CANADA

A. National Framework for Management of Radioactive Waste and Nuclear Fuel Waste

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 Chalk River Laboratories (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 (including medical and industrial uses)

Canada has 19 operating nuclear power plants generating about 16% of national electricity production, while nuclear accounts for more than 50% in Ontario and 33% in New Brunswick, the two provinces with operating NPPs. All are CANDU pressurized heavy water (PHWR) reactors, fueled with natural (un-enriched) uranium oxide fuel. In addition, there are a number of research reactors. Radioactive waste is also produced in the production of nuclear fuel, in research and development facilities, medical facilities, industries, and universities.

The Government of Canada has jurisdiction over nuclear energy, and Natural Resources Canada (NRCan) is the lead government department responsible for developing and implementing uranium, nuclear energy and radioactive waste management policies. 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 is the Canadian Nuclear Safety Commission (CNSC).

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.

Canada's approach to radioactive waste management is founded upon the Government of Canada's 1996 *Policy Framework for Radioactive Waste*. The *Policy Framework*

provides a national context for radioactive waste management and a set of principles governing institutional and financial arrangements to ensure that the management of radioactive waste is carried out in a safe, environmentally sound, comprehensive, cost-effective and integrated manner. The *Policy Framework* states that the federal government has the responsibility to develop policy, regulate, and oversee owners to ensure that they comply with legal requirements and meet their funding and operational responsibilities in accordance with approved waste management plans.

Waste owners are responsible for their waste, in accordance with the "polluter pays" principle and are required to develop their own management approach, individually or in cooperation with others waste owners. Those approaches are subject to regulatory review by Canada's regulator, the CNSC.

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

B. National Legal and Regulatory Framework

The *Nuclear Safety and Control Act* (NSCA), the *Nuclear Fuel Waste Act* (NFWA), the *Nuclear Liability Act* (NLA), which will be replaced by the *Nuclear Liability and Compensation Ac*t (NLCA) on January 1, 2017, and the *Nuclear Energy Act* (NEA) are the centerpieces of Canada's legislative and regulatory framework for nuclear matters.

The NSCA, which was passed by Parliament in 1997, is the key piece of legislation that governs the safety of the nuclear industry and radioactive waste management in Canada. The NSCA provides legislative authority for the regulation of the nuclear sector and established the CNSC as Canada's independent federal nuclear regulator. The CNSC regulates 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.

In addition to the powers and responsibilities of the CNSC outlined above, the NSCA authorizes the Commission to require that operators of nuclear facilities provide financial guarantees as a condition of their licence. This is a discretionary power that the Commission has used to require operators of uranium mines and mills, uranium refineries and fuel fabrication facilities, nuclear power plants and research reactors and facilities to provide financial guarantees to support decommissioning activities and the long-term management of radioactive waste. The financial guarantees are based on decommissioning plans accepted by the CNSC, using conservative cost estimates for implementing those plans. Financial guarantees ensure that the costs of decommissioning will be borne by the licensees, not the taxpayers.

In the case of nuclear fuel waste, the Government of Canada passed the NFWA in 2002 to ensure a national plan is developed and implemented for the long-term management of nuclear fuel waste. It also requires waste owners to set aside, in segregated trusts, sufficient funding to pay for the full lifecycle cost of implementing the Government-selected, long-term management plan for nuclear fuel waste. Pursuant to the NFWA, it is the owners of the waste, through the Nuclear Waste Management Organization (NWMO), that are responsible for defining an approach for long-term waste management, providing funding and, subsequently implementing the approach, following Government acceptance and with ongoing Government oversight.

The NFWA required that the NWMO submit to the Government, a comprehensive study of options for the safe and secure long-term management of nuclear fuel waste and provide a recommendation on the most appropriate approach. Following extensive studies, comprehensive public consultation including with Indigenous peoples and an evaluation of the social and ethical considerations of each option, the NWMO submitted its recommendation to the Government of Canada for review in November 2005. In 2007, the Government of Canada selected the NWMO's recommendation for Adaptive Phased Management (APM) as its preferred approach for the long-term management of nuclear fuel waste in Canada. The goal of the APM approach involves containing and isolating the nuclear fuel waste in a deep geologic repository (DGR) located at a safe site within an informed and willing host community. The NWMO is now responsible for implementing APM, subject to obtaining all the necessary regulatory approvals.

The NEA came into force in 2000 and addresses the development and utilization of nuclear energy, including research and development activities.

The NLA which came into force in 1976, established liability for civil injury and damage arising from nuclear accidents and provided for a well-defined compensation system for victims. It generally applies to nuclear reactors, fuel fabrication facilities, or facilities for the long-term management of nuclear fuel waste. Although the basic principles underlying the NLA remain valid, this legislation was over thirty years old, and needed updating to address issues that became evident over the years, and to keep pace with international trends.

The NLCA received Royal Assent in February 2015, and will repeal and replace the NLA when it comes into force on January 1, 2017. The NLCA increases the amount of compensation available to address damage caused by a nuclear incident from $75 million under the NLA to $650 million, transitioning over a three-year period to $1 billion, a level commensurate with international standards. The NLCA broadens definitions of compensable damage to include economic loss, preventative measures and environmental damage, improves the procedures for delivery compensation and extends the limitation period for submitting compensation claims for bodily injury to 30 years. The NLCA also implements the provisions of the International Atomic Energy Agency's (IAEA) Convention on Supplementary Compensation for Nuclear Damage, allowing Canada to become a party to the Convention, which it signed in December 2013. Canada will ratify the Convention once the NLCA comes into force. The NLCA maintains the underlying

principles and key strengths of the NLA, including making nuclear operators absolutely and exclusively liable for nuclear damage, but expands upon it.

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

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

The CNSC 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, in the context of radioactive waste management, it is the licensee's responsibility to demonstrate to the satisfaction of the regulatory body that a nuclear fuel waste 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.

C. Current Practices and Technologies for Waste Management and Decommissioning, Including Long-Term Plans

C.1 Current Practices

C.1.1 Radioactive Waste

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 protect people and to control and limit the release of potentially harmful substances into the environment.

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).

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. Wastes may be processed on-site or may be shipped to a commercial processing facility (mainly in the USA) for treatment. In such cases, the treated waste is returned to Canada for storage.

Atomic Energy of Canada Limited (AECL), a Crown Corporation wholly owned by the Government of Canada, is responsible for the federal government's radioactive waste and decommissioning obligations at AECL and other sites across Canada. AECL oversees its contractor, Canadian Nuclear Laboratories (CNL), which operates Canada's nuclear laboratories, and implements programs and projects to manage federal radioactive waste responsibilities.

CNL operates a commercial waste service for small producers and owners of radioactive waste, such as hospitals and universities. CNL accepts, on a fee-for-service basis, low- and intermediate-level radioactive waste (L&ILRW) from these organizations for long-term management. The waste may be shipped to CRL directly or through a consolidator or broker. 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 commercial waste treatment or disposal facilities in the United States.

C.1.2 Nuclear Fuel Waste

In Canada, nuclear fuel waste 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 – typically seven to ten years, depending on site-specific needs and organizational administrative controls – and when the associated heat generation has diminished, the nuclear fuel waste can be transferred to an onsite dry storage facility. These dry storage facilities consist of large, reinforced concrete cylinders or containers.

A Canada Deuterium Uranium (CANDU) fuel bundle is approximately 100 mm diameter by 500 millimetres long, with a total mass of about 25 kg (including about 20 kg of uranium). Each nuclear power plant in Canada has enough storage space to store all the nuclear fuel waste produced during the operating life of the station. A typical 600-

megawatt CANDU nuclear reactor produces approximately 90 tonnes of heavy metal nuclear fuel waste annually.

The fuel cycle in Canada is a once-through process (currently, there is no reprocessing or intent to reprocess nuclear fuel waste for recycling of its uranium and plutonium content). Nuclear fuel waste is considered to be (high-level) waste.

C.2 Overview of Progress on the Long-Term Management of Radioactive Waste and Nuclear Fuel 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. A key challenge will be to develop, build and sustain stakeholder support and public confidence in these initiatives so that they can be successfully implemented.

C.2.1 Nuclear Fuel Management

In 2005, the NWMO recommended the APM approach to the Government of Canada. The APM approach involves centralized containment and isolation of nuclear fuel waste in a deep geologic repository in a suitable rock formation, with the option of an interim shallow-underground storage facility, located at a site in an informed and willing host community. A key element of the APM approach is that it is sufficiently flexible to adjust to changing social and emerging technological developments. In 2007, the Government of Canada selected the APM approach as Canada's plan for the long-term management of nuclear fuel waste, and directed NWMO to move forward on implementation of the plan.

Through public dialogue and consultation, the NWMO developed a site selection process aimed at identifying a willing and informed community with a suitable site to host a deep geologic repository for the long-term management of nuclear fuel waste. This voluntary site selection process for a DGR was initiated in 2010 and by 2012, twenty-two communities in Ontario and Saskatchewan came forward to participate in the process and learn more about the APM project. Study areas have been narrowed through assessments, and as of December 2015, the NWMO had focused its siting process on nine Ontario communities. Those nine communities are continuing to engage with the NWMO and explore the possibility of hosting a DGR and Centre of Expertise for the long-term management of nuclear fuel waste.

The NWMO is also advancing work on the development of repository designs and safety cases, including governance and capacity building to provide the necessary, skills, expertise, and capabilities required to implement APM.

Further information about the implementation of the government-selected plan is available on the NWMO's website at www.nwmo.ca

C.2.2 Low- & Intermediate-Level Radioactive Waste Management

In Canada, the development and implementation of plans for the long-term management of radioactive waste is the responsibility of the waste owner.

Ontario Power Generation (OPG) and AECL collectively own 92% of Canada's 283,000 m^3 of L&ILRW, and AECL is responsible for a further 2 million m^3 of historic low-level radioactive waste (LLRW). Historic LLRW consists largely of radium and uranium contaminated soils. Both organizations have initiatives underway to establish long-term waste management facilities at their sites for L&ILRW, and AECL's contractor, CNL is implementing two projects to construct facilities for historic waste in the Port Hope, Ontario area. These initiatives are described below:

Ontario Power Generation Deep Geologic Repository for Low- and Intermediate Level Radioactive Waste

OPG is Canada's largest nuclear utility and has a centralized storage facility for L&ILRW at the Bruce Nuclear site.

In 2004, the Municipality of Kincardine and OPG entered into a hosting agreement that would enable OPG to prepare a site, construct, and operate a DGR at the Bruce Nuclear site, which is located within the community. The repository would manage L&ILRW from OPG's twenty (20) nuclear reactors at the Bruce, Pickering, and Darlington generating stations, all located in Ontario, including L&ILRW arising from reactor refurbishment.

On January 24, 2012, the Federal Minister of the Environment and the President of the CNSC announced the establishment of a three-member Joint Review Panel (JRP) to review the environmental effects of OPG's proposed project. The JRP held a total of 33 days of public hearings in September and October 2013, and September 2014.

On May 6, 2015, the JRP submitted its report to the Minister of the Environment for review and decision under the Canadian Environmental Assessment Act, 2012, which included a total of 97 recommendations. In its report, the JRP concluded that the DGR Project is not likely to cause significant adverse environmental effects, provided that the mitigation measures proposed and commitments made by OPG during the review, and the mitigation measures recommended by the Panel, will be implemented.

On February 18, 2016, the Minister of Environment and Climate Change requested additional information and further studies on the environmental assessment for the DGR project. OPG has committed to complete the studies and provide the information by December 31, 2016.

If the project is authorized to proceed to the next phase of the permitting process, the Minister of Environment and Climate Change's environmental assessment decision statement will include conditions related to the project that will be legally binding on the

proponent.

Decommissioning and Waste Management Projects at AECL Sites

AECL's inventory of radioactive and nuclear fuel waste, located at its CRL (Ontario), Whiteshell Laboratories (Manitoba), and three prototype reactor sites in Ontario and Quebec, includes used research reactor fuel, and L&ILRW in solid and liquid form. More than half of the liabilities are the result of Cold War activities during the 1940s, 50s, and early 60s. The remaining liabilities stem from research and development for nuclear reactor technology, the production of medical isotopes and national science programs. AECL also manages the waste produced by ongoing nuclear science and technology activities at its CRL.

AECL's waste inventory is currently being managed in a number of waste managmenet areas at the Chalk River and Whiteshell Laboratories and includes various types of storage, including silos, tile holes, bunkers, shielded above-ground storage buildings as well as a new fuel packaging and storage facility. The nuclear fuel waste will eventually be sent to the NWMO's DGR for long-term management, and AECL's contractor, CNL has initiated three projects that will address the bulk of AECL's inventory of radioactive waste.

The first project involves the construction and operation of a near-surface disposal facility (NSDF) at CRL for low-level radioactive waste from past, present and future activities at CRL and other AECL locations. The facility will consist of an engineered mound or landfill with multiple disposal cells, and will replace the current practice of placing the waste in temporary storage. The facility will be sized to hold approximately one million m^3 of waste, and will allow CNL to decommission more than 100 buildings and structures at CRL that are outdated and no longer needed, and remediate contaminated lands and historic waste burials that are impacting groundwater at the site. CNL plans to complete the construction of the facility so that it can commence operations and receive waste by early 2020.

The other two projects relate to CNL's plan to decommission two reactors in situ or in place – specifically the Nuclear Power Demonstration (NPD) prototype reactor in Rolphton, Ontario and the WR-1 research reactor at Whiteshell Laboratories near Pinawa, Manitoba. For both reactors, the reactor vessels and much of the associated reactor components and systems are located below grade in the subsurface portion of the facility. CNL plans to remove the above-ground portions of both facilities, and fill the subsurface portions of the facilities with grout to "entomb" the reactors in place.

CNL plans to complete the decommissioning of the NPD reactor by the end of 2021, and close Whiteshell Laboratories, including the decommissioning of the WR-1 reactor, by the end of 2024.

Management of Historic Waste

Historic LLRW is waste that was managed in the past in a manner that is no longer considered acceptable, and for which the owner cannot reasonably be held responsible. The Government of Canada has accepted responsibility for the long-term management of this waste.

The bulk of Canada's historic LLRW– about 1.7 million m^3 – is located in the southern Ontario communities of Port Hope and Clarington. These materials relate to the historic operations of a radium and uranium refinery in the Municipality of Port Hope dating back to the 1930s.

In March 2001, the Government of Canada and the local municipalities entered into an agreement based on community-developed proposals to address the cleanup and long-term management of these wastes, thereby launching the Port Hope Area Initiative (PHAI). The PHAI Management Office is the proponent for the PHAI on behalf of the Government of Canada.

The PHAI involves the construction of two above-ground engineered waste management facilities in the communities to consolidate the historic waste, some of which is currently dispersed in an urban environment. In 2012, the Government of Canada announced $1.28 billion in funding to construct the facilities, cleanup the communities, and emplace the historic waste in the new facilities. CNL plans to construct and being operating the two waste management facilities by the end of 2017.

Most of the remaining historic waste to be dealt with in Canada is located along the Northern Transportation Route between Port Radium, Northwest Territories and Fort McMurray, Alberta. The waste results from the past transport of radium and uranium bearing ore and concentrates from the Northwest Territories to Fort McMurray, Alberta. In 2003, the Government of Canada completed a cleanup of contaminated sites in Fort McMurray, and the resulting contaminated soils are safely stored in a long-term, above-ground mound at the local municipal landfill. Strategies are currently being developed for the cleanup of the remaining contamination along the Northern Transportation Route, which is estimated to consist of about 14,000 cubic metres of contaminated soils.

C.2.3 Uranium Mine and Mill Tailings Management

All currently active uranium mining sites in Canada are situated in northern Saskatchewan. However, Elliot Lake, Ontario was the major uranium mining centre in Canada for over 40 years. Since the last Elliot Lake mining facility closed in 1996, uranium mining companies have committed well over $75 million to decommission all mines, mills, and waste management areas. Water treatment and minor engineering works continue to be the main activities at these locations. Water quality within the area watershed has improved dramatically since the closure and decommissioning of the mines and currently meets Ontario Drinking Water Standards.

Where appropriate and necessary, the CNSC has embarked on a program to bring inactive uranium mining sites in Canada under regulatory control.

C.3 Research and Development

In 2007, the NWMO assumed responsibility for directing and managing all aspects of the technical research and development program for Canada's nuclear fuel waste. (From 1996 to 2006, the technical research and development program was funded and managed by OPG. Previously, it was largely funded by the Government of Canada and managed by AECL).

The key goal of the NWMO's technical research and development program is to support implementation of Adaptive Phased Management, the approach selected by the Government of Canada in June 2007 for long-term nuclear fuel waste management. The research and development program focuses on long-term used fuel storage and repository engineering, geoscience, safety assessment as well as technical support to the collaborative siting process.

Cameco Corporation, AREVA Resources Canada Inc., the CNSC and the Government of Saskatchewan provide funding to support research related to uranium mine and mill tailings management. For example, both Cameco and AREVA Resources Canada support ongoing research at the University of Saskatchewan.

Both Cameco and AREVA conduct research to improve tailings management at their facilities. Cameco, in co-operation with universities and industry partners across North America, are researching methods to remove the trace metal selenium from the Key Lake mill effluent. This research will be shared with other mining companies experiencing similar concerns with tailings management. Research at AREVA has developed a method to contain arsenic as a relatively insoluble stable mineral in the Tailings Management Facility at McClean Lake, protecting nearby water resources.

The Canadian Nuclear Safety Commission funds an extramural research program to obtain knowledge and information needed to support its regulatory mission. The program provides the CNSC with access to independent advice, expertise, experience, information and other resources via contracts placed in the private sector, and with other agencies and organizations in Canada and elsewhere.

C.4 Decommissioning and Dismantling Policies and Projects

Together with supporting Regulations, the NSCA requires that the shutdown and decommissioning of licensed nuclear facilities be carried out according to plans approved by the CNSC. The NSCA includes provisions for ensuring that applicants provide such financial guarantees for funding the decommissioning of their facilities as the CNSC may require.

Decommissioning projects are underway at AECL's CRL and Whiteshell Laboratories, and at its demonstration/prototype power reactor sites at Douglas Point and Rolphton in Ontario, and at the Gentilly I reactor in Quebec. These reactors, as well as the National Research Experimental (NRX) reactor at Chalk River and the WR-1 reactor at Whiteshell, are now partially decommissioned and are in a state of "storage-with surveillance". AECL is continuing to submit decommissioning plans for components of its research facilities.

On December 28, 2012, the Gentilly-2 Nuclear Generating Station (NGS) 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. The reactor was defueled in 2013, the heavy water has been drained from the cooling and moderator systems, and the facility is currently in a safe storage state. Activities to prepare for final decommissioning continue, which is expected to occur in the mid-2050s.

OPG submitted a comprehensive plan on decommissioning strategies for the Pickering NGS to the CNSC in 2013. The Pickering NGS is comprised of eight reactor units. Two of those units are in safe storage while the other six units are scheduled to operate until 2022; at which time two units would be shut down, and the four remaining units would operate to 2024. The comprehensive decommissioning strategy for Pickering NGS facility identified the preferred strategy as deferred decommissioning. This strategy involves storing and monitoring the reactors and station for 30 years after shut-down to allow radiation and thermal levels to decay prior to dismantling, demolition and site restoration.

C.5 Financing of Radioactive and Nuclear Fuel Waste Management

Each radioactive waste owner funds radioactive waste management from its operating budget (producer pays). Under CNSC licence conditions, each licensee is required to provide a financial guarantee (in the form of a segregated fund or other financial instrument), to cover the expected costs of waste management and decommissioning of their facilities. The *Nuclear Fuel Waste Act* also requires the establishment of trust funds for the purpose of long-term nuclear fuel waste management. Required annual contributions to the funds are determined by a set formula (approved by the Minister of Natural Resources), based on quantities of nuclear fuel waste the licensee owns.

D. Radioactive Waste Classification, Quantities, and Inventory

The current waste classification system in Canada is based on IAEA GSG-1, as documented in Canadian Standards Association (CSA) N292.0 - *General principles for the management of radioactive waste and irradiated fuel*. The standard does not specify rigid numeric boundaries between the waste classes. This is left up to each waste owner, according to the needs of their waste management facilities, and 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.

Historically, a number of different classification schemes have been used by different parts of the industry and waste owners. Consequently, there is a wide variation in data on legacy wastes.

Canada recognizes four main classes of radioactive waste:

• high-level radioactive waste (HLRW)
• intermediate-level radioactive waste (ILRW)
• LLRW
• uranium mine and mill waste

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

D.1 High-level radioactive waste

HLRW is used (irradiated) nuclear fuel or waste that generates significant heat (typically more than 2 kilowatts per cubic metre) via radioactive decay. In Canada, the term "nuclear fuel waste", is used rather than the term "spent fuel", because discharged fuel is considered a waste material even when it is not fully spent. In spite of the name difference, for the purposes of this report, the two terms can be used interchangeably. Nuclear fuel waste is associated with high levels of penetrating radiation, which requires shielding. Furthermore, nuclear fuel waste contains significant quantities of long-lived radionuclides, meaning that long-term isolation is also required. Waste forms derived from nuclear fuel waste (e.g., nuclear fuel reprocessing wastes) can exhibit similar characteristics and may be considered HLRW. Placement in deep, stable geological formations is considered the preferred option for the long-term management of HLRW.

D.2 Intermediate-level radioactive waste

ILRW 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 ILRW may have heat generation implications in the short term (e.g., refurbishment waste) because of its total radioactivity level.

D.3 Low-level radioactive waste

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

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

Very-short-lived low-level radioactive waste – 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 very-short-lived LLRW 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 very-short-lived LLRW is the half-life of the predominant radionuclides. In practice, the management of very-short-lived LLRW should be applied only to radionuclides with a half-life of 100 days or less.

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

D.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 can contain significant concentrations of long-lived radioactive elements, namely thorium-230 and radium-226.

Each waste owner maintains their own waste inventory and waste tracking system. NRCan compiles a national report of waste inventories and forecasts on a triennial basis to support Canada's National Reports for IAEA Joint Convention review meetings. The summary reports are publicly available.

The inventories of radioactive waste and nuclear fuel waste currently in storage are summarized in Table 1a & b (radioactive waste) and Table 2 (nuclear fuel waste).

Table 1a: Radioactive Waste in Storage (as of 31 Dec 2013)

WASTE IN STORAGE (AS STORED VOLUME)									
	Processed for Disposal (Y/N)	Total Volume (m^3)(1)	Distribution (%)						
Waste Class			RO	FFE	RP	NA	DF	DC/ RE	ND
HLRW		N/A(2)							
ILRW	partial	35,000	44			55		1	
LLRW – contaminated soil	partial	2,105,000(3)						100	
LLRW – other	partial	248,000	44	6		49		2	
LLRW (Total)	partial	2,353,000	5	1		5		89	

RO – Reactor Operations
FFE – Fuel Fabrication/Enrichment
RP – Fuel Reprocessing
NA – Nuclear Applications
DF – Defense Waste
DC/RE – Decommissioning/Remediation
ND - Not Determined

Notes:

(1) Rounded to nearest 1000 m^3
(2) HLRW in Canada is nuclear fuel waste. See Table 2
(3) Contaminated soils from past practices

Table 1b: Uranium Mining & Milling Waste (as of 31 Dec 2013)

Uranium Mine and Mill Waste (tonnes)		
Sub-Class	**Operational Facilities**	**Inactive Sites**
Tailings	15,350,000	200,760,000
Mineralized Waste Rock	16,960,000	-
Non-Mineralized Waste Rock	138,710,000	23,200,000

Note: Rounded to nearest 10,000 tonnes.

Table 2: Nuclear Fuel Waste in Storage expressed as Mass of Uranium (metric tonnes) (as of 31 Dec 2013)

TYPE	Current Amount Nuclear Power Plants	Current Amount (Prototype/Demonstration/Research Reactors)
Wet Storage (at reactor)	28,950	-
Wet Storage (away from reactor)	-	-
Dry Storage (at reactor)	18,020	420
Dry Storage (away from reactor)	-	70
Sent for reprocessing	-	-
Total held for other countries	-	-

Note: Rounded to nearest 10 tonnes mass of uranium

Table 3: Translation Matrix of Canadian Waste Classification System (from NEWMDB) to IAEA Classification

Canada Waste Classification	VLLRW	LLRW	ILRW	HLRW
LLRW		100%		
ILRW			100%	
HLRW (including spent nuclear fuel)				100%
Uranium mine and mill tailings	N/A	N/A	N/A	N/A

N/A = not applicable

E. Tabulation of Processing, Storage, and Disposal Facilities

Summary information for nuclear fuel waste and radioactive waste treatment and storage facilities is provided in Table 4 below.

Table 4: Processing, Storage & Disposal Facilities

SUMMARY OF PROCESSING, STORAGE & DISPOSAL FACILITIES								
TYPE	**Planned**	**Under Construction**	**In Commissioning**	**In Operation**	**Shut Down**	**Decommissioned**	**Other**	**TOTAL**
Nuclear Fuel Waste Wet Storage	0	0	0	10	0	0	5(1)	15
Nuclear Fuel Waste Dry Storage	0	0	0	10	0	0	0	10
Nuclear Fuel Waste Reprocessing & Recycling	0	0	0	0	0	0	0	0
Nuclear Fuel Waste Conditioning	1	0	0	0	0	0	0	1
Nuclear Fuel Waste Disposal	1	0	0	0	0	0	0	1
Waste Processing & Conditioning	0	0	0	6	0	0	0	6
Waste Storage	0	0	0	17	0	0	0	17
Waste Disposal	2	2	0	0	0	0	0	4

Note: (1) Storage facilities that have been shut down and partially decommissioned to a safe shutdown stage.

Summary information on waste producing facilities is provided in Table 5.

Table 5: Summary of Major Sources of Waste

SUMMARY OF MAJOR SOURCES OF WASTE								
TYPE	**Planned**	**Under Construction**	**In Commissioning**	**In Operation**	**Shut Down**	**Decommissioned**	**Other**	**TOTAL**
Prototype/ Demonstration/ Research Reactors	0	0	0	7	0	4	7(1)	18
Nuclear Power Reactors	0	0	0	19	3	0	0	22
Nuclear Fuel Waste Reprocessing & Recycling	0	0	0	0	0	0	0	0
Other (Fuel Cycle Facilities)	0	0	0	5	0	0	0	5

Note: (1) Five Prototype/Research Reactors have been shut down and partially decommissioned to a safe shutdown stage. Two others, MAPLE-1 and 2 were partially commissioned, but the project was terminated in 2008. Both reactors are in safe storage, waiting for final decommissioning.

F. Trends and Future Prospects

Canada's projected waste inventory, trends and future prospects will be provided in the next iteration of the *Status and Trends Report*.