Canadian Nuclear Laboratories | Laboratoires Nucléaires Canadiens

Plan

CANADIAN NUCLEAR LABORATORIES INTEGRATED WASTE STRATEGY

COMPANY WIDE

CW-508600-PLA-002

Revision 0

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1. EXECUTIVE SUMMARY

The Canadian Nuclear Laboratories (CNL) Integrated Waste Strategy (IWS) provides a communication tool which focuses on the management of wastes using a lifecycle (cradle to grave) approach. It establishes integration and alignment with the goals and requirements of CNL's primary business missions, including lifecycle cost optimization.

The IWS applies to all CNL managed radioactive and non-radioactive waste streams for the full waste management lifecycle including pre-treatment, treatment, storage, transport, and disposal.

The purpose of this initial version of the IWS is to capture the CNL baseline waste strategies Table 2, highlight existing waste capability gaps within the strategies and produce an action plan to develop the strategy.

Table 1 Baseline Waste Strategy

Waste Classification	Baseline Waste Strategy
High Level Waste (HLW)	• Consolidate used fuel at Chalk River Laboratories (CRL) and place it in safe, secure and suitable storage facilities until disposal facility become available. • Repatriate suitable HLW (Used Fuel).
Intermediate Level Waste (ILW)	• Consolidate ILW at CRL in safe, secure and suitable storage facilities, making use of existing capacity, until disposal facilities become available. • Manage suitable ILW in situ where agreed.
Low Level Waste (LLW)	• Provide capability and capacity for managing solid LLW to support the CNL mission, including accelerated decommissioning. • Manage suitable LLW in situ where appropriate.
Mixed Waste & Hazardous Waste	• Process off-Site with return of radioactive material, if applicable. • Identify and maximise use and reuse opportunities as appropriate.
Clean Waste	• Reduce waste generation and optimize waste management, including use of waste hierarchy.

As part of the data gathering process, gaps and issues were identified within the waste lifecycle by CNL stakeholders and subject matter experts (SMEs), and for each gap an associated action was identified to improve the waste management approach, making best use of capabilities, both at CNL and through the supply chain. These formed the IWS Action Plan, a summary of which is shown in Table 2.

Table 2 IWS Action Plan Summary

Waste Area	Action
Characterization	Identify and prioritize waste characterization gaps.
	Develop technical and programmatic improvements to address gaps with a focus on Facilities Decommissioning (FD) and Environmental Remediation (ER) across CNL.
	Produce long term strategies to enable reliable processes to be put in place to align with best practice.
Inventory/ Data	Ongoing inventory and forecast refinement as assumptions made and risks identified are mitigated.
	Identify suitable Waste Data Tracking System platform to provide Data support and integrate across CNL.
Processing	Review processing technology requirements (based upon previous studies), identify areas requiring further assessment and develop standard waste treatment approaches for specific waste streams and waste types.
	Carry out option studies as required.
Storage	Review and implement interim storage and waste packaging options to support missions.
	Review and implement storage requirements at CRL , taking into consideration the needs of off-site producers
Transport	Review and identify options for transportation of waste.
	Produce and implement CNL transportation strategy to support the Decommissioning and Waste Management (D&WM) mission.
Long Term Management & Disposal	Near Surface Disposal Facility (NSDF) Project – design and implement.
	Identify right size solution for management of waste destined for deep geologic disposal
	Continue to cooperate and coordinate with Nuclear Waste Management Organization (NWMO) regarding all CNL managed fuel.
Optimization	Prioritize projects requiring option studies, which have been identified and agreed with stakeholders and SME's.
	Begin use of Best Available Technique (BAT) Optioneering process.
	Continue to identify and assess projects until complete.
Communication	Maintain IWS as 'Live' document, updating on regular basis.
	Roll out strategy to ensure the appropriate parties are engaged and aware of the IWS.
	Ensure all wastes captured in IWS, and progress on identified gaps continues.

As the IWS is a living document, it will initially be reviewed annually and updated or modified when major changes occur in waste strategy. Further iterations of the IWS will describe how these strategies will be improved and optimized.

2. INTRODUCTION

2.1 Background

Canadian Nuclear Laboratories (CNL) has a number of locations across Canada (Figure 1), and has been instrumental in the development of Canada's nuclear industry. Through expertise in physics, metallurgy, chemistry, biology, ecology and engineering, CNL has enabled Canadians to benefit from the development and deployment of peaceful and innovative applications of nuclear technology. For more than 70 years, nuclear technology has evolved to meet the needs of the world ,including Canada, for clean, reliable energy; sustainable economic growth; and public health, safety and security. On behalf of Atomic Energy of Canada Limited (AECL), the Canadian Nuclear Energy Alliance (CNEA) is contracted to manage and operate CNL sites under a Government-owned, Contractor-operated (GoCo) arrangement which was implemented in 2015 September.

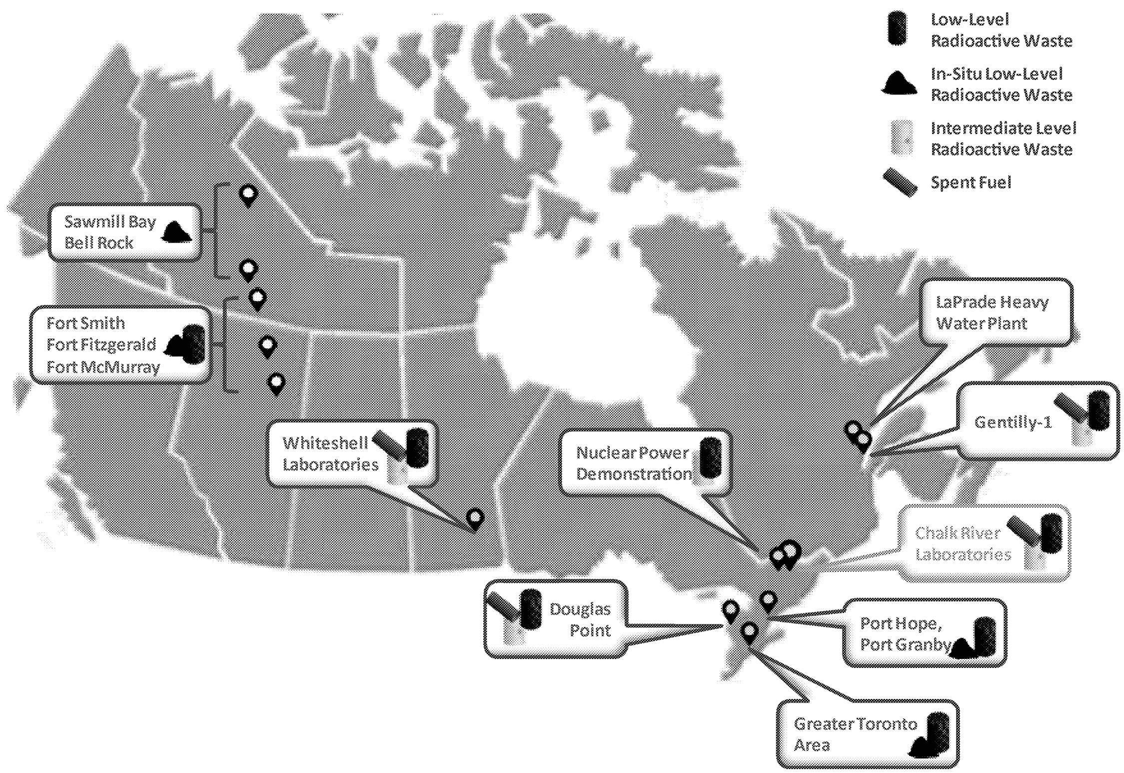


Figure 1 CNL Locations

2.2 Purpose

The purpose of an Integrated Waste Strategy (IWS) at CNL is to ensure the integration of the management of waste across CNL, and better define pathways for all CNL managed wastes using a lifecycle (cradle to grave) approach. It will also enable completion of the scope to refine the Interim Waste Storage strategy, an area that has been highlighted as a gap in strategy, to facilitate accelerated decommissioning.

The purpose of this version of the IWS is to capture the CNL baseline waste strategies for all CNL sites, highlight gaps within the strategies, and identify actions required to improve the waste management approach.

It is a living document, therefore as work progresses to further integrate waste management practices, further iterations of the IWS will describe how these strategies will be improved and optimized.

The IWS defines the waste management lifecycle phases and describes the strategies for managing the various types of waste. CNL's IWS has been developed in accordance with government policies, regulatory requirements, and company environment [1] and health & safety [2][3]policies with regard to waste management, and will support the CNL plans to integrate the ongoing enduring missions of Science and Technology (S&T), Capital and Decommissioning and Waste Management (D&WM).

2.3 Scope

The principles and strategies contained within this document apply to all waste managed by CNL at CNL licensed sites, and to the management of both solid and liquid wastes of all waste classifications, including Radioactive (High Level, Intermediate Level, Low- Level and Mixed) and Non- Radioactive (Hazardous and Clean) waste. Liquid and air effluent waste discharges (for example, those which meet the requirements as stated in 'Acceptability Criteria for Routine and Non-Routine Discharge of Liquids on the CRL Site' [4]) are not considered as waste and as such are not described within this document. The tactical and waste technical details regarding the methods that will be deployed to deliver the strategies exist within the projects at CNL sites.

The UK Nuclear Decommissioning Authority (NDA) has developed a specification and associated guidance document on the content and format of an IWS, ENG 01 '*Specification and Guidance on the Content and Format of an Integrated Waste Strategy*` [5]; this document uses the UK NDA specification as an aid in guiding the development of CNL's IWS.

2.4 CNL Sites

This section provides a brief description of each CNL site and the baseline plan for the sites, as at 2016 December.

2.4.1 Chalk River Laboratories

Chalk River Laboratories (CRL) are located in the town of Deep River, Ontario, 190 km northwest of Canada's national capital, Ottawa. The CRL site comprises approximately 4000 hectares along the Ottawa River. The CRL site contains several licence-listed nuclear facilities, including the National Research Universal (NRU) reactor and many other unique facilities and laboratories. The site has unique capabilities, expertise and specialized facilities that support innovation in safety, security, health, environmental and clean energy technologies.

The long term plan for CRL is revitalization of the site, to transform the site into a world-class, right-sized and sustainable campus. To enable this, a program of accelerated decommissioning of old, unused and redundant facilities is underway.

2.4.2 Nuclear Power Demonstration

The Nuclear Power Demonstration (NPD) site is located on the Ottawa River near the town of Rolphton, Ontario, approximately 25 km from CRL. The NPD reactor operated as a training facility from 1962 until 1987. NPD is presently in the Storage with Surveillance (SwS) phase of decommissioning under a Waste Facility Decommissioning Licence issued by the Canadian Nuclear Safety Commission (CNSC).

The current plan is to complete in-situ decommissioning, with the exception of some hazardous material, such as asbestos insulation and floor tiles, which will be removed as required prior to demolition. The general approach to in-situ decommissioning involves preparing systems and structures for grouting to create a monolith below grade. The below grade sealed structures will contain any radiological sources within it for a period of institutional control. A protective cover will be added on the surface which will also serve to channel water away from the site and protect it from the elements. The project description NPD closure project document [6] provides further details.

2.4.3 Douglas Point

The Douglas Point (DP) site is located at the Bruce site, on the shores of Lake Huron near the town of Kincardine, Ontario. It housed Canada’s first full scale nuclear power plant, operational from 1968 to 1984. DP is presently in the SwS phase of decommissioning under a Waste Facility Decommissioning Licence issued by the CNSC. The current plan is near-term decommissioning of the site with the exception of the reactor which will continue in ongoing SwS. The associated used fuel will remain in dry storage at the site until it can be moved to CRL.

2.4.4 Gentilly-1 & La Prade

The Gentilly-1 (G-1) site is located at Bécancour, Québec, and is situated within the boundaries of the G-2 site, which is owned by Hydro Quebec. It ceased operations in 1979 and is presently in the SwS phase of decommissioning under a Waste Facility Decommissioning License issued by the CNSC. The current plan is near-term decommissioning of the site with the exception of the reactor which will continue in ongoing SwS. The associated used fuel will remain in dry storage at the site until it can be moved to CRL.

La Prade, also located at Bécancour, Québec, is a heavy water (D_2O) storage facility. The current plan is to continue safe storage of D_2O at the site with continued transfers of heavy water from CRL to La Prade. Although tritiated heavy water is not currently classified as a waste, resale opportunities are still to be realized and waste may be produced as the result of upgrading processes. Therefore this material is captured within the IWS, as some portion of the material may require disposal as waste in the future.

2.4.5 Whiteshell Laboratories

Whiteshell Laboratories (WL) are located 100 km northeast of Winnipeg, Manitoba and operated from 1961 to 2002. The WL site covers an area of about 4,375 hectares with the main part of the site is located on the east bank of the Winnipeg River. WL carried out nuclear research and development activities for higher temperature versions of the Canada Deuterium Uranium (CANDU) reactor. The initial focus of research was the 60 MW Thermal WL Reactor-1 (WR-1) Organic Cooled Reactor that began operation in 1965 and continued to operate until 1985. WL also has a range of nuclear facilities and hot cells that provided support for these programs. The Canadian Nuclear Fuel Waste Management program, including the Underground Research Laboratory (URL) located at Lac du Bonnet, was based at WL.
The current plan is to decommission the entire WL site, transport spent fuel to CRL for storage, with the following areas expected to be left in-situ:

- WR-1 Reactor;
- 21 of the 25 Low Level Waste (LLW) Trenches;
- Inactive (non-radioactive) Landfill;
- Sewage Lagoons; and the
- Contaminated Outfall River Sediments.

All other structures will be decommissioning and the grounds will be remediated to an approved end-state criteria which is currently being developed/ finalized. Following in-situ decommissioning, institutional controls and surveillance activities will be required to monitor environmental performance of the entombed material at the WL site [7].

2.4.6 Historic Waste Program Management Office

The Historic Waste Program Management Office (HWP MO) is located at Port Hope, Ontario. Historic LLW is LLW that was managed in the past in a manner no longer acceptable, but for which the current owner cannot reasonably be held responsible and which the government of Canada has accepted long term responsibility. Through its HWP MO, CNL implements federal programs and projects related to the safe management of historic low-level waste across

Canada, on behalf of AECL, a federal Crown corporation. The HWP MO includes the projects under the Port Hope Area Initiative (PHAI) and the national Low-Level Waste Programs (LLWP).

2.4.6.1 Port Hope Area Initiative

The PHAI represents the Government of Canada's commitment to respond to the community-recommended solutions for the cleanup and local, long-term, safe management of historic LLW in the municipalities of Port Hope (PH) and Clarington and is currently one of the largest environmental restoration projects being undertaken in Canada.

The PH Project involves the cleanup of approximately 1.2 million m^3 of historic LLW from various sites in PH, the construction of an engineered aboveground mound where the waste will be safely contained, and the long-term monitoring and maintenance of the new waste management facility. The mound will be capped and closed and the existing site restored.

The Port Granby (PG) Project, in the Municipality of Clarington, will relocate approximately 450,000 m^3 of historic LLW and marginally contaminated soils, located at an existing waste management facility on the shoreline of Lake Ontario, to a new, engineered aboveground mound to be built about a kilometre north of the current site. The mound will be capped and closed and the existing site restored.

2.4.6.2 Low Level Waste Programs

The HWP MO manages historic LLW, on behalf of the federal government, stored at numerous waste sites located throughout Canada and has successfully completed projects in Ontario, British Columbia, Alberta and the Northwest Territories. At many of these sites, materials have been placed in interim storage pending the development and implementation of a long-term management approach. At other sites, the waste is in long-term storage. Larger volumes of contaminated soil can be potentially managed at or near the source. Ongoing site monitoring, inspection and maintenance are conducted at all storage and In-situ sites by the LLWP.

3. CNL WASTE MANAGEMENT

3.1 Radioactive Waste Framework

In accordance with Canada's Radioactive Waste Policy Framework, the owners of radioactive waste are responsible for the funding, organization, and management of their respective waste in addition to the operation of long-term waste management facilities, as required. The waste framework structure, highlighting how CNL sites fit into the picture is shown in Figure 2.

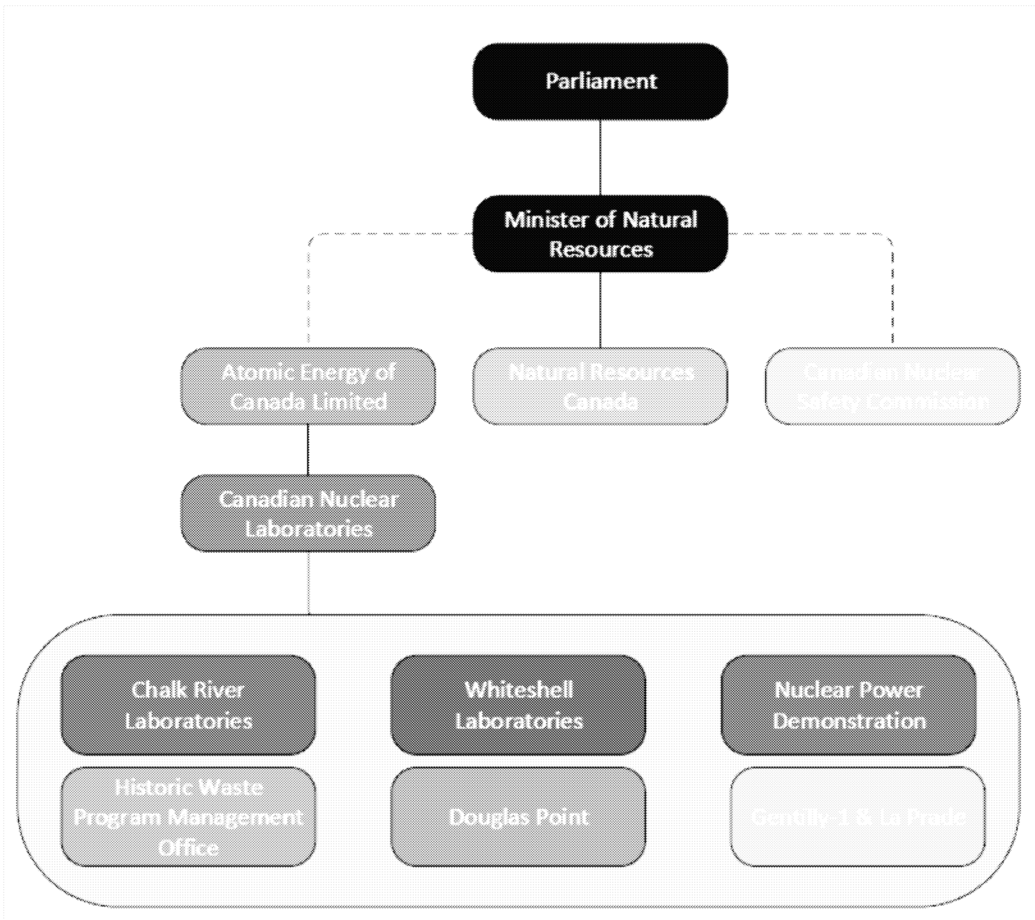


Figure 2 Waste Framework

AECL is a federal Crown corporation responsible for managing Canada's radioactive waste liabilities and enabling nuclear science and technology which is delivered through a contractual arrangement with CNEA for the management and operation of CNL. Natural Resources Canada (NRCan) is the lead federal government department responsible for developing and implementing uranium, nuclear energy and radioactive waste management policies in Canada. In accordance with the *Nuclear Safety and Control Act*, section 9, [8] the CNSC mandate is to:

Regulate the use of nuclear energy and materials in order to

- Protect the health, safety and security of Canadians and the environment
- Implement Canada's international commitments on the peaceful use of nuclear energy.
- Disseminate objective scientific, technical and regulatory information to the public.

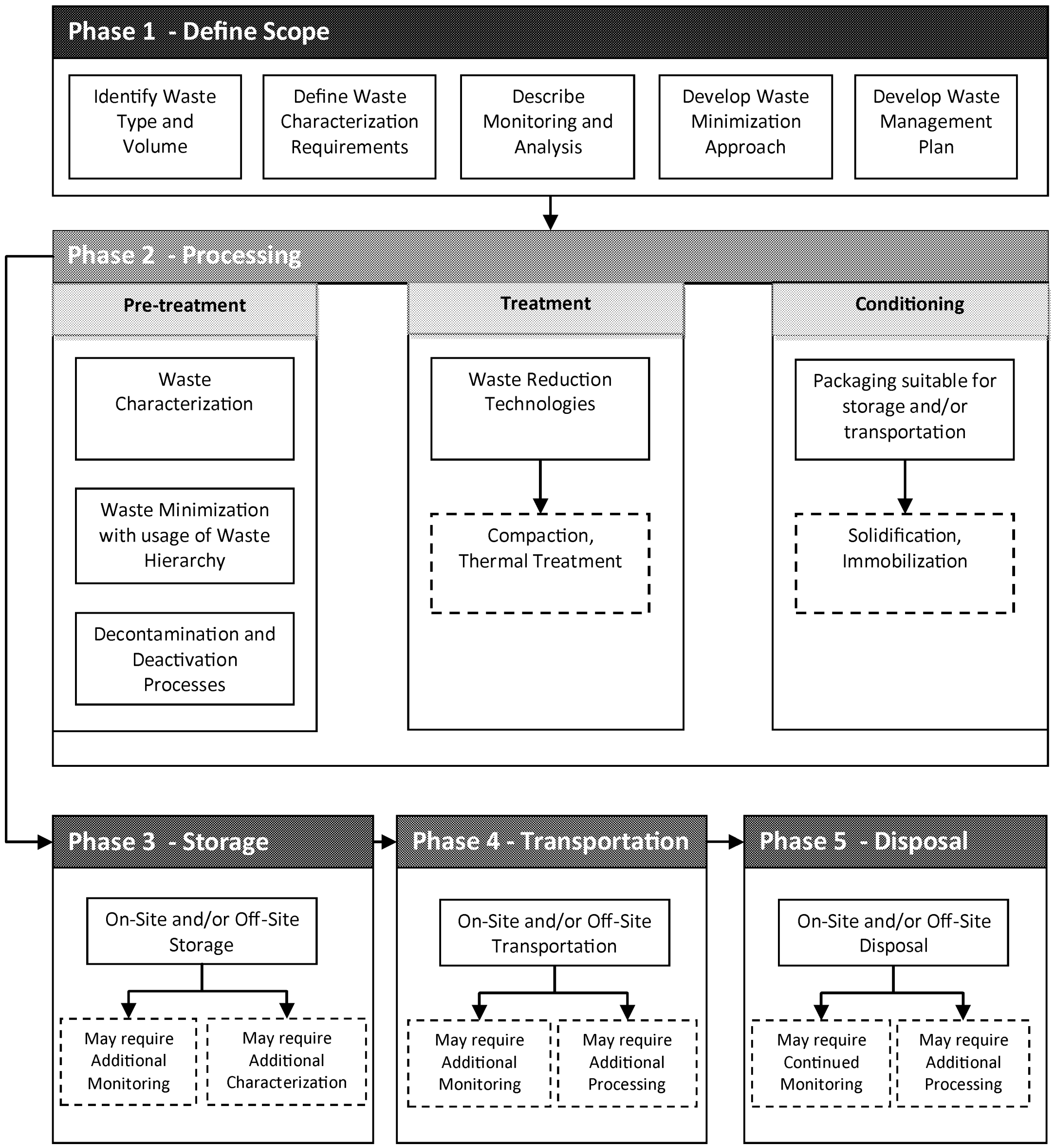
3.2 Waste Management Goals and Activities

CNL's strategic objectives include the requirement to safely and cost effectively accelerate D&WM efforts, thereby facilitating the S&T Mission and reducing Canada's liability. D&WM strategic priorities include:

- Improving integration of D&WM with CNL's enduring S&T mission
- Constructing and operating the Near Surface Disposal Facility (NSDF)
- Establishing an Integrated Waste Strategy (IWS) for all CNL managed waste
- Consolidating Intermediate-Level Waste (ILW) and used fuel for long-term storage
- Aligning decommissioning and environmental remediation (ER) to international best practice
- Accelerating remediation of Waste Management Areas (WMA)and other affected areas
- Repatriate Special Nuclear Material (SNM) to the United States

3.3 Waste Management Lifecycle

The previous CNL strategy for the management of waste is a reflection of a waste management approach that supported research and development (R&D) and limited decommissioning program activities throughout CNL. It was based upon systematic and progressive hazard reduction, taking advantage, where possible, of the process of natural radioactive decay to reduce levels of radioactivity and hence risk to people and the environment. Current and future waste management strategy must consider larger scale decommissioning and ER. Work is underway to integrate this into waste planning cycles. This is shown in Figure 3.



*Legend for shapes: solid line boxes indicate an **Activity**; dotted-line indicates **sub-activities.**

Figure 3 Waste Management Lifecycle and Examples of Performed Activities

3.4 Statement of Waste Management Policy and Principles

The program description document (PDD) [9] describes the CNL Waste Management (WM) Program, which establishes program boundaries, and provides oversight, compliance and services for WM.

To support development and ensure a consistent application of the WM Program across all operations and activities at CNL sites, a WM Program organization has been established. The WM Program and its Main Functional Roles are shown in Figure 4.

Figure 4 WM Program Main Functional Roles

The WM Program is integrated with other CNL programs and projects in order to effectively implement processes to ensure compliance with requirements and to meet goals and objectives. Figure 5 maps the WM Program, a functional support area of D&WM and the various organizations and sites it functionally is responsible for and/or supports.

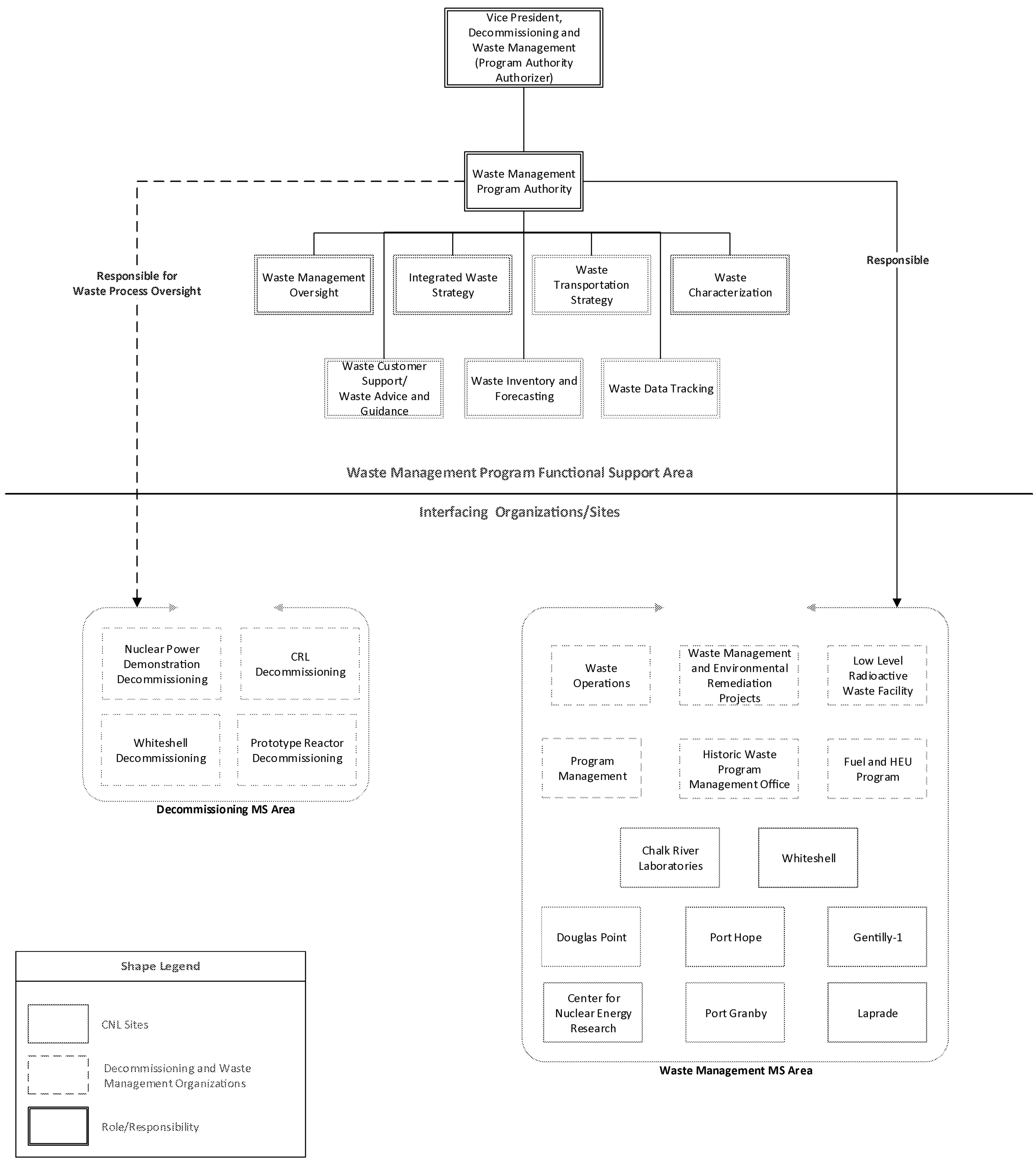


Figure 5 WM Program and the Interfacing Management system (MS) Areas

WM Program also facilitates and oversees all aspects of the waste management process and provides oversight and SME support to waste generators to ensure that the waste lifecycle process and waste hierarchy Figure 6 are implemented in accordance with the applicable policies and procedures governing these activities.

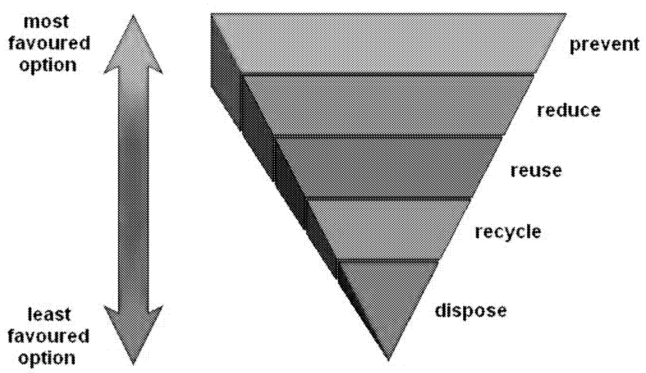
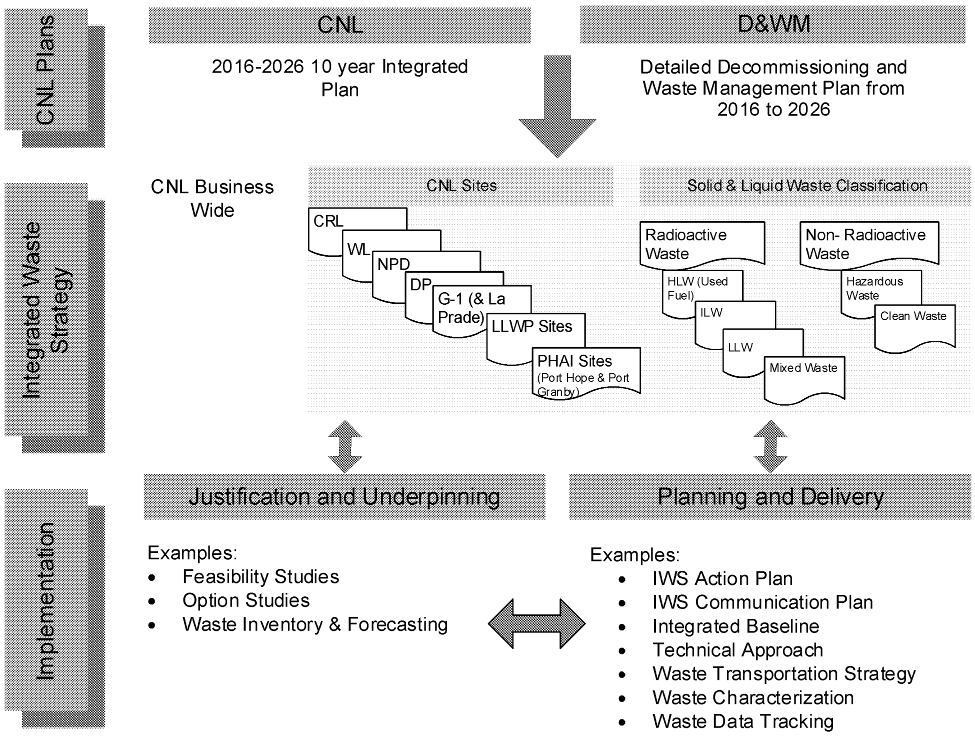


Figure 6 Waste Hierarchy

- As well as safety, compliance and cost minimization, the following are the main waste management drivers:
- use the waste hierarchy as practicable;
- minimize waste handling;
- use existing assets (e.g. current storage facilities) and the current supply chain, as practicable;
- optimize waste processes as practicable;
- use a graded approach; and
- adopt use of best practice for

3.5 IWS Interactions

Figure 7 illustrates the interaction of the IWS with other CNL strategies, plans and implementation processes.



s.21(1)(a)
s.21(1)(b)

Figure 7 IWS Interaction with Other CNL Strategies and Plans

The IWS has been developed taking the CNL & D&WM Plans into consideration. This will ensure alignment and integration across the organization, particularly where wastes are to be transferred between sites for consolidation, storage and disposal. As the IWS develops, the planning and delivery tools (examples include the IWS action plan, waste transportation strategy and waste data tracking) will be utilized to inform the waste strategy. [redacted] Options are being evaluated regarding the development of an improved waste data tracking system which will enable a fully integrated system for capturing waste data across CNL.

The IWS Action plan will highlight the activities required to address gaps and to provide capabilities to enable waste management life-cycle processes gaps or issues. These activities will include justification and underpinning of the strategy through the production of feasibility and option studies, as required.

3.6 Waste Management Technological Underpinning

CNL's D&WM has developed a program of generic technical underpinning and waste management innovation that will begin to both underpin existing strategies and evaluate new strategic approaches. This will require the involvement and assistance of CNL's S&T program. Examples of significant opportunities that have been or are currently being pursued include;

- trials to identify acceptable waste cementation formulations Figure 8
- technologies for segmentation and dismantling
- remotely-operated inspection robots for high radiation environments
- radiation monitoring using unmanned aerial vehicles in case of nuclear or radiological emergency
- development of portable active air sample stations
- technology for fuel transfers
- imaging and remote sampling analysis technologies
- technology for the remote retrieval of legacy waste from storage facilities Figure 8

Figure 8 Full scale testing of Cement formulations to support liquid/sludge inventories (left). Cemented Molybdenum-99 Waste Retrieval Tool (middle) NRU Fuel Cap Grapple (right)

3.7 Constraints and Dependencies

One of the primary missions of CNL is the revitalization of CRL to renew and grow capabilities through collaborations and strategic development of people, facilities and equipment. Accelerated decommissioning of more than 120 structures will assist in providing space to build new structures. Another mission is to close redundant sites, including NPD and WL on an accelerated schedule. Completing this work will reduce the nuclear legacy liabilities and associated risks. This section highlights the constraints and dependencies which affect this program of work.

3.7.1 Regulatory

The IWS process is not a regulatory process but is considered best practice, and regulatory and stakeholder approvals must be obtained where required to enable the IWS to be successful.

3.7.2 Financial

Although accelerated decommissioning is a priority at CNL, the program of work is constrained and dependent upon funding limits. Therefore all gaps are prioritised and targeted based upon this constraint.

3.7.3 Timing

Consideration of the anticipated waste volumes and their associated schedule of arising has aided in identification of potential gaps, and their associated urgency with respect to the program of work, in processing, storage, transportation and disposal capability to ensure delivery of the associated activities. This has highlighted a near term storage gap at CRL in particular for LLW, and the transportation of, and storage capability at CRL for, WL ILW and High Level Waste (HLW).

A key enabler for accelerated decommissioning is the availability of the NSDF which will accept LLW and other suitable waste streams. While the need for storage is assumed until NSDF is operational, any delays to the facility will have a large impact as extended storage of waste will be required. In particular, consideration of timing constraints with the decommissioning of NPD and WL has been fundamental in preparing the IWS, to ensure these projects are successful.

3.7.4 Technical

The strategy to complete decommissioning activities is to maximise the use of available and proven technologies. However, this is not possible for all areas and key technical gaps include the requirement to obtain approval for a suitable fuel shipping cask for transport of material from WL to CRL for storage, and the need to determine the level of processing required for waste to meet transport regulations. Technical decisions would impact schedule and cost.

3.7.5 Transport

A key constraint and dependency to the CNL strategy is the packaging and transportation of waste. [redacted] Transport plans will then be produced which will enable coordination and consolidation of waste transport, and will consider logistics, route capacity and availability of equipment (e.g. flasks). In the near term, this has been identified as particular importance for transferring radioactive waste from WL to CRL for storage and/ or disposal, where stakeholder issues and logistics have not yet been fully developed and agreed.

3.7.6 Waste Management

Key specific waste management constraints and dependencies include inventory uncertainty, infrastructure management and lack of waste processing capability at sites. [redacted] Aging facilities and infrastructure in the WMA's will require on-going maintenance and upgrades. The lack of waste processing capability within CNL means that there is a high dependency upon external waste routes to process waste. The IWS process will inform gaps in capabilities including the need for future development of additional waste handling and processing facilities.

3.8 Proposed Site End States and Contaminated land

Currently, no site end states at CNL have been agreed with regulators and stakeholders, which may impact strategic decisions. To enable work to commence in the interim end states have been identified. This is particularly important at WL, NPD and for the PHAI projects. CRL does not have to be fully defined yet as it is still an operational site with an assumed lifespan until 2100. Table 3 provides an overview of the proposed interim end states.

s.21(1)(a)
s.21(1)(b)

Table 3
Identified Interim End States

Site	Year	Interim End State
CRL	2020 >2020	Produce an agreement with Stakeholders that identifies end land uses for the CRL site and the cleanup criteria required to achieve each particular use. [redacted]
NPD	2021	Reactor in-situ decommissioning complete, site stabilized
DP	by 2026	Ongoing SwS of reactor building, decommissioning of all other buildings.
G-1	by 2026	Ongoing SwS of reactor building, decommissioning of all other buildings.
WL	2024	WR-1 in-situ decommissioning complete, 10,800 acres of land unaffected, and only a small portion, approximately 0.5 per cent of the former laboratories site, would be maintained under institutional control [redacted]
Port Hope	2020	Long-term monitoring and maintenance of the new waste management facilities. The mounds will be capped and closed and the existing site restored.
Port Granby	2023	
LLRWMO	To Be Determined	Consolidation of wastes at specific sites.

4. FORMULATION OF INTEGRATED WASTE STRATEGY

4.1 IWS Methodology

The process followed is based on the UK NDA guidance, ENG 01 '*Specification and Guidance on the Content and Format of an Integrated Waste Strategy*` [5]. The key areas developed as part of the process were:

- **Data Gathering:** included preparation of an inventory of waste currently being generated, waste in storage, and future anticipated wastes until the assumed end date of 2100. An inventory of wastes to be managed is incorporated into the IWS (Section 5.2) and will be used to inform the IWS;
- **Critical Evaluation of Waste Management Options:** involved laying out current baseline waste pathways in the form of flow diagrams [12] that incorporate waste generation, pre-disposal[1] and disposal, and identifying what may be required in the future to meet waste management needs and highlighting gaps and issues within the waste flow; and
- **Identifying Future Activities:** included development of an IWS action plan [Section 9]. The action plan highlights waste areas and issues to be focused on for further investigation/ studies. It will be reviewed on a regular basis (more frequently in the beginning until the document has reached maturity) and updated by WM Programs as gaps and issues are addressed to complete the strategy.

4.1.1 IWS Integrated Project Team

Figure 9 highlights the identified SMEs who engaged and provided input to the preparation of the IWS. Although primarily driven by D&WM, the goal was to gain representation from all areas of CNL to capture all current and future waste routes and gaps and ensure integration of the strategy.

[1] Pre-disposal includes all of the steps carried out prior to disposal, including processing (pre-treatment, treatment & conditioning), storage, transportation and disposal of waste [23]

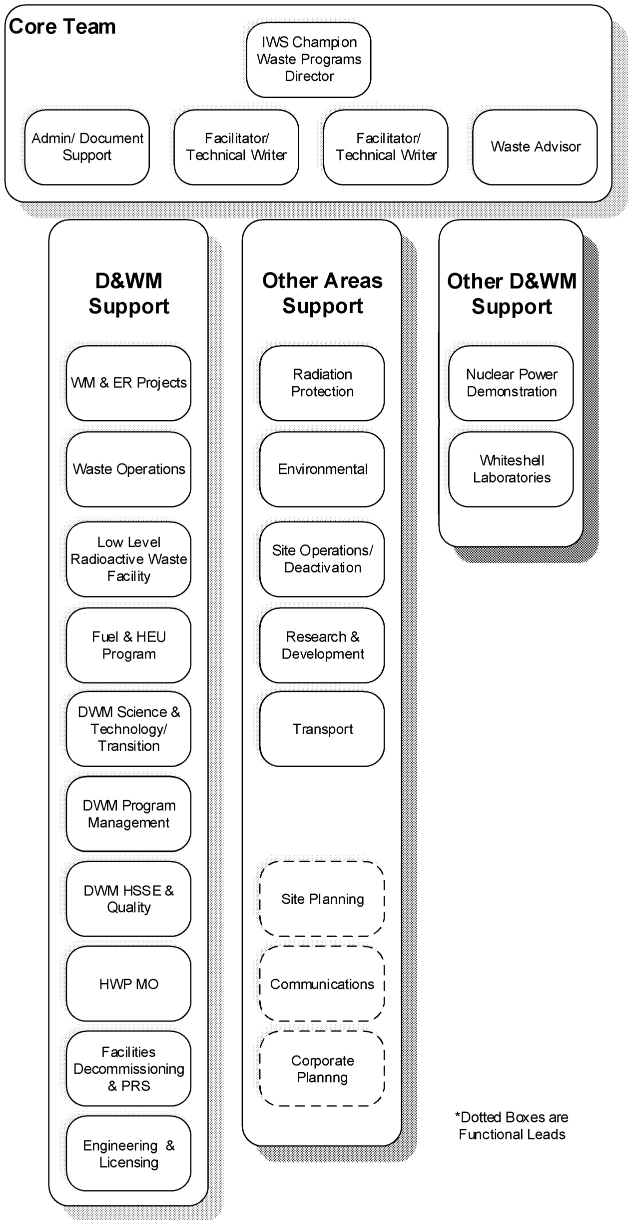


Figure 9 IWS Integrated Project Team

4.2 Option Studies

Historically within D&WM, to ascertain whether or not to proceed with a project and determine if an option is feasible or a strategy needs to be implemented and across CNL, a range of option study processes have been implemented.

To provide improved consistency, CNL's WM Program is currently in the process of establishing an optioneering tool in the form of a guidance document [13] following the concept shown in

Figure 10. Initially this tool is intended for D&WM use, but with the intent of rolling out to other areas of CNL, where proposed new processes or problem resolution can be thoroughly evaluated with technical competence, objectivity and transparency and to provide underpinning and justification of options selected.

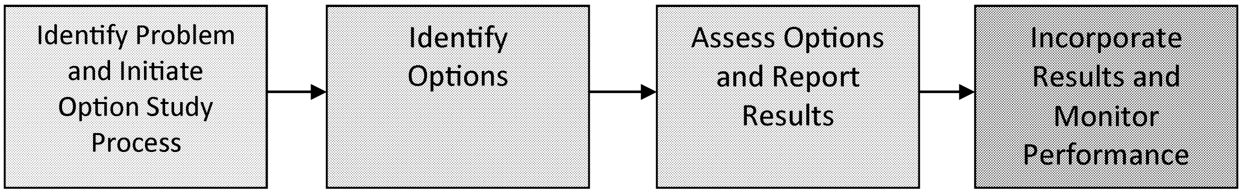


Figure 10 Fundamental Concept of Option Study

This process will be used to carry out option studies identified in the IWS Action plan (Section 9) and address gaps in the IWS. This enables changes to the IWS to be managed in a controlled manner to ensure justification and underpinning of all waste routes is completed, providing optimized and integrated solutions for all CNL managed waste.

4.3 Assumptions, Exclusions, Risks and Opportunities

4.3.1 Assumptions

The following assumptions have been used to prepare the IWS:

- Existing waste inventory and forecasted volumes are accurate [14]
- An NSDF will be site prepared, constructed, and commissioned to operate [15];
- WL and NPD projects will be delivered to align with CNL Plans;
- CNL managed used fuel will be accepted at the Nuclear Waste Management Organization (NWMO) used fuel repository (for the purposes of this report, known as the used fuel Deep Geologic Repository (DGR));
- ILW will be stored at CRL until a future disposal route is identified;
- Off-site processing routes remain available for hazardous & mixed waste; and
- Off-site landfills will be available to accept clean waste.

4.3.2 Exclusions

The following exclusions have been used to prepare the IWS:

- Costs are not considered:
- Technical solutions are not provided: and
- Processed waste volumes are not included in some areas. These are noted in the inventory information.

s.21(1)(a)

s.21(1)(b)

4.3.3 [redacted]

[redacted]

[redacted]

4.3.4 Opportunities

[redacted]

4.4 Stakeholder Engagement

CNL has informed the public about the PHAI, NSDF, and the WL and NPD Closure projects, via the CNL website, information bulletins and newsletters. Various activities have been undertaken including open houses, public information sessions and site tours.

The IWS is primarily a communication tool, therefore, CNL and other nuclear industry stakeholders have been included in the production of the IWS. A nuclear industry event to view the IWS process and the output was held. In the future, communication of the IWS to a wider audience including the public will be considered.

5. OVERVIEW OF INTEGRATED WASTE STRATEGY

To realize CNL's objectives; to revitalize the Chalk River campus by clearing redundant buildings and liabilities; investing in facilities and infrastructure; and modernizing systems and work practices, there is a focus on accelerated decommissioning. These activities will significantly increase the rate at which wastes arise and the need for new waste management capabilities to be implemented. The goal of the Integrated Waste Strategy is to document the current baseline waste routes and identify any future routes that are anticipated to ensure gaps and issues are identified and addressed to meet the business needs of CNL.

5.1 IWS Waste Flow Overview

As part of preparation of the IWS, a series of workshops were held to engage and gain input from CNL stakeholders and SME's. At these workshops, current and future wastes were identified with their corresponding waste streams captured. It is important to note that the identified waste streams used within the IWS are not the same as the six waste types identified within the NSDF project [15]. These are waste types for handling purposes and waste streams identified in the IWS for NSDF disposal will fall into the general categories specified for the NSDF. A colour coding system was agreed with the workshop members to highlight any gaps and issues. This is explained in Figure 11.

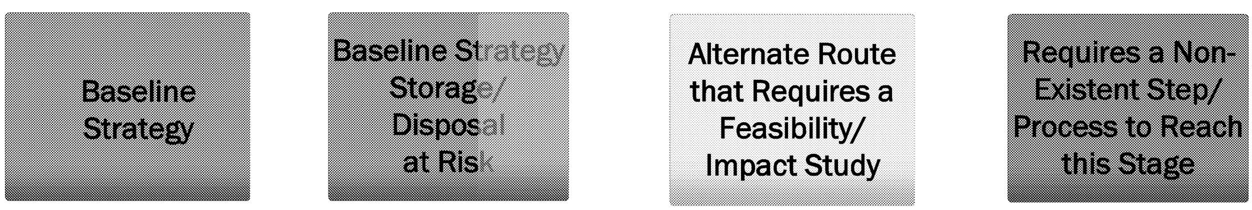
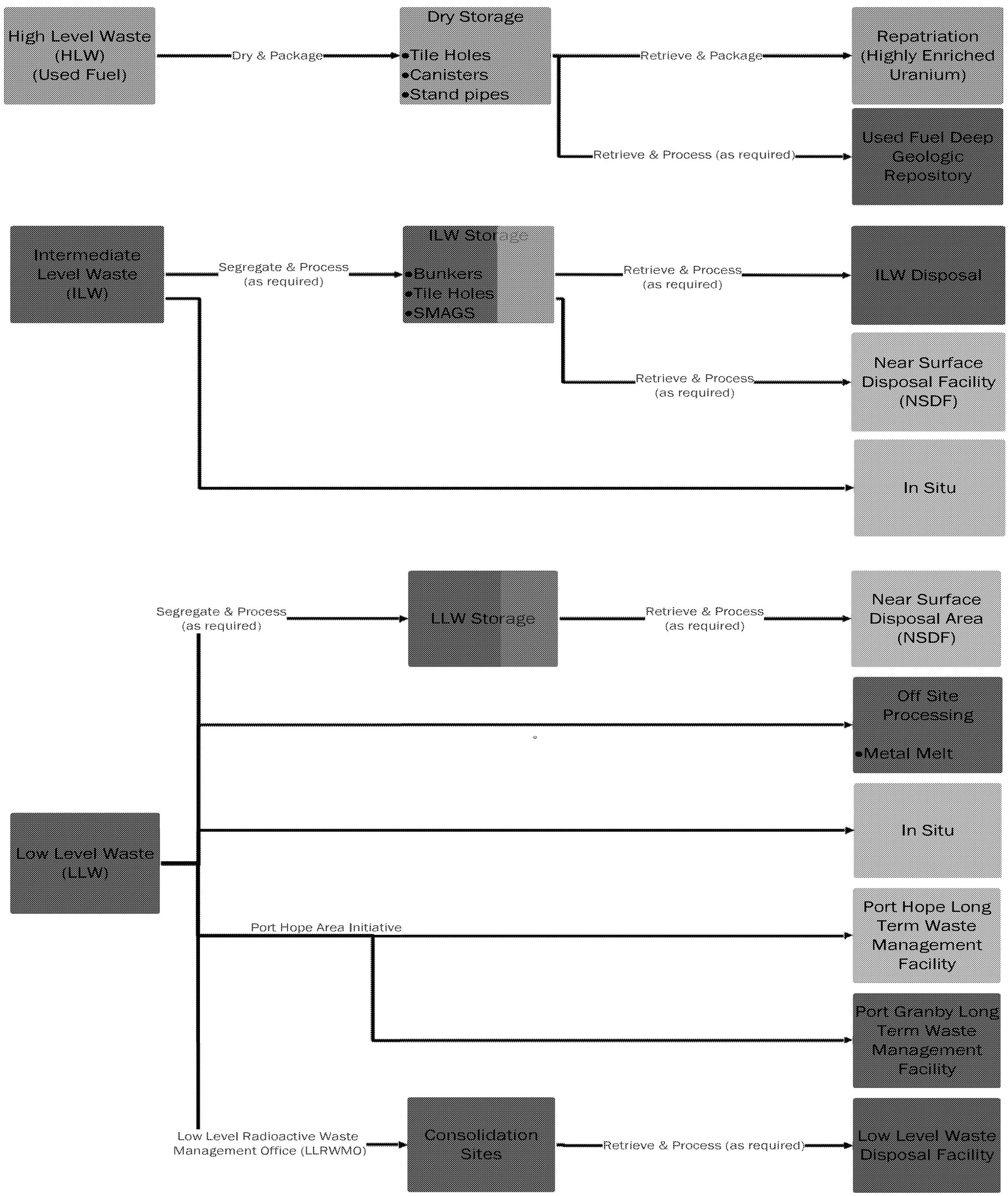


Figure 11 Colour Coding Legend

The information gathered from the workshops was used to produce visuals of the waste flow from generation to final disposition. An overview of the CNL waste flow is shown in Figure 12. Full waste flow diagrams are provided in [11] and are explained in more detail in sections 6 & 7. The waste flow diagrams will assist in the communication of the waste strategies.

It should be noted that at this stage of the process, waste routes have not been fully optimized. This will be addressed within the action plan (section 9) and in future revisions of the IWS where the use of option studies will show that the options identified are justified and underpinned.


High Level Waste (HLW) (Used Fuel)
Dry & Package
Dry Storage
•Tile Holes
•Canisters
•Stand pipes
Retrieve & Package
Repatriation (Highly Enriched Uranium)
Retrieve & Process (as required)
Used Fuel Deep Geologic Repository
Intermediate Level Waste (ILW)
Segregate & Process (as required)
ILW Storage
•Bunkers
•Tile Holes
•SMAGS
Retrieve & Process (as required)
ILW Disposal
Retrieve & Process (as required)
Near Surface Disposal Facility (NSDF)
In Situ
Low Level Waste (LLW)
Segregate & Process (as required)
LLW Storage
Retrieve & Process (as required)
Near Surface Disposal Area (NSDF)
Off Site Processing
•Metal Melt
In Situ
Port Hope Area Initiative
Port Hope Long Term Waste Management Facility
Port Granby Long Term Waste Management Facility
Low Level Radioactive Waste Management Office (LLRWMO)
Consolidation Sites
Retrieve & Process (as required)
Low Level Waste Disposal Facility

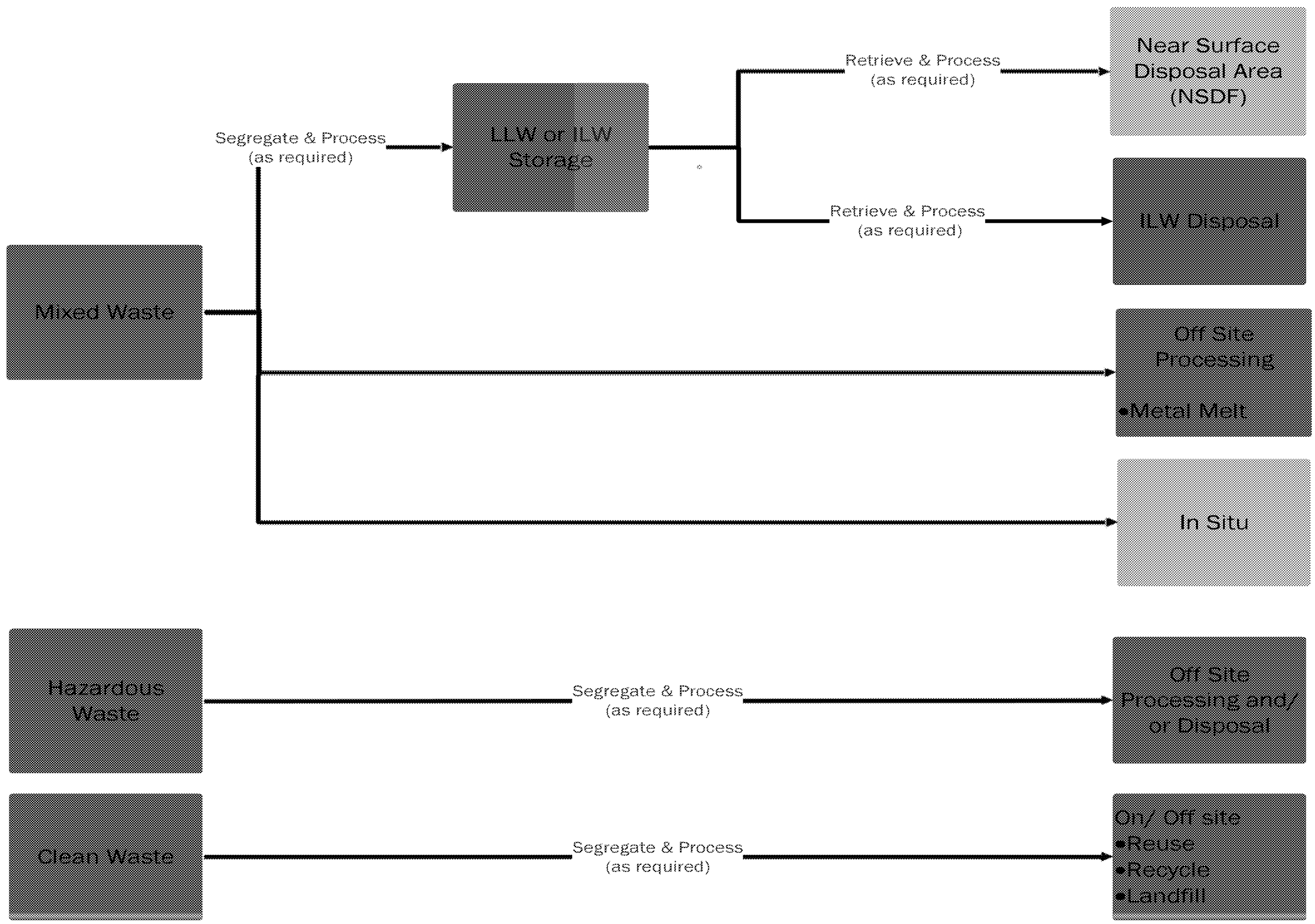


Figure 12 Overview of CNL Waste Flow

5.2 Waste Inventory and forecast information

[redacted]

s.21(1)(a)

s.21(1)(b)

Table 5
Baseline Cumulative Waste Forecast for CNL Managed Waste Streams

Waste Stream	Year				
	2015 (m^3)	2026 (m^3)	2046 (m^3)	2070 (m^3)	2100 (m^3)
High Level Waste	254	290	291	293	293
Intermediate Level Waste	2,430	8,339	13,739	19,258	20,268
Low Level Waste	54,479	274,659	567,475	841,275	860,466[2]
Hazardous/Mixed Waste	-[3]	2,650	6,650	11,450	11,450
Clean Waste	-[4]	465,260	754,929	1,184,292	1,214,641

The waste forecast is based on best available information and is documented in the CNL Lifetime Waste Forecast [14]. As strategies and plans evolve, the waste forecast will be updated accordingly. These forecasts are used to identify gaps and areas of concern regarding waste storage and to refine the Interim Waste Storage strategy. This is further discussed in the IWS linked document, CRL Storage Gap and Future Demand [16]. Figure 13 depicts the waste volume in 2100, by percentage (%).

[2] excludes PHAI wastes (1.7 M m^3).

[3] Hazardous/ mixed waste volumes for 2015 are not included as waste is dispositioned as it arises, with LLW portion of mixed waste being captured in the LLW volume .

[4] clean waste volumes for 2015 are not included as waste is dispositioned as it arises.

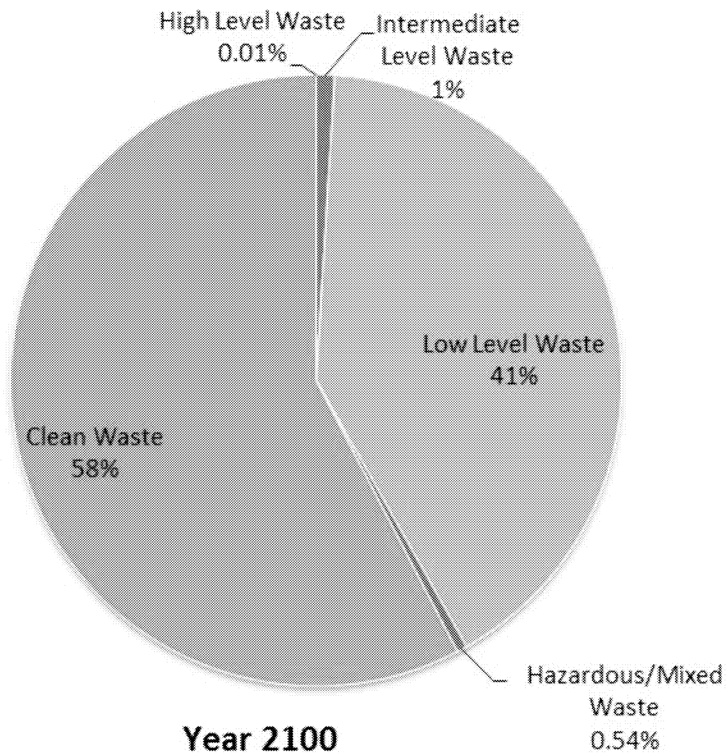


Figure 13 Forecasted waste volume by classification (%) at 2100

6. CNL INTEGRATED WASTE STRATEGIES

The CNL IWS has been produced to identify all waste routes, focusing on the anticipated larger volumes of decommissioning waste to be produced in the near term and ensuring sufficient storage is available until operational disposal facilities and routes become available. Sections 6.1 and 6.2 discuss the current (or baseline) CNL waste strategy by waste classification, and highlight specific challenges and gaps in the near term and longer term.

[redacted] Work is underway to develop characterization program improvements as characterization an essential predisposal activity that is common to all waste management steps and involves determination of physical, chemical and radiological properties of the waste. Gaps within these pathways will be highlighted and addressed in a phased manner, using option studies as appropriate. The studies will consider the wider CNL business in order to ensure the decisions and outcomes reflect optimal solutions for all wastes throughout the waste lifecycle.

6.1 Radioactive Waste

6.1.1 High Level Waste

In general, CNL sites do not generate large volumes of HLW. However, it does have a wide range of solid HLW (Used Fuel) currently in dry storage at CRL (this includes NPD fuel), WL, DP and G-1. This consists of CANDU type fuel and research reactor fuel.

[redacted]

The management of used fuel will be integrated across CNL and co-location storage options will be identified, awaiting national solutions which include the used fuel DGR, currently at the siting stage. Processing of some of the used fuel will be required, based on the parent fuel to meet waste acceptance criteria (WAC) of the used fuel DGR. A small portion of legacy research fuel at CRL is in the process of being transferred from in ground storage (Tile Holes) to an above ground facility known as the Fuel Packaging & Storage (FPS) Facility to improve storage conditions until the used fuel DGR is available.

Used fuel that is eligible for repatriation will follow the US DOE/ National Nuclear Security Administration (NNSA) non-proliferation M^3 (Material Management and Minimization) Mission approach, and will be returned to the US. This is completed under a commitment made in 2010 by the government of Canada to work cooperatively to repatriate highly enriched uranium (HEU), currently stored at CRL, and eliminate proliferation risks. This work also includes repatriation of liquid Target Residue Material (TRM) generated as a by-product of isotope production and currently stored in the Fissile Solution Storage Tank (FISST) at CRL, [redacted]

6.1.1.1 HLW Strategy Challenges

[redacted]

To meet the WL, DP and G-1 decommissioning timelines, fuel transfers to CRL and associated work including retrieval, packaging and transport of fuel waste require a range of technical solutions and integration with CRL. It is anticipated that some of the research reactor fuel and fuel debris currently stored within stand pipes at WL will be difficult to retrieve and transport to CRL. Therefore, processing of some fuels may be required at WL, entailing provision of a new or modified facility. At CRL, the lack of suitable storage capability available to accept the fuel has been recognised and effort is required to identify and implement storage requirements at CRL prior to shipment of waste. Planning of this work is underway.

Transport capabilities for used fuel from WL, DP and G-1 to CRL need to be identified and implemented. CRL is providing support with the development of these capabilities and capturing and managing the wider transportation approach through the D&WM Integrated Transportation Strategy [10]. Activities range from examining waste management system design concepts and developing process plans, to conducting R&D on the suitability of various waste packages. These activities are designed not to limit future options for long term management of waste for CNL and/or AECL.

In the long term it is assumed that CNL managed used fuel will be accepted at the national used fuel DGR. The preliminary WAC for the used fuel DGR have been developed, based upon the safety case for CANDU fuel, therefore, it is difficult to determine what processing will be required to ensure that the wide range of CNL research fuel will be acceptable. Infrastructure management & assessment of fuel management at CRL is required to ensure used fuel is safe until retrieval for processing for disposal at the used fuel DGR. Work continues through integration with CNL programs and NWMO to ensure all CNL managed fuel is compliant with the used fuel DGR WAC when these requirements and capabilities are available.

6.1.2 Intermediate Level Waste

ILW is generated from reactor parts and components associated with reactor operations and decommissioning and from isotope production processes.

CNL Objective for ILW:

- To consolidate ILW at CRL and place it in safe, secure and suitable storage facilities, making use of existing capacity, until disposal facilities become available.
- To manage suitable ILW In Situ where agreed.

[redacted]

6.1.2.1 Solid ILW

For radioactive material not suitable for NSDF disposal, interim storage capabilities will be developed. Solid ILW at CRL is segregated, processed and packaged as required, and stored at the CRL site. Solid ILW from other sites, with the exception of NPD and WL WR-1 waste will be processed as required to meet transport regulations and transferred to CRL for storage until suitable final ILW disposal is identified. NPD and WR-1 ILW will be managed as per In-situ decommissioning. Some ILW may be suitable for disposal at the NSDF through the use of decay in storage, which can lower the activity and dose rate of radioactive waste.

6.1.2.2 Liquid ILW

Liquid ILW is treated (immobilized) and stored as solid ILW. At CRL, treatment is undertaken at the Waste Treatment Centre (WTC) where liquid is evaporated and bituminized in drums and stored as solid ILW.

Liquid waste from molybdenum isotope production is cemented (Cemented Molybdenum Waste (CMW)) and stored as solid ILW. Options are currently being assessed to determine methods to manage this waste.

[redacted]

6.1.2.3 ILW Strategy Challenges

In the near term, due to limited storage capacity at CRL, identification and implementation of options will be required to ensure space is available to meet the storage needs for solid ILW, in particular for WL ILW which will be transferred to CRL.

s.21(1)(a)

s.21(1)(b)

[redacted]

To reduce the associated hazards, the Stored Liquid Waste (SLW) project at CRL is evaluating approaches to retrieve and immobilize radioactive liquid wastes from a series of legacy tanks, and decommission the associated tanks and structures. Continued storage of these wastes in aging tanks is identified as an environmental risk and a priority project in the D&WM Mission at the CRL site.

In the long term, further treatment of ILW may be required to meet any final WAC on an, as yet unsited geologic disposal facility. The feasibility of locating a disposal facility at CRL has previously been assessed. This facility was known as the Geologic Waste Management Facility (GWMF) and the outcome determined that CRL was feasible to host such a facility [18]. Further options and locations still need to be identified and assessed, and national discussions held, to determine the best way forward for management of wastes requiring greater isolation when disposed.

6.1.3 Low Level Waste

LLW is generated from operational, decommissioning and ER activities. Waste streams include dry active waste (e.g. Personal protective equipment & clothing), metal, rubble, concrete, wood, equipment, soil and vegetation and liquid waste from processes and laboratory operations.

CNL Objective for LLW:

- To provide capability and capacity for managing solid LLW to support the CNL Mission, including accelerated decommissioning.
- To manage suitable LLW in situ where appropriate.

6.1.3.1 Solid LLW

The baseline strategy for solid LLW including dry active waste, demolition and decommissioning wastes at CRL, WL, DP & G-1 is to segregate where practical, process as required and place in storage. Processing includes waste packaging. Currently waste is packaged in B25's (2.5 m^3 metal boxes) or larger containers (e.g. ISO containers or supersacs), if suitable. LLW is placed in storage in Shielded Modular Above Ground Storage (SMAGS) facilities at WL and CRL. Once available, waste will be transferred directly to the NSDF at CRL for disposal. [redacted]

s.21(1)(a)
s.21(1)(b)

[redacted] It is proposed that NPD and WR-1 wastes will be into the in-situ decommissioning at their respective licensed sites.

Through ER projects, prudent management and cleanup of legacy contaminated and affected sites will progressively reduce the Government of Canada's risk and liability. CNL will use comprehensive site characterization to understand radioactive and hazardous material contamination levels, environmental transport, conceptual site models and key site specific parameters to support risk assessments. This will be used to determine which areas require remedial actions or no further action.

In the near term, the largest volume of waste generated at CRL will arise from facilities decommissioning (FD). As the majority of waste volume will be LLW, disposition will be enabled by the NSDF, located at CRL. Waste generated prior to construction of NSDF will be placed in storage at CRL, until the facility becomes available. LLW currently in storage at DP & G-1 will also be transferred to CRL for storage and/or disposal in support of planned decommissioning activities.

LLW soil, managed by the PHAI project, is waste which has been contaminated with residue ore from the former radium and uranium refining activities of Eldorado nuclear. PH waste will be remediated and placed in the PH Long Term Waste management Facility (LTWMF) and material at the current PG site will be excavated and transferred to the PG LTWMF. Both facilities are above ground storage mounds.

Historic LLW, managed by the HWP MO will be managed locally to the area of remediation, or transferred to CRL for storage and disposal.

6.1.3.2 Liquid LLW

Liquid LLW is retrieved and processed (immobilized) so that it can be treated as solid LLW. Liquid LLW at CRL is evaporated at the WTC, then bituminized where it will then fall into the ILW solid waste stream.

6.1.3.3 LLW Strategy Challenges

As the NSDF is not yet available, near term challenges associated with waste storage need to be addressed to ensure sufficient capability is available to meet the high volume of waste encountered with an accelerated program of decommissioning. SMAGS has limited capacity and will not meet CNL storage needs. To address this, additional waste storage options are being assessed and off-site processing of some waste streams is being utilized to manage storage capacity and to reduce waste liabilities. The increased use of larger packaging is also being investigated. The SMAGS facilities are limited in the type of package they can accommodate, but new storage areas handle a range of suitable bulk containers.

In the long term, regulatory and stakeholder approval is required for the management of legacy LLW In-situ. If this strategy is not approved and agreed, there is a risk that the design of the NSDF will not accommodate the associated increased LLW inventory.

Effort is also required to actively pursue the retirement or significant reduction of historic liabilities at all sites. This includes consideration of consolidation of HWP sites. Work is underway to determine the options for efficient management of the wastes.

6.1.4 Mixed Waste

Mixed waste is radioactive waste that is also be classified as hazardous waste on the basis of its non-radiological characteristics. There are many examples of mixed waste at CNL which are typically encountered through operational, R&D, post operational clean out (POCO), decommissioning and ER activities.
Mixed waste, in general, are currently dispositioned via an off-site processor with any residual radioactive material being returned to site for disposal. Once NSDF becomes operational, it is expected to be able to accept suitable mixed waste.

[redacted]

6.1.4.1 Mixed Waste Strategy Challenges

There are challenges associated with mixed waste due to limited options for addressing the waste. Currently at CNL, the only available pathway is to send the material to off-site processors with the radioactive component being returned to CNL for storage/ disposal. This can be an expensive option; therefore the development of on-site treatment capabilities should be explored. This may be resolved with the commencement of operations at NSDF as it is intended that the facility will accept mixed waste. This is currently being reviewed as part of the WAC production process.

Another major challenge is ensuring identification of all potential mixed wastes that may be present at CNL, and determining the processing needs of the wastes. The challenge is to ensure they are identified to mitigate the risk of producing orphan wastes which have no known waste route available, creating uncertainties in the waste program. The IWS is assisting in documenting known mixed waste and will be instrumental in ensuring that strategies are in place to manage the wastes.

[redacted]

[redacted]

6.1.5.1 Unirradiated Fuel Strategy Challenges

There are large volumes of scrap Low Enriched Uranium (LEU) which currently do not have a disposition pathway identified. Options are currently being assessed to determine a way forward.

Slightly Enriched Uranium (SEU) is currently stored at CNL. One option being assessed is to process the material to remove hydrogen. This assessment is currently underway.

There are large volumes of natural and depleted Uranium at CNL. As this is not currently a sought after commodity, it is difficult to sell/ determine pathways for use. Therefore this material may become waste in the future.

CNL has some plutonium and mixed plutonium/ thorium in storage which requires a disposition route. Options including repatriation and recycling are being assessed. Some form of processing, which has still to be determined, may be required to meet the acceptance criteria of the receiving facility.

6.2 Non- Radioactive Waste

6.2.1 Clean Waste

Clean waste includes conventional trash, metal, construction, demolition and decommissioning material, ground material and vegetation.

The baseline strategy for clean waste is to apply the waste hierarchy to avoid, re-use and recycle to the extent practicable. Waste that does require disposal is sent to either on-site (for CRL & WL) or off-site landfills.

6.2.1.1 Clean Waste Strategy Challenges

Based upon current usage, the CRL landfill is estimated to reach capacity in the near term. Therefore efforts are underway to identify and assess options for disposing of clean waste to ensure waste routes are available to meet the demands of the accelerated decommissioning program.

Ground material is included within the IWS as it has the potential to become waste if reuse opportunities are not identified. Suitable laydown area capabilities are being improved to stage and grade material so that reuse of soils on the CRL site can be coordinated and optimized.

6.2.2 Hazardous Waste

Hazardous waste at CNL is packaged in accordance with regulations and transferred off-site for processing and disposal.

6.2.2.1 Hazardous Waste Strategy Challenges

One potential challenge for hazardous waste is ensuring that suitable off-site routes remain available throughout the lifetime of CNL.

7. SPECIFIC WASTES FOR CONSIDERATION

This section highlights particular wastes that have been identified as challenging and/ or difficult to manage. They may require further studies and assessments to ensure the optimum solutions for processing and disposition have been identified, or are challenging with respect to regulator and/or stakeholder considerations.

7.1 Stored Liquid Waste (SLW)

CNL will retrieve and immobilize legacy radioactive liquid waste located in tanks at CRL, resulting in a significant quantity of immobilized radioactive waste product. [redacted]

7.2 Target Residue Material (TRM)

CNL is in the process of repatriating suitable HEU stored at CRL to eliminate all future storage, reprocessing and disposal costs, and discharge the liability approximately 50 years earlier than planned. The current schedule assumes CNL will have repatriated the currently accepted National Research Experimental (NRX) and NRU fuel rods and the TRM liquid, provided the U.S. Department of Energy continues to support these activities under international nuclear non-proliferation agreements. The TRM is currently stored in FISST at CRL. [redacted]

7.3 Cemented Molybdenum Waste (CMW)

[redacted]

7.4 Organic Contaminated material (HB40/ OS-84)

The WR-1 reactor at WL was organically cooled with liquid aromatic hydrocarbon compounds HB40 and OS-84. The liquid coolant has since been removed from the reactor, however other materials coated with coolant, and residual liquid in pipes may still be present. Due to the nature of these compounds, which are assumed will be left in situ as part of decommissioning of the WR-1 reactor, WL are currently performing studies on HB-40 in support of the WR-1 in-situ decommissioning. While it is assumed that any contaminated material currently in storage at WL will meet any NSDF and future ILW disposal facility WAC, this is yet to be confirmed.

7.5 Radioactive Vegetation

Off-site processing and on-site storage is available for radioactive vegetation [19] but is currently limited in scope, reliability and efficiency. As revitalization of the CRL site progresses, the limitations in management options may cause issues and increase costs to projects.

7.6 Radioactively Contaminated Polychlorinated Biphenyls (PCB's)

Previously, radioactively contaminated PCB's have been processed off-site, with the radioactive component being returned to CNL for storage and eventual disposal. However, there is concern that further PCB material may be encountered during decommissioning activities which may be contaminated. Studies are required to determine if there is such likelihood of this material being present, and if so, options for processing and disposal need to be identified. This will require discussions with Environment Canada.

7.7 Graphite

There is [redacted] of graphite in the NRX reactor at CRL which will require removal during decommissioning, and it is likely that there is more graphite in other areas at CNL. Currently, WMA B can only accept small volumes of graphite and other moderators, e.g. Beryllium, due to criticality concerns. It is unclear whether the WAC for NSDF will be enable accommodation of such large volumes. If it cannot, effort will be required to identify a suitable alternative pathway.

7.8 Asbestos

Asbestos is likely to be the largest single hazardous material generated from decommissioning. Removal is carried out by specialized workers. Small amounts are bagged and disposed of via approved routes; however large volumes encountered during decommissioning do not currently have a fully operational and optimized route identified. Work is underway to open new off-site waste routes for clean asbestos waste.

7.9 Radioactively Contaminated Mercury

Radioactively contaminated mercury is known to be present in the WMAs. This may pose issues with disposal of legacy wastes, and processing may be required to treat the mercury present. Characterization of the wastes in storage is required to determine the extent of the issue and options for treatment need to be assessed.

7.10 Dichlorodiphenyltrichloroethane/ Dichlorodiphenyldichloroethane (DDT/DDE)

WL has packaged legacy Dichlorodiphenyltrichloroethane/ Dichlorodiphenyldichloroethane (DDT/DDE) currently stored in trenches at their WMAs, for which there is currently no identified waste route. The condition of the original packaging is not known but it is assumed that it has degraded and the material will now be mixed with soil and remnant packaging. Characterization of the wastes in storage is required to determine the extent of the issue and options for treatment need to be assessed.

7.11 Lead

It is assumed that a large volume of lead will be produced as a result of decommissioning. Due to difficulties in ensuring lead is suitable for release as clean waste, most will be classified as LLW. Currently it is assumed this waste will be packaged and stored until disposed of at NSDF, but may require treatment/ encapsulation to meet WAC. The plan is to store the waste for treatment and disposal until option studies can be undertaken to determine the best route(s) to meet business needs.

7.12 Remediation Waste

Although the legacy material that is to be remediated is likely to already be captured within the other waste pathways, degradation of waste and packages creates an additional challenge due to mixing of a range of materials, and contamination with soil and sand. This may cause additional problems with waste characterization, segregation and disposition.

8. DISPOSAL ROUTES

The waste flow diagrams [12]detail various disposal routes used by CNL which are either CNL managed and operated or are contracted. Whichever option is used depends upon current and future availability. In some cases use of optioneering to determine an optimised solution may be required, especially where it is known that routes may not continue to provide needed capabilities in the future.

8.1 Radioactive Long Term Waste Management and Disposal Routes

The following Long Term Waste Management Facilities are currently operational or under construction at CNL:

- The HWP MO has two long term management facilities which will accept historic LLW from their specific projects through the PHAI. The PH LTWMF is under construction. The facility will provide safe, long-term storage for the approximately 1.2 million m^3 of historic low-level waste to be cleaned up in the community as part of the Port Hope Project. Approximately 450,000 m^3 of that waste is already located at the existing waste management facility, within the boundaries of the new facility site, and will be relocated to the aboveground engineered mound during the cleanup. The PG LTWMF began operations in 2016 October. The facility will provide safe, long-term storage for the approximately 450,000 m^3 of LLW and contaminated soil. The multi-component cover system will reduce surface water infiltration through the waste, provide protection of the mound from inadvertent intrusion into the waste, and reduce levels of gamma radiation on the surface of the mound to background levels. The cover will be approximately 2.75 m thick and will include a capillary drainage layer system that will provide additional protection against moisture infiltration into the waste.
- The HWP MO also has a long term management facility that has been closed and is currently under long-term monitoring in Fort McMurray, Alberta. The facility provides safe, long-term storage for approximately 43,000 m^3 of historic LLW recovered from the remediation of uranium ore impacted sites along the Northern Transportation Route (NTR) in Fort McMurray.
- The CRL Bulk Material Landfill is a long term management facility which began operations in 2010 and accepts LLW sewage sludge from the on-site sewage treatment plant.

There are no approved final disposal routes available for radioactive waste in Canada. However, there are some proposals underway for future disposal routes and facilities at CNL:.

- The NSDF is a proposed engineered facility for radioactive waste disposal currently in the design stage, to be located at CRL and with an initial capacity of 525,000 m^3, increasing to 1,000,000 m^3. It will provide near term disposition for stored legacy waste, enable accelerated decommissioning at CRL and closure of WL, achieve the immediate reduction of the estimated cleanup liability, and demonstrate a cost-effective disposal method for LLW [redacted] The facility is expected to be operational for approximately 50 years. A Project description is provided in [15]

- A program to develop a national repository for permanent disposal of used fuel has been approved by the federal government and undertaken by the NWMO. The national Used Fuel DGR is currently in the siting process and is anticipated to be operational by ~2045 and accepting AECL's used fuel by ~2055. The used fuel DGR is a network of underground tunnels and placement rooms for used nuclear fuel containers. It is designed to safely contain and isolate Canada's used nuclear fuel over the long term. The repository is assumed to be located in a crystalline or sedimentary rock geosphere at a nominal depth of 500 m. [20]

Other long term waste management and disposal routes which are part of the IWS include:

- in situ management is proposed for NPD, the WL WR-1 reactor and specific, suitable WMAs. Environmental assessments for specific projects have been submitted to CNSC and project descriptions are available [6] &[7].
- Determining a final ILW Disposal solution is being progressed by CNL's D&WM division, who will be working with other Canadian nuclear operators, regulators and agencies to advance progress. A consent-based process could result in more than one storage facility and/or disposal facility, depending on the outcome of discussions with host communities; the Nuclear Safety and Control Act may envision and provide consent for multiple disposal facilities as a matter of equity between regions of the country.

8.2 Non radioactive Disposal Routes

CNL has conventional landfills located at its CRL & WL sites. The capacity of these landfills are limited and effort is made to divert waste from landfill.

A clearable waste program [21] is in place at CNL to optimize use of the waste hierarchy. This involves confirmation monitoring of suspect contaminated materials to ensure wastes can be transferred off-site for reuse, recycling or disposal, as appropriate.

CNL has contracts in place with various off-site processors to provide suitable processing and disposal routes for a wide range of materials.

9. AREAS REQUIRING FURTHER DEVELOPMENT

9.1 Gap Analysis

[redacted]

9.1.1 Waste Characterization

[redacted]

9.1.2 Waste Inventory/ Data

[redacted]

s.21(1)(a)
s.21(1)(b)

9.1.3 Waste Processing

[redacted]

9.1.4 Waste Storage

[redacted]

9.1.5 Waste Transport

[redacted]

9.1.6 Long Term Management & Disposal

[redacted]

9.1.7 Optimization of waste routes

[redacted]

9.1.8 Communication

[redacted]

9.2 Action Plan and Program

[redacted]

Table 6
Summary Action Plan

Waste Area	Action	D&WM Owner(s)	Key Stakeholder(s)/ Groups
Characterization	Identify and prioritize waste characterization gaps	Waste Management (WM) Programs	Waste Operations
	Develop technical and programmatic improvements to address gaps with a focus on Facilities Decommissioning (FD) and Environmental Remediation (ER) across CNL.	Waste Management & Environmental Restoration (WM&ER) FD WM Programs	D&WM
	Produce long term strategies to enable reliable processes to be put in place to align with best practice.	WM Programs	CRL Operations/ Site Transition D&WM Whiteshell (WL)
Inventory/ Data	Ongoing inventory and forecast refinement as assumptions made and risks identified are mitigated.	WM Programs	CRL Operations/ Transition D&WM All CNL sites
	Identify suitable Waste Data Tracking System platform to provide Data support and integrate across CNL.	WM Programs	All CNL
Processing	Review processing technology requirements (based upon previous studies) and identify areas requiring further assessment and develop standard waste treatment approaches for specific waste streams and waste types.	WM Programs Waste Operations	CRL Operations/ Transition D&WM CRL S&T All CNL sites
	Carry out option studies as required.	WM Programs Waste Operations	All D&WM
Storage	Review and implement interim storage and waste packaging options to support missions.	WM Programs Waste Operations	FD
	Review and implement storage requirements at CRL taking into consideration the needs of off-site producers.	WM Programs Waste Operations	WM &ER WL DP G-1
Transport	Review and identify options for transportation of waste.	WM Programs WM&ER	WL DP G-1 HWP MO
	Produce and implement CNL transportation strategy to support the D&WM mission.	WM Programs WM&ER	WL DP G-1 HWP MO

Long Term Management & Disposal	NSDF Project – design and implement.	Low Level Radioactive Waste Facility	Waste operations
	Identify right size solution for management of waste destined for deep geologic disposal (non-NSDF waste).	Low Level Radioactive Waste Facility	
	Continue to cooperate and coordinate with NWMO regarding all CNL managed fuel.	WM&ER	
Optimization	Prioritize projects requiring option studies which have been identified and agreed with stakeholders and SME's.	WM Programs	All D&WM
	Begin use of Best Available Technique (BAT) Optioneering process.	WM Programs	
	Continue to identify and assess projects until complete.	WM Programs	All D&WM
Communication	Maintain IWS as 'Live' document, updating on regular basis.	WM Programs	All CNL
	Roll out strategy to ensure the appropriate parties are engaged and aware of the IWS.	WM Programs	All CNL
	Ensure all wastes captured in IWS, and progress on identified gaps continues.	WM Programs	All CNL

10. CONCLUSIONS

An IWS can be a useful communication tool for waste strategy. This revision of the CNL IWS provides a high level overview of the management of all waste across CNL from cradle to grave and details the baseline waste strategy upon which completion and further optimization of waste pathways can be developed.

Gaps in the IWS have been identified and an action plan produced. Further iterations will be produced as the IWS develops.

At a national level, an area which would benefit from further work is collaboration with other Canadian waste generators to identify and develop waste management opportunities including disposal of radioactive wastes. Discussions are currently underway and this work may lead to reductions in the number of enabling and disposal facilities required nationally.

11. GLOSSARY

Although definitions are provided in [9] it is recognised that the Integrated Waste Strategy may be used to inform a national approach to waste strategy in the future. Therefore the references provided have, as far as possible, been obtained from the national Canadian Standards Association CSA standard N 292.0 [22] and international IAEA safety glossary guidance [23].

Characterization: Determination of the physical, chemical, biological, and/or radiological waste characteristics for use in the assessment of health, safety, and environmental hazards. [22]

Cradle to Grave approach: An approach in which all the stages in the lifetime of a facility, activity or product are taken into consideration. [23]

Clean Waste**:** Non- hazardous material that is declared to be non-radioactive by its history, location and use; or non-hazardous material that has been determined to meet regulatory requirements for unconditional clearance by means of suitable radiological monitoring. [9]

Conditioning — operations that produce a waste package suitable for handling, transport, storage, and/ or disposal.
Note: Conditioning may include the conversion of the radioactive waste to a solid waste form, enclosure of the radioactive waste in containers, and, if necessary, providing an overpack. [22]

Disposal — placement of radioactive waste in an appropriate facility without the intention of retrieval. [22]

Disposition — consignment of, or arrangements for the consignment of, radioactive waste for some specified (interim or final) destination.
Note: For example, for the purpose of processing, disposal, or storage. [22]

Facility — assembly of structures, systems, components, and/or associated land where radioactive materials are produced, processed, managed, used, handled, stored, or disposed of on such a scale that consideration of safety is required. [22]

Handling — the physical manipulation and movement of waste material. [22]

Hazardous substance — non-nuclear substances that are potentially hazardous to human health and/or the environment due to their nature and quantity and that require special handling and storage techniques. [22]

Hazardous Waste: Materials that are potentially hazardous to human health and/ or the environment due to their nature and quantity and that require special handling and storage techniques. [22]

High Level Waste (Used Fuel): Used (i.e. irradiated) nuclear fuel that has been declared as radioactive waste and' or is waste that generates significant heat (typically more than 2kW/m3) via radioactive decay. [22]

Highly Enriched Uranium: Uranium containing 20% or more of the isotope $_{235}$U**.**

In situ: 'In the original place' [Oxford English Dictionary]

In situ decommissioning: a proven technology which has been in use for over six decades in the United States and is a well-understood decommissioning solution. It involves removing the above ground structure and placing contaminated materials into the below grade structure. The below grade structure, reactor vessel and systems and components will be sealed by grouting. The structure will then be capped with concrete and covered with an engineered barrier. In-situ decommissioning will isolate the contaminated systems and components inside the below grade structure. [cnl.ca]

Interim storage: Radioactive material in storage for the purpose of processing. [22]

Intermediate Level Waste: Typically exhibits levels of penetrating radiation sufficient to require shielding during handling and interim storage. [22]

Low Enriched Uranium: Uranium containing less than 20% of the isotope $_{235}$U.

Low Level Waste: Contains material with radionuclide content above established clearance levels and exemption quantities, but generally has limited amounts of long-lived activity. [22]

Mixed Waste: Radioactive waste that also contains hazardous substances. [22]

Operational waste: Waste associated with normal operation of a facility.[22]

Overpack: An enclosure used by a single consignor to consolidate one or more small means of containment for the ease of handling but that is not a minimum required means of containment. [24]

Package (radioactive material): Packaging — the assembly of components necessary to enclose the radioactive contents completely. [22]

Pre-disposal: Any waste management steps carried out prior to disposal, such as pre-treatment, treatment, conditioning, storage and transport activities. [23]
Pre-Treatment: Any or all of the operations prior to waste treatment, such as collection, segregation, chemical adjustment and decontamination.[23]

Radioactive Waste: A gas, liquid, sludge or solid containing a nuclear substance in excess of the clearance or exemption criteria and without foreseeable use. [22]

Radioactive Waste Management: All steps in the management of radioactive waste [22]

Slightly Enriched Uranium: Uranium containing less than 5% of the isotope $_{235}$U (this is a sub-category of LEU.

Stakeholder: Interested party; concerned party. [23]

Storage: the short or long-term management of radioactive waste in a facility that provides for containment with the possibility for retrieval where institutional controls and maintenance are required. [22]

Transport: handling activities and means associated with the movement of radioactive waste. [22]

Treatment: Operations intended to benefit safety and/or economy by changing the characteristics of the waste. Three basic treatment objectives are:

(a) Volume reduction;

(b) Removal of radionuclides from the waste;

(c) Change of composition. [22]

Waste: Residual material, generated as a result of a process, operation or activity that has no further use in that process, operation or activity and is declared for reuse, recycling or disposal. [22]

Waste acceptance criteria: quantitative or qualitative criteria, specified by the regulatory body or by the operator of a waste management facility, that are to be used to determine the acceptability of the radioactive waste for inclusion in a short-term or long-term waste management facility. [22]

Waste processing: Any operation that changes the characteristics of waste, including pre-treatment, treatment and conditioning. [22]

Waste stream: a series of wastes resulting from a particular source and with consistent characteristics. [22]

12. ACRONYMS & ABBREVIATIONS

AECL	Atomic Energy of Canada Limited
BAT	Best Available Technique
CANDU	Canada Deuterium Uranium
CMW	Cemented Molybdenum Waste
CNEA	Canadian Nuclear Energy Alliance
CNL	Canadian Nuclear Laboratories Ltd.
CNSC	Canadian Nuclear Safety Commission
CRL	Chalk River Laboratories
CSA	Canadian Standards Association
D_2O	Heavy Water (Deuterium Oxide)
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
DGR	Deep Geologic Repository
DOE	Department of Energy
DP	Douglas Point
D&WM	Decommissioning & Waste Management
ER	Environmental Remediation
FD	Facilities Decommissioning
G-1	Gentilly-1
GoCo	Government-owned, Contractor-operated
GWMF	Geologic Waste Management Facility
HEU	Highly Enriched Uranium
HLW	High Level Waste
HSSE	Health, Safety, Security & the Environment
HWP	Historic Waste Program
HWP MO	Historic Waste Program Management Office
IAEA	International Atomic Energy Authority
ILW	Intermediate Level Waste
IWS	Integrated Waste Strategy
FISST	Fissile Solution Storage Tank

FPS	Fuel Packaging & Storage
LEU	Low Enriched Uranium
LTWMF	Long Term Waste Management Facility
LLW	Low Level Waste
LLWP	Low Level Waste Program
LLRWMO	Low Level Radioactive Waste Management Office
MS	Management System
NDA	Nuclear Decommissioning Authority
NNSA	National Nuclear Security Administration
NPD	Nuclear Power Demonstration
NRCan	Natural Resources Canada
NRU	National Research Universal
NRX	National Research Experimental
NSDF	Near Surface Disposal Facility
NWMO	Nuclear Waste Management Organization
OSDF	On Site Disposal Facility
PCB	Polychlorinated Biphenyls
PDD	Program Description Document
PG	Port Granby
PHAI	Port Hope Area Initiative
PH	Port Hope
POCO	Post Operational Clean Out
R&D	Research and Development
SEU	Slightly Enriched Uranium
SLW	Stored Liquid Waste
SMAGS	Shielded Modular Above Ground Storage
SME	Subject Matter Expert
SNM	Special Nuclear Material
S&T	Science and technology
SwS	Storage with Surveillance
TDG	Transport of dangerous Goods

TRM	Target Residue Material
UK	United Kingdom
URL	Universal Research Laboratories
US	United States
WAC	Waste Acceptance Criteria
WL	Whiteshell Laboratories
WM	Waste Management
WMA	Waste Management Area
WM Program	Waste Management Program
WR-1	Whiteshell Reactor -1
WTC	Waste Treatment Centre
WM&ER	Waste Management & Environmental Restoration

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