cover with geotextile and geomembrane layers was installed over WMA C to minimize the infiltration of atmospheric water into the stored waste.

Groundwater monitoring data at WMA C indicates that a plume is emanating from this area. The primary contaminant is tritium, although organic compounds are also observed at elevated concentrations in some boreholes. Routine groundwater monitoring around WMA C indicates that the tritium contamination levels have remained stable over time.

5.1.7.1.4 Waste Management Area D

WMA D was established in 1976 to store obsolete or surplus equipment and components – such as pipes, vessels and heat exchangers – that are known or suspected to be contaminated but do not require enclosure. Much of this legacy material has been removed, either returned to owners or dispositioned through offsite metal recycling in the last three years. The area also stores closed marine containers holding drums of contaminated oils and liquid scintillation cocktails. The bulk of these mixed and hazardous wastes have been disposed of through commercial service agreements or transferred to the Mixed Waste Storage Facility for short term storage also in WMA D, which was in place in 2011. The Mixed Waste Storage Facility is composed of three interconnected, engineered structures designed for the safe short-term storage and handling of mixed liquid waste (i.e., waste that is both chemically and radiologically hazardous). The structures have two storage rooms with proper leak containment and ventilation, as well as a sampling or bulking area with fumehoods, exhaust and leak containment capabilities.

The site consists of a fenced compound that encloses a gravel-surfaced area in which the components are placed. If the components have surface contamination, they must be packaged appropriately for the package to be free of surface contamination. The Low-Level Radioactive Waste Management Office (LLRWMO) occupies two buildings for the storage of historic low-level radioactive waste from non-AECL sites. All storage in WMA D is above ground. No burials are authorized in this area.

5.1.7.1.5 Waste Management Area E

WMA E is an area that received suspect and slightly contaminated soils and building materials, and other bulk soils and building debris from approximately 1977 to 1984. The waste materials were used to construct a roadway in WMA E, which was intended to become a WMA for suspect contaminated materials. This site was to be used in place of WMA C for this type of waste, but was not put into operation.

5.1.7.1.6 Waste Management Area F

WMA F was established in 1976 to accommodate contaminated soils and slag from Port Hope, Albion Hills and Ottawa – all located in Ontario. The stored materials are known to contain low levels of radium-226, uranium and arsenic. Emplacement was completed in 1979, and the site is now considered closed, although it is subject to monitoring and surveillance to assess possible migration of radioactive and chemical contaminants.

5.1.7.1.7 Waste Management Area G

WMA G was established in 1988 to store the entire inventory of spent fuel from the NPD prototype CANDU power reactor in above-ground concrete canisters. WMA G currently consists of 12 NPD fuel canisters, and 2 calcine waste canisters (CWC). There are 11 NPD canisters that are full, and one empty canister as a spare. The CWC were constructed for the anticipated waste that would be created by the processing of radioisotopes separated in the new Dedicated Isotope facility at CRL. However, both of the CWC are empty and in an extended shutdown state, as are other Dedicated Isotope Facility systems. There are currently no plans to construct more canisters.

5.1.7.1.8 Waste Management Area H

WMA H began operating in 2002. It is the location for the modular above-ground storage (MAGS) structures and the shielded modular above-ground storage (SMAGS) structures. Dry low-level wastes are packaged and, in some instances, compacted in steel containers prior to storage in MAGS (see figure 5.8) and SMAGS. In March 2014, the CNSC granted approval for the construction of six SMAGS structures at CRL. The first two of six SMAGS structures have been completed and are operational; construction of the third SMAGS is scheduled to commence in 2014. The remaining three SMAGS structures are planned to be built at intervals of three to four years. These structures will provide storage capacity for the next 20 to 30 years (see figure 5.8).

Figure 5.8: MAGS structure in Waste Management Area H



5.1.7.1.9 Waste Management Area J

Construction of the new BML located in WMA J at CRL was completed in 2010. The BML is designed for the long-term management of the dewatered sewage sludge produced at the sewage treatment plant at CRL. The facility consists of an engineered landfill lined with impermeable layers of geotextile and semi-permeable layers of clay. The leachate from the waste is collected and sent for further processing following analysis. Once all phases (a total of four) are complete, the BML will be able to accommodate 100 years of sewage sludge generated at CRL and will ensure proper long-term management of the waste in an environmentally responsible manner. Dewatered sewage sludge has been stored in roll-off containers in WMA C since 2004, and the contents of these containers were safely emplaced into the BML in late 2010.

5.1.7.1.10 Liquid dispersal area

Development of the liquid dispersal area commenced in 1953 when the first of several infiltration pits was established to receive active liquids via pipeline from the NRX rod bays. The pits are located on a small dune in an area bounded on the east and south by wetlands and by WMA A on the west.

Reactor Pit #1 was a natural closed depression used between 1953 and 1956 for radioactive aqueous solutions. Dispersals included an estimated 74 TBq of strontium-90, along with a wide variety of other fission products, and approximately 100 grams of plutonium (or other alpha emitters expressed as plutonium). Between 1956 and 1998, the pit was backfilled with solid materials that included contaminated equipment and vehicles previously stored in WMA A, plus potentially contaminated soils from excavations in the active area.

Reactor Pit #2 was established in 1956 to succeed Reactor Pit #1. A pipeline was used to transfer NRX rod bay water. Samples of water from the holding tank were analyzed for soluble and total alpha, soluble and total beta particles, strontium-90, tritium, cesium-137 and uranium.

The chemical pit was also established in 1956 to receive radioactive aqueous wastes from active laboratories on site (other than the reactors). Its construction is similar to that of Reactor Pit #2 – namely, an excavation backfilled with gravel and supplied by a pipeline.

The last facility in the liquid dispersal area is the Laundry Pit, which was installed in 1956. As its name implies, the Laundry Pit was used for waste water from the active area laundry and the decontamination centre, but it was only employed for that purpose for a year. The recorded inventory is 100 GBq of mixed fission products.

The liquid dispersal area has not been used since 2000, and there are no plans for future use of this area. Two groundwater plumes emanate from the liquid dispersal area, as would be expected for dispersal facilities. One plume from the reactor pits contains tritium as the only nuclide released in significant quantities. Routine groundwater monitoring around the reactor pits shows that the tritium contamination levels have significantly decreased since dispersal operations were halted. This groundwater monitoring shows the presence of other radiological contaminants but at low concentrations that are declining over time.

The second plume emanates from the chemical pit, with the contaminant of primary concern being strontium-90. Routine groundwater monitoring around the chemical pit indicates improving conditions – in that the contamination levels in the groundwater are decreasing. The effects of this contaminant migration are mitigated by a plume treatment system known as the chemical pit treatment plant. This facility removes a significant fraction of strontium-90 from groundwater collected from four collection wells that are spaced across the width of the plume near the pit. In 2013, the chemical pit treatment plant treated 2,550 m³ of groundwater, removing 2.1 GBq of strontium-90 and reducing input concentrations from 743 Bq/litre (average) to 3.5 Bq/litre (average). The current groundwater treatment facility has been operated close to 20 years and is approaching its design life. Thus, replacement of the current treatment system with a modern, more effective system is being planned. Options to construct a new treatment facility were evaluated and a conceptual design of the most favourable option was finalized in 2013.

5.1.7.1.11 Acid, chemical and solvent pits

Three small pits are located north of WMA C and are collectively known as the acid, chemical and solvent (ACS) pits. Constructed in 1982 and in operation until 1987, the pits were individually used for inactive ACS wastes. The acid pit received about 11,000 litres of liquid wastes (hydrochloric, sulphuric and nitric acids) and a small amount of solid wastes (potassium carbonate powder, acid batteries and citric acid). The solvent pit received approximately 5,000 litres of mixed solvents, oils, varsol and acetone, while the chemical pit received smaller volumes of wastes.

5.1.7.1.12 Waste Tank Farm

The Waste Tank Farm contains seven underground stainless steel tanks that store intermediate-level liquid radioactive waste. The first series of three tanks contains ion exchange regeneration solutions from fuel rod storage bays. One of the three tanks is empty and provides a transfer destination for the contents of either of the other two tanks should they develop a leak.

The second series of four tanks contains acid concentrate, mainly resulting from fuel reprocessing between 1949 and 1956. The last transfer of solutions to any of the storage tanks at the waste tank farm occurred in 1968; no solutions have been added since then. One of the four tanks is empty and serves as a backup in the event that one of the other tanks leaks. Recovery of liquid from a single lined tank commenced in 2012 and is slated for completion in 2014.

In 2012 AECL expedited the Tank 40D leak avoidance project to reduce the environmental risk of a leak in an aging storage structure. To date, AECL has removed 75 percent of the contents and processed this waste in the Waste Treatment Centre. Refer to section K.6.2.3 for more information.

5.1.7.1.13 Ammonium Nitrate Decomposition Plant

The Ammonium Nitrate Decomposition Plant was built in 1953 and was used to decompose the ammonium nitrate in liquid wastes from the fuel processing plant. The plant was shut down in 1954 following several leak events (releases) and was subsequently dismantled, with much of the equipment being buried *in situ*.

As would be expected for this type of facility, a contaminant plume emanates from the nitrate plant compound, with the contaminant of primary concern being strontium-90. Routine groundwater monitoring at the perimeter of the compound indicates stable conditions – in that contamination levels in the groundwater remain stable over time.

The effects of this contaminant migration are mitigated by a plume treatment system, known as the wall and curtain treatment system, which operates passively by using a clinoptilite zone installed in the ground next to an impermeable barrier that extends across the plume flow path. This passive treatment system removes a significant fraction of the strontium-90 activity in the influent. In 2013, the system prevented the discharge of 53.1 GBq of strontium-90 and reduced input concentrations from 2,590 Bq/litre (average) to less than 1 Bq/litre (average). Since 1998, the treatment system has prevented the discharge of 5.64×10^{11} Bq of strontium-90.

5.1.7.1.14 Thorium Nitrate Pit

In 1955, about 20 m³ of liquid waste from a uranium-233 extraction plant on the CRL site was discharged into a pit. The solution contained 200 kilograms of thorium nitrate, 4,600 kilograms of ammonium nitrate, 10 grams of uranium-233 and 1.85×10^{11} Bq each of strontium-90, cesium-137 and cerium-144. The pit was filled with lime to neutralize the acid and precipitate the thorium, and was then covered with soil.

5.1.7.1.15 Glass block experiments

In 1958, a set of 25 hemispheres of glass (weighing two kilograms each) of mixed fission products was buried below the water table as part of a program to investigate methods for converting high-level liquid radioactive solutions into a solid. A second set of 25 blocks of aged fission products was buried in 1960. The burials were designed to test how well the glassified wastes would retain the incorporated fission products if exposed to leaching in a natural groundwater environment. The glass blocks have since been recovered and transferred to secure storage in the WMAs.

5.1.7.1.16 Bulk storage area

The bulk storage area was used prior to 1973 to store large pieces of equipment from the control area. Significant cleanup of this area was completed, resulting in reduction of future liability. The cleanup of the area was completed in November 2013.

5.1.7.1.17 Emissions

The operation of the CRL WMAs results in the release of radioactive and non-radioactive contaminants into the environment. Most of the existing releases are historic. They resulted from discontinued practices such as dispersal of intermediate-level liquid waste and sand trench disposal of intermediate solid and liquid wastes. The releases contaminated onsite land, groundwater and surface water, and also resulted in offsite releases of contaminants to the Ottawa River.

The contaminant concentrations in offsite water bodies, however, are well below the standards set for both drinking water and the protection of aquatic life. DRLs have been established for airborne and liquid effluents released from the CRL site. CRL has developed administrative levels set at a fraction of the DRL and close to the normal operating levels. These administrative levels are used to provide timely warning that a higher than expected release has occurred and that the situation will be investigated promptly.

5.1.7.1.18 CRL Waste Treatment Centre

The CRL Waste Treatment Centre (WTC) treats wet solid wastes and liquid wastes from CRL facilities that are contaminated or suspected of being contaminated by radioactivity. The WTC also treats small volumes of liquid radioactive waste received by CRL from offsite waste generators.

The wet solid wastes are baled (after compacting, if possible) and transferred for storage in concrete bunkers in WMA B. Between 50 and 150 bales measuring 0.4 m³ are produced per year. In addition to those quantities, the WTC generates solid waste internally. This waste includes disposable clothing, paper and cleaning materials, and is compacted (where possible), baled and stored in WMA B bunkers. Liquid waste is treated in variable amounts per year, ranging from 1,500 m³ to 4,000 m³ per year. These wastes consist of primarily of liquid wastes from the decontamination centre, chemical active drain system and reactor active drain system. Smaller amounts of concentrated legacy stored liquid wastes originating from historical operations are pre-treated locally with ion exchange media to reduce radioactive content prior to final treatment in the WTC. Treatment facilities include a liquid waste evaporator, which concentrates the waste, and a liquid waste immobilization system, which immobilizes the concentrated liquid in a bitumen matrix in drums that are then stored in WMA B.

Atmospheric releases of radionuclides from the WTC occur via roof vents. Roof vents are monitored for particulate gross alpha activity, particulate gross beta activity, tritium oxide and iodine-131. Treated liquid effluent from the WTC is discharged to the process outfall after sampling for gross alpha, gross beta and tritium oxide. The liquid effluent is also regularly monitored for suspended solids, total phosphorus, nitrates, pH, conductivity, organic carbon, chemical oxygen demand, solvent extractable, metals, volatile organics and semi-volatiles.

5.1.7.1.19 Whiteshell Laboratories

Whiteshell Laboratories (WL) is a nuclear research and test establishment located in Manitoba on the east bank of the Winnipeg River, about 100 kilometres northeast of Winnipeg. Comprising a number of nuclear and non-nuclear facilities and activities, the major facilities on site include the Whiteshell Reactor-1 (WR-1), the shielded facilities, research laboratories, and liquid and solid radioactive WMAs and facilities, including the Concrete Canister Storage Facility (CCSF) complex for the dry storage of spent research reactor fuel. WL is currently undergoing decommissioning. Annex 7.1 provides further information on these decommissioning activities.

The one WMA is located approximately 1.5 kilometres northeast of the main WL site (2.7 kilometres by road). The area is approximately 148 by 312 metres, representing 4.6 hectares. The WMA, which has been in operation since 1963, provides storage for low- and intermediate- level radioactive wastes. The following facilities are located within the WMA:

- an incinerator for liquid organic waste
- LLW storage bunkers
- LLW unlined earth trenches
- LLW/ILW storage bunkers
- ILW in-ground concrete bunkers
- high-level radioactive waste (HLW)/ILW in-ground concrete standpipes (similar to the CRL tile holes described in section 5.1.7.1.2)

- liquid waste storage tanks

The CCSF, described in annex 4.5.14, is located next to the WMA.

The WL site is near the northeast boundary of the plains area of Manitoba. The WMA site is located about 10 metres above the normal Winnipeg River level, and is well above any recorded flood levels (river levels are also controlled by nearby hydroelectric dams). The Winnipeg River flows through an area underlain by granite and granitic gneisses of the Precambrian Shield. The area is the transitional zone between the coniferous forest of the Canadian Shield and the aspen parklands of the Prairies.

The WMA soil cover consists of 5.5 metres of highly plastic medium-brown clays above 4.6 metres of medium-plastic light-brown clay. The upper clay exhibits pronounced volume changes depending on moisture content and is susceptible to frost heave. Both clays are impermeable. A stable glacial till deposit underlies the entire area at a depth of approximately 10.5 metres. The glacial till is compact and has a high bearing strength. The granitic Lac du Bonnet batholith lies below the till at a depth of approximately 12 metres.

Hydrologically, the WMA is located in a groundwater discharge zone, which means that the groundwater flow is predominantly upward from the underground aquifer to the surface. The depth of WMA excavations is limited to ensure that the impermeable clay layers are not penetrated.

The incineration facility is used to incinerate waste laboratory solvents, and was formerly used to incinerate the organic coolant waste arising from the operation, shutdown and cleanup of the WR-1 reactor.

From 1963 to 1985, LLW was buried in unlined trenches approximately six metres wide by four metres deep, and with lengths up to 60 metres. Trenches were covered with at least 1.5 metres of excavated material after they were filled. There are 25 filled trenches located in the WMA. Trench storage of LLW was discontinued in 1985 in favour of engineered above-ground LLW storage bunkers. The LLW bunkers are constructed of concrete, with overall dimensions of 26.4 metres long by 6.6 metres wide by 5.2 metres high, with a wall thickness of 0.3 metres, which comes to a total of 805 m³ of storage space each. A SMAGS structure has been constructed (discussed in section 5.1.7.1.8) for the storage of future decommissioning LLW wastes.

In-ground or partially in-ground bunkers are used to store ILW wastes. Possessing a variety of dimensions, these bunkers are constructed of reinforced concrete, with a wall thickness of 0.25 metres. In-ground, concrete standpipes (similar to the CRL tile holes described in section 5.1.7.1.2) were used at WL from 1963 to the mid-1970s (when the use of above-ground concrete canisters commenced) to provide storage for HLW/ILW packages. The standpipes are constructed of reinforced concrete, 0.2 metres thick, with a 0.3-metre integral base lined with galvanized steel pipes. A removable concrete shielding plug, about 0.9 metres thick, provides access.

5.1.8 EnergySolutions Canada Corporation

EnergySolutions Canada (ESC), formally known as Monserco Limited, has been in operation since 1978 and manages the handling and processing of low-level radioactive material. At its Brampton, Ontario facility, ESC is contracted to collect low-level waste and slightly contaminated metals from power plants, hospitals, universities and research institutes. This waste consists mainly of personal protective equipment used in the refurbishment of the reactors. Additional LLW may arise from the decommissioning and dismantling of buildings or facilities where radioactive material has been handled or processed. Radioactive material can be sorted and/or repackaged at the Brampton facility and/or directly shipped to the United States for processing via incineration or recycling (metal melt). The resultant ash from incineration is returned to ESC. ESC then routes the ash to the appropriate Canadian waste management location for storage in a licensed and engineered facility. Contaminated metal is processed via a metal melt and is recycled within the nuclear industry, thereby eliminating long-term liability.

In order to support the CANDU tooling refurbishment, decontamination and waste management needs, ESC commissioned a 12,000 m² (130,000 ft²) licensed facility within Brampton, Ontario. Key services at the recently commissioned facility include:

- waste processing and transportation
- contaminated tooling/equipment inspection and decontamination
- monitoring and unconditional release
- temperature-controlled indoor storage
- radioactive sealed source servicing
- emergency response services

5.1.9 Cameco Blind River Refinery/Port Hope Conversion Facility/Port Hope Fuel Fabrication Facility waste and by-product management

Conserving resources and recycling of waste materials is an important part of operations – for both environmental and economic reasons. At the Cameco Blind River Refinery (see figure 5.9), nitrogen oxide air emissions are recovered and converted to nitric acid for reuse. At the Port Hope Conversion Facility, ongoing recycling programs include in-plant recovery of hydrofluoric acid from air emissions for recycling, and the creation and sale of an ammonium nitrate by-product for use as commercial fertilizer. At the Port Hope Fuel Fabrication Facility, scrap generated from fuel pellet manufacturing is recovered.

Figure 5.9: Cameco Blind River Refinery



There are several process streams in the refining and conversion processes that result in materials that contain economically attractive quantities of natural uranium. These recyclable products are suitable for use as alternate feed for uranium mills and are sent on for further processing to recover their uranium content.

The Blind River and Port Hope waste management programs collect, clean, monitor and, if necessary, cut to acceptable sizes all scrap material to the extent practicable before releasing it to commercial recycling agencies. Material that cannot be recycled, or does not meet strict release guidelines, is either compacted or incinerated to reduce volume, then drummed for storage on site or, in some instances, processed further and combined with the uranium-bearing recyclable products noted above. The stored non-recyclable material that cannot be cleaned is primarily insulation, sand, soil and some scrap metal. These materials will remain in storage until future recycling or disposal routes are identified.

Cameco was previously the licensee for the Welcome WMF and the Port Granby WMF. AECL became the licensee for these two large historic WMFs in the Port Hope area: the Welcome WMF in the Municipality of Port Hope in 2009 and the Port Granby WMF in the Municipality of Clarington in 2011. These facilities, which were established in 1948 and 1955, respectively, together contain roughly 900,000 m³ of LLW and contaminated soils. Both facilities have been closed to any additional waste emplacements for many years, pre-dating the formation of Cameco. The long-term management of these facilities will be addressed through the Port Hope Area Initiative. In addition, the Government of Canada has agreed to accommodate 150,000 m³ of wastes from the Cameco Port Hope Conversion Facility arising from early operations of that site, also within the framework of the PHAI. These wastes include drummed radioactive wastes, contaminated soils and decommissioning wastes. For further information in regards to the PHAI, refer to annex 8.2.1.1

Annex 6 – Uranium Mine and Mill Facilities

6.1 Background

Owned by Eldorado Gold Mines (a private company), the first radium mine in Canada began operating in 1933 at Port Radium in the Northwest Territories. Uranium ore concentrate was sent to Port Hope, Ontario, where radium was extracted. At that time, uranium had little or no commercial value, and the focus was on the ore's radium-226 content. The Port Radium Mine produced ore for radium until 1940 and reopened in 1942 to supply the demand for uranium from defence programs in the United Kingdom and the United States.

In 1943, Canada, the United Kingdom and the United States instituted a ban on private exploration and development of mines to extract radioactive materials. The Government of Canada also nationalized Eldorado Gold Mines in 1943 and established the federal Crown Corporation Eldorado Mining and Refining, which had a monopoly on all uranium prospecting and development. Canada subsequently lifted the ban on private exploration in 1948.

In 1949, Eldorado Mining and Refining began the development of a uranium mine in the Beaverlodge area of northern Saskatchewan and, in 1953, milling the ore onsite commenced. The Gunnar and Lorado uranium mines and mills began operating in the same area in 1955 and 1957, respectively. Several other small satellite mines also opened in the area in the 1950s, sending ore for processing to either Eldorado or the Lorado mills.

In Ontario, 15 uranium mines began production between 1955 and 1960 in the Elliot Lake and Bancroft areas. Ten of the production centres in the Elliot Lake area and three in the Bancroft area produced tailings. The last of these mines ceased operations and was decommissioned in the 1990s. (These former mining and milling sites are discussed in annex 8.)

At present, all active uranium mines are located in Saskatchewan. Uranium mining is ongoing at Rabbit Lake, McArthur River and Cigar Lake. Uranium mills and operational tailings management facilities (TMFs) exist at McClean Lake, Rabbit Lake and Key Lake. Non-operational tailings management areas (TMAs) in Saskatchewan are located at Rabbit Lake, Key Lake, Cluff Lake, Beaverlodge, Gunnar and Lorado. See figure B.3 for the locations of operating and inactive uranium mining and milling sites in Canada.

6.2 Province of Saskatchewan

Saskatchewan is the only province in Canada with operating uranium mines. In the past, mine and mill operators have requested harmonization in areas such as inspections and reporting requirements, involving the Saskatchewan Ministry of Environment, the Saskatchewan Ministry of Labour Relations and Workplace Safety, and the Canadian Nuclear Safety Commission (CNSC). An agreement currently exists between the CNSC and the Government of Saskatchewan to encourage greater administrative efficiency in regulating the uranium industry. The agreement lays the groundwork for the two groups to coordinate and harmonize their respective regulatory regimes.

6.3 Operational tailings and waste rock management strategy

6.3.1 Overview

About one-quarter of the world's primary uranium production comes from uranium deposits in the Athabasca Basin in northern Saskatchewan. These deposits include:

- the current production sites of Rabbit Lake, Key Lake and McArthur River
- the Cigar Lake mine site scheduled to begin production in 2014 with processing at the McClean Lake mill

The newer sites include the highest-grade uranium ore bodies in the world (at McArthur River and Cigar Lake), averaging about 20 percent uranium. Some of these ores in the Athabasca Basin have high nickel and arsenic content (up to five and one percent, respectively), which introduces additional considerations into the management of tailings and waste rock resulting from mining and milling these ores.

Past production centres, which are no longer actively producing uranium, include:

- the Uranium City district mines and mills of Gunnar, Lorado and Beaverlodge
- the decommissioned Cluff Lake site, where production was terminated at the end of 2002

6.3.2 Tailings management strategy

Mills with TMFs are located at Rabbit Lake, Key Lake and McClean Lake. There is no mill at the McArthur River mine, because the ore is transported to Key Lake for processing. Similarly, the ore from Cigar Lake is transported to McClean Lake for processing.

All three sites currently use the same basic approach: previously mined open pits have been converted to engineered disposal systems for tailings. Although there are certain differences in detail, two basic principles underlie the containment of the tailings and their potential radionuclide and heavy metal contaminants:

- **Hydraulic containment during the operational phase:** As a result of dewatering during mining, the water level in the pit at the start of tailings placement is well below the natural groundwater level in the area. This dewatering creates a cone of depression in the groundwater system, resulting in the natural flow being directed toward the pit from every direction. This hydraulic containment feature is maintained throughout the operational life of the tailings facility by maintaining the pit in a partially dewatered state. Since water has to be pumped continuously from the pit, current water treatment technology results in high-quality effluent suitable for discharge to surface water.
- **Passive long-term containment, using the hydraulic conductivity contrast between the tailings and their surrounding geologic materials:** Long-term environmental protection is achieved through control of the tailings' geochemical and geotechnical characteristics during tailings preparation and placement. This control creates future passive physical controls for groundwater movement in the system, which will exist after the decommissioning of operational facilities.

The tailings contain a significant fraction of fine-grained materials (e.g., chemical precipitates formed during the ore processing reactions). Tailings consolidation occurs during operation and will be completed during the initial decommissioning steps. The outcome is that the consolidated tailings have a very low hydraulic conductivity. When surrounded by a material with a much higher hydraulic conductivity, the natural groundwater path travels around the impermeable plug of tailings.

Potential contaminant transport from the tailings is controlled by diffusion from the outer surface of the tailings mass; this is a slow process, with minimal advective contaminant flux, and a consequently high level of groundwater protection. Potential contaminant transport is further minimized by the geochemical properties of the tailings. Reagents are added during tailings preparation to precipitate dissolved elements such as radium, nickel and arsenic to stable insoluble forms, which enables long-term concentrations in the tailings' pore water to remain low.

A constructed permeable zone around the tailings may be installed (in the form of sand and gravel) while the tailings are placed, as is done at Rabbit Lake. Alternatively, the permeable zone may exist naturally, as is the case at McClean Lake and Key Lake. This natural permeable zone allows for subaqueous placement of tailings, which has advantages in terms of radiation protection and prevention of ice formation with the

tailings mass. At McClean Lake, the sandstone formation surrounding the tailings has a hydraulic conductivity contrast of more than a factor of 100 relative to the tailings.

Extensive characterizations of the natural geologic formations and groundwater system, as well as the tailings' properties, are used to acquire reliable data for the computer models used to predict long-term environmental performance based on the fundamental principles governing the system. This performance will be confirmed during the life of the operation and through the post-decommissioning monitoring, which will be continued until stable conditions are achieved and for as long as desired thereafter.

Section 6.4 of this annex provides site-specific details for the Athabasca Basin tailings facilities. The development of these facilities began nearly 30 years ago, and their favourable operational experience and design evolutions – based on that experience – provide confidence in their performance, both now and in the future.

6.3.3 Waste rock management strategy

In addition to tailings from the milling process, uranium production results in large volumes of waste rock being removed before miners can access and mine the ore. The segregation of these materials according to their future management requirements is now a core management strategy. Material excavated from open pits is classified into three main categories: clean waste (both overburden and waste rock), special waste (containing sub-economic mineralization) and ore.

6.3.3.1 Clean waste

This term refers to waste materials that are benign with respect to future environmental impact and that can be disposed in surface stockpiles or used onsite for construction purposes. These different types of materials are described below:

- **Surficial soils with high organic content:** When practical depths are present, a thin layer of surface soil is stripped and separately stockpiled for replacement as the future surface soil layer during site reclamation activities.
- **Overburden soils:** A few metres of glacial till (typically around 10 metres) are present before the underlying sandstone rock is encountered. This material is either stockpiled separately for future use as fill during reclamation or used as the base for clean waste rock stockpiles.
- **Waste rock:** The Athabasca Basin is a sandstone basin that overlies the Precambrian Shield basement rock. The sandstone depth is shallow around the Basin perimeter, and increases to as much as 1,200 metres toward the centre of the Basin. Depths up to about 200 metres are practical for open-pit mining, so that the sites at and near the Basin perimeter primarily feature this mining method.
- **Large volumes (depending on the depth) of unmineralized sandstone:** This material is mined to reach the ore body and is stockpiled on the surface near the pit, and the stockpiles, minus whatever amount has been used for construction purposes, are subsequently reclaimed and vegetated.

6.3.3.2 Waste segregation

As mining approaches the ore body, a zone of altered (partially mineralized) rock is present. Both this halo of altered rock, and the basement rock below it, may contain small amounts of uneconomic uranium and/or various metals such as nickel or arsenic.

In some instances, because it contains sulphide, there is the potential for acidic leachate when the rock is exposed to moisture and oxygen from the atmosphere. This phenomenon of acid rock drainage (ARD) is common to many types of mining. Sophisticated methods are now available to segregate those amounts of

waste rock that represent a potential environmental risk – due to either ARD and/or dissolved contaminants in leachate – if left on the surface for the long term.

This material, referred to as “special waste”, is managed differently from the environmentally benign waste rock. The segregation methods include borehole logging, collection and analyses of borehole samples prior to mining and analyses of samples during mining. In addition to a retrospective laboratory analysis, qualified geological interpretation of the mining faces reinforced with real-time analyses made with an ore radiometric scanner are used to segregate each truckload – according to uranium content – as ore, special waste or waste rock, and direct it to the appropriate stockpile.

Since uranium ore deposits are in secular equilibrium with their progeny, good correlations can be made between radioactivity of the ore and its uranium content. The latest technical development is the application of a hand-held, portable scanner that uses x-ray fluorescence to perform field characterization for arsenic. This method has recently been tested at McClean Lake, and has since been incorporated into the mine site’s overall waste rock management strategy.

Volumes of waste rock are much smaller for underground mining, but the same general considerations apply. Clean waste materials are stockpiled and used for construction or reclamation purposes. Any surplus amounts can be stockpiled, and the stockpiles reclaimed and vegetated. Special waste is either used as aggregate and underground backfill, or is returned underground to other mined areas or transferred to sites with mills or mined-out open pits.

6.3.3.3 Special waste

As noted above, waste rock near ore bodies is potentially problematic. Because it has some halo mineralization around the ore deposit, it therefore potentially generates acid in some instances and/or becomes a source of contaminated leachates when exposed to an atmosphere containing oxygen. Disposal of this special waste in mined-out pits and flooding to cut off the oxygen supply from the atmosphere and stop oxidation reactions is now a widely recognized solution, provided that the pit is suitable for the long-term management of the risk. If not, engineered covers present an *in situ* solution to impede the interaction of oxygen and moisture with the special waste. As it is mined, the special waste is segregated and temporarily stored on the surface on lined pads, with drainage collection systems for collection and treatment of runoff water. After mining activities have ended, the special waste is backhauled into the mined-out pit (see figure 6.4). At a large pit with two or more zones, the direct transfer of special waste from the mining zone to a mined-out zone is practical. Typically, any waste material with uranium content greater than approximately 300 parts per million triuranium octoxide (U_3O_8) or 0.025 percent (250 parts per million) uranium is classed as special waste.

Similar to tailings facilities, extensive characterizations of natural geologic formations, groundwater system and waste rock properties are used to acquire reliable data for the computer models used to predict long-term performance. This performance is confirmed by post-decommissioning monitoring, which is continued until stable conditions are achieved and for as long as desired thereafter.

6.3.3.4 Ore

The cut-off grade that defines the threshold between ore to be processed through the mill and mineralized waste will vary depending on market conditions for uranium. Typically, cut-off grades are on the order of 0.1 percent for the Saskatchewan mines.

6.3.4 Waste water treatment and effluent discharge

All mine and mill facilities provide water treatment systems to manage contaminated water collected from their tailings disposal facilities, as well as water inflows collected during open-pit or underground mining and seepages from waste rock piles. The treatment processes vary from flow-through to batch discharge systems and largely rely on conventional physical settling and chemical precipitation methods found in the

general metal mining industry. Typically, these sites have a single point of final discharge into the receiving environment; however, the Key Lake operation has two treated water discharge points. Uranium mines and mills also treat for radionuclides. Specifically, focus is placed on treatment for radium-226, using barium chloride precipitation. In the case of Rabbit Lake, additional treatment has been incorporated to reduce uranium levels in effluent discharge. The quality of effluent is controlled by regulatory approved codes of practice, as well as by effluent quality regulation.

In northern Saskatchewan, effluent quality regulation ensures that Saskatchewan Surface Water Quality Objectives (SSWQO) are maintained in the receiving environment downstream of the operations. If the effluent is found acceptable (i.e., in compliance with regulatory limits), it is released to the environment. Otherwise, the effluent is recycled to the water treatment plants or mill for reprocessing. In 2013, the total volume of treated wastewater that met regulatory requirements and was subsequently discharged to the receiving environment was 13.829 million m³ from five active uranium mining and/or milling sites in northern Saskatchewan (refer to table 6.1).

Table 6.1: Active uranium mining/milling site waste water volumes

Active uranium mining and/or milling site in northern Saskatchewan	Total volume of waste water that met SSWQO requirements
AREVA – McClean Lake	1,515,057 m ³
Cameco – Rabbit Lake	4,252,361 m ³
Cameco – Cigar Lake	346,648 m ³
Cameco – McArthur River	2,267,301 m ³
Cameco – Key Lake (Horsefly Lake)	4,229,015 m ³
Cameco – Key Lake (Wolf Lake)	1,218,206 m ³
Total	13,828,588 m³

To reduce the impact of effluent discharges to the receiving environment, the uranium mining and milling facilities have developed ecological risk models to evaluate the impacts of treated effluent discharges. The prime concerns resulting from this work are chronic, not acute, and relate to control of metals, not radionuclides. The control of nickel and arsenic loading has been a core focus; however, more recently, attention has turned to molybdenum and selenium loadings. This broader spectrum of contaminants of concern has led to efforts to develop and install the next generation of treatment technology based on the use of membrane and/or chemical precipitation technologies.

6.4 Waste management facilities

6.4.1 Key Lake

6.4.1.1 Tailings management

The purpose of tailings management at Key Lake is to isolate and store the waste residue from the milling process so that the public and the environment are protected from any future impact. Conceptually, this effort involves containing the solids and treating the water to quality standards acceptable for release to the environment. The waste metal precipitates removed during water treatment are disposed of as solids in the TMF.

From 1983 to 1996, waste from the Key Lake mill was deposited in an above-ground TMF (AGTMF) that covered an area 600 metres by 600 metres (36 hectares) and 15 metres deep. The TMF was constructed five metres above the groundwater table, using engineered dikes for perimeter containment and a modified bentonite liner to seal the bottom and isolate the tailings from the surrounding soil infrastructure.

Since 1996, the mined-out Deilmann open pit has been used as the TMF. Commissioned in January 1996, it is used to store tailings produced by milling a blend of McArthur River ore and special waste from McArthur River and Key Lake. The TMF has a bottom drainage layer constructed on top of the basement rock at the bottom of the mined-out pit. Tailings are deposited on top of this drainage layer, and water is continually pumped out to promote solids consolidation of overlying tailings.

Tailings were initially deposited into the pit by sub-aerial deposition, with the water being extracted from the tailings mass through the bottom drain layer and the raise well pumping system. The facility was later changed to sub-aqueous deposition by allowing the pit to partially flood.

Through the use of a tremie pipe system, tailings are deposited under the water cover, providing benefits in terms of placement and attenuation of radon emissions. In this system, tailings are placed in the mined-out pit by using what is termed “a natural surround” containment strategy. Tailings and residual water on the surface are removed during tailings placement, both by the drainage blanket and by surrounding groundwater wells. The residual water extracted from the tailings mass is collected for treatment. The consolidated tailings form a low-permeability mass relative to the higher-permeability area surrounding the tailings.

After decommissioning, groundwater will follow the path of least resistance (i.e., around the tailings rather than through them), which minimizes environmental impacts. At the end of 2013, the Deilmann TMF (see figure 6.1) contained 5.214 million tonnes (dry weight) of tailings.

Figure 6.1: Deilmann Tailings Management Facility at Key Lake



6.4.1.2 Waste rock management

Waste rock management facilities include two special waste storage facilities and three waste rock storage areas. The waste rock disposal areas comprise primarily benign rock and, therefore, do not have containment or seepage collection systems. The special waste contains low (uneconomic) levels of uranium and other potential contaminants, so this material is contained in engineered facilities that consist of underliners and seepage collection systems. Material from the special waste areas is being reclaimed for blending with high-grade McArthur River ore for the Key Lake mill feed. All other waste rock areas are inactive.

To reduce the decommissioning liability associated with the Deilmann North waste rock pile, approximately 1.3 million m³ of nickel-rich waste rock were excavated and disposed of in the Gaertner pit.

6.4.1.3 Contaminated industrial wastes

Contaminated industrial wastes are either recycled or landfilled in the AGTMF. Leachates from these materials are collected by the AGTMF's seepage collection system and returned to the mill for process make-up water or treated and released to the environment. It is estimated that 11,755 m³ of uncompacted waste were placed at this site in 2013.

6.4.2 Rabbit Lake

6.4.2.1 Tailings management

The Rabbit Lake above-ground tailings management facility (RLAGTMF) is about 53 hectares in area and contains approximately 6.5 million tonnes of tailings, which were deposited between 1975 and 1985. These tailings were all derived from the processing of the original Rabbit Lake ore deposit. The tailings within the AGTMF are confined by earth-filled dams at the north and south ends, and by natural bedrock ridges along the east and west sides. The AGTMF is currently undergoing long-term stabilization and progressive reclamation.

The original Rabbit Lake open-pit mine was converted to a TMF in 1986 by using pervious surround technology. Since its commissioning, the Rabbit Lake in-pit tailings management facility (RLITMF) has been used as a tailings repository for ore from the Rabbit Lake, B-zone, D-zone, A-zone and Eagle Point mines (see figures 6.2(a) and (b)). At the end of 2013, the RLITMF contained 8.309 million tonnes (dry weight) of tailings.

The pervious surround, consisting of sand and crushed rock, is placed on the pit floor and walls in advance of the tailings deposition. The pervious material allows drainage of the excess water contained in the tailings to an internal seepage collection system, and also allows the water contained in the surrounding host rock to be collected, which maintains a hydraulic gradient toward the facility during operations. The collected water is treated prior to its release into the environment. Upon final decommissioning and return to normal hydro-geologic conditions, groundwater will flow preferentially through the pervious surround rather than through the low permeability tailings. Discharge of contaminants will be limited to diffusion across the tailings/pervious surround interface.

Figure 6.2(a): Rabbit Lake in-pit tailings management facility



Figure 6.2(b): Rabbit Lake in-pit tailings management facility



6.4.2.2 Waste rock management

The Rabbit Lake site contains a number of clean and mineralized stockpiles of waste rock, produced over the course of mining various local deposits since 1974. Some of the waste rock has been used for construction material. For example, waste rock was used to construct the road and pervious surround for the RLITMF. Eagle Point special waste is stockpiled on a lined storage pad until it is returned underground as backfill. Some waste rock piles were used as backfill and cover material in their respective pits. One rock pile, consisting primarily of Rabbit Lake sediments, has been contoured and vegetated.

Current projections are that no waste rock will remain on the surface at Eagle Point after the mining and backfilling of mined-out stopes is complete. The A-zone (28,307 m³ of clean waste) and D-zone (200,000 m³ of primarily lake-bottom sediments) waste rock piles have been flattened, contoured and vegetated. The B-zone waste pile contains an estimated 5.6 million m³ of waste material stored on a pile covering an area of 25 hectares. The B-zone pile was contoured and reclaimed through installation of an engineered cover followed by a 1-metre till cover complete with vegetation and drainage channels to promote controlled

runoff. All the special waste from the A-zone (69,749 m³), B-zone (100,000 m³) and D-zone (131,000 m³) open-pit mines was returned to the pits and covered with layers of waste rock and/or clean till before the mined-out pits were allowed to flood.

There are approximately 6.7 million m³ of predominantly sandstone waste rock, with some basement rock and overburden tills, stored on the West #5 waste rock pile adjacent to the RLITMF. Mineralized waste is stored on four piles (1.8 million m³) adjacent to the Rabbit Lake mill. Runoff and seepage from these areas are collected in the RLITMF.

6.4.2.3 Contaminated industrial wastes

Radioactive and other contaminated materials from the Eagle Point mine and Rabbit Lake mill are disposed of in the contaminated landfill site located on the west side of the RLAGTMF. It is estimated that 5,800 m³ of uncompacted waste were placed at this site in 2013.

6.4.3 McClean Lake

6.4.3.1 Tailings management

McClean Lake was the first new uranium mill built in North America over a 15-year period of inactivity. The mill and TMF are state-of-the-art efforts in worker and environmental protection for processing high-grade uranium ore. Open-pit mining of the initial ore body (John Everett Bates, or JEB) began in 1995. After the ore was removed and stockpiled, the pit was developed as a TMF (see figures 6.3(a) and (b)). The design of the TMF has been optimized for performance, both during operation and for the long term, by employing key features such as:

- production of thickened tailings within the mill process (addition of lime, barium chloride and ferric sulphate) to remove potential environmental contaminants from the solution and yield geotechnically and geochemically stable tailings
- transport of the tailings from the mill to the TMF through a continuously monitored pipe-in-pipe containment system
- final sub-aqueous tailings placement within the mined-out JEB pit for long-term, secure containment in a belowground facility
- use of natural surround as the optimum approach for long-term groundwater diversion around the consolidated tailings plug
- subaqueous tremie placement, from a floating barge, of the thickened tailings below a water cover in the pit; this method minimizes segregation of fine and coarse material, prevents the freezing of the tailings and enhances radiation protection due to the attenuation of radon emissions by the water cover
- use of dewatering wells around the entire pit perimeter to minimize clean groundwater inflow while maintaining hydraulic containment during operations – that is, the water levels are maintained such that groundwater flow is toward the pit
- a bottom filter drain feeding a dewatering drift and raise wells to allow collection and treatment of discharged pore water during tailings consolidation
- recycling of pit water by a floating barge and a pipe-in-pipe handling system
- complete backfilling of the pit upon decommissioning with clean waste rock and a till cap

At the end of 2013, the JEB TMF contained 1.829 million tonnes (dry weight) of tailings.

Figure 6.3(a): JEB Tailings Management Facility at McClean Lake



Figure 6.3(b): JEB Tailings Management Facility at McClean Lake



6.4.3.2 Waste rock management

Open-pit mining at McClean Lake has progressed from one pit to the next, and has included the JEB, Sue C, Sue A, Sue E and Sue B pits (see figures 6.4(a) and (b)). The Sue B pit was the most recent open pit, and mining was completed on November 26, 2008). Since the completion of Sue B, open-pit mining has not occurred at McClean Lake.

Figure 6.4(a): Sue mining area at McClean Lake

The majority of the wastes removed from the JEB and Sue C open pits were overburden material or sandstone. The overburden and clean waste rock stockpiles are located near the pits. The pad for the waste rock stockpile has been constructed using overburden. Special waste from the Sue C and JEB pits was stockpiled during mining and was subsequently backhauled into the Sue C pit upon completion of mining.

Figure 6.4(b): Sue mining area at McClean Lake

All wastes (exclusive of the overburden) from the Sue A pit were also deposited into the mined-out Sue C pit. This approach was conservative, due to the uncertainty regarding segregating special waste based on its arsenic content. Waste rock is segregated into clean and special waste based on acid-generating potential (using a simple laboratory test), radiological content (using the ore scanner) and a key non-radiological contaminant (arsenic, using an x-ray fluorescence scanner that was successfully tested during Sue A mining and subsequently implemented into segregation procedures). Special waste from Sue E was also placed in the mined-out Sue C pit, while clean waste was placed in a separate Sue E waste rock stockpile.

All material removed from the Sue B pit was classified as special waste and placed in the mined-out Sue E pit below an elevation of 400 metres above sea level. The total waste rock inventory at McClean Lake at the end of 2013 was 51.7 million tonnes of clean material (primarily waste rock) and 10.2 million tonnes of mineralized waste rock (special waste).

6.4.3.3 Contaminated industrial wastes

Chemically or radiologically contaminated waste materials originate from the mining, milling and water treatment areas of the McClean Lake operation. All the contaminated material is collected in yellow dumpsters, distributed around the site and deposited in the landfill for chemically and radiologically contaminated materials at the perimeter of the TMF. This landfill is within the hydraulic containment area of the JEB TMF. During final site decommissioning, these materials will be excavated and deposited in the JEB TMF. The existing contaminated waste temporary landfill was expanded in September 2008. This extension encompassed an area of approximately 2,089 m³. The area averaged three metres in depth, providing an additional 6,267 m³ of storage space. From the end of 2010 to the end of 2013, approximately 1,535 m³ of waste was placed in the landfill.

6.4.4 Cigar Lake

6.4.4.1 Tailings management

Cigar Lake does not have a mill and does not produce tailings. Cigar Lake ore will be processed at the McClean Lake mill.

6.4.4.2 Waste rock management

There are five waste rock storage pads in operation at Cigar Lake. The current inventories result from test mining and mine construction activities conducted at the site. The waste rock is classified as either clean waste rock, potentially acid-generating waste rock or mineralized waste rock. Potentially acid-generating and mineralized waste rock is temporarily stored on engineered lined containment storage pads. Leachate from these pads is contained and collected for treatment in the mine water treatment plant. When possible, clean or benign waste rock is used as fill or construction material onsite. While some potentially acid-reactive waste rock may be used as backfill in the mine, the majority of this material is expected to be eventually transported to the McClean Lake mine site for disposal in a mined-out pit.

6.4.4.3 Contaminated industrial wastes

These materials are stored on stockpile B, one of the stockpiles used to store potentially acid reactive waste rock, described in section 6.4.4.2, at Cigar Lake. Contaminated industrial wastes will ultimately be disposed of underground during backfilling of exhausted mine chambers and drifts. It is estimated that 413 m³ of uncompacted waste were placed on the stockpile in 2013.

6.4.5 McArthur River

6.4.5.1 Tailings management

McArthur River does not have a mill and does not produce tailings.

6.4.5.2 Waste rock management

The McArthur River operation generates waste rock from production mining, development mining and exploration drilling. The waste rock is classified as either clean waste rock, potentially acid-generating waste rock or mineralized waste rock. The potentially acid-generating and mineralized waste rock is temporarily stored on engineered lined containment storage pads. Leachate from these pads is contained

and pumped to effluent treatment facilities. The segregated clean waste rock is disposed of on a pile that does not include the leachate containment and control systems.

The mineralized waste rock is shipped to the Key Lake operation and used as blend material for the ore feed to the Key Lake mill. The potentially acid-generating waste is crushed and screened, and the coarse material is used as aggregate for underground concrete backfilling operations. The clean waste is used for general road maintenance, both onsite and on the haul road between McArthur River and Key Lake.

6.4.5.3 Contaminated industrial wastes

A transfer area, located adjacent to the mine headframe, is used to sort and temporarily store contaminated material. The contaminated material is shipped to the Key Lake operation, where it is disposed of in the AGTMF.

Annex 7 – Decommissioning Activities

7.1 AECL Whiteshell Laboratories

7.1.1 Background

Whiteshell Laboratories (WL) has provided research facilities for the Canadian nuclear sector since the early 1960s. In 1997, Atomic Energy of Canada Limited (AECL) decided to discontinue research programs and operations at the facility, and the Government of Canada concurred with the decision in 1998. In 1999, AECL began to prepare plans for the safe and effective decommissioning of the WL.

The WL is a nuclear research and test establishment located in Manitoba (see figure 7.1) on the east bank of the Winnipeg River about 100 kilometres northeast of Winnipeg, about 10 kilometres west of Pinawa and nine kilometres upstream from Lac du Bonnet. The major structures located on the site include the Whiteshell Reactor-1 (WR-1) reactor, the shielded facilities, research laboratories and liquid and solid radioactive waste management areas (WMAs) and facilities, including the Concrete Canister Storage Facility (CCSF) for the dry storage of spent research reactor fuel.

The WL is currently licensed under a nuclear research and test establishment decommissioning licence, in place since December 31, 2002. This licence authorized AECL to operate and undertake decommissioning activities at the facility until December 31, 2008. The Commission renewed the decommissioning licence until December 31, 2018.

During the initial six-year period of the decommissioning licence (2002–2008), the decommissioning activities focused on the shutdown and decontamination of nuclear and radioisotope laboratory buildings and facilities. Also during this period, two nuclear facilities, the Van de Graaff Accelerator and the Neutron Generator, were completely decommissioned.

Major activities completed since the Fourth National Report include final preparations to demolish the principal radioisotope laboratory building, further development of plans and benchmarking of different methodologies and costs for the standpipe remediation in the WMA. Major activities planned for the balance of the current licensing period (until December 31, 2018) include the demolition of the radioisotope laboratory building stages 4 and 7, the start of decommissioning of the WR-1 reactor and the re-establishment of the functions of the existing site liquid-waste treatment, active laundry and decontamination facilities into updated facilities; decommissioning of their existing buildings will follow. Also included is remediation and expansion of waste storage facilities in the WMA, reconfiguration of the site infrastructure service systems, completion of the pre-project standpipe work to define the preferred remediation option and demolition of redundant non-nuclear service buildings. Activities planned for subsequent licensing periods include the final decommissioning of the WR-1 reactor, WMA storage structures, the shielded facilities and the enabling facilities.

Figure 7.1: Aerial view of WL main site (2010)



7.1.2 Underground Research Laboratory

The Underground Research Laboratory (URL), located approximately 15 kilometres northeast of AECL's WL in Manitoba, was an underground experimental facility used for research into controlled blasting techniques, rock mechanics and hydrological studies associated with potential deep underground disposal of spent fuel and the behaviour of various materials under the conditions of storage in deep-rock formations. No spent fuel or high-level radioactive materials were ever placed in the URL.

Two underground radioisotope laboratories (using low levels of tracer isotopes) were licensed by the Canadian Nuclear Safety Commission (CNSC) under its *Nuclear Substances and Radiation Devices Regulations*. These laboratories were closed and decontaminated several years ago. CNSC staff confirmed this during an inspection conducted prior to the revocation of the CNSC's operating licence in 2003. The URL, therefore, no longer contains CNSC-licensed laboratories and requires no further radiological decommissioning. The present URL Closure Project is much more closely related to a mine shutdown than a nuclear decommissioning project, and is following the requirements of Manitoba's *Mines and Minerals Act* and related regulations. Placement of the concrete bulkheads on the URL shaft and ventilation raise surface openings during October 2010 safely concluded the underground portion of work in the URL Closure Project and achieved the URL safe sustainable closure state. The primary requirement for achieving this state was the sealing of selected boreholes, ventilation raise and main shaft. Final URL site closure will follow a minimum three-year period of site environmental and post-closure borehole hydraulic and geochemical monitoring. As the monitoring period comes to an end, preparations are underway to seal the 22 post-closure boreholes and to pursue reuse or removal of the URL surface facilities. At that point, provincial regulatory approval will be secured in order for AECL to transfer the leased lands to the Province of Manitoba.

7.2 AECL Gentilly-1 Waste Management Facility

The Gentilly-1 Waste Management Facility (WMF) consists of a permanently shut down, partially decommissioned prototype reactor and associated structures and ancillaries. This facility is presently in the long-term storage-with-surveillance phase of a deferred decommissioning program. Located on the south bank of the St. Lawrence River about 15 kilometres east of Trois-Rivières, Quebec, the Gentilly complex accommodates both the Gentilly-1 WMF and the Gentilly-2 nuclear power plant, a CANDU 600-megawatt unit.

The Gentilly-1 Nuclear Generating Station consists of a CANDU-BLW-250 reactor and was put into service in May 1972. It attained full power for two short periods in 1972 and operated intermittently for a total of 183 effective full-power days until 1978, when it was determined that certain modifications and considerable repairs would be required. The station was put into a layup state in 1980, and the decision not to rehabilitate the station was made in 1982.

The main components of the Gentilly-1 Nuclear Generating Station were the reactor core, heat transport system, turbines and shielding. The reactor was heavy-water moderated, cooled by light water and fuelled with natural uranium in the form of zircaloy-clad uranium dioxide pellets. The reactor vessel was a vertical cylinder that contained a heavy-water moderator and was traversed by 308 pressure tubes and surrounding calandria tubes. The heat produced by the reactor fuel (mostly by boiling) was removed by the light-water coolant and then pumped through inlet and outlet headers and feeder pipes in a closed circuit. The steam generated by the reactor core was separated from the liquid coolant in the steam drum before being delivered to the turbine generator.

The decision to permanently shut down the reactor was made in 1984. A two-year decommissioning program began in April of that year to bring the Gentilly-1 Nuclear Generating Station to an interim safe and sustainable shutdown state that is equivalent to storage with surveillance. The moderator (heavy water) was drained and shipped to other operating sites. Non-radioactive hazardous materials, such as combustible and flammable materials, laboratory supplies and oils, were identified and removed. The transfer of spent fuel from wet storage in the reactor pool to dry storage in the purpose-built canister storage area was completed in 1986. Major and minor decontamination activities (disassembly, decontamination and

consolidation) were completed as required. All major radioactive or radioactively contaminated components not shipped to other licensed facilities were consolidated onsite in either the reactor building or turbine building. Areas that possess significant residual contamination or radioactive materials have been reduced to a few locations. Radiological surveys were performed at the completion of each decommissioning activity.

A three-phase approach has been established for reactor decommissioning. Phase 1 brings the facility to a safe, sustainable shutdown state. Phase 2 is a period greater than 30 years of storage-with-surveillance. Final decommissioning, approximately 10 years, occurs in Phase 3. The Gentilly-1WMF has completed Phase 1 and is currently in Phase 2.

7.3 AECL Douglas Point Waste Management Facility

The Douglas Point Waste Management Facility (DPWMF) is located at the site of the former Douglas Point Nuclear Generating Station (DPNGS) situated on the Bruce nuclear site. The DPNGS, which consists of a 200-megawatt CANDU reactor, was put into service in 1968. It was owned by AECL and operated by Ontario Hydro (now Ontario Power Generation, or OPG) until 1984. During this operational period, the station generated 17×10^9 kilowatt hours of electricity and attained a capacity of 87.3 percent.

The main components of the DPNGS were the reactor, heat transport system, turbines and power-generating equipment. The reactor was heavy-water moderated, cooled by pressurized heavy water and fuelled with natural uranium. The reactor core contained 306 horizontal fuel-containing pressure tubes and was surrounded by the heavy-water moderator. The heat transport system pumps circulated the pressurized heavy water through the reactor coolant tubes to eight boilers, where the heat was transferred to the boiler steam and water system. The reactor primarily used heavy concrete, steel and water as shielding to protect the surrounding area from radiation during operation. Steam generated in the boilers was transferred to the turbine for power generation.

The DPNGS was permanently shut down on May 5, 1984 and placed in an interim safe and sustainable shutdown state. This interim state is referred to as the storage-with-surveillance state. The DPNGS then became the DPWMF.

Following the shutdown of the reactor, the primary heat transport and moderator medium (heavy water) was drained and shipped to other operating sites. The booster rods were removed and shipped to Chalk River Laboratories (CRL) for storage in February 1985. Non-radioactive hazardous materials, such as combustible and flammable materials, laboratory supplies and oils, were identified and removed. The transfer of spent fuel from wet storage in the reactor pool to a dedicated dry storage facility was completed in 1987. Major and minor decontamination activities (disassembly, decontamination and consolidation) were completed as required. All major radioactive or radioactively contaminated components that were not shipped to other facilities licensed to receive them were consolidated onsite. Areas that possessed significant residual contamination or radioactive materials were reduced to a few locations, and radiological surveys were performed at the completion of each decommissioning activity.

The DPWMF is presently in the storage-with-surveillance phase of a deferred decommissioning program. For decommissioning purposes, the DPWMF is divided into three planning envelopes. Envelope A consists primarily of nominally uncontaminated buildings and structures, which may be decommissioned at any time, with health, safety and environmental concerns taken into account. Envelope B consists primarily of contaminated buildings, which will be decommissioned after allowing for a period of radioactive decay and after long-term WMFs become available. Envelope C includes the spent fuel canister area.

A three-phase approach has been established for reactor decommissioning. Phase 1 brings the facility to a safe, sustainable shutdown state. Phase 2 is a period, between 50 and 60 years, of storage-with-surveillance. Final decommissioning, approximately 10 years, occurs in Phase 3. The DPWMF has completed Phase 1 and is currently in Phase 2.

7.4 AECL Nuclear Power Demonstration Waste Management Facility

The Nuclear Power Demonstration Waste Management Facility (NPDWMF) consists of a permanently shut down, partially decommissioned demonstration CANDU reactor and associated structures and ancillaries. The facility, which is currently in the interim storage-with-surveillance phase of a deferred decommissioning program, is located on the west bank of the Ottawa River in Ontario, some 25 kilometres upstream from the AECL CRL and 15 kilometres from the town of Deep River. The NPD nuclear generating station (NGS), consisting of a 20-megawatt CANDU pressurized-water reactor, was placed in service in October 1962 and operated by Ontario Hydro until May 1987. In 1988, operating and compliance responsibilities were transferred from Ontario Hydro to AECL, and the facility became the NPDWMF.

The facility produced electrical power for the Ontario Hydro grid, trained people for the commercial nuclear power plants of Ontario Hydro and performed experiments in process systems concepts to be incorporated in the design of the commercial nuclear power plants. During this operations period, the station generated 3×10^9 kilowatt hours of electricity at a net electrical capacity factor of 65 percent.

The main components of the NPD NGS were the reactor, heat transport system, turbine and electrical power generator equipment. The reactor was heavy-water moderated, cooled by pressurized heavy water and fuelled with natural uranium. The reactor core contained 132 horizontal fuel-containing pressure tubes and was surrounded by a heavy-water moderator. The heat transport system pumps circulated the hot pressurized heavy water through the reactor coolant tubes to a heat exchanger/boiler unit, where the heat was transferred to the boiler steam and water system. The reactor, boiler and auxiliary systems were installed below ground and were surrounded by concrete shielding to protect the surrounding accessible areas from radiation during operation. Steam generated in the boilers was transferred to the turbine/generator for electrical power generation.

The NPD NGS was permanently shut down on May 24, 1987 and placed into an interim safe and sustainable shutdown phase. This interim storage period is referred to as the storage-with-surveillance phase. Following the shutdown of the reactor, the heavy water from the primary heat transport and moderator systems was drained and shipped offsite. The reactor was defuelled and the fuel bundles were transferred to CRL for storage. Demineralizer system equipment was removed from the various nuclear process systems and transferred to CRL. Major and minor decontamination activities were completed as required. The facility was functionally divided into nuclear and non-nuclear areas, with any equipment or structures either radioactive or radioactively contaminated confined to the nuclear area. All cross connections between the two areas were blocked off, sealed or permanently locked.

A three-phase approach has been established for reactor decommissioning. Phase 1 brings the facility to a safe, sustainable shutdown state. Phase 2 is a period, greater than 30 years, of storage with surveillance. Final decommissioning, approximately seven years, occurs in Phase 3. The NPDWMF has completed Phase 1 and is currently in Phase 2.

7.5 AECL Chalk River Laboratories decommissioning activities

7.5.1 Pool Test Reactor

The Pool Test Reactor (PTR) was a type of reactor with fuel elements suspended in a pool of water that served as the reflector, moderator and coolant. It was a low-power research reactor (less than 100 watts), designed and built to conduct reactivity studies on irradiated fuel samples and to determine the cross-section of fission products. PTR usage then shifted to testing and calibration of self-powered flux detectors on a commercial basis.

The PTR began operating in 1957 and was permanently shut down in 1990. The fuel was removed and placed in a tile hole at the CRL site. Since then, the PTR has been monitored and kept under surveillance, and is currently in a safe shutdown state. The decommissioning objective is to return the area to the site landlord for use as general active laboratory space at CRL.

The PTR consists of a pool that is approximately 4.5 m² and six metres deep, and contains about 125,000 litres of water. Specific decommissioning activities undertaken with regard to the PTR include:

- removing the PTR equipment: aluminum-graphite reflectors, fission chamber, core plate and support, oscillator mechanism, core tube support brackets, control rod drive system and control rod support
- draining and drying the pool
- removing the deionized water supply and purification system from the pool
- removing all electrical components associated with the facility, including meters, switches and panels, with wiring to be removed to clear termination points
- removing all signs and fixtures associated with the facility from walls, floor and ceiling
- segregating and transferring all waste generated by the decommissioning project to WMAs for storage and disposal as appropriate

The detailed decommissioning plan (DDP) was prepared and submitted to the CNSC for approval. Decommissioning activities began upon receipt of CNSC approval and were completed in 2012. AECL completed the end-state report and successfully removed the PTR facility from regulatory control.

7.5.2 Plutonium Recovery Laboratory

The Plutonium Recovery Laboratory was constructed in 1947 and was in operation from 1949 to 1957. During that period, it was designed to extract plutonium isotopes from enriched fuels used in research reactors. Following shutdown in 1957, the majority of the processing equipment was flushed, decontaminated and removed. The only process systems remaining are the fuel dissolver tanks, rod lifting mechanisms and basement sumps.

This facility has a footprint of about 514 m². Actual decommissioning activities are expected to be initiated in the next three years, after regulatory approval to decommission has been received. Decommissioning is to be carried out in three phases.

- Phase 1, carried out over a three-year period, brings the facility to a safe sustainable shutdown state, suitable for an ensuing period of storage with surveillance.
- Phase 2 is the storage-with-surveillance period.
- Phase 3 is the removal of the facility through a series of decommissioning work packages and achievement of the final end state.

The Plutonium Recovery Laboratory decommissioning is currently in Phase 2, and AECL is currently finalizing the DDP to support the decommissioning application to the CNSC.

7.5.3 Plutonium tower

The plutonium tower was used to develop means to extract plutonium from fuel rods irradiated in the National Research Experimental (NRX) reactor and was operated for a few years in the late 1940s. The building was permanently shut down in 1954. All process equipment was removed from the building, and an initial cleanup was carried out. Further decontamination and dismantling was carried out in the 1980s.

The plutonium tower building is 19.2 metres high and has a footprint of about 28 m². All process equipment was removed from this building. Future decommissioning activities will include:

- a confirmatory radiological survey of the concrete tower interior, annexes and underground pipe chase to update the hazard status

- isolation of process and service lines entering the building from neighbouring interconnected buildings
- demolition of the annexes, concrete tower, building structure and footings/foundations
- segregation and transfer of solid wastes to appropriate WMFs at the CRL site
- removal of contaminated soil and backfilling the area, as required

A DDP has been prepared and regulatory approval has been granted. Decommissioning work will begin with the removal of the plutonium tower wooden annexes, which is expected to take approximately one year. Removal of the wooden annexes will reduce fire hazard on the CRL site. The concrete tower will be decommissioned at a later date.

During the reporting period, AECL submitted an application to the CNSC for the approval to decommission the plutonium recovery laboratory. CNSC staff are currently undertaking a review of the environmental assessment (EA) requirements for the project

7.5.4 Waste water evaporator

The waste water evaporator, which was constructed in 1952, was used to process and treat liquid radioactive wastes produced by the NRX fuel reprocessing work conducted between 1952 and 1958. Some evaporation activities were carried out between 1958 and 1967 to concentrate about 450 m³ of stored process wastes remaining from earlier fuel processing. The facility was shut down in 1971. It has a footprint of about 130 m². Future decommissioning activities will include:

- isolation of process and service lines entering the building from neighbouring interconnected buildings
- removal, treatment and storage of any liquid wastes from the tank, process lines and equipment
- decontamination of process equipment, processing cells and other components in the building to remove contamination
- removal of process equipment, processing cell, building structure and footing/foundations
- segregation and transfer of solid wastes to appropriate WMFs at the CRL site
- removal of contaminated soil surrounding the building to a distance of one metre from the building footprint, and backfilling the area as required

A DDP has been prepared and regulatory approval has been granted. Decommissioning work is planned to be completed over the next three years.

7.5.5 National Research Experimental Reactor

The National Research Experimental (NRX) reactor, Canada's first large-scale research reactor, commenced operation in 1947 and played a major role in developing the CANDU reactor. The reactor was used extensively for the testing of fuels and materials, and for nuclear physics research in support of the Canadian nuclear power program.

The reactor is a vertical assembly of permanent tubes that are kept in a calandria and contain the reactor fuel assemblies. The reactor is heavy water moderated and light water cooled, and has a power rating of 42 megawatts. After approximately 250,000 hours of operating time, the NRX reactor was shut down on January 29, 1992.

The NRX reactor facility is divided into three planning envelopes: the NRX reactor, the fuel storage bays and the ancillary buildings. The deferred decommissioning strategy of the NRX reactor is planned in three phases:

- Phase 1 brings the facility to a safe sustainable shutdown state, suitable for an ensuing period of storage with surveillance.
- Phase 2 is the storage-with-surveillance period.
- Phase 3 is the removal of the NRX reactor through a series of decommissioning work packages and achievement of the final end state.

The NRX deferred decommissioning strategy began with the permanent shutdown of the NRX reactor facility. Shutdown operations for the NRX reactor, fuel storage bays and ancillary buildings have been completed and all facilities are currently in a safe shutdown state.

AECL is currently finalizing the DDP to support the decommissioning application to the CNSC. Decommissioning activities are expected to be initiated in the next three years, after regulatory approval to decommission has been received.

Removal of the NRX above-ground stack duct, a 1.2-metre diameter, 500 metre-long length of carbon steel, was completed and the material was recycled through metal melts for reuse in the nuclear industry.

7.5.6 Heavy Water Upgrading Plant

The Heavy Water Upgrading Plant (HWUP) housed electrolytic cells for upgrading the heavy water used in the early prototype NPD and Douglas Point reactors. Removal of equipment and tanks from the storage building has been completed, and approximately 75 percent of the process equipment from the main processing building has been removed. Future decommissioning activities will include:

- removing the remaining 25 percent of the process mechanical equipment from the main processing building
- commencing and completing the removal of the underground storage tanks
- remediating the concrete slab and building structure of the main processing building to improve building structure
- submitting an end-state report to the CNSC for the approval to remove the HWUP facility from the CRL site licence

7.6 Cluff Lake Project

The Cluff Lake Project, owned and operated by AREVA, began in 1981 and was completed at the end of 2002, when ore reserves were depleted (see figure 7.4 (c)). More than 62 million pounds of U_3O_8 was produced over the 22-year life of the project. Site facilities included the mill and tailings management area (TMA), four open-pit and two underground mines, the camp for workers and site infrastructure. Cluff Lake is the most recent of the northern Saskatchewan uranium mines to move into decommissioning. The decommissioning licence was received from the CNSC in July 2004 after five years of public consultation, EA and regulatory review. This marked the completion of the planning phase of work to return the site to a natural state. The objective is to return the site as closely as is practical to its original state in a manner that both protects the environment and allows traditional uses such as fishing, trapping and hunting to be carried out safely.

Site staff and contractors carried out the majority of the decommissioning work between 2004 and 2006, with revegetation of restored areas carrying into 2007. Up until mid-2013, a small number of staff remained onsite in order to carry out the environmental monitoring program and provide minor maintenance to restored areas. In September 2013, the Cluff Lake Project reached a major milestone when the decommissioning of the remaining infrastructure was completed and site occupancy ceased. Environmental monitoring of the site now occurs through quarterly monitoring campaigns. An extensive follow-up monitoring program to assess the performance of the decommissioned site is ongoing. Ultimately, when all stakeholders judge the performance of the decommissioned site satisfactory, it is expected that the site will

be transferred to the Government of Saskatchewan through the institutional control framework established by the *Reclaimed Industrial Sites Act* (see section H.10.3).

The following subsections briefly describe the main decommissioning activities.

7.6.1 Mill area

Decommissioning the mill involved two phases, which were completed in 2004 and 2005 (see figures 7.2(a) and (b)). The mill demolition work was broadly similar to demolition of other similarly sized industrial facilities, with special measures needed to protect workers from residual contamination and industrial hazards and to prevent the spread of contaminants into the environment. Two warehouses were retained for storage and equipment repair up until 2013, when they were demolished during site cleanup activities. Waste materials were disposed of in one of the open pits at the site, together with much larger volumes of waste rock. Following the mill demolition, till material was placed throughout the former mill area to serve as a growth medium for native wood species planted at the site and to ensure that radiological clearance levels were achieved throughout the area.

Figures 7.2(a) and (b): (a) a photograph of the Cluff Lake mill areas during operation, and (b) a photograph of the area following decommissioning but prior to the revegetation becoming established



7.6.2 Tailings management area

The TMA at Cluff Lake is a surface impoundment, constructed using a series of engineered dams and dikes and extending over about 70 hectares. It formerly consisted of a solids containment area, water-decantation area and water-treatment facilities (see figure 7.3(a)). Thickened tailings were pumped to the solids containment area, where consolidation and liquid decantation occurred. The decant water, together with wastewater from other sources, was piped to a two-stage water treatment facility for radium-226 precipitation. Currently, the TMA is surrounded by two diversion ditches, which divert runoff from the upstream drainage basin around the TMA to the downstream water body.

Decommissioning of the TMA was initiated by covering the tailings with till in stages to promote consolidation. When consolidation was complete, the TMA cover was contoured to provide positive drainage using locally available till with a minimum cover thickness of one metre, and then revegetated (see figure 7.3(b)). The surface contour and vegetated cover promote runoff of rainfall and snowmelt, as well as evapotranspiration of moisture to the atmosphere, which minimizes net infiltration through the tailings. Extensive characterization of the tailings and the site's geology and hydrogeology has been performed to acquire reliable data on which to base the assessment of long-term performance. One of the objectives of the follow-up monitoring program is to verify the key assumptions used in the long-term performance assessment. Seven nested piezometers were installed in the TMA in 2010 and six additional piezometers were installed in 2012 in order to collect additional hydrogeological data for comparison with the key assumptions.

Figures 7.3(a) and (b): Photographs show the Cluff Lake TMA during operation and after decommissioning, but prior to the revegetation becoming established



7.6.3 Mining area

Mining involved four open pits and two underground mines (see figure 7.4(a)). One open pit (“D” pit) and its associated pile of waste rock were reclaimed in the mid-1980s. Water quality data from the flooded pit shows stable, acceptable surface water quality, and native species of vegetation have been re-established on the waste rock pile.

Two open pits have been used for the disposal of waste rock, with one of these two pits also used to accept industrial waste during operations and decommissioning. This waste included the mill demolition waste.

The major decommissioning activities consisted of:

- dismantling and disposing of all above-ground structures
- sealing all access openings (ramps, ventilation shafts) to the two underground mines, and allowing them to flood naturally
- relocating waste rock to complete the backfilling of one open pit (Claude pit), then re-contouring and establishing vegetation on these areas
- removing a portion of – and then re-contouring – the waste rock within another open pit (Dominique-Janine North) and then allowing this pit and the contiguous Dominique-Janine extension pit to flood to the natural level to eventually form a small lake that meets surface water quality criteria (see figure 7.3 (b))
- reclaiming the remaining Claude waste rock pile by re-sloping for long-term stability, compacting the waste rock surface, covering with till and establishing a vegetation cover
- re-contouring and establishing native vegetation on all disturbed areas

Extensive characterization of the waste rock, the geologic formations in the area and the site hydrogeology has been performed to acquire reliable data for the assessment of long-term performance. One of the objectives of the post-closure monitoring program is to verify the key assumptions used in the assessment of long-term performance. Eleven nested piezometers were installed in the Claude pit in 2010 and seven additional piezometers were installed in 2012 in order to collect additional hydrogeological data for comparison to the key assumptions.

Figures 7.4(a), (b) and (c): Photographs show one of the Cluff Lake mining areas during operations (a), decommissioned (b), and 20 years after decommissioning (c) but prior to revegetation becoming established



(a)



(b)



(c)

7.7 Bruce Heavy Water Plant

The Bruce Heavy Water Plant (BHWP) nuclear facility was contained within the boundaries of the Bruce nuclear site located in Tiverton, Ontario. It began producing heavy water in 1973 and continued until the last production facilities were shut down in 1998. Decommissioning of some of the older production systems began in 1993.

The demolition of the BHWP (see figure 7.5) was completed in 2006. All contaminated soil has been remediated, and a three-year period of end-state environmental monitoring has been completed. In February 2014, the CNSC granted a licence to abandon the facility.

Figure 7.5: Demolition of the BHWP site



7.8 Dalhousie University SLOWPOKE-2 Reactor

Dalhousie University's SLOWPOKE-2 Reactor (DUSR) facility was part of Dalhousie's Trace Analysis Research Centre. The SLOWPOKE-2 is a small reactor design with a maximum thermal power of 20 kilowatts based upon a critical assembly immersed in light water. SLOWPOKEs are mainly used for neutron activation analysis, but may also be used for teaching, training, irradiation studies, radiography and tracer production.

Criticality of this reactor was achieved July 8, 1976, and it began regular operations one week later. During its life, the DUSR accumulated nearly 40,000 hours of operation, with an average duty rating of more than 1,000 hours per year. At decommissioning, total power output slightly exceeded 313,000 kilowatt hours.

In 2008, Dalhousie University notified the CNSC of its intention to decommission the reactor, allowing the CNSC to begin the EA process for the project. A public hearing was held in March 2009 to approve the EA guidelines, and in January 2011 the Commission accepted the EA screening report allowing the decision to proceed on the application for a decommissioning licence.

In January 2011, the Commission issued the DUSR a decommissioning licence that was valid for a five-year period. Dalhousie University engaged AECL, designer of the SLOWPOKE-2, as the sole contractor to conduct the decommissioning activities. Decommissioning of the DUSR began January 2011 and was concluded by April 2011 (see figures 7.6 and 7.7).

Figure 7.6: Removal of highly enriched uranium core from reactor container



Figure 7.7: Removal of highly enriched uranium core shipping flask from reactor pool



Reactor components that could be reused were sent to other operating SLOWPOKE reactor facilities. Conventional wastes were disposed of or sent for recycling. Radioactive wastes from decommissioning totaled 7.7 m³ and were sent to permanent storage at AECL's CRL in Ontario. The spent nuclear fuel, consisting of a highly enriched uranium (93 percent) core, was sent temporarily to secure storage at AECL's CRL site, and then continued on to the United States Department of Energy's Savannah River site as soon as the facility was able to receive it (it was closed for crane maintenance for several months). The major controlled liquid release from the project (21,000 litres) was from the discharge of reactor pool water after it had been treated and confirmed to meet free release limits accepted by the CNSC.

The highest individual radiation dose from the project was 0.93 millisievert, less than half of the action level of 2 millisieverts, and only 2 percent of the 50 millisievert/year regulatory effective dose limit for nuclear energy workers.

In August 2011, a public hearing was held on the application for a licence to abandon the DUSR facility. The Commission issued the abandonment licence and revoked the DUSR decommissioning licence. The abandonment licence expired 30 days after being issued on September 30, 2011, releasing the DUSR from CNSC regulatory oversight.

In summary, the DUSR was successfully decommissioned and the reactor pool filled with concrete, allowing Dalhousie University to assume complete unrestricted use of the building and the spaces previously associated with the DUSR (see figures 7.8 and 7.9).

Figure 7.8: Backfilling pool with concrete



Figure 7.9: Filled and painted former reactor room



7.9 Gently-2 Nuclear Generating Station

Following the Quebec Government's decision, and upon the recommendation of Hydro-Québec, the generating station's commercial operation ended on December 28, 2012. The generating station was placed in a guaranteed shutdown state and decommissioning activities are being undertaken. Hydro Québec has adapted a deferred decommissioning strategy approach. The activities under this strategy are divided into several phases, the first three of which are:

- a) 2013–2014, stabilization phase
- b) 2015–2020, dormancy and transfer of fuel phase
- c) 2021–2059, dormancy and site monitoring phase

Figure 7.10 shows the schedule of major decommissioning activities for G-2 and the following subsections outline these activities.

7.9.1 Stabilization phase

During this phase, scheduled to occur from 2013–2014, station reconfiguration is planned and the required preparation activities to reach the dormancy and fuel transfer phase are carried out.

The main activities are:

- removal of spent fuel and its storage in a pool
- drainage of heavy water circuits (coolant and moderator) and their storage

- drainage of large volumes (light water, oil)
- shutdown of systems that are no longer required
- introduction of monitoring programs for the next phase (environment, radioprotection, safety)

7.9.2 Dormancy and fuel transfer phase

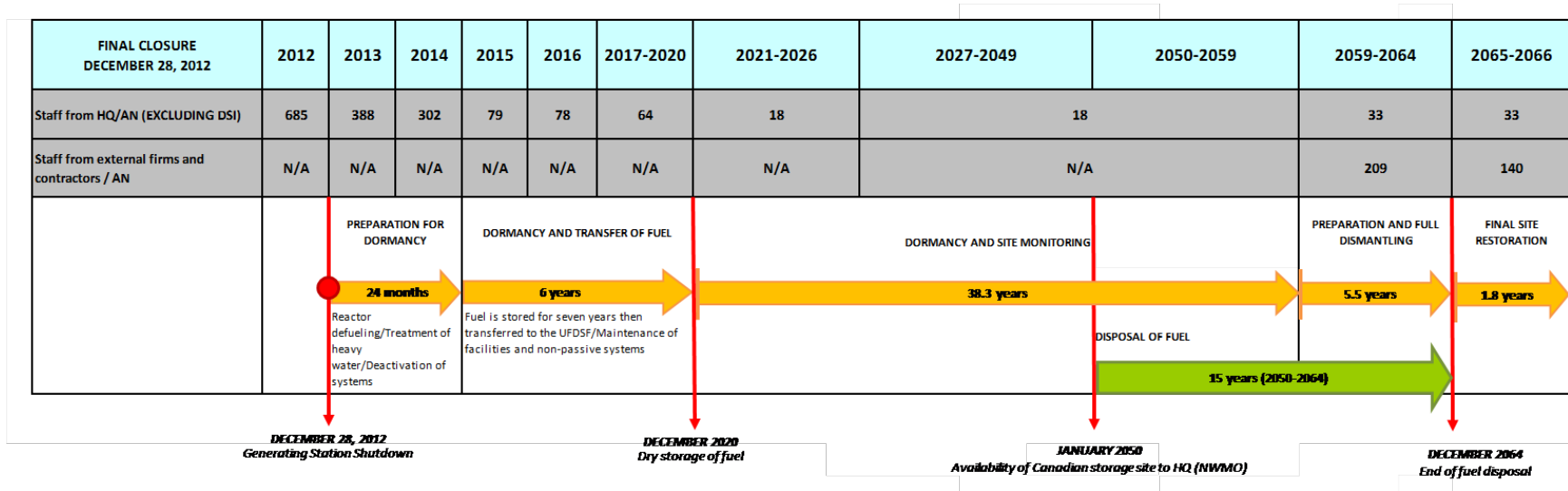
This phase, scheduled to occur from 2015-2020, consists of completing the transfer of spent fuel stored in the pool to the dry storage facility at the generating station's secure site. Two additional units will be built to store all of the spent fuel in the pool. Other activities planned for this phase are mainly the establishment of preventive maintenance; aging management of systems, structures, systems and components (SSCs); and environmental monitoring programs.

At the start of 2015, an organization dedicated to the completion of this phase will be operational and will include the human and budgetary resources required to fulfill its mandate.

7.9.3 Dormancy and site monitoring phase

During this phase, scheduled to occur from 2021-2059, the former generating station will be in dormancy for approximately 40 years before preparation and dismantling activities are undertaken. The transfer of spent fuel to the national storage site is planned to begin in 2050. Final site restoration will be completed in 2066.

Figure 7.10: Schedule for major decommissioning activities at Gentilly-2 Nuclear Power Reactor



Annex 8 – Inactive Uranium Mines and Mills Tailings Management Areas

8.1 Introduction

There are 20 tailings management sites that have resulted from the operation of uranium mines in Canada: 14 in Ontario, four in Saskatchewan and two in the Northwest Territories. Refer to figure B.3 for a map of their locations.

8.1.1 Saskatchewan

There are four inactive uranium tailings sites in Saskatchewan: Beaverlodge, Lorado, Gunnar and Cluff Lake. In September 2013, AREVA's Cluff Lake mining facility completed decommissioning activities and site occupancy ceased; see annex 7.6 for further information.

8.1.1.1 Beaverlodge

Cameco holds a waste facility operating licence for the decommissioned Beaverlodge uranium mine located near Uranium City in the northwest corner of Saskatchewan. Mining of ore at this site began in 1950 and milling in 1953, with both activities continuing until closure in 1982. Decommissioning began in 1982 and was completed in 1985. Since then, the site has been in a monitoring and maintenance phase. All mine structures have been removed from the site, all but one of the open pits has been completely backfilled, and mine shafts have been capped and decommissioned.

All of the control structures associated with this site are passive. Three small, water-level control structures exist but there are no effluent treatment plants. There are roads, waste rock piles and tailings management areas (TMAs) that are subject to inspection programs and local and area-wide environmental monitoring programs.

The Beaverlodge site has three TMAs, which contain 5.8 million tonnes of tailings and 4.3 million tonnes of uranium tailings disposed of underground – for a total of 10.1 million tonnes of lower-grade uranium mine tailings. In addition, there are approximately 5.1 million tonnes of waste rock on the site.

At decommissioning in 1982, the site consisted of 73 separate properties that covered approximately 744 hectares. There were 17 different mining areas; 10.161 million tonnes of ore were recovered that averaged 0.25 percent uranium (0.10 to 0.43 percent ranges). The Saskatchewan *Reclaimed Industrial Sites Act* later came into effect and created an institutional control framework for the long-term provincial management of post-decommission properties. As a result, five of the 73 Beaverlodge properties were exempt from Canadian Nuclear Safety Commission (CNSC) licensing and entered into this framework in 2009. However, these properties were not part of the overall radiological waste inventory considered in this report.

Figure 8.1: Beaverlodge former mill area



8.1.1.2 Gunnar legacy uranium mine, mill and tailings site

On April 2, 2007 the governments of Canada and Saskatchewan announced the first phase of the cleanup of the Gunnar legacy uranium mine site in northern Saskatchewan. Private sector companies that no longer exist operated this facility from the 1950s until the early 1960s. When the site was closed, the regulatory framework in place was not sufficient to ensure the appropriate containment and treatment of the waste, which led to environmental impacts on local soils and lakes. The total cleanup cost, which the governments of Canada and Saskatchewan will share, was estimated to be \$24.6 million.

The Gunnar mine site is located on the southern tip of the Crackingstone Peninsula along the north shore of Lake Athabasca, approximately 25 kilometres southwest of Uranium City, Saskatchewan (see figure 8.2). The Gunnar mine site has been abandoned since 1964 and was not adequately decommissioned.

In 2010 the Saskatchewan Government was ordered by the CNSC to removed hazards associated with engineered structures on the site by dismantling the buildings and safely managing all hazardous materials associated with the demolition work. The conditions of the order were met by September 2011 (see figures 8.3 and 8.4).

In November 2013 the Saskatchewan Research Council (SRC) submitted an environmental impact statement that concluded that no significant adverse residual impacts have been identified for any aspect of the project.

The remediation work will only proceed under a CNSC licence, in which a licensing decision is anticipated by December 2014.

Figure 8.2: Aerial view of Gunnar mine site



Figure 8.3: Before completion of CNSC order



Figure 8.4: After completion of CNSC order



8.1.1.3 Lorado legacy uranium mill and tailings site

The Lorado legacy mill site is located north of Lake Athabasca in the northwest corner of Saskatchewan, approximately eight kilometres southwest of Uranium City (see figure 8.5). EnCana West Limited (EWL) had been identified as the owner of the land on which a portion of the unconfined tailings from the Lorado milling operation exists. The remainder of the site is provincial Crown land. In 2008, EWL negotiated an agreement with the Government of Saskatchewan. EWL has paid a significant amount of money in exchange for the Saskatchewan government to assume current and future control of and responsibility for the site.

In 2007, the SRC was named the site manager. After a provincial environmental assessment (EA) was completed, the SRC was issued a CNSC licence to complete remediation work at the site. This remedial work is expected to begin in June 2014 and be completed by September 2015. The site will then enter a post-remediation phase before being considered for release from CNSC licensing into the Saskatchewan government's Institutional Control Program. The post-remediation phase is expected to be 10 years.

Figure 8.5: Lorado tailings site



8.1.2 Northwest Territories

There are two licensed legacy uranium mine, mill and tailings sites in the Northwest Territories: Port Radium mine and Rayrock mine.

8.1.2.1 Port Radium legacy uranium mine, mill and tailings site

The Port Radium site (see figure 8.6(a)) is located in the Northwest Territories at Echo Bay on the eastern shores of Great Bear Lake about 265 kilometres east of the Déné community of Déline at the edge of the Arctic Circle. Mining at the Port Radium site occurred from 1932 to 1940, from 1942 to 1960 and from 1964 to 1982 – in the last instance, to recover silver. The site covers approximately 12 hectares and is estimated to contain 1.7 million tonnes of uranium and silver tailings (see figure 8.6(b)). The site was partially decommissioned in 1984, according to the standards of the day. In 2006, the Government of Canada reached an agreement with the local community and completed the remediation of the site in 2007 under a CNSC licence.

The Department of Indian Affairs and Northern Development (DIAND) will continue performance and environmental monitoring and reporting under the licence. Radiological results for Port Radium sampling in 2012 are summarized as:

- < 0.005 Bq/L for radium-226
- < 0.02 Bq/L for lead-210
- < 0.005 Bq/L for polonium-210
- < 0.01 Bq/L for thorium-230

These levels are below the discharge limits specified in the licence conditions, and below the Canadian Water Quality Guidelines and Health Canada's drinking water criteria.

Figure 8.6(a): Aerial view (1950s) of Port Radium mine



Figure 8.6(b): Aerial view (2002) of Port Radium mine



8.1.2.2 Rayrock legacy uranium mine, mill and tailings site

Uranium mining and milling occurred at the Rayrock site from 1957 until 1959, when it was abandoned (see figure 8.7). Following an EA and the issuance of an Atomic Energy Control Board (AECB) licence (reissued as a CNSC licence in 2001), DIAND decommissioned and rehabilitated the Rayrock site (including the capping of the tailings) in 1996. Performance monitoring and reporting of the results have been ongoing since 1996.

DIAND sampled surface water for 2011 and reported the following radiological concentrations at the final point of control:

- 0.06 Bq/L for lead-210
- 0.03 Bq/L for polonium-210
- 0.14 Bq/L for radium-226
- <0.01 Bq/L for thorium-228
- 0.54 Bq/L for thorium-230
- 0.01 Bq/L for thorium-232
- 0.053 Bq/L for uranium-234
- 0.0025 Bq/L for uranium-235
- 0.053 Bq/L for uranium-238

For the 2011 sampling period, many of the radionuclide concentrations were below detection limits and in all cases were below the limits set by the Canadian Water Quality Guidelines and Health Canada's drinking water criteria.

Figure 8.7: Rayrock mine



8.1.3 Ontario

8.1.3.1 Elliot Lake area

There are 12 inactive uranium mine sites and 10 uranium TMAs in and around Elliot Lake, Ontario. All of the Elliot Lake uranium mines were brought into production between 1955 and 1958. By 1970, five of the mines had been shut down; by 1992, most had ceased operations. Decommissioning of the last of the Elliot Lake uranium mines – Stanleigh, Quirke, Panel, Stanrock and Denison mine sites – was essentially complete by the end of 1999. All of the sites have been substantively decommissioned, with all mine features capped or blocked, all facility structures demolished, and all sites landscaped and revegetated.

The uranium ore in the Elliot Lake area is classified as low grade (containing less than 0.1 percent U_3O_8). It also contains pyrite and uranium decay products such as radium-226. When exposed to oxygen and water, the tailings become acid generating and may mobilize contaminants. Most of the Elliot Lake TMAs, therefore, have some degree of effluent treatment system associated with each site. All of the TMAs have been closed, and all construction activities related to the containment structures have been completed. Currently, the mining companies conduct site-specific and regional environmental monitoring programs, operate the effluent treatment plants, and inspect and maintain the sites.

Rio Algom Ltd. is responsible for the Quirke, Panel, Spanish American, Stanleigh, Lacnor, Nordic, Buckles, Pronto and Milliken mine sites and their associated TMAs, while Denison Mines Inc. is responsible for the Denison, Stanrock and Can-Met mine sites and their TMAs.

Decommissioning of uranium mines and mills is governed by the *Uranium Mine and Mills Regulations* under the *Nuclear Safety and Control Act* (NSCA). Two of the mine sites – Denison and Stanrock – currently have the CNSC uranium mine decommissioning licences in effect.

In 2004, Rio Algom Ltd. consolidated all of its Elliot Lake mine sites under one CNSC licence: a waste facility operating licence governed by the *Class I Nuclear Facility Regulations* under the NSCA.

8.1.3.1.1 Effluent treatment and environmental monitoring

In Elliot Lake, the TMAs use a mixture of both dry and wet covers. Four of the TMAs – Lacnor, Nordic, Pronto and Stanrock – are engineered with dry covers, and vegetation has been established over the tailings at all of these sites. Active water treatment is required at all of the dry TMAs to correct for acid generation and radium dissolution in the effluent streams according to the predicted performance for the dry tailings covers. It is expected that water treatment will be required for many more years to come at these sites as the acid-generating potential of the tailings becomes slowly exhausted due to surface water infiltration and oxidation of the tailings.

The other TMAs – Quirke, Panel, Stanleigh, Spanish American and Denison – are all water covered, and most require some form of active water treatment. However, the extent of treatment required is greatly reduced over that of the effluents resulting from the dry cover TMAs (the water covers minimize exposure to oxygen and the resulting generation of acid). Many of these sites currently require only minimal treatment, and it is expected that the effluent treatment plants will not be required for the length of time predicted at the sites with dry covers.

With respect to environmental monitoring, the licensees have implemented two programs at their TMAs: the TMA Operational Monitoring Program (TOMP) and the Source Area Monitoring Program (SAMP). The first collects data to track TMA performance and supports decisions regarding the management and discharge compliance of the TMAs. The second program was developed to monitor the nature and quantities of contaminant releases to the watershed.

In addition to these measures, both Rio Algom Ltd. and Denison Mines Inc. have jointly implemented two watershed-wide programs, referred to as the Serpent River Watershed Monitoring Program (SRWMP) and the In-Basin Monitoring Program.

The SRWMP is designed to evaluate the effects of all mine discharges and water-level changes on the receiving watershed, focusing on water and sediment quality, benthos, fish health, and radiation and metal doses to humans and wildlife. The Serpent River watershed comprises more than 70 lakes and nine sub-watersheds, which cover an area of 1,376 km² and drain into Lake Huron via the Serpent River.

The In-Basin Monitoring Program, a companion program to the SRWMP, focuses on the risks to biota feeding at the TMAs by monitoring the physical, chemical and ecological conditions at the TMAs, including ecological changes. Both programs run in five-year cycles. The first cycle was completed in 1999, the second cycle summary report was completed in 2007, the third cycle results were combined with results from the TOMP and the SAMP in one consolidated *State of the Environment (SOE) Report* in 2011 and the fourth cycle of the *SOE Report* will be completed in 2016.

CNSC staff reviewed the results of the various monitoring programs that Rio Algom Ltd. and Denison Mines Inc. implement, including SAMP, TOMP and SRWMP; the most recent licensee's *Operating Care and Maintenance Annual Reports* (2011 and 2012); and the 2011 *SOE Report*, and found that overall the environmental conditions are improving at the Elliot Lake site. More specifically, water quality is improving and environmental impacts, such as lower taxonomic richness and abundance in the benthic communities, are now only evident immediately downstream of the Quirke, Denison and Stanleigh TMAs. Lakes further afield are in good environmental health, with benthic community metrics similar to control and health indicators of white suckers similar to reference lakes. Sediment contaminant levels continue to be slightly elevated, which is to be expected due to the low depositional rates and bioturbation in these environments.

The CNSC licenses the Rio Algom Ltd. and Denison Mines Inc. mine sites for possession, care and maintenance of nuclear substances that are found in the TMAs. There are no emissions from the TMAs except for surface water runoff. The licensees treat TMA waters as required prior to release and TMA effluent quality at the final points of control meets the discharge limits that are set in each individual licence. There are no recommendations or modifications to the SAMP or TOMP at any of the sites.

These sites will continue to require monitoring and active management until effluents meet discharge criteria without treatment. These sites will then require some form of ongoing (permanent) care and maintenance.

8.1.3.1.2 Community involvement

With respect to community involvement, the mining companies maintain a public presence in Elliot Lake, offering facility tours, a website and a public information program that keeps the community and city council updated with respect to ongoing activities at the sites. The Serpent River Region Environmental Committee, a local environmental committee, attends facility inspections along with the CNSC and the Joint Regulatory Group (which represents the other federal and provincial regulators that have an interest in the Elliot Lake operations).

8.1.3.2 Agnew Lake legacy mine, mill and tailings site

The Agnew Lake mine, located about 25 kilometres northwest of Nairn Centre, Ontario, ceased operation in 1983. The uranium mine site was decommissioned and monitored by Kerr Addison Mines from 1983 until 1988. The site was then turned over to the Province of Ontario in the early 1990s. The Ontario Ministry of Northern Development and Mines holds a CNSC waste nuclear substance licence for the Agnew Lake TMA. CNSC staff conduct a compliance inspection of the Agnew Lake mine once every three years. The Ministry of Northern Development and Mines reported the following 2010 sampling results for the radiological surface water at the final point of control:

- < 0.01 Bq/L for radium-226
- 0.1 Bq/L for lead-210
- < 0.01 Bq/L for polonium-210

- < 0.01 Bq/L for thorium-230

These levels are below the Ontario Provincial Water Quality Objectives (PWQO).

8.1.3.3 Bancroft area

Uranium tailings management sites also exist at the Madawaska, Dyno and Bicroft mines in the area surrounding Bancroft, Ontario. The Madawaska mine has been inactive since 1983, while operations at the Dyno and Bicroft sites ceased in the early 1960s.

8.1.3.3.1 Dyno idle mine, mill and tailings site

The Dyno idle mine property is located at Farrel Lake, about 30 kilometres southwest of Bancroft, Ontario. The mill circuit at Dyno operated between April 1958 and April 1960. The property consists of an abandoned, sealed underground uranium mine; a mill, which has been largely demolished; a tailings area; one dam (see figure 8.8); and various roadways. The site is managed and monitored by EWL Management Ltd., which holds a CNSC waste nuclear substance licence for the Dyno idle mine site.

During the sampling period of 2012, EWL Management Ltd. provided the following results for the radiological surface water at the final point of control:

- Uranium concentrations during the spring and fall of 2012 (0.288 µg/L and 0.300 µg/L, respectively) were within the range reported in previous years (0.1–2.0 µg/L). The observed uranium concentrations during 1990, 2002 and 2004–2012 were all below the PWQO of 5.0 µg/L.
- Radium-226 concentrations during the spring and fall of 2012 (0.094 Bq/L and 0.073 Bq/L, respectively) were below the range of the concentrations reported during previous years (0.14–0.38 Bq/L). The measured radium-226 concentrations during 1990, 2002 and 2004–2012 were all below the PWQO of 0.6 Bq/L.
- Thorium-230 concentrations during the spring and fall of 2012 (0.013 Bq/L and 0.011 Bq/L, respectively) were within the range of concentrations reported for 2004–2011 (<0.005–0.08 Bq/L).
- Polonium-210 concentrations during the spring and fall of 2012 (0.015 Bq/L and 0.016 Bq/L, respectively) were within the historical range (<0.005–0.19 Bq/L).
- Lead-210 concentrations during the spring and fall of 2012 (0.02 Bq/L and <0.02 Bq/L, respectively) were within the range of concentrations reported for 2004–2011 (<0.02–0.1 Bq/L).

Figure 8.8: Main tailings dam, Dyno mine site



8.1.3.3.2 Madawaska closed mine, mill and tailings site

The Madawaska mine property is located six kilometres southwest of the town of Bancroft, Ontario, on Highway 28. Initial mining and milling operations at Madawaska (Faraday) mine ran from 1957 until 1964, and again from 1976 to 1982. Reclamation activities were carried out from 1983 to 1992. The CNSC is currently re-evaluating the licensing requirements for the Madawaska site. The site is currently being safely managed by EWL. CNSC staff inspect the site annually.

During the sampling period of 2013, EWL Management Ltd. provided the following results for the radiological surface water at the final point of control:

- Uranium concentrations during the spring and fall of 2013 were 0.0227 mg/L and 0.0364 mg/L, respectively, and were within the range of the monitoring data from 2006 to 2012 (0.006–0.053 mg/L), as well as the historical range from 1983 to 2012. Concentrations of uranium during the spring and fall of 2013 were greater than the PWQO (0.005 mg/L), consistent with previous years of sampling.
- Radium-226 concentrations during the spring and fall of 2013 were 0.03 Bq/L and 0.24 Bq/L, respectively. The spring 2013 concentration was within the range of 2006–12 monitoring data (0.010–0.140 Bq/L), whereas the fall 2013 concentration was generally higher than the 2006–2012 data. Concentrations of radium-226 during the spring and fall of 2013 were below the PWQO (0.6 Bq/L), which was consistent with data collected from 1984 to 2012.
- Thorium-230 concentrations during the spring and fall of 2013 were below the analytical detection limit of 0.005 Bq/L, consistent with concentrations reported in previous years (<0.005–0.05 Bq/L).

- Lead-210 concentrations during the spring and fall of 2013 were below the analytical detection limit of 0.02 Bq/L. The observed concentrations of lead-210 in 2013 were within the range reported in previous years (<0.02–0.06 Bq/L).
- Polonium-210 concentrations during the spring and fall of 2013 were 0.014 Bq/L and <0.005 Bq/L, respectively. The observed concentrations of polonium-210 in 2013 were within the range reported in previous years (<0.005–0.06 Bq/L).

8.1.3.3 Bicroft tailings site

The uranium tailings stored in the Bicroft Tailings Storage Site resulted from processing low-grade uranium ore at the Bicroft mine from 1956 to 1962 (see figure 8.9). Remediation work has included vegetation of exposed tailings in 1980 and upgrading of dams in 1990 and 1997. In 2005, the Barrick Gold Corporation (Barrick) was issued a waste nuclear substance licence for the Bicroft tailings management site. The effluents discharge results generally meet the PWQO's results, with a few exceptions. As part of its licence application, therefore, Barrick conducted a screening level human health and ecological risk assessment to demonstrate that there is no unreasonable risk to health, safety and the environment, and to support a five-year surface water-sampling program. In 2010, the results for the radiological surface water at the final point of control were 1.3 Bq/L for radium-226 and 17 ppb for uranium.

Figure 8.9: South Tailings Basin Spillway at Bicroft Tailings Storage Facility



8.2 Contaminated lands

8.2.1 Historic contaminated lands

Very low-level uranium and radium contaminated sites, resulting from early industrial practices (1930s to 1950s), were identified in the 1970s and have been subject to Government of Canada oversight through the Low-Level Radioactive Waste Management Office (LLRWMO) since 1982. Until sufficient information on the characteristics of the sites and the likely hazards associated with activities at these sites could be gathered, the CNSC maintained an interest in the sites.

In May 2014 CNSC staff informed the Commission that adequate information was available to declare that the CNSC has no regulatory interest in these sites. Other government agencies, including Natural Resources Canada and various provincial and municipal ministries, may still have an interest in identifying the presence of low levels of contaminants at these sites. These agencies have been made aware of the sites.

8.2.1.1 Port Hope Area Initiative for the long-term management of historic low-level radioactive wastes

On March 29, 2001, an agreement was signed between the Government of Canada (represented by the Minister of Natural Resources) and the communities of Port Hope, Hope Township and Clarington for the construction of long-term waste management facilities (WMFs) for historic low-level radioactive waste (LLW) and for the cleanup of contaminated sites in the Port Hope area. The wastes consist of about 2 million m³ of LLW and contaminated soils, containing radium-226, uranium and arsenic as the primary contaminants.

With this agreement, the Government of Canada began an initiative – the Port Hope Area Initiative (PHAI) – to evaluate and implement a long-term solution for the management of the wastes from the Port Hope area sites. This initiative has been divided into two projects that accord with municipal boundaries. The Port Hope Project entails the cleanup and long-term management of wastes from various contaminated sites in the Municipality of Port Hope – formerly the Town of Port Hope and Hope Township. The Port Granby Project involves the implementation of a long-term management approach for radioactive wastes at the existing Port Granby WMF in the Municipality of Clarington (see figure 8.10).

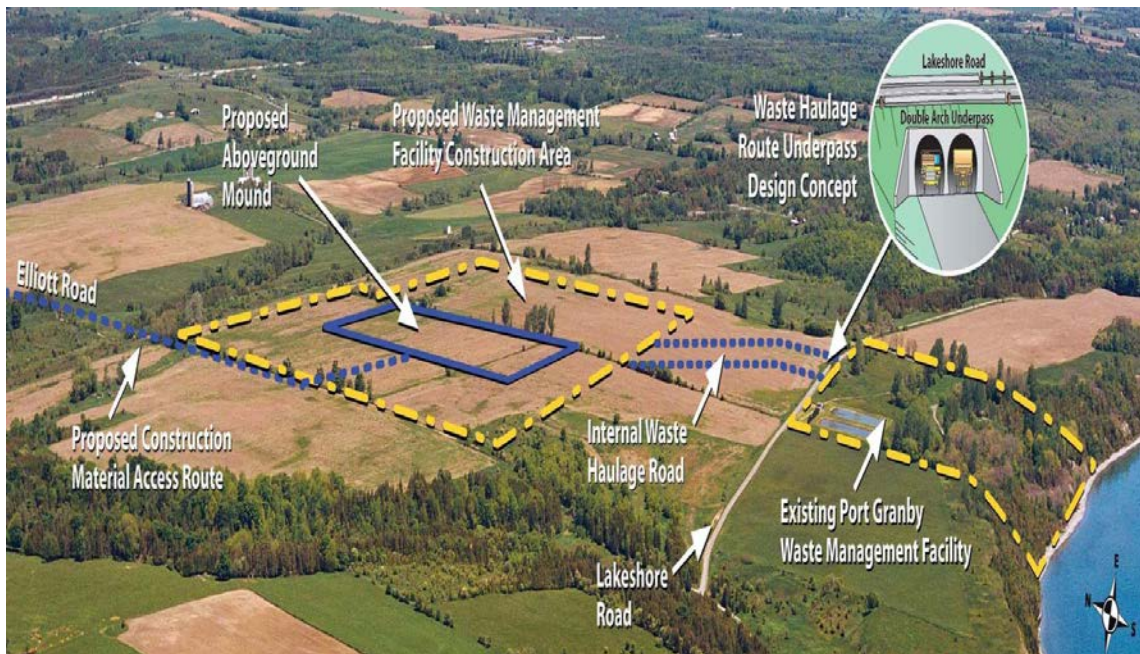
Single-purpose-built facilities are being planned to manage the wastes from each cleanup project: the Port Hope Long-Term Waste Management Facility (PHLTWMF) and the Port Granby Long-Term Waste Management Facility (PGLTWMF). The PHLTWMF, with an estimated design capacity of 1.8 million m³, is planned to accept a variety of wastes from the area. These include wastes from the major unlicensed sites in the Municipality of Port Hope, such as the Alexander Street ravine, the waterworks, the viaducts area, the Mill Street south site, the landfill and the harbour. Other wastes, such as contaminated roadways and soils from private properties, will also be included, along with wastes from Cameco's Welcome Waste Management Facility and specified historic wastes from the Cameco conversion facility. Wastes from consolidation sites and temporary storage sites within the community that are being temporarily managed by the LLRWMO will also be included, along with non-radiologically contaminated industrial wastes, as requested by the municipality and provided for in the agreement.

The PHLTWMF is planned for an expanded site at the existing Welcome Waste Management Facility located in the Municipality of Port Hope, which currently contains an estimated 500,000 m³ of LLW and contaminated soils. An EA process has been completed for this project and on November 15, 2012 the Commission issued a 10-year licence to AECL for the Port Hope Project. This project, as well as the PGLTWMF, is moving forward in a phased approach. The Port Hope Project is currently in its implementation phase (Phase 2), which includes construction of the new long-term WMF and associated new state-of-the-art water treatment plant and remediation of the existing facility and the contaminated sites in the area of Port Hope, followed by a closure of the long-term WMF. AECL is currently completing the construction of the water treatment plant, which is planned to be commissioned in the summer of 2014.

The PGLTWMF, with an estimated design capacity of 600,000 m³, is being planned to accept wastes only from the existing Port Granby WMF located in the Municipality of Clarington. The site considered for these wastes is immediately northwest of the existing facility and away from the Lake Ontario shoreline. An EA process has been completed for this project and on November 29, 2011 the Commission issued a 10-year licence to AECL for the Port Granby Project. The project is currently in its implementation phase (Phase 2), which includes construction of the new long-term WMF and associated new state-of-the-art water treatment plant and decommissioning and remediation of the existing facility, followed by a closure of the long-term WMF. AECL is currently completing the construction of the water treatment plant, which is planned to be commissioned in the summer of 2014.

After completing the Port Hope and the Port Granby projects, both long-term waste management facilities will be capped and the projects will move to a long-term monitoring and surveillance phase (Phase 3).

Figure 8.10: Port Granby concept diagram



8.2.1.2 Port Hope contaminated sites

A number of contaminated sites have been identified in the Municipality of Port Hope. Some of these sites are known as major unlicensed sites, others are known as small-scale sites, and there are also some licensed and unlicensed temporary storage and consolidation sites. Although many of these sites are not currently licensed by the CNSC, the CNSC is aware of them and is comfortable with how they are being managed. The sites are safe for casual access, pending implementation of the PHAI, which will remediate them once the long-term waste management facilities for the project have been developed.

The major sites are generally well known by the community and municipality, and will not be further developed until the historic waste deposits can be removed to an appropriate storage facility. Small pockets of contaminated soils, however, also exist on roadways and municipal road allowances and on municipal, private and commercial properties. These sites are known collectively as small-scale sites.

The development of these sites (which may include common activities such as road repair, infrastructure repair and maintenance, property regrading/landscaping, and private or commercial property development or renovation) is accommodated under the Construction Monitoring Program, an administrative program between the LLRWMO and the Municipality of Port Hope.

The municipality forwards projects that require municipal building permits to the LLRWMO for review and action. This action often results in a radiological monitoring of excavated materials in construction areas. If contaminated soils that need to be removed are identified, they are accepted at the Pine Street Extension Temporary Storage Site, a CNSC-licensed storage facility. The project may then continue as planned. The LLRWMO also accepts applications to the program directly from residents for projects that do not require building permits.

Larger projects, which may negatively impact upon the LLRWMO's ability to receive radioactive waste at its temporary storage site (it currently has a receiving capacity of approximately 2,000 m³), are accommodated through the construction of small purpose-built consolidation or storage sites. In the long term, through the PHAI, the objective is to consolidate this material within the purpose-built PHLTWMF.

List of Acronyms and Abbreviations

ACS	acid, chemical and solvent
AECA	<i>Atomic Energy Control Act</i>
AECB	Atomic Energy Control Board
AECL	Atomic Energy of Canada Limited
AGTMF	above-ground tailings management facility
ALARA	as low as reasonably achievable
AMP	administrative monetary penalty
AMPR	<i>Administrative Monetary Penalties Regulations</i>
APM	Adaptive Phased Management
ARD	acid rock drainage
ASDR	l'aire de stockage des déchets radioactifs (radioactive waste storage area)
ASME	American Society of Mechanical Engineers
BHWP	Bruce Heavy Water Plant
BML	Bulk Materials Landfill
Bq	becquerel
CANDU	Canada Deuterium-Uranium
CANSTOR	CANDU Storage
CCSF	Concrete Canister Storage Facility
CCP	CNSC Compliance Program
CEAA 2012	<i>Canadian Environmental Assessment Act, 2012</i>
CEA Agency	Canadian Environmental Assessment Agency
CEPA	<i>Canadian Environmental Protection Act</i>
CINFR	<i>Class I Nuclear Facility Regulations</i>
CLEAN	Contaminated Lands Evaluation and Assessment Network
CNSC	Canadian Nuclear Safety Commission
CRL	Chalk River Laboratories

CSA	Canadian Standards Association
CWC	calcine waste canister
DDP	detailed decommissioning plan
DFATD	Department of Foreign Affairs, Trade and Development Canada
DGR	Deep Geologic Repository (Ontario Power Generation)
DIAND	Department of Indian Affairs and Northern Development
DO	designated officer
DPNGS	Douglas Point Nuclear Generating Station
DPWMF	Douglas Point Waste Management Facility
DRL	derived release limit
DSM	dry storage module
DTMF	Deilmann tailings management facility
DUSR	Dalhousie University SLOWPOKE-2 Reactor
EA	environmental assessment
EC	Environment Canada
EIS	environmental impact statement
EMS	environmental management system
ESC	EnergySolutions Canada
EWL	EnCana West Limited
FERP	Federal Emergency Response Plan
FISST	Fissile Solution Storage Tank
FNEP	Federal Nuclear Emergency Plan
FPS	Fuel Packaging and Storage
G1WMF	Gentilly-1 Waste Management Facility
GBq	gigabecquerel
GNSCR	<i>General Nuclear Safety and Control Regulations</i>
GoCo	government-owned, contractor-operated
GTRI	Global Threat Reduction Initiative

GSR	General Safety Requirements (IAEA)
GWMF	Geological Waste Management Facility
HC	Health Canada
HEPA	high-efficiency particulate air
HEU	highly enriched uranium
HLW	high-level radioactive waste
HQ	Hydro-Québec
HWUP	Heavy Water Upgrading Plant
IAEA	International Atomic Energy Agency
IAS	independent assessment study
ICP	Institutional Control Program
ICRP	International Commission on Radiological Protection
IGDRS	installation de gestion des déchets radioactifs solide
ILW	intermediate-level radioactive waste
IRRS	Integrated Regulatory Review Service
ITRG	Independent Technical Review Group
JEB	John Everett Bates
JRP	Joint Review Panel
LCH	licence conditions handbook
LEU	low-enriched uranium
L&ILW	low- and intermediate-level radioactive waste
LLRWMO	Low-Level Radioactive Waste Management Office
LLW	low-level radioactive waste
LWE	liquid waste evaporator
MACSTOR	modular air-cooled storage
MAGS	modular above-ground storage
MBq	megabecquerel
MNR	McMaster Nuclear Reactor

mSv	millisievert
N/A	not available
NB EMO	New Brunswick Emergency Measures Organization
NB Power	New Brunswick Power Corporation
NCA	Nuclear Cooperation Agreement
NEA	<i>Nuclear Energy Act</i>
NFWA	<i>Nuclear Fuel Waste Act</i>
NGS	nuclear generating station
NLA	<i>Nuclear Liability Act</i>
NLLP	Nuclear Legacy Liabilities Program
NPD	Nuclear Power Demonstration
NPDWMF	Nuclear Power Demonstration Waste Management Facility
NRCan	Natural Resources Canada
NRU	National Research Universal
NRX	National Research Experimental
NSCA	<i>Nuclear Safety and Control Act</i>
NS EMO	Nova Scotia Emergency Measures Organization
NSERC	Natural Sciences and Engineering Research Council
NSR	<i>Nuclear Security Regulations</i>
NSRDR	<i>Nuclear Substances and Radiation Devices Regulations</i>
NSSR	National Sealed Source Registry
NTR	Northern Transportation Route
NWMD	Nuclear Waste Management Division
NWMO	Nuclear Waste Management Organization
OECD	Organization for Economic Co-operation and Development
OPG	Ontario Power Generation
OSCQ	Organisation de la sécurité civile du Québec
PCB	polychlorinated biphenyl

PGLTWMF	Port Granby Long-Term Waste Management Facility
PHAI	Port Hope Area Initiative
PHLTWMF	Port Hope Long-Term Waste Management Facility
PTNSR	<i>Packaging and Transport of Nuclear Substances Regulations</i>
PTR	Pool Test Reactor
PWMF	Pickering Waste Management Facility
PWQO	Ontario Provincial Water Quality Objectives
QA	quality assurance
RA	responsible authority
RCSA	retube components storage area
RISERS	respect, integrity, service, excellence, responsibility and safety
RLAGTMF	Rabbit Lake above-ground tailings management facility
RLITMF	Rabbit Lake in-pit tailings management facility
RMC	Royal Military College
RPR	<i>Radiation Protection Regulations</i>
RWOS 1	Radioactive Waste Operations Site 1
SAMP	Source Area Monitoring Program
SaskEMO	Saskatchewan Emergency Management Organization
SCA	safety and control area
SLOWPOKE	Safe Low-Power Critical Experiment
SLWC	stored liquid waste cementation
SMAGS	shielded modular above-ground storage
SOE	State of the Environment
SRC	Saskatchewan Research Council
SRWMF	Solid Radioactive Waste Management Facility
SRWMP	Serpent River Watershed Monitoring Program
SSCs	structures, systems and components
SSR	Specific Safety Requirements (IAEA)

SSTS	Sealed Source Tracking System
SSWQO	Saskatchewan Surface Water Quality Objectives
Sv	sievert
TBq	terabecquerel
TC	Transport Canada
TLD	thermoluminescent dosimeter
TMA	tailings management area
TMF	tailings management facility
TOMP	TMA Operational Monitoring Program
TPMB	Transportation Package Maintenance Building (Western Waste Management Facility)
TRIUMF	TriUniversity Meson Facility
TRM	target residual material
UMMR	<i>Uranium Mines and Mills Regulations</i>
UNENE	University Network of Excellence in Nuclear Engineering
URL	Underground Research Laboratory
VLLW	very-low-level radioactive waste
VSLW	very-short-lived low-level radioactive waste
WL	Whiteshell Laboratories
WMA	waste management area
WMF	waste management facility
WR-1	Whiteshell Reactor-1
WTC	Waste Treatment Centre
WVRB	Waste Volume Reduction Building (Western Waste Management Facility)
WWMF	Western Waste Management Facility

