



Plan

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Title: <b>DARLINGTON NUCLEAR SITE PRELIMINARY DECOMMISSIONING PLAN</b>
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**Darlington Nuclear Site Preliminary  
Decommissioning Plan**

**NK38-PLAN-00960-10001-R003**  
December 2021

Order Number: CO 50004089  
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### Revision Summary

Revision Number	Date	Comments
R003	December 2021	<ul style="list-style-type: none"> <li>• Revised to update information for CNSC quinquennial review.</li> <li>• Entire document – Revised to reflect OPG’s current planning assumptions, strategy for decommissioning the DNGS, CNSC staff recommendation regarding timeline for DDP submission and TLG’s Decommissioning Cost Study for DNGS.</li> <li>• Entire document – Consistent terminology used throughout for Storage With Surveillance and remove reference to OPG’s L&amp;ILW DGR.</li> <li>• Revised to be in compliance with CSA N294:19.</li> <li>• Section 1.0 – Revised to highlight the scope change to a site PDP that addresses interfaces with the DWMF located on the Darlington Nuclear Site.</li> <li>• Section 1.1 – Updated regulatory submissions required for transition to decommissioning and for the application for a licence to perform decommissioning activities.</li> <li>• Sections 1.2.1 and 1.2.2 – Updated licensing documents consistent with the latest DNGS Licence and LCH.</li> <li>• Section 1.2.3 – Replaced the Canadian Environmental Assessment Act (CEAA) 2012 with the Impact Assessment Act (IAA).</li> <li>• Section 1.2.4 – Updated to the most current list of International Atomic Energy Agency Guides/Standards, consistent with CSA N294:19 references.</li> <li>• Section 1.3 – New Section to describe the applicable OPG programs relevant to decommissioning.</li> <li>• Section 1.5 – Updated planning assumptions for shutdown and decommissioning.</li> <li>• Figure 2-1 – Replaced with a clearer figure of the location of DNGS.</li> <li>• Section 2.2.1 – Updated the main group of buildings forming the station and the list of new buildings/structures to support the Darlington Refurbishment Project.</li> <li>• Updated Figure 2-2 with the latest site plane of DNGS layout.</li> <li>• Figure 2-3 (Legend) – Updated to include new Buildings on the Darlington Nuclear Site since 2015.</li> <li>• Section 2.2.5 – updated text on the vacuum building.</li> <li>• Section 2.2.7 – Simplified text related to other non-nuclear systems and structures to refer back to Section 2.2.1 where these are mostly described.</li> <li>• Section 2.2.8 – Updated to include the interface of DWMF with DNGS. Removed the new HWMB West Annex, RFRISA and Retube Waste Processing Building as these are already included in Section 2.2.1.</li> <li>• Added Figure 2-11 – Aerial View of the Darlington Waste Management Facility.</li> </ul>

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		<ul style="list-style-type: none"> <li>• Section 2.3 (including: 2.3.1, 2.3.2.1, 2.3.2.2, 2.3.2.3, 2.3.2.4, 2.3.3.1, 2.3.3.2, 2.3.3.3, 2.3.4) – Updated references and information related to the description of the surrounding environment, per the DNGS Safety report and the 2020 Environmental Risk Assessment for the Darlington Nuclear Site.</li> <li>• Section 2.3.2.3 – Included updates on Darlington groundwater monitoring program and latest annual Environmental Protection Report.</li> <li>• Section 2.3.2.4 – Updated seismic data.</li> <li>• Section 2.3.3.2 – Updated total commercial fish harvest.</li> <li>• Section 2.3.3.3 – Updated Lake Ontario water level to latest Fisheries and Oceans Canada, water levels bulletin.</li> <li>• Section 2.3.4 – Updated current use of land adjacent to the DNGS and revised to incorporate changes from the latest DNGS Safety Report.</li> <li>• Section 2.3.5, including Table 2-1 – Population statistics updated and added text related to the 10-year DNGS Refurbishment Project.</li> <li>• Section 2.3.6 – Updated text and revised title to 'Indigenous Communities'.</li> <li>• Sections 2.3.7 – Updated to reflect latest community engagement, OPG emergency response plan and emergency drills in the community surrounding DNGS.</li> <li>• Added new sub-section 2.3.7.1 on Indigenous Relations.</li> <li>• Section 2.4 – Provided updates on DNGS refurbishment and OPG's production of molybdenum-99.</li> <li>• Section 3.1 – Included scope that the DNGS PDP is considered as the site PDP.</li> <li>• Table 3-1 – Updated per list of buildings considered in cost estimations for the DNGS.</li> <li>• Section 3.3 and Figure 3-1 – Updated per CSA N294:19.</li> <li>• Section 3.4.1 – Revised the decommissioning strategies, consistent with CSA N294:19 and updated the list of major activation radionuclides and fission products based on latest decommissioning OPEX.</li> <li>• Section 3.4.2 (including 3.4.2.1 to 3.4.2.4) – Revised to be consistent with CSA N294:19 and align with Canadian OPEX for the phases of Storage with Surveillance.</li> <li>• Section 3.4.3.1 – Updated with OPG's decommissioning experience and CNL's progress with its decommissioning and site remediation projects.</li> <li>• Section 3.4.3.2 – Updated to latest statistics on International Decommissioning Strategies and Experience.</li> <li>• Section 3.5 – Revised timeline for conducting scoping and characterization surveys.</li> <li>• Section 3.6 – Updated to reflect the elements of risk and uncertainty associated with decommissioning the DNGS.</li> <li>• Section 4.0 and Figure 4-1 – Modified for consistency with the DNGS Costing Report. Added interfaces with the other facilities on the Darlington Nuclear Site. Added a new Figure 4-2 to address the DNGS Decommissioning Interferences.</li> </ul>
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		<ul style="list-style-type: none"><li>• Section 4.1, including subsections 4.1.1 to 4.1.4 – Revised per feedback from OPG’s Safe Storage Project Group, updated the SWS Planning / Stabilization Activities and the regulatory submissions.</li><li>• Section 4.2, including subsections 4.2.1 to 4.2.5 – Updated to reflect activities carried out during SWS.</li><li>• Section 4.2.2 – Removed plans for preparing site abandonment plan as these will be carried out once Dismantling &amp; Demolition is complete, i.e., at later stage of decommissioning.</li><li>• Section 4.2.4 – Provided additional details on the structure of the DDP that will be prepared prior to Dismantling and Demolition. Added the purpose of the Decommissioning Safety Assessment.</li><li>• Section 4.3 (including subsections 4.3.1, 4.3.2, 4.3.4, 4.3.5, 4.3.7 to 4.3.10) – Updated to OPG’s planning assumptions and to meet new clauses of CSA N294:19.</li><li>• Section 4.4: New text to describe OPG’s strategy for waste management and characterization.</li><li>• Section 4.4.1.3 – Provided updates on OPG’s disposal options for LLW and ILW.</li><li>• Table 4-2 – Updated estimated volumes of L&amp;ILW generated during decommissioning.</li><li>• Section 4.4.1.2 – Updated assumptions for management of high-level waste.</li><li>• Section 4.4.1.3 – Updated assumptions for management of low- and intermediate-level waste.</li><li>• Section 4.4.2.1 and Table A-1 –Updated the inventory of hazardous materials at DNGS.</li><li>• Section 5.1 – Updated to TLG 2022 cost estimates.</li><li>• Section 6.1 – Added elements of risk associated with decommissioning activities and how these will be managed.</li><li>• Section 6.3 – Updated to the DNGS decommissioning costing report.</li><li>• Section 6.4 – Revised per OPG’s staffing plan for SWS.</li><li>• Section 7.0 – Clarified need for an Impact Assessment (IA).</li><li>• Section 7.1.1 – Updated text on air quality.</li><li>• Section 7.1.2 – added reference to DNGS latest annual Groundwater Monitoring Report and updated text.</li><li>• Sections 7.1.4 and 7.1.5 – Revised per the latest updates on wildlife and aquatic life on and around the Darlington Nuclear Site, respectively.</li><li>• Section 7.2.2 – Revised text to include the potential impacts of demolition noise during decommissioning and the mitigation strategies.</li><li>• Section 7.3.2 – Revised to reflect changes from CEAA 2012 to Impact Assessment Act (IAA).</li><li>• Sections 7.3.4, 7.3.5, 7.3.6, 7.3.7 and Table 7-1 – Revised to current decommissioning planning assumptions and the DNGS Costing Report.</li><li>• Table 8-1 – Revised list of hazards, description / comments, as required.</li></ul>
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	<ul style="list-style-type: none"><li>• Section 8.1.1 – Revised timeline when the Occupational Dose Estimate for decommissioning of the DNGS will be prepared.</li><li>• Section 8.2 – Updated text to include qualified use of personnel throughout the decommissioning phases.</li><li>• Section 9.1 – Revised to include compliance with licensing conditions in relation to security during decommissioning.</li><li>• Section 10.0 – Added reference to OPG’s Nuclear Management System.</li><li>• Section 11.0 – Updated information regarding record keeping.</li><li>• Section 12.0 – Updated the Public Involvement Program.</li><li>• Section 13.0 – Revised title and text to reflect changes from CEAA 2012 to IAA.</li><li>• Updated Section 14: References.</li><li>• Appendix A – Updated Types, Quantities and Locations of Hazardous Materials Stored at DNGS.</li><li>• Appendix B – Updated with revised decommissioning cost estimate and DNGS Costing Report.</li><li>• Previous Appendix C and Table C-1 on estimated workforce during the course of decommissioning of PNSG – Deleted so as not to duplicate information in the DNGS Costing Report.</li><li>• Appendix C – Updated compliance matrix against CSA N294:19.</li></ul>
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### Acronyms

<b>ALARA</b>	- As Low As Reasonably Achievable
<b>APM</b>	- Adaptive Phased Management
<b>BNGS</b>	- Bruce Nuclear Generating Station
<b>CANDU</b>	- Canada Deuterium Uranium
<b>CCNS</b>	- Centre for Canadian Nuclear Sustainability
<b>CEAA</b>	- Canadian Environmental Assessment Act
<b>CFVS</b>	- Containment Filtered Venting System
<b>CLOCA</b>	- Central Lake Ontario Conservation Authority
<b>CN</b>	- Canadian National
<b>CNSC</b>	- Canadian Nuclear Safety Commission
<b>CSA</b>	- Canadian Standards Association
<b>DDP</b>	- Detailed Decommissioning Plan
<b>DGR</b>	- Deep Geologic Repository
<b>DLC</b>	- Darlington Learning Center
<b>DNGS</b>	- Darlington Nuclear Generating Station
<b>DOC</b>	- Decommissioning Operations Contractor
<b>DP</b>	- Douglas Point
<b>DRL</b>	- Derived Release Limit
<b>DSC</b>	- Dry Storage Container
<b>DWMF</b>	- Darlington Waste Management Facility
<b>DYEC</b>	- Durham York Energy Centre
<b>EA</b>	- Environmental Assessment
<b>EPG</b>	- Emergency Power Generator
<b>ESA</b>	- Endangered Species Act
<b>ESDR</b>	- End State Determination Report
<b>ESSB</b>	- Engineering Services & Support Building
<b>G-1</b>	- Gentilly-1
<b>GSR</b>	- General Safety Requirements
<b>HF</b>	- Human Factors
<b>HFEP</b>	- Human Factors Engineering Program Plan
<b>HSA</b>	- Historical Site Assessment
<b>HWMB</b>	- Heavy Water Management Building
<b>HWP</b>	- Heavy Water Plant
<b>IA</b>	- Impact Assessment
<b>IAC</b>	- Indigenous Advisory Council
<b>IAA</b>	- Impact Assessment Act
<b>IAEA</b>	- International Atomic Energy Agency
<b>IFB</b>	- Irradiated Fuel Bay
<b>IGLD</b>	- International Great Lakes Datum
<b>IIS</b>	- Isotope Irradiation System
<b>ILW</b>	- Intermediate Level Waste
<b>ITC</b>	- Immobilized Tritium Container
<b>KI</b>	- Potassium Iodide
<b>L&amp;ILW</b>	- Low and Intermediate Level Waste
<b>LLW</b>	- Low Level Waste
<b>MAPLE</b>	- Multipurpose Applied Physics Lattice Experiment

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- MARSSIM** - Multi-Agency Radiation Survey and Site Investigation Manual
- MECP** - Ministry of the Environment, Conservation and Parks
- MSC** - Modular Shielded Container
- NBP** - New Brunswick Power
- NGS** - Nuclear Generating Station
- NPD** - Nuclear Power Demonstration
- NPP** - Nuclear Power Plant
- NRCan** - Natural Resources Canada
- NRU** - National Research Universal
- NRX** - National Research Experimental
- NSCA** - Nuclear Safety and Control Act
- NWMO** - Nuclear Waste Management Organization
- OH&S** - Occupational Health and Safety
- ONFA** - Ontario Nuclear Funds Agreement
- OPEX** - Operating Experience
- OPG** - Ontario Power Generation
- OSB** - Operations Support Building
- PCB** - Polychlorinated Biphenyl
- PDP** - Preliminary Decommissioning Plan
- PHT** - Primary Heat Transport
- PNGS** - Pickering Nuclear Generating Station
- PPE** - Personal Protective Equipment
- PROL** - Power Reactor Operating Licence
- PTR** - Pool Test Reactor
- QA** - Quality Assurance
- RFRISA** - Re-Tube and Feeder Replacement Island Support Annex
- RPO** - Refurbishment Project Office
- RSSI** - Radiation Survey and Site Investigation
- RWPB** - Retube Waste Processing Building
- RWSB** - Retube Waste Storage Building
- SAP** - Stabilization Activity Plan
- SCA** - Safety and Control Area
- SCR** - Station Condition Record
- SEIA** - Socio-Economic Impact Assessment
- SIO** - Safety Improvement Opportunities
- SON** - Saugeen Ojibway Nation
- SOP** - Sustainable Operations Plan
- SSC** - Structures, Systems and Component
- SSG** - Specific Safety Guide
- SSP** - Storage and Surveillance Plan
- SSR** - Specific Safety Requirements
- SSS** - Safe Storage State
- SSTF** - Spent Solvent Treatment Facility
- SWS** - Storage with Surveillance
- TDS** - Target Delivery System
- TLG** - TLG Services LLC
- TRF** - Tritium Removal Facility

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- UFDSB** - Used Fuel Dry Storage Building
- VLLDS** - Very Low Level Drain State
- VSDS** - Visual Survey Data System
- WBS** - Work Breakdown Structure
- WR-1** - Whiteshell Reactor
- WWMF** - Western Waste Management Facility
- ZEEP** - Zero Energy Experimental Pile

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### **Abstract**

This Preliminary Decommissioning Plan (PDP) describes the activities that will be required to decommission Darlington Nuclear Generating Station (DN GS) and restore the site for other Ontario Power Generation uses. It is also referred to as the site PDP as it addresses the interfaces of the DN GS with the Darlington Waste Management Facility (DWMF) located on the Darlington Nuclear site. This PDP demonstrates that decommissioning is feasible with existing technology and it provides the schedule as well as the basis for estimating the cost of decommissioning.

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## 1.0 INTRODUCTION

Darlington Nuclear Generating Station (DNGS) is owned and operated by Ontario Power Generation (OPG). DNGS is a four unit Canada Deuterium Uranium (CANDU) Nuclear Generating Station (NGS) with a total output of 3,524 Megawatts. DNGS is located in the Municipality of Clarington in Durham Region approximately 70 km east of Toronto.

This Preliminary Decommissioning Plan (PDP) is the proposed plan for the decommissioning of DNGS and since it also addresses the interfaces of the DNGS with the Darlington Waste Management Facility (DWMF) located on the Darlington Nuclear Site, it is referred to as the Site PDP. Details of the DWMF decommissioning are provided in the DWMF PDP [R-1].

This PDP is prepared in accordance with the Canadian Nuclear Safety Commission (CNSC) Regulatory Guide G-219<sup>1</sup> [R-2] and the Canadian Standards Association (CSA) N294 Standard [R-4]. The purpose of this PDP is to define the areas to be decommissioned and the sequence of the principal decommissioning work for DNGS. This PDP also demonstrates that decommissioning is feasible with existing technology and it provides a basis for estimating the cost of decommissioning.

The PDP (and the associated cost estimate) will be revised, at a minimum, every five years, unless specified otherwise by the CNSC.

### 1.1 Phased Approach to Decommissioning Planning

Planning for the eventual decommissioning of the DNGS is an ongoing process and the planning assumptions will evolve over time. This document describes the preliminary plan as it exists at the time of writing and it supersedes all previous versions of the PDP for the DNGS. This plan will continue to be revised periodically throughout the life of the DNGS to incorporate:

- Operational experience;
- Industry best practices;
- Technological advances;
- Changes in planning assumptions;
- Changes to site conditions;
- Changes to proposed decommissioning objectives and/or strategy;
- Changes in ownership or management structure;
- Modification of the facility;
- Updated cost and funding information;

<sup>1</sup> REGDOC-2.11.2, Decommissioning, was published January 2021 and supersedes G-219. OPG has communicated the timing for a gap analysis and implementation plan to REGDOC-2.11.2 in [R-3].

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- Changes in regulatory requirements;
- Changes in recordkeeping requirements; and
- Benchmarking reviews.

The transition to decommissioning of DNGS will be managed through the following regulatory submissions:

- A Sustainable Operations Plan (SOP) – The SOP will describe OPG’s approach for shutting down the DNGS. Further details on the content of the SOP are provided in Section 4.1.3.
- A Stabilization Activity Plan (SAP) – The SAP will outline the plan for managing the arrangements and activities that will be conducted in support of the transition of DNGS from its final shutdown state to its Safe Storage State (SSS). Further details on the content of the SAP are provided in Section 4.1.3.
- A Detailed Decommissioning Plan (DDP) – The DDP will be prepared and submitted to the CNSC with the application for a decommissioning licence approximately two to five years prior to the Storage with Surveillance (SWS) period. The DDP<sup>2</sup> will cover the decommissioning activities for the entire period of the decommissioning and will either include details of the Storage and Surveillance Plan (SSP) or the later will be submitted as a separate document. Towards the end of SWS, the DDP will be revised to describe OPG’s detailed plan for managing the arrangements and activities that will be conducted in support of Dismantling & Demolition. The methods and technologies available for use at the time of decommissioning will be reviewed, and where appropriate they will be adopted and described in the revised DDP. Further details on the content of the DDP are provided in Sections 4.1.3 and 4.2.4.

## 1.2 Applicable Legislation, Standards and Regulatory Guidance

All decommissioning activities will be performed in accordance with the most relevant legislation, regulations, codes and standards.

The following subsections identify some of the current legislation applicable to OPG’s decommissioning activities.

### 1.2.1 Canadian Nuclear Safety Commission

The CNSC was established under the Nuclear Safety and Control Act (NSCA) as Canada’s independent nuclear regulator. The NSCA, 1997 and its regulations placed a requirement on operators of nuclear facilities to make adequate provisions for their safe operation and decommissioning. With reference to decommissioning and waste management, the following regulations under the Act have relevance to the decommissioning of a nuclear facility:

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<sup>2</sup> Note that the DDP that will be produced and submitted to the CNSC prior to SWS will include details of the Storage and Surveillance Plan (SSP) or the latter will be submitted as a separate document.

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- Class I Nuclear Facilities Regulations (SOR/2000-204);
- General Nuclear Safety and Control Regulations (SOR/2000-202); and
- Nuclear Substances and Radiation Devices Regulations (SOR/2000-207).

The CNSC identifies the regulatory basis for decommissioning, as defined in the following key references:

- ‘Decommissioning Planning for Licensed Activities’, Regulatory Guide G-219, June 2000 [R-2]<sup>1</sup>;
- ‘Financial Guarantees for the Decommissioning of Licensed Activities’, Regulatory Guide G-206, June 2000 [R-5]<sup>3</sup>;
- ‘Public Information and Disclosure’, REGDOC-3.2.1, May 2018 [R-6]; and
- ‘Indigenous Engagement’, REGDOC-3.2.2, version 1.1, August 2019 [R-7].

The guidance indicates the production of a PDP by the licensees as soon as possible in the life cycle of the licensed activity. Additionally, the CNSC requires the development and updating of decommissioning plans throughout the facility life cycle to:

- Identify the impacts of decommissioning and demonstrate that the planned decommissioning activities will remediate all significant impacts and hazards to persons and the environment;
- Ensure compliance with all applicable requirements and criteria; and
- Ensure that the financial responsibility for decommissioning is maintained by the licensee and that appropriate mechanisms are put in place to identify the costs of decommissioning, together with provisions and maintenance of adequate funding to carry out decommissioning operations.

### 1.2.2 Canadian Standards Association

In addition to the publications produced by the CNSC, the CSA has produced guidance on the decommissioning of facilities as follows:

- ‘Decommissioning of facilities containing nuclear substances’, CSA N294;
- ‘Management of low- and intermediate-level radioactive waste’, CSA N292.3; and
- ‘Interim dry storage of irradiated fuel’, CSA N292.2.

Other CSA standards that are relevant to decommissioning are:

<sup>3</sup> REGDOC-3.3.1, Financial Guarantees for Decommissioning of Nuclear Facilities and Termination of Licensed Activities was published in January 2021 and supersedes G-206. OPG has communicated the timing for a gap analysis and implementation plan to REGDOC-3.3.1 in [R-3].

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- ‘Management system requirements for nuclear facilities’, CSA N286;
- CSA N288 series on environmental management for nuclear facilities – in particular:
  - ‘Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills’, CSA N288.4;
  - ‘Effluent monitoring programs at Class I nuclear facilities and uranium mines and mills’, CSA N288.5;
  - ‘Environmental risk assessments at Class I nuclear facilities and uranium mines and mills’, CSA N288.6;
- ‘General principles for the management of radioactive waste and irradiated fuel’, CSA N292.0; and
- ‘Fire Protection for CANDU Nuclear Power Plant (NPP)’, CSA N293.

### 1.2.3 Other Applicable Legislation and Regulatory Guidance

Other key legislation and regulatory guides include:

- Environmental Protection Act;
  - Regulation 347: General – Waste Management
- Ontario Water Resources Act;
- Occupational Health and Safety (OH&S) Act;
- Fisheries Act;
- National Pollutants Release Regulations; and
- Impact Assessment Act (IAA), if applicable<sup>4</sup>;

### 1.2.4 International Atomic Energy Agency Guides/Standards

OPG will also consider the recommendations and guidance from the International Atomic Energy Agency (IAEA) relevant to decommissioning. Some of these include, but are not limited to the following:

- Leadership and Management for Safety, General Safety Requirements (GSR), No. GSR Part 2, IAEA, 2016;
- Safety Assessment for Facilities and Activities, General Safety Requirements, No. GSR Part 4 (Rev. 1), IAEA, 2016;

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<sup>4</sup> The Canadian Environmental Assessment Act (CEAA) 2012 [R-8] has been superseded by the IAA [R-9].

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- Predisposal Management of Radioactive Waste, General Safety Requirements, No. GSR Part 5, IAEA, 2009;
- Decommissioning of Facilities, General Safety Requirements, No. GSR Part 6, IAEA, 2014;
- Disposal of Radioactive Waste, Specific Safety Requirements (SSR), No. SSR-5, IAEA, 2011;
- Decommissioning of Nuclear Power Plants, Research Reactors and Other Nuclear Fuel Cycle Facilities, Specific Safety Guide (SSG), No. SSG-47, IAEA 2018;
- Release of Sites from Regulatory Control on Termination of Practices, Safety Guide, No. WS-G-5.1, IAEA, 2006;
- Safety Assessment for the Decommissioning of Facilities Using Radioactive Material, Safety Guide, No. WS-G-5.2, IAEA, 2008;
- Storage of Radioactive Waste, Safety Guide, No. WS-G-6.1, IAEA, 2006;
- Safe Enclosure of Nuclear Facilities During Deferred Dismantling, Safety Report Series, No. 26, 2002;
- Safety Considerations in the Transition from Operation to Decommissioning of Nuclear Facilities, Safety Report Series, No. 36, 2004;
- Standard Format and Content for Safety Related Decommissioning Documents, Safety Report Series, No. 45, IAEA, 2005;
- Decommissioning Strategies for Facilities Using Radioactive Material, Safety Reports Series, No. 50, IAEA, 2007;
- Management of Project Risks in Decommissioning, Safety Report Series, No. 97, 2019;
- Monitoring Programmes for Unrestricted Release Related to Decommissioning of Nuclear Facilities, Technical Reports Series, No. 334, IAEA, 1992;
- Application of Remotely Operated Handling Equipment in the Decommissioning of Nuclear Facilities, Technical Reports Series, No. 348, IAEA, 1993;
- Radiological Characterization of Shut Down Nuclear Reactors for Decommissioning Purposes, Technical Reports Series, No. 389, IAEA, 1998;
- State of the Art Technology for Decontamination and Dismantling of Nuclear Facilities, Technical Report Series, No. 395, IAEA, 1999;

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- Organization and Management for Decommissioning of Large Nuclear Facilities, Technical Report Series, No. 399, IAEA, 2000;
- Methods for the Minimization of Radioactive Waste from Decontamination and Decommissioning of Nuclear Facilities, Technical Report Series, No. 401, IAEA, 2001;
- Record Keeping for the Decommissioning of Nuclear Facilities: Guidelines and Experience, Technical Reports Series, No. 411, IAEA, 2002;
- Transition from Operation to Decommissioning of Nuclear Installations, Technical Report Series, No. 420, IAEA, 2004;
- Decommissioning of Underground Structures, Systems and Components, Technical Reports Series No. 439, IAEA, 2006;
- Dismantling of Contaminated Stacks at Nuclear Facilities, Technical Reports Series No. 440, IAEA, 2005;
- Management of Problematic Waste and Material Generated During the Decommissioning of Nuclear Facilities, Technical Reports Series No. 441, IAEA, 2006;
- Redevelopment of Nuclear Facilities after Decommissioning, Technical Report Series, No. 444, IAEA, 2006;
- Selection and Use of Performance Indicators in Decommissioning, Nuclear Energy Series, No. NW-T-2.1, IAEA, 2011;
- Policies and Strategies for Radioactive Waste Management, Nuclear Energy Series, No. NW-G-1.1, IAEA, 2009;
- Policies and Strategies for the Decommissioning of Nuclear and Radiological Facilities, Nuclear Energy Series, No. NW-G-2.1, IAEA. 2011;
- Selection of Decommissioning Strategies: Issues and Factors, IAEA-TECDOC-1478, IAEA, 2005;
- New Methods and Techniques for Decontamination in Maintenance or Decommissioning Operations, IAEA-TECDOC-1022, IAEA, 1998;
- Safe and Effective Nuclear Power Plant Life Cycle Management Towards Decommissioning, IAEA-TECDOC-1305, IAEA, 2002;
- On-site Disposal as a Decommissioning Strategy, IAEA-TECDOC-1124, IAEA, 1999;

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- Approaches relating to decommissioning of nuclear facilities, PDRP-2, IAEA, 1998; and
- Managing the Unexpected in Decommissioning, No. NW-T-2.8, IAEA, 2016.

### 1.3 Applicable Programs

OPG's Nuclear Management System [R-10] provides a framework that establishes the processes and programs required to ensure OPG achieves its safety objectives, continuously monitors its performance against these objectives, and fosters a healthy safety culture.

OPG is responsible for planning, executing and funding all the phases of decommissioning of all of OPG's owned nuclear facilities. Decommissioning work will be conducted in accordance with the management system requirements and in compliance with OPG's Decommissioning Program [R-11], which ensures that when retiring a licensed nuclear facility permanently from service and rendering it to a predetermined end-state condition, actions are taken in the interest of health, safety, environment, security, quality and economics. The Decommissioning Program is further implemented through two standards to address the requirements and processes for decommissioning planning [R-12] and conduct of decommissioning [R-13]. The Decommissioning Program describes the interface with the Nuclear Management System as well as other Interfacing Governance such as the Nuclear Waste Management program, Integrated Aging Management.

### 1.4 Regulatory Compliance and Compliance with Applicable Standards

This document outlines the preliminary decommissioning planning work that has been completed. In accordance with the requirements described in CNSC Regulatory Guide G-219 [R-2] and CSA Standard N294:19 [R-4], it includes or references:

- A description of the facilities to be decommissioned;
- A description of the decommissioning strategy that will be employed;
- An outline of the work that will be required to complete the decommissioning;
- A discussion of the decommissioning cost estimate and financial guarantee;
- A proposed schedule for the decommissioning work;
- An estimated inventory of the radioactive wastes that will be generated during decommissioning;
- A preliminary assessment of the potential environmental and socio-economic effects of decommissioning; and
- A preliminary assessment of the radiological and conventional safety issues involved in decommissioning.

Appendix C refers to the specific requirements of CSA N294:19 and identifies the respective sections of the PDP that cover these requirements. With regards to

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compliance with CNSC Guide G-219 [R-2], this is shown through the demonstration of compliance with CSA N294:19 [R-4]. The correspondence between the requirements set out in CSA Standard N294:19 and this plan is shown in Appendix C: Table C-1, Table C-2 and Table C-3.

## 1.5 Planning Assumptions

The assumed station shutdown dates and decommissioning timelines (i.e., SWS, Dismantling & Demolition, and Site Restoration) are in accordance with the latest information available. Planning for decommissioning of DNGS is based on the following fundamental assumptions:

1. For financial planning purposes, it has been assumed that the individual reactor units at the DNGSs will be shut down based on business planning considerations in the following sequence [R-14]:
    - a. Unit 2, End of life, December 2050;
    - b. Unit 3, End of life, December 2053;
    - c. Unit 1, End of life, December 2055; and
    - d. Unit 4, End of life, December 2056.
- Note: All dates are nominal. Any modifications associated with shutdown dates may impact these dates.
2. The above dates assume that the refurbishment of the reactor units is expected to occur from 2016-2026 (see later paragraph for dates) and also assume a 30-year nominal operating life post refurbishment. All other dates in this document are based on these dates and are shown for financial planning purposes only.
  3. For planning purposes, it is assumed that decommissioning (planning for Dismantling & Demolition) will commence in the following sequence [R-14]:
    - a. Unit 1 in January 2083;
    - b. Unit 2 in January 2084;
    - c. Unit 3 in January 2085;
    - d. Unit 4 in January 2086; and
    - e. Unit 0 in January 2086.

Note: All dates are nominal.

4. OPG will retain ownership of the site throughout the course of the decommissioning and subsequent restoration for other industrial use (commonly known as 'brownfield<sup>5</sup>' status).
5. OPG will be responsible for all work conducted during the shutdown of the units, the Preparation for Safe Storage or Stabilization period and the SWS stages of the decommissioning although some specialized services may be provided by contractors working under the supervision of OPG staff.

<sup>5</sup> As per nuclear industry practice, a brownfield is defined as a former industrial land that has the potential to be developed for new industrial uses.

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6. A Decommissioning Operations Contractor (DOC)<sup>6</sup>, a company or consortium selected on the basis of experience, safety record, overall approach and cost, will perform all work during the Dismantling & Demolition and the Site Restoration stages. OPG will provide the necessary oversight.
7. Electric heating will be available while the station is in SWS (for maintaining it in a warm state), during preparation for Dismantling & Demolition, during Dismantling & Demolition, and up to the end of large component removal (calandria and steam generators).
8. Above-ground structures will be surveyed for contamination, decontaminated if required and demolished.
9. Underground metal and concrete piping will be excavated for survey and removed, if necessary. Uncontaminated materials beyond one meter will be left in place, while contaminated materials that exceed the site release criteria will be removed and disposed of appropriately.
10. Sub-surface structures will be surveyed for contamination, decontaminated if required and, consistent with international practices, dismantled to a 'nominal removal depth' of one meter below grade, backfilled with concrete rubble and/or soil and graded over. If contamination is present beyond one meter depth, OPG will be responsible to remediate until the respective screening levels are met. Additionally, the one meter depth allows for the placement of both gravel for drainage and topsoil for erosion control through the establishment of vegetation and provides significant attenuation of any residual gamma radionuclides that may remain within the site release limits. At-grade foundation slabs exceeding one meter in thickness will be abandoned in place and covered with a one meter thick layer of backfill.
11. Used Fuel Dry Storage Buildings (UFDSBs) will be dismantled concurrent with their corresponding station. Used fuel will be removed from the site to a licensed long term-storage facility before start of dismantling activities. Please refer to Section 4.4.1.2 for more details regarding management of high-level waste.
12. Low- and Intermediate-Level Waste (L&ILW) arising from decommissioning activities will be disposed of in long-term disposal facilities, as described in Section 4.4.1.3. Non-radioactive hazardous waste will be disposed of at approved disposal facilities.
13. Decontamination and dismantling activities will be coordinated at all four Darlington units to optimize the project schedule and maintain continuity in the overall process.
14. 'Clearance Levels' based on guidance provided in CSA N292.5 [R-15] will be developed prior to the decommissioning. These criteria will standardize the approach for segregation of the decommissioning wastes into those requiring long-term management and those that can be recycled, left on site or disposed of in conventional waste facilities.
15. For the purpose of the financial guarantee, no salvage credit is assigned to equipment and components removed during decommissioning; these are considered

<sup>6</sup> Decommissioning Operations Contractor (DOC), as used in the TLG Cost Estimate, is equivalent to "Decommissioning Contractor(s)" terminology, which has been used throughout the PDP document.

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- waste for costing purposes. However, consistent with the principles of the waste management hierarchy, recycling of clean materials will be pursued.
16. The site will be graded and made available for other OPG uses after completion of decommissioning.
  17. The refurbishment of the DNGS units is considered as part of this PDP. The following planning dates are assumed, with each unit refurbishment outage being three to four years in length [R-16]:
    - Unit 1, 2022-2025
    - Unit 2, 2016-2020
    - Unit 3, 2020-2024
    - Unit 4, 2023-2026

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## **2.0 DESCRIPTION OF THE DARLINGTON NUCLEAR GENERATING STATION AND SURROUNDING AREA**

### **2.1 Location of Darlington Nuclear Site**

The Darlington Nuclear Site is located on the north shore of Lake Ontario, about 70 km east of the City of Toronto. It is situated in the Municipality of Clarington, which is in the Regional Municipality of Durham, in the Province of Ontario. The centre of the site is approximately at latitude 43° 53' north and longitude 78° 43' west. A map showing the location of the DNGS within the local area is provided in Figure 2-1.

The Darlington Nuclear Site is comprised of a land parcel of 485 hectares plus additional water lot areas extending into Lake Ontario to accommodate station-related structures and features. The site includes those portions of Lots 18 to 24 inclusive and those portions of road allowances between Lots 18 and 19, Lots 20 and 21, Lots 22 and 23 and that portion of the road allowance between Lots 24 and 25 designated as Parts 1 and 2 on Reference Plan 10R744 in the Broken Front Concession, in the Municipality of Clarington.

A water lot was obtained to reclaim land from Lake Ontario for the construction of the water intake tunnel and the discharge pipe. Water lot location HY162 is part of the bed of Lake Ontario lying in front of Lot 1741 Registered Plan 97, Lots 21, 22 and 23 and the road allowance between Lots 22 and 23 all in the Broken Front Concession, in the Municipality of Clarington. Approximately 10 ha of the total water lot area of 17 ha have been reclaimed. The water lot has a frontage of about 1,254 m on the north shore of Lake Ontario.

OPG owns all of the property described above except for the railway corridor that is owned by Canadian National Railway (CN) and the station switchyard that is owned by Hydro One.

The Darlington Nuclear Site is bounded by the South Service Road on the north and by Lake Ontario on the south. The multi-lane Highway 401 runs east/west, immediately north of the South Service Road (about 1650 meters from the station buildings). Solina Road and agricultural land bound the site on the west and the St. Mary's Cement Bowmanville plant occupies the land east of the site.

The Darlington Nuclear Site is accessible by road or rail. The Holt Road interchange provides direct access to the site from Highway 401. Two other interchanges, one on either side of the site, are located within 3 km. The site can also be accessed from Park Road, which connects to the South Service Road.

The CN's Toronto to Montreal main line passes through the exclusion zone of DNGS. The line runs within 390 m of the Powerhouse. The rail line is dual track and the type and condition of the track are considered excellent. There is an earthen berm along the south side with the top about 8.5 m above the track. A rail siding area has been provided near the eastern boundary of the OPG property. Holt Road and Park Road (the two roads leading to the station) both cross the railway line on overpasses.

**Plan**

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The Darlington Nuclear Site has a total frontage of about 3,160 m on the north shore of Lake Ontario. Large cargo vessels move along shipping lanes in Lake Ontario, which are designated by the Ministry of Transport. St. Mary's Cement Company operates a dock about 1.1 km to the east of the site. The largest lake vessels are able to use this dock. The ports of Oshawa, Whitby and Cobourg are nearest to the Darlington Nuclear Site and they receive small lake vessels. Port Darlington, located east of the Darlington Nuclear Site and several other small berthing facilities in the area, are used by recreational boaters.

Plan

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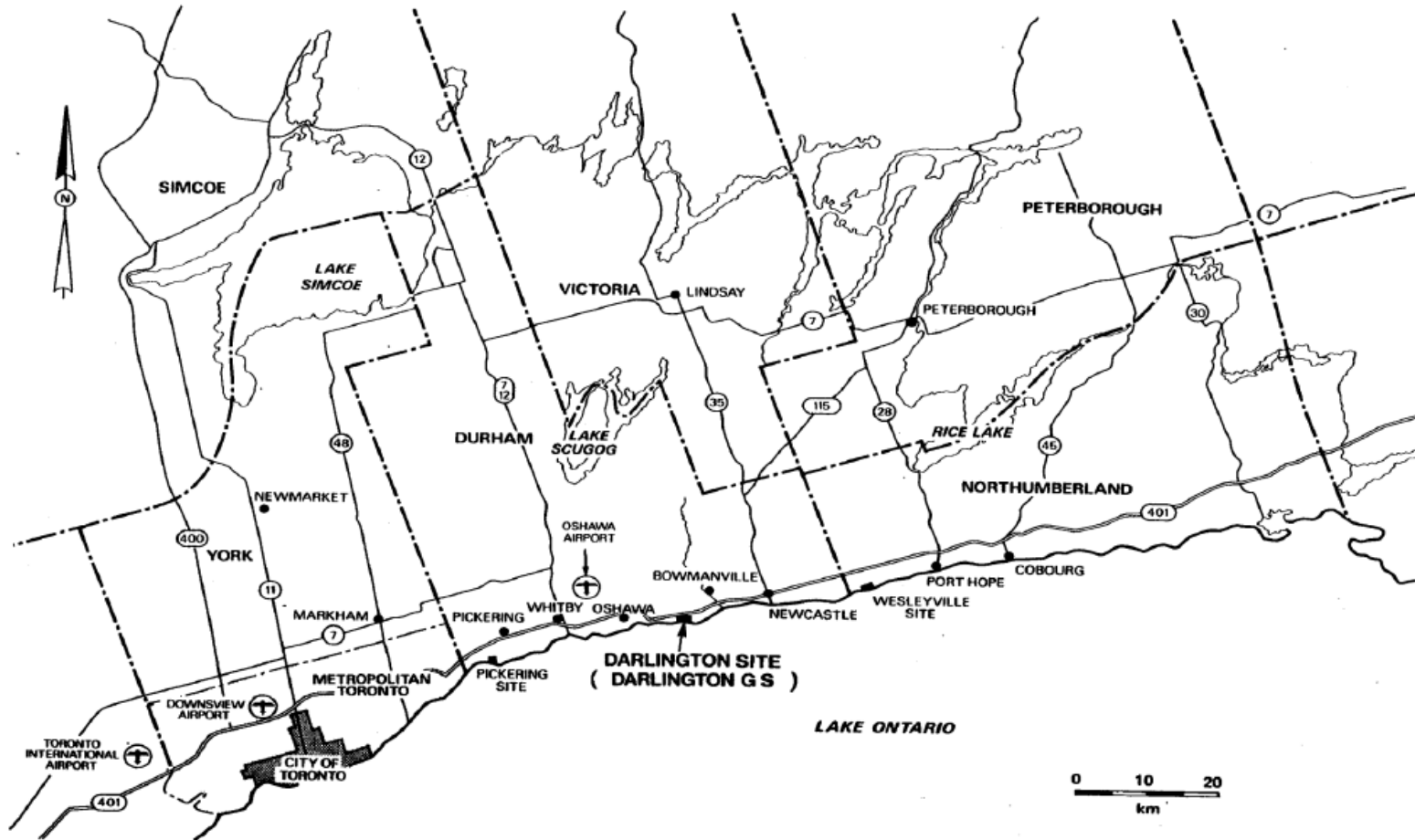


Figure 2-1: Location of Darlington Nuclear Generating Station

**Plan**

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## Plan

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## 2.2 Description of the Darlington Nuclear Generating Station

### 2.2.1 Overview

The design of the station is based on a four-unit layout with central service and control areas. Each unit consists of a single reactor housed in a reinforced concrete vault with four steam generators protruding into shielded access-controlled rooms above the vault and a single turbine-generator housed in an adjacent powerhouse [R-17].

The main group of buildings forming the station consists of:

- Four Reactor Building structures which house the reactor and four steam generators for each unit;
- Four Reactor Auxiliary Bays;
- Two Fuelling Facilities Auxiliary Areas (east and west), each with an Irradiated Fuel Bay (IFB) and a fuel handling and service area;
- A Central Service Area-Nuclear – Nuclear/radioactive area that contains facilities that support fuelling machine head removal, treatment and storage of heavy water, spent ion exchange resins, and active wastes;
- A Central Service Area-Conventional – Conventional with stores, laboratories, workshops, electrical and air conditioning equipment, and the central control area;
- A Vacuum Building;
- A Tritium Removal Facility (TRF)<sup>7</sup>;
- A Pressure Relief Duct with valve manifold connecting to the Vacuum Building;
- A Powerhouse housing all four turbine-generator sets and their auxiliary equipment;
- Four combined cooling and service water pump houses;
- An emergency electrical power and water supply complex, consisting of an emergency service water pumphouse, emergency power supply generator sets buildings, emergency power supply fuel management structures, and emergency electrical rooms and associated tunnels;
- A Water Treatment Plant Building;
- Four standby generator areas and four fuel tanks;
- A Heavy Water Management Building (HWMB);
- Flammable Storage Building;
- High-Pressure Gas Cylinder/Compressed Gas Bottle Storage Building;

<sup>7</sup> The TRF, housed inside the HWMB, is also located on the DNGS within the boundaries of the Darlington Nuclear Site, within the DNGS Protected Area and has been in operation since October 1988. It is used to reduce the levels of tritium in OPG NGSS heavy water inventories.

**Plan**

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--

- Sewage Treatment Plant;
- Emergency Response Team Facility;
- Hazardous Material and D<sub>2</sub>O Storage Building;
- A Main Security Building and an Auxiliary Security Building;
- DWMF [R-1] (not part of this PDP);
- Emergency Power Generator (EPG) Structure (EPG 3) and associated seismic fuel storage building;
- Auxiliary Heating Steam Boiler House; and
- Two administrative buildings (Operations Support Building (OSB) Refurbishment and Engineering Services & Support Building (ESSB)/Darlington Learning Center (DLC)).

A plan of the site is shown in Figure 2-2, Figure 2-3 and a cut-a-way view of the station layout is shown in Figure 2-4.

To support the Darlington Refurbishment Project, the following new buildings/structures are or will be constructed on the site:

- Safety Improvement Opportunities (SIO) Containment Filtered Venting System (CFVS) Building;
- HWMB West Annex;
- Re-Tube and Feeder Replacement Island Support Annex (RFRISA);
- Refurbishment Project Office (RPO);
- Retube Waste Processing Building (RWPB);
- Retube Waste Storage Building (part of Waste Storage); and
- Transformer Storage Facility.

In support of Darlington Refurbishment project, the new HWMB West Annex and RFRISA may potentially be contaminated. Furthermore, the RWPB is likely to be contaminated due to the processing and handling of Intermediate Level Retube waste. These buildings are expected to remain on site until station end of life (in 2050's) and have been conservatively accounted for as part of the decommissioning cost estimate.

Plan

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



Figure 2-2: Site Plan of Darlington Nuclear Generating Station Layout

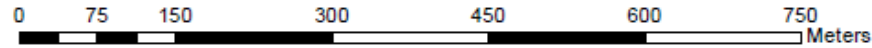
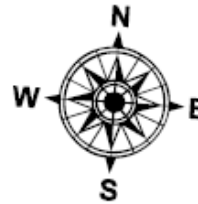
Plan

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**Legend**

- |   |  |
|---|--|
|  OPG Ownership               |  EMF Hazard       |
|  Protected Area              |  Exclusion Zone   |
|  Ongoing / Proposed Projects |  Waterfront Trail |
|  2017 Demolition             |  Fitness Loop     |
|  Future Proposed Demolition  |  DNNP Fence Line  |
|  Material Laydown            |  |



Projection: UTM NAD83 CSRS Zn17N  
Map Scale - 1:3,800

Plan

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Operating Island Buildings		Site Buildings		Site Buildings	
0	Unit 0	107	(Project and Mod) Building Maintenance Shop	400	Baseball Diamond
1	Powerhouse	112	Turbine Parts Shop	401	Information Centre
U1	Unit One	113	Field Skills Facility	403	West Parking Lot
U2	Unit Two	114	Drawing Storage Facility	411	Operations Support Building (OSB)
U3	Unit Three	115	Computer Development Facility	412	East Parking Lot
U4	Unit Four	116	Project Office	414	Upper & Lower Parking Lot
WF	West FFAA	118	Lakeshore Garage	415	Bill Gearing Guardhouse
EF	East FFAA	119	Surplus Furniture Warehouse	416	Main Security Building
P1	Pumphouse One	124	Hydro Transformer Substation DS2	420	Chlorine Addition Station
P2	Pumphouse Two	125	Steamheating Boiler House	421	Domestic Water Pumphouse
P3	Pumphouse Three	126	Steam Relief Stack	422	Settlement Pond
P4	Pumphouse Four	128	Site and Facility Maintenance Shop #1	423	Hydro Transformer Substation
WTP	Water Treatment Plant	130	Warehouse Annex	424	DWMF Firewater Backflow Preventer Shed
8	FPS Firehall - Building #8	131	East Warehouse	432	Emergency Vehicle Garage
9	Construction Change Room	134	Sewage Treatment Plant	440	Rail Siding North
10	Retube Waste Processing Building	136	Flammable Storage building	441	Rail Siding South
T11	Recycle Shed	137	Gas Bottle Storage	443	MISA HUT
14	Lube Oil Tanks	138	HMS & HWS Facilities	444	Emergency Equipment Storage Bldg #1
15	EPS Building	140	Warehouse Yard	500	Soccer Fields
16	ESW Pumphouse/Chlorine Addition Bdg	141	Maintenance Computer Development Facility	502	Fitness Trail Parking Lot
17	Circulating Water Discharge Structure	201	Yard Maintenance Shed	504	SF6 Building
18	Emergency Power Generator (EPG) #1	T204	Hydrogen Trailer	505	Holt Road Guardhouse
19	Stairwell Enclosure (to EPG Tunnels)	206	Heavy Sand Shed/Facilities	506	Hepcoe Garage
20	EPG #2	300	Auxiliary Security Building	507	Hepcoe
21	Stairwell Enclosure (to EPG Tunnels)	301	Modification and CMO Office	508	Meteorological Tower
22	EPG Fuel Management Building	302	Pipe Fab/Machine Shop	509	Domestic Water Meter and Valve Station
23	EPG #3	305	Facilities Storage Building	510	Radiation Emission Monitor STA#2
T27	NTS Periodic Inspections Trailer	306	Paint Shop	511	Radiation Emission Monitor STA#1
29	Reactor Maintenance Building	311	Facilities Vehicle Garage #2	512	Radiation Kiosk
T30	Reactor Maintenance CCTV Trailer	312	Quonset Building	513	Covered Walkway
31	Sheet Metal Shop	313	BBH Building	514	Seismic Monitoring Station
32	Inactive Liquid Waste Storage	323	Cable Reel Yard		
36	Standby Generators Fuel Storage	324	Pipe Hanger Storage Shop		
T37	TRF Maintenance Offices	325	Warehouse Yard (YD 26)		
38	Standby Generator One	326	Warehouse Yard (YD 25)		
39	SG1 and SG2 Fuel Management Building #1	327	Warehouse Yard (YD 27)		
40	Standby Generator Two	329	Darlington Learning Centre (DLC)		
41	HWMB West Annex	330	Engineering Service and Support Building (ESSB)		
42	D20 Management Building (TRF)	331	OSB Parking Lot		
43	Stairwell Enclosure (to SG Tunnel)	332	ESSB Parking Lot		
T44	Hydrogen Trailer	353	ESSB Parking Lot		
45	Stairwell Enclosure (to SG Tunnel)	354	Executive Parking Lot		
46	Vacuum Building	355	MSB Parking Lot		

**Plan**

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47	Stairwell Enclosure (to SG Tunnel)	356	DWMF Amenities Building		
48	Stairwell Enclosure (to SG Tunnel)	357	Bus Shelter		
T49	Service Maintenance Storage Trailer	358	UFDS Sampling Station Bldg		
50	Compressed Gas Bottle Storage	359	DWMF Process Building		
51	Service and Storage Building/Vehicle Maintenance Garage	362	DWMF Storage Building		
T53	Security Personnel Access and Gate	363	DWMF Storage Building #2		
54	Standby Generator Three	364	Retube Waste Storage Building		
55	Standby Generator Fuel Management Building #2	208	Refurbishment Project Office (RPO)		
56	Standby Generator Four				
58	Island Garage				
59	Standby Generators Fuel Storage				
61	Inergen Fire Protection System Enclosure (Standby Generators 1, 2)				
62	Inergen Fire Protection System Enclosure (Standby Generators 3, 4)				
63	Scaffold Storage Building				
65	Retube and Feeder Replacement Island Support Annex				
T96	T-G Hall Relocatable Outage Trailer				
T97	T-G Hall Relocatable Outage Trailer				
T98	T-G Hall Relocatable Outage Trailer				
T99	T-G Hall Relocatable Outage Trailer				
C24	Firewater Pumphouse				
CFVS	CFVS: Containment Filtered Venting System				

**Figure 2-3: Site Plan of Darlington Nuclear Generation Station Layout (Legend)**

Plan

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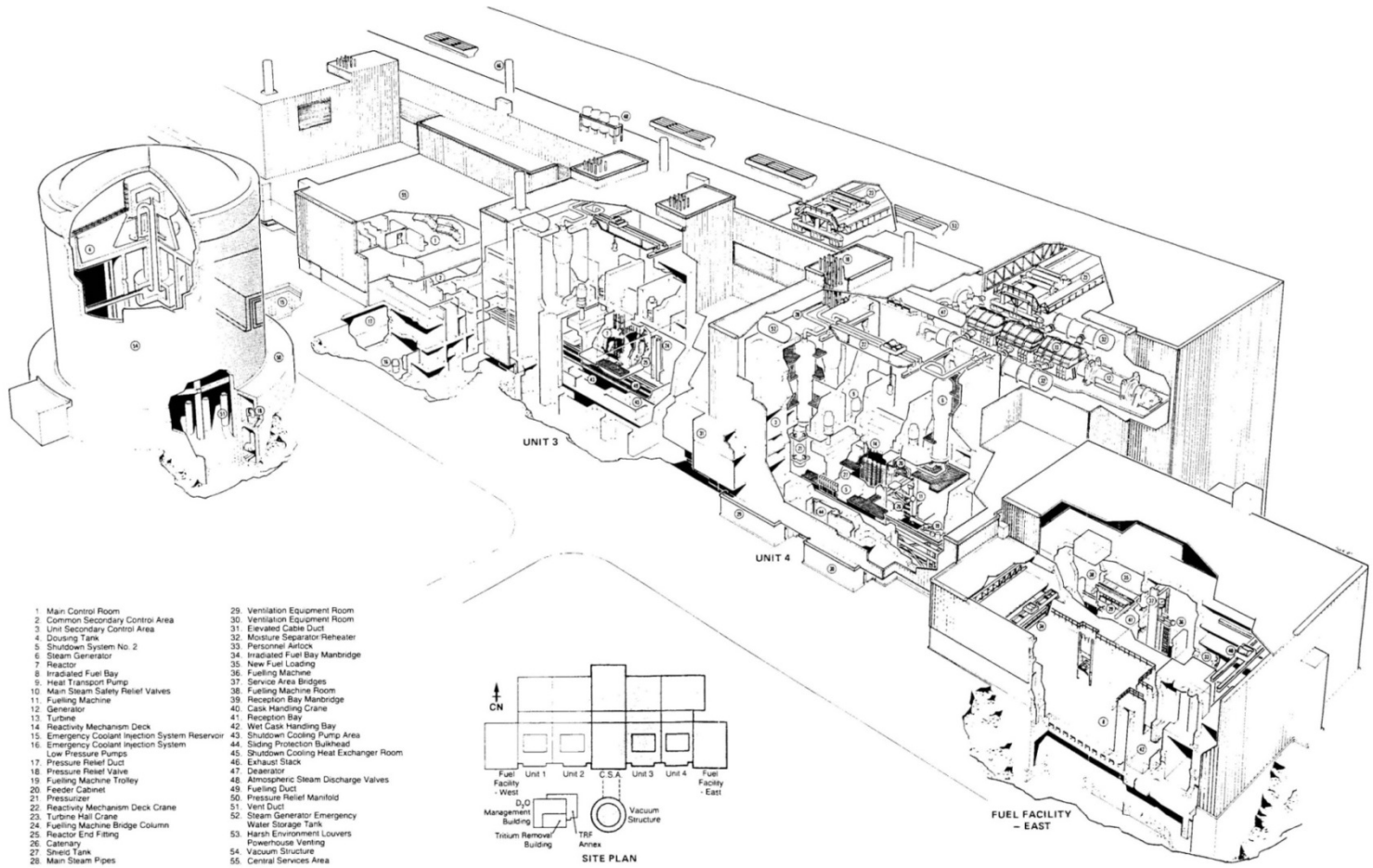


Figure 2-4: Darlington Nuclear Generating Station Layout – Cut-A-Way

**Plan**

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### 2.2.2 Reactor Building

The reactor building supports and encloses the reactor and some of its associated equipment [R-17]. The structure is divided vertically into three areas:

1. The fuelling duct and basement below grade;
2. The Reactor Vault on grade level; and
3. Rooms directly above the Reactor Vault which house the steam generators, Primary Heat Transport (PHT) pump motors and reactivity drive mechanisms.

Each Reactor Assembly and its Heat Transport system are enclosed in a rectangular reinforced concrete Reactor Vault, which is located over and connected to, the fuelling duct. The Reactor Vault along with the vacuum structure, the fuelling duct, and the Pressure Relief Duct forms a part of the containment envelope which serves to contain any activity which might be released during an accident. A cut-a-way view of the Reactor Vault is shown in Figure 2-5. The Reactor Assembly (calandria vessel and shield tank) is shown in Figure 2-6.

The Heat Transport System (see Figure 2-7) simplified flow diagram, which depicts the fuel channels, feeder pipes, headers, Steam Generators (see Figure 2-8) and PHT Pumps (see Figure 2-9), is designed to circulate pressurized heavy water through the fuel channels and Steam Generators. The heat from the heavy water is transferred to natural water in the Steam Generators (often called 'boilers'). The Steam Generators (four per unit with two on each side) protrude through the top of the Reactor Vaults into two areas called the Steam Generator Rooms. These rooms are enclosed by shielding walls to permit access to the central area directly above the Reactor during operation. The four PHT Pumps also protrude out of the Reactor Vault. The pump casing is located within containment but the motors are outside containment so that they are accessible during normal operations.

### 2.2.3 Reactor Auxiliary Bay

The Reactor Vault is surrounded by a steel frame building called the Reactor Auxiliary Bay. The Reactor Auxiliary Bay houses the Reactor Auxiliary Systems and the Steam Generator Auxiliaries.

The Reactor Auxiliary Bays consist of four identical modules, one surrounding each Reactor Building. They are eight level buildings (three-storey concrete basement structure and five-storey steel structure with concrete floors). The basement floor is at the same level as the one in the Reactor Building [R-17].

### 2.2.4 Other Nuclear Systems & Structures

The Fuelling Duct runs the length of the station and serves as a connection between the Reactor Vaults, the Fuel Handling and Service Areas (in the East and West Fuelling Facilities Auxiliary Areas) and the Pressure Relief Duct that, in turn, connects to the Vacuum Building through the valve manifold and vacuum ducts.

**Plan**

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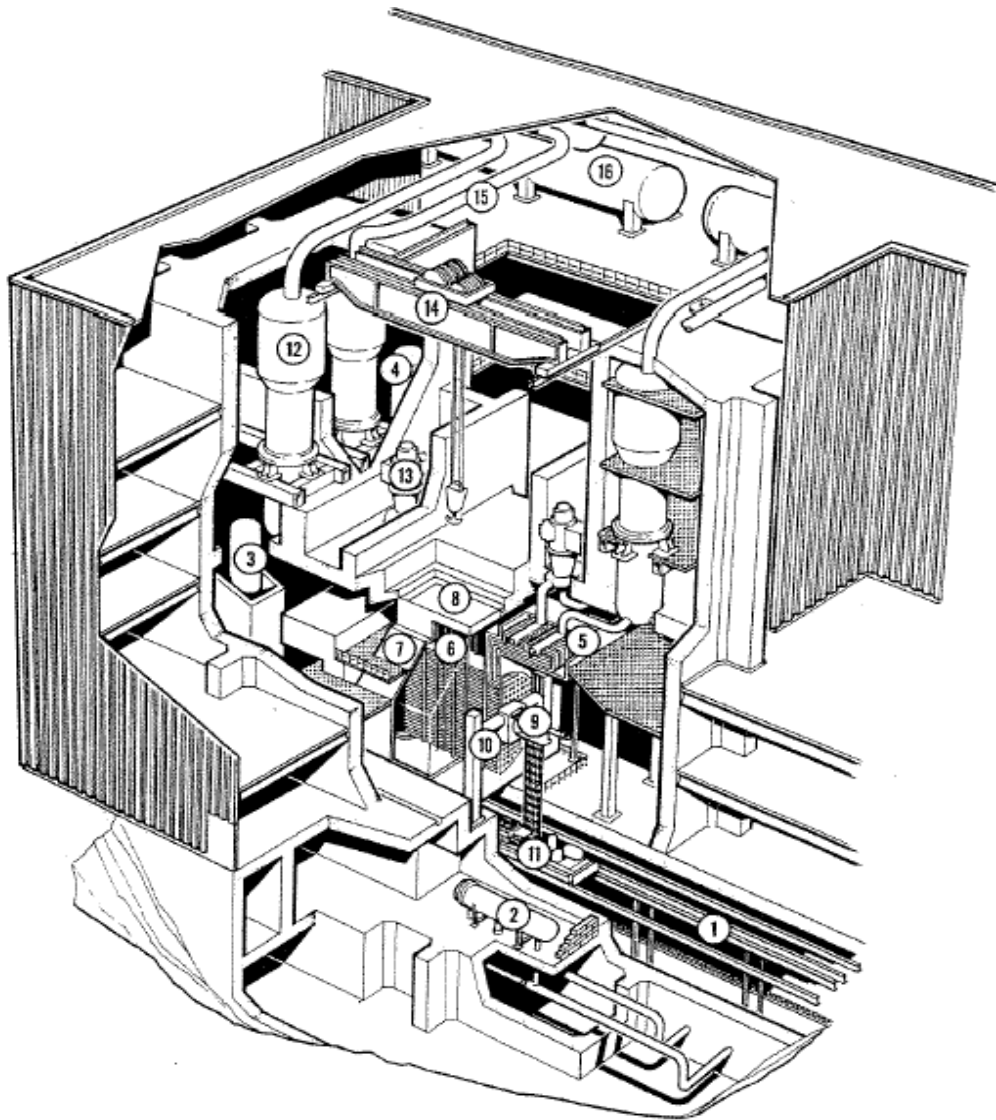
The Fuel Handling and Service Areas, Irradiated Fuel Reception, Wet Cask Handling and IFBs are all located in the Fuelling Facilities Auxiliary Areas, one at each end of the station. Associated with these bays are shipping flask loading facilities.

The Central Service Area-Nuclear contains facilities for fuelling machine head removal, treatment and storage of heavy water, spent ion exchange resins, and active wastes. It is located below grade in the south portion of the Central Service Area and is of reinforced-concrete construction.

Plan

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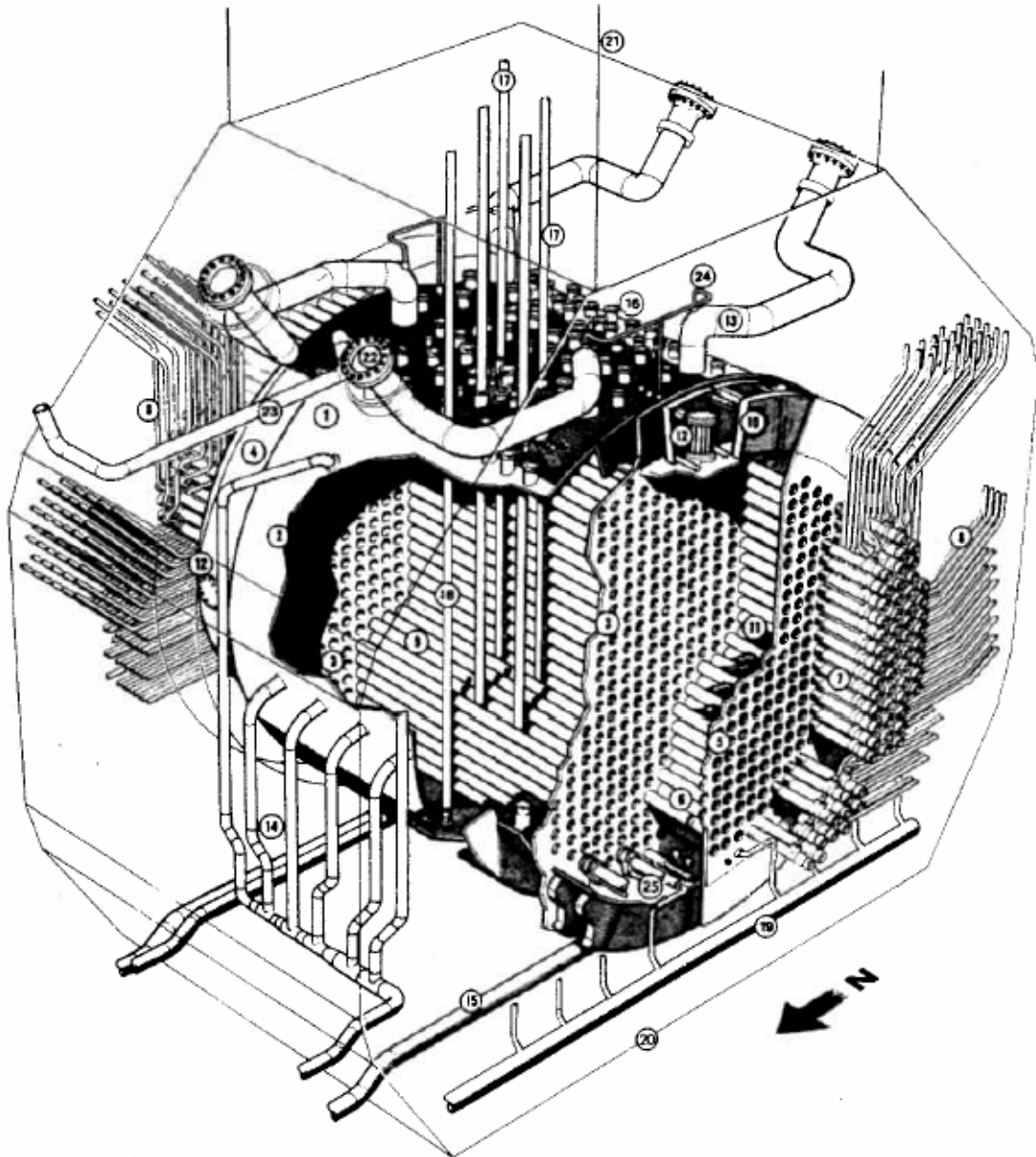
- 1 Fuelling Duct
- 2 Shutdown Cooling Heat Exchanger
- 3 Pressurizer
- 4 Heavy Water Storage Tank
- 5 Feeder Cabinet
- 6 Calandria
- 7 Shield Tank
- 8 Reactivity Mechanism Deck
- 9 Fuelling Machine Head
- 10 Fuelling Machine Bridge Column
- 11 Fuelling Machine Transport Trolley
- 12 Steam Generator
- 13 Heat Transport Pump
- 14 Bridge Crane
- 15 Main Steam Line
- 16 Deserator

Figure 2-5: Darlington Nuclear Generating Station Reactor Vault

Plan

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- |   |   |
|---|---|
| <ul style="list-style-type: none"> <li>1. CALANDRIA</li> <li>2. CALANDRIA MAIN SHELL</li> <li>3. CALANDRIA-SIDE TUBESHEET</li> <li>4. CALANDRIA SUB-SHELL</li> <li>5. FUELLING MACHINE-SIDE TUBESHEET</li> <li>6. LATTICE TUBES</li> <li>7. END FITTINGS</li> <li>8. FEEDERS</li> <li>9. CALANDRIA TUBES</li> <li>10. SHIELD TANK SOLID SHIELDING</li> <li>11. STEEL BALL SHIELDING (END SHIELD)</li> <li>12. MANHOLE</li> <li>13. EMERGENCY DISCHARGE PIPES</li> <li>14. MODERATOR INLETS</li> </ul> | <ul style="list-style-type: none"> <li>15. MODERATOR OUTLETS</li> <li>16. NOZZLES FOR VERTICAL REACTIVITY CONTROL UNITS AND VIEWING PORT</li> <li>17. THIMBLES FOR VERTICAL CONTROL UNITS</li> <li>18. GUIDE TUBES FOR VERTICAL REACTIVITY CONTROL UNITS</li> <li>19. END SHIELD COOLING PIPING</li> <li>20. SHIELD TANK</li> <li>21. SHIELD TANK EXTENSION</li> <li>22. RUPTURE DISC ASSEMBLY</li> <li>23. MODERATOR OVERFLOW</li> <li>24. PRESSURE BALANCE LINES</li> <li>25. INLET AND OUTLET STRAINERS</li> </ul> |
|---|---|

Figure 2-6: Darlington Nuclear Generating Station Reactor Assembly

Plan

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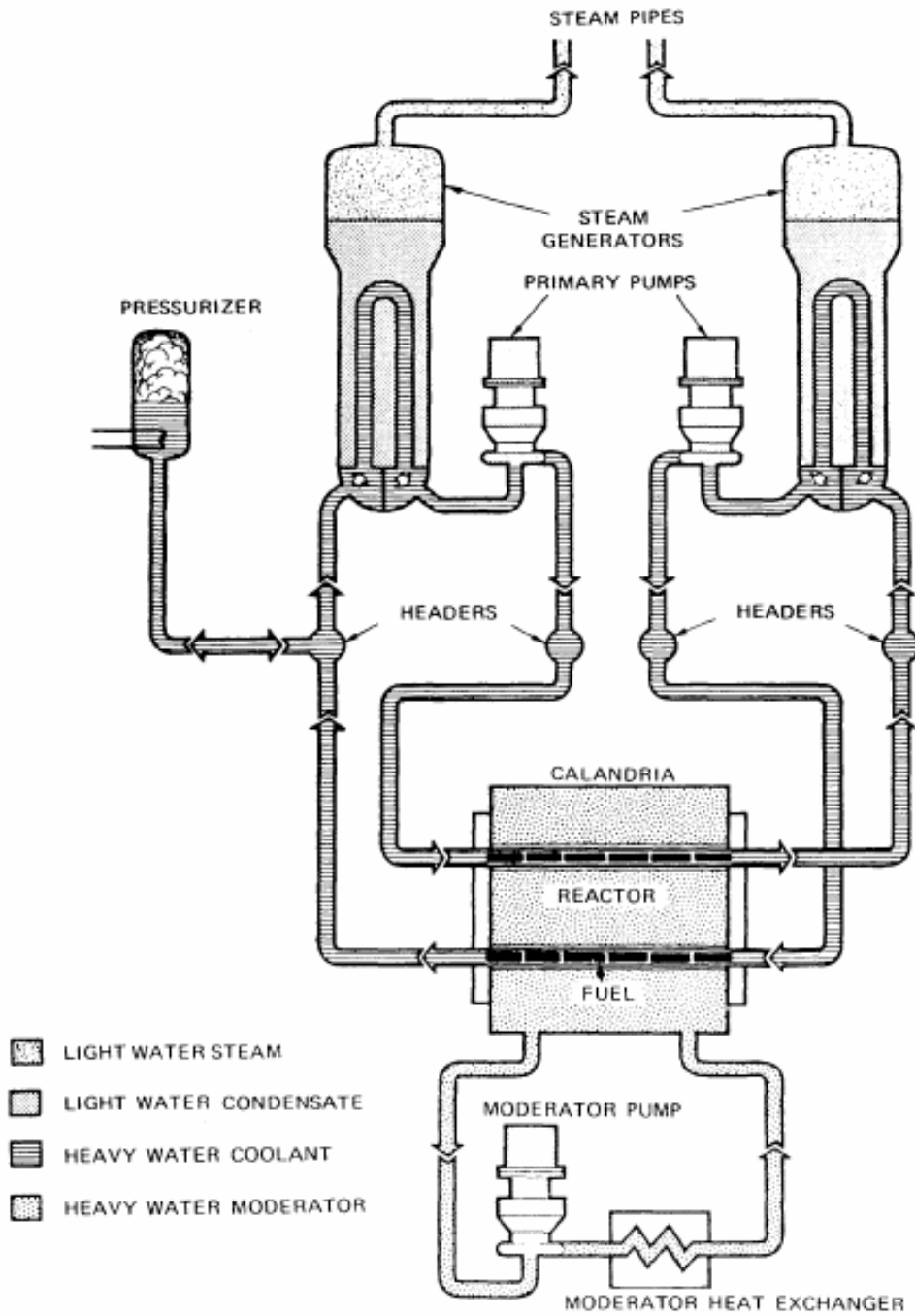


Figure 2-7: Simplified Reactor Systems Flow Diagram

Plan

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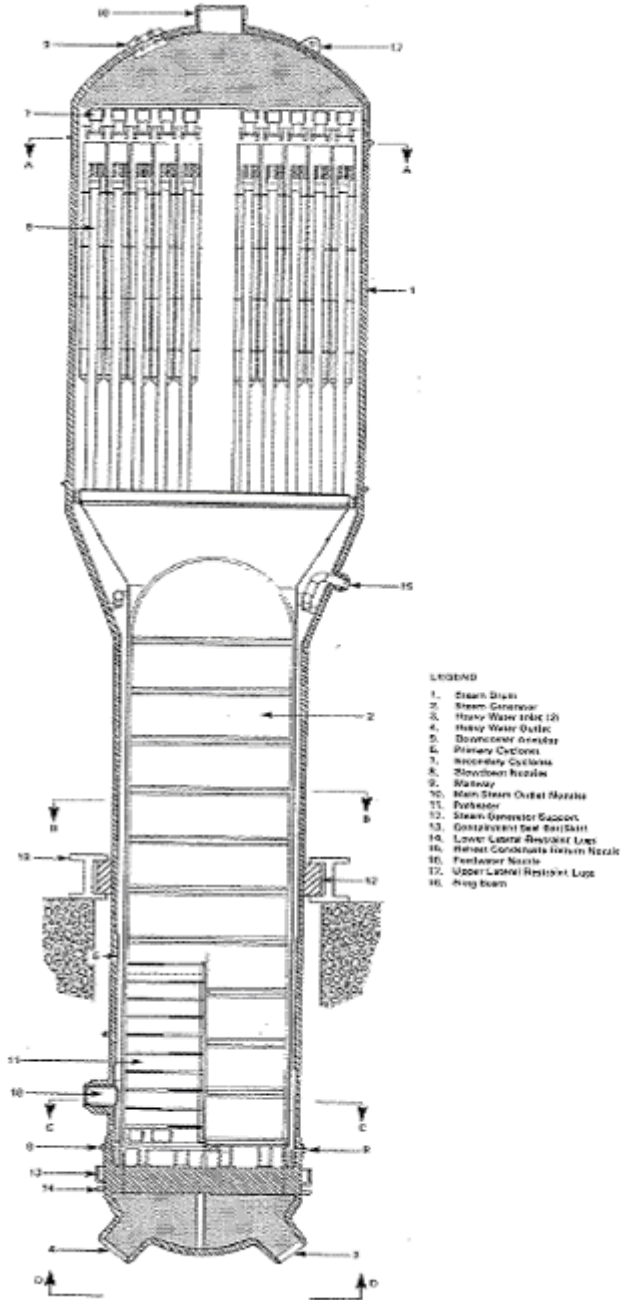


Figure 2-8: Darlington Nuclear Generating Station Steam Generator

Plan

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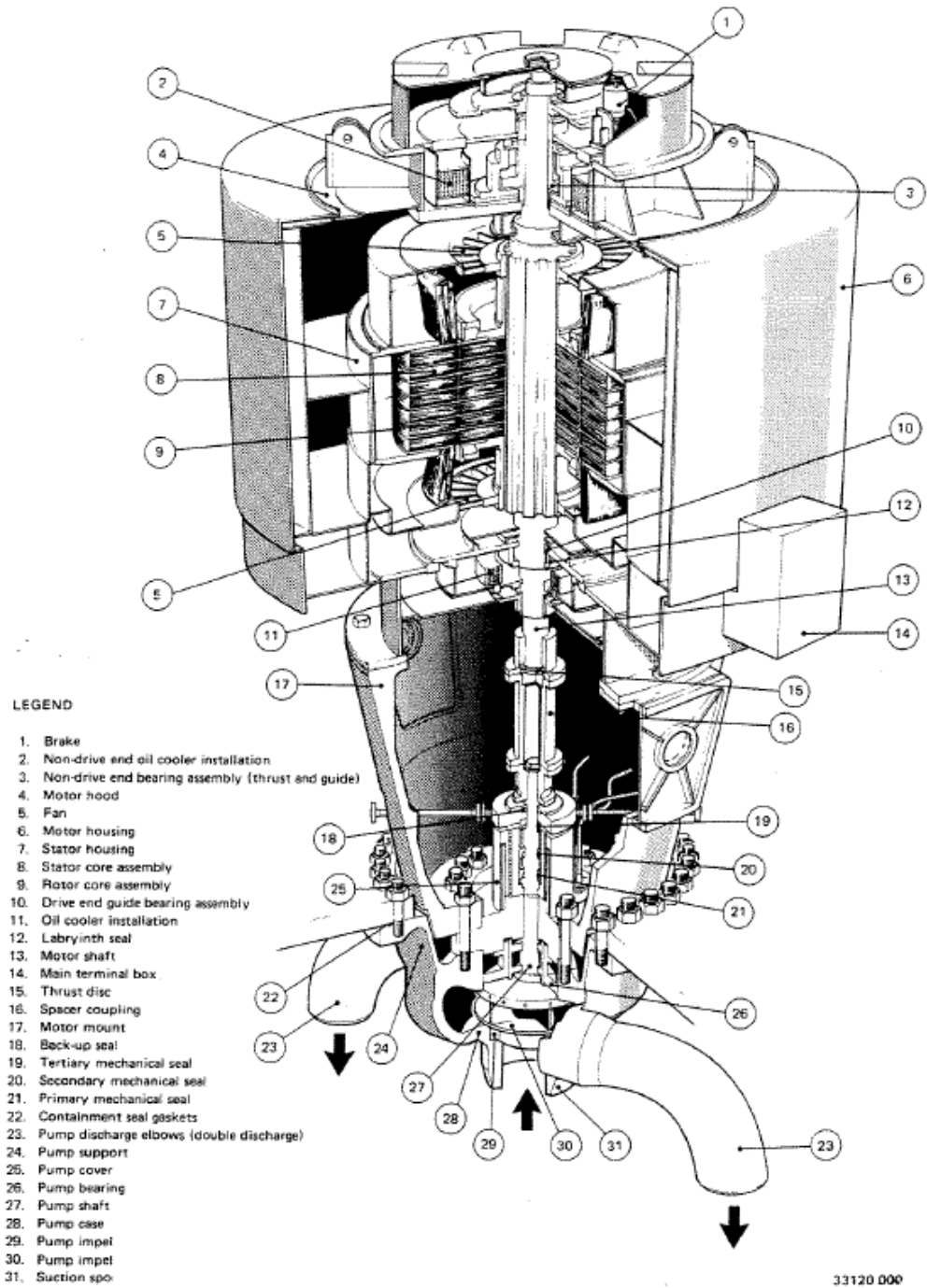


Figure 2-9: Darlington Nuclear Generating Station Heat Transport Pump

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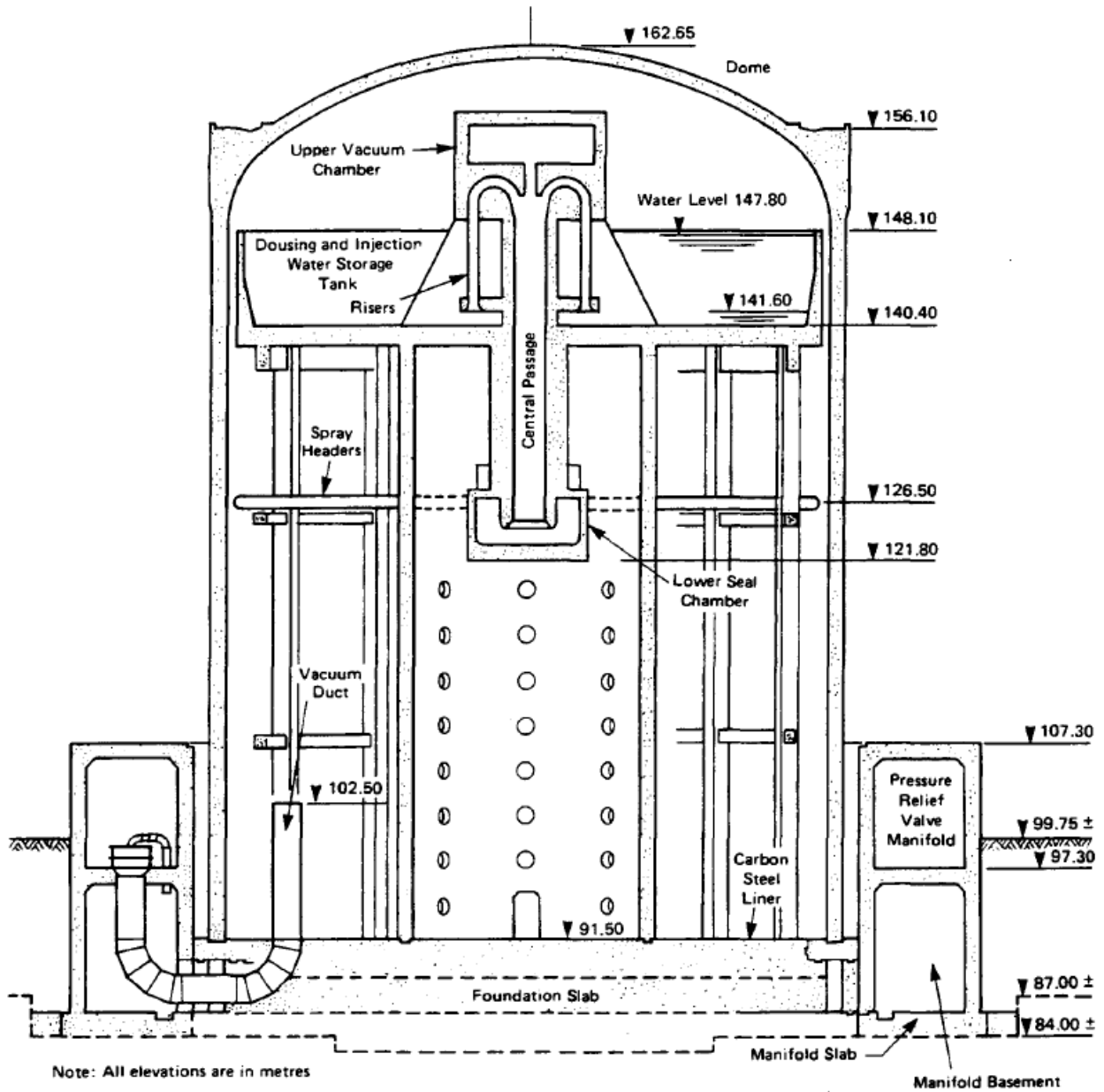


Figure 2-10: Darlington Nuclear Generating Station Vacuum Building Cross-Section

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### 2.2.5 Vacuum Building

The Vacuum Building (Figure 2-10) consists of a cylindrical perimeter wall with a fixed end-support at the foundation slab and a spherical roof dome connected monolithically to a peripheral ring girder. An elevated cylindrical water storage tank supported on a cylindrical support structure and columns is located inside the structure. The upper vacuum chamber is directly supported on the cylindrical support structure and extends upward above the tank floor and is stiffened by four concrete walls. The water storage tank has its own wall and hence is structurally independent of the containment superstructure [R-17].

A Pressure Relief Duct with valve manifold is connected to the Vacuum Building. As pressure increases inside the Reactor Building during accident conditions the pressure forces the water in the storage tank into the upper chamber resulting in activation of the spray headers to condense steam. The condensation of steam lowers containment pressure allowing for a delay in releases of radioactive materials to the atmosphere and public domain. This was further enhanced with the installation of Safety Improvement Opportunities (SIO) Containment Filtered Venting System (CFVS)<sup>8</sup> to better control releases.

### 2.2.6 Powerhouse

The Powerhouse Complex consists of four Turbine Halls and four Turbine Auxiliary Bays together with the Central Service Area – Conventional.

Each Turbine Hall houses a turbine-generator and some of its auxiliary equipment. Two overhead cranes serve the whole length of the Turbine Halls and Central Service Area - Conventional, either individually or in tandem.

The Turbine Auxiliary Bays are located adjacent to the Turbine Halls. The Turbine Auxiliary Bays house auxiliary equipment for the turbine-generators, switchgear, laboratories and sanitary facilities. They provide a corridor through the whole length of the Powerhouse, as well as vertical movement via stairs and elevators. The cooling water discharge duct is located at the lowest level of the basement and forms part of the sub-structure of the Turbine Auxiliary Bays.

The main passageways of the station run east and west through the Turbine Auxiliary Bays and through the Central Service Area. The Central Service Area - Conventional is located immediately north of the Central Service Area – Nuclear. It is an integral part of the Powerhouse Complex. The northern part of the Central Service Area - Conventional houses the Service Auxiliary Bay together with a loading bay at elevation 100 m, workshops, lay down areas, stores, personnel showers, a lunchroom, classrooms, offices, laboratories and common service equipment such as air compressors, air conditioning equipment, telephone equipment, etc. The Central Control Area is located in the southern part of the Central Service Area - Conventional.

<sup>8</sup> CFVS is part of the vacuum building but there is also a new auxiliary building (small footprint but 2-3 stories high) attached to the vacuum building.

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This area includes the Main Control Room, Control Equipment Rooms and Cabling Rooms.

### 2.2.7 Other Non-Nuclear Systems & Structures

Condenser Cooling Water and Service Water are supplied from Lake Ontario by an intake tunnel extending into the lake. The Condenser Cooling Water System and the Service Water System include the intake structure and intake tunnel, a forebay, pump houses, piping to the unit condensers and discharge ducts, cooling water discharge duct, a discharge structure, a discharge tunnel and, finally, a diffuser through which the water is returned to the lake.

The non-nuclear structures that are already on the Darlington Nuclear Site or that will be constructed to support the Darlington Refurbishment Project are provided in Section 2.2.1.

The station switchyard lies north of the station and is owned by Hydro One. The site roads are laid out to serve the arrangement of the buildings on the Darlington Nuclear Site.

### 2.2.8 Other Nuclear Facility on the Darlington Site: DWMF

The DWMF is a Class 1B nuclear facility, owned and operated by OPG. It is located within the boundaries of the Darlington Nuclear Site, and approximately 460 m east of the DNGS Protected Area, as shown in Figure 2-2 and Figure 2-11.

The objective of the DWMF is to provide safe storage of used fuel from the DNGS in the UFDSBs and intermediate level, retube waste in a Retube Waste Storage Building (RWSB).

The DWMF currently includes a Dry Storage Container (DSC) Processing Building, the RWSB, and UFDSBs #1 and #2. The DSC Processing Building UFDSB #1 and #2 are surrounded by a security fence and an outer concrete jersey barrier with tie-ins for various site services. The RWSB is located in a separate area, surrounded by its own security fence. The DWMF will be expanded to include two additional UFDSBs.

There are currently multiple interfacing systems and services between the DWMF and DNGS to ensure safe operations of these facilities. The interfacing systems include:

- Fire Detection;
- Security;
- Public Address system.

The interfacing services include:

- Environmental Monitoring;
- Fire Detection;

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- Radiation Protection;
- Security; and
- Emergency Response.

Although the life cycle plans of DNGS and the DWMF are separate from each other, the impact that the decommissioning of DNGS may have on the DWMF is included in this PDP (See Sections 4.0). There is a specific plan that defines the areas to be decommissioned and the general structure and sequence of the principal decommissioning work for the DWMF, which is described in the DWMF PDP [R-1].

The impact of DNGS shutdown and decommissioning on the DWMF is further described in Section 4.0.



Figure 2-11: Aerial View of the Darlington Waste Management Facility

## 2.3 Description of the Surrounding Environment

### 2.3.1 Natural Environment

The Darlington Nuclear Site is situated in an undulating to moderately rolling limestone till plain, spotted with remnants of a lake plain deposit. Inland, the previously irregular terrain has been graded in the powerhouse area to an elevation of about 100 m. The surface elevation generally rises towards the north with a mean elevation of 122 m just south of the railway tracks. North of the tracks, the ground is irregular ranging from 120 to 128 m elevation. A higher ridge, starting from the shore just east of Raby Head, extends diagonally across the site in a north-westerly direction. In general, the area possesses no significant topographic features [R-17].

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The dominant vegetation cover surrounding the Darlington Nuclear Site relates to agricultural use, including row crops and pastureland. As of 2018, approximately 265 ha, or 57%, of the DN site area is covered by vegetation communities. Upland vegetation communities and wetland vegetation communities cover approximately 46% and 11% of the Darlington Nuclear Site area, respectively. The Darlington Nuclear site forest community consists of deciduous and mixed forest classes dominated by such indigenous species as Sugar Maple, White and Green Ash, Manitoba Maple, Trembling Aspen, Balsam Poplar, White Birch, Eastern White Cedar, and Willow species [R-18].

Two individual Butternut trees, listed as a nationally endangered species provincially and federally, have been inventoried at the Darlington Nuclear Site in the eastern part of the site, last observed in 2019 [R-18].

Wildlife habitat is associated with the vegetation communities, and natural and developed areas found within the Darlington Nuclear Site. Regionally, over 350 bird species and 50 mammalian species (e.g., coyote, red fox and white-tailed deer) have been inventoried, as well as a number of reptiles and amphibians and insect species of interest [R-18].

Eight species of amphibians and five species of reptiles have been inventoried for the Darlington Nuclear Site during the breeding season from 2008 to 2019. Amphibians that currently breed within the area are American toad, northern leopard frog, and green frog. Reptiles are recorded as incidental observations. In 2019, many Eastern Garter snakes and a Dekay's Brownsnake were found under previously laid snake boards; reports of snakes are generally becoming more frequent [R-18].

To date, 299 insect species (butterflies, dragonflies/damselflies, moths, and other insects) have been inventoried for the Darlington Nuclear Site. Other invertebrate groups that have been identified include tiger beetles (2 species), spiders (2 species) and other insects (9 species) [R-18].

One reptile species, eighteen breeding bird species, three mammals (bats), one insect, and one tree species at risk with a provincial ranking of endangered, threatened or special concern were recorded at the DNGS site over the period from 2006 to 2019 [R-18].

**2.3.2 Geophysical Environment**

**2.3.2.1 Soils**

The soils onshore are between 21 m and 36 m thick cover the bedrock over most of the site. The soils consist of a thin layer of topsoil and up to 3 m of loose to dense silt clay and fine sand overlaying between 2 m and 20 m of dense to very dense sandy till. The till is underlain by interglacial soils consisting of alternate layers of very dense, pervious fine sand and hard, impervious varied silt and clay. A layer of very dense silty fill (generally less than 5 m thick) lies between the interglacial soils and the bedrock.

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The soils offshore range from 7 m to 8 m thick at the shoreline and become less than 1 m thick about 1000 m offshore. The soils consist of thin interglacial soils overlying silty till. Gravel, cobbles, and boulders are found in some areas.

A sand, gravel, and cobble beach exists at the base of the steep shoreline cliffs that are found to the east and west of the new protected shoreline at the site [R-17].

**2.3.2.2 Bedrock**

The bedrock consists of nearly flat lying limestone of Middle Ordovician age. The upper rock unit consists of dark brown, very thin to medium bedded shaley limestone of the Whitby Formation. The Whitby Formation ranges in thickness from 8 m to 1.5 m, thinning towards the eastern part of the site. North of the Powerhouse area near the CN tracks, the upper surface of the bedrock is at an elevation of about 91 m while the bedrock at the shoreline is around 88 m. At a distance of 1,000 m from the shoreline, the bedrock elevation is about 85 m.

The bedrock is hard and sound. At the bedrock surface, there is a zone of broken, weathered rock up to 2 m in thickness. This zone is characterized by weathered, open, water-bearing bedding joints.

The nuclear containment structures are founded on hard and sound shaley limestone of more than adequate bearing capacity to carry the structural loading without any adverse response [R-17].

**2.3.2.3 Groundwater**

Water-bearing zones of low permeability occur within the interglacial soils and in the upper part of the bedrock. The groundwater levels in the interglacial soils were measured in September 1976. The levels ranged from a depth of about 16 m below ground in the west part of the site to about 1 m in the east. The apparent groundwater movement is from north to south toward Lake Ontario. The hydraulic gradient is approximately 2 percent [R-17].

The majority of the groundwater within the interglacial deposits is most likely recharged upstream from the station, north of the CN line where the deposits are close to the surface and the upper till is thin. Recharge to the interglacial deposits in the vicinity of the station will be limited due to the thick upper till layer comprised of fine-grained, low permeability soils.

Inside the protected area at DNGS, groundwater flow is further influenced by anthropogenic subsurface features such as foundations, drain systems and sumps, and the vacuum building. Within the protected area, groundwater flows to the northwest toward the forebay. However, to the south of the powerhouse, there is groundwater flow from the east toward the forebay as well as southerly flow toward Lake Ontario. This likely occurs since the powerhouse extends to bedrock, inhibiting connection between groundwater flows at the north and south of the structure.

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It was detected that there was a presence of elevated tritium in groundwater in the protected area attributed to the Injection Water Storage Tank spill, which occurred southwest of Unit 0, in December 2009. Overall, tritium concentrations have declined since the spill, confirming that there are no new sources of tritium in groundwater.

Tritium concentrations at perimeter groundwater monitoring locations remained very low. Municipal drinking water samples collected from downstream Water Supply Plants, as part of the annual OPG DNGS Environmental Monitoring Program, were well below the Ontario Drinking Water Quality Standard for tritium of 7,000 Bq/L. Groundwater monitoring wells within the protected area will continue to be monitored to verify the tritium concentration trends [R-19].

**2.3.2.4 Seismicity**

The western Lake Ontario region lies within the tectonically stable interior of the North American continent, which is characterized by low rates of seismicity. Only one seismic event with a magnitude of greater than 4 has ever been recorded within 100 km of the station. This earthquake occurred on April 27, 1954. It had a magnitude of 4.1 and it was centered 9 km southeast of St. Catharines (just under 100 km from the Darlington Nuclear Site).

The historical record of earthquakes for the region confirms relatively low seismic activity. Over the period of record since 1840, within the region to 150 km from the Darlington site, the maximum seismic event has only generated a calculated peak ground motion at the site of less than 1.5% of gravity. Over this period of records, only seven events were reported to have occurred within 150 km of the site with sufficient magnitude to generate a calculated peak ground motion at the site greater than 0.5% of gravity [R-17].

From July 2017 to March 2021 inclusive, there have been an additional 12 seismic events (two of which are man-made seismic events) reported in Ontario of a magnitude greater or equal to 3.0. The magnitude of these earthquakes range between 3.0 and 4.1, with one earthquake of 3.0 magnitude occurring within a 100-km radius of the Darlington Nuclear Site [R-20].

**2.3.3 Aquatic Environment**

**2.3.3.1 Drainage**

Darlington Creek is the main drainage feature located to the northeast and east of the DNGS site. The watershed area for Darlington Creek includes the northeastern portion of the Darlington Nuclear Site and there is a direct runoff to the creek in this area. Darlington Creek drains through St. Marys' Cement property as a channelized stream to the immediate east of the Darlington Nuclear Site. Most of the DNGS site drains to the south directly to Lake Ontario. Drainage features on the Darlington Nuclear Site include ditches, ponds and storm drains [R-17]. There are also a number of major cold-water streams entering Lake Ontario within 50 km of the station. The Raby Head Wetlands, two small, locally significant wetlands, are located just east of DNGS. The Bowmanville and Westside Marshes are located further to the east.

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These two large, provincially significant wetlands are managed by the Central Lake Ontario Conservation Authority (CLOCA) [R-21]. Coot’s Pond is located about 900 meters northwest of the Darlington Nuclear Site and another smaller pond (Tree Frog Pond) is slightly further away to the northeast.

**2.3.3.2 Fish**

In 2019, the total commercial catch from Lake Ontario commercial fishery harvested over 305,800 pounds of locally caught fish [R-22].

While recreational fishing does occur at the Darlington Nuclear Site, the site is not known to host concentrations of sport fish similar to the Pickering Nuclear Site and Bruce Nuclear Site, because DNGS utilizes an offshore diffuser for cooling water discharge rather than a surface discharge channel. The diffuser prevents the formation of an extensive thermal plume, and therefore does not seem to be a fish attractant. In addition, DNGS was the first OPG station where fish protection principles were considered in the decision-making process for both design and shoreline location of the intake. The intake incorporates a porous concrete intake “field” that circumvents the impingement and entrainment problems associated with a more traditional velocity cap intake. The intake is designed to minimize the entrainment of all juvenile and adult fish and the drawdown of cooling water (i.e., the maximum height above the intake from which water is drawn) [R-23].

Major cold water streams are along the northern shore of Lake Ontario. These streams are concentrated within 50 km of the Darlington Nuclear Site, but they also extend in the west to the 100 km limit. The major species of fish found either inhabiting or migrating up these streams during the spawning season are the salmonoids: Coho Salmon, Chinook Salmon, Rainbow Trout, Brown Trout, and Lake Trout. Highest fishing activities are found at the branches of these streams [R-17]. Alewife and emerald shiner are two of the most abundant fish species along the Darlington Nuclear Site shore.

Major populations of warm water species of fish inhabit the Kawartha Lakes, distributed 25 to 100 km from Darlington Nuclear in the north to east quadrant. The major species of fish are walleye, muskellunge, small-mouth bass, large-mouth bass, and yellow perch. The data required to carry out a detailed analysis of distribution of the fish populations in these lakes are not presently available. Lake Simcoe supports large populations of lake trout, herring, smelt and whitefish, walleye, northern pike, muskellunge, panfish, large-mouth and small-mouth bass [R-17].

Although the fish community also includes species that are subject of conservation concern, there is no evidence that the Darlington Nuclear Site nearshore area contains unique habitat such as spawning or limited nursery areas for any of these species. Further detail on the fish community is provided in the DNGS Environmental Risk Assessment [R-18].

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**2.3.3.3 Lake Water Levels**

The Darlington Nuclear Site is protected from high lake levels by the new shoreline, which is built to elevation 101 m, 1 m above site grade level and about 2.9 m above the highest water level recorded. This new shoreline will provide an adequate safety barrier against the severest anticipated combination of spring runoff and wave action [R-17].

Based on measurements of the monthly average water levels of Lake Ontario (i.e., the average levels of the whole lake) from 1918 to 2019, the annual maximum monthly average water levels range from a low of 73.74 m relative to the International Great Lakes Datum (IGLD) (1934) to a high of 75.91 m relative to the IGLD (2019). Lake Ontario water levels have been regulated since the completion of the St. Lawrence Power Project in 1958. The mean monthly Lake Ontario water level from 2004 to 2019 has varied between 74.63 m (December) – 75.79 m (June) above the mean sea level [R-24].

**2.3.4 Current Use of the Adjacent Land**

The St Marys’ Cement plant is located immediately east of the Darlington Nuclear Site. The lands immediately to the north and west of the Darlington Nuclear Site are currently either agricultural or unused land. The Town of Bowmanville, part of the Municipality of Clarington, is located northeast of the site.

The main recreational facility in the area is the 209 ha Darlington Provincial Park which is located 4.8 km west of the station. It is a popular facility, with campsites, swimming facilities, fishing, controlled hunting, boating, etc. There are also 19 conservation areas within 40 km of the site; three within the Metropolitan Toronto and Region Conservation Authority, 11 within the CLOCA and five within the Ganaraska Conservation Authority.

In addition to these facilities, there are numerous golf courses, local parks, swimming areas, and snowmobile trails.

There are no industrial plants manufacturing hazardous materials within 8 km of the Darlington site. St. Marys’ Cement Company owns the Calcining Facility and quarry on the property to the east of the site. Blasting and the possible detonation of stored explosives have been investigated and it has been concluded that this does not present a hazard to the station [R-17].

Industry in the Bowmanville community has primarily been light to medium manufacturing. The two largest plants produce rubber products and iron castings. Durham York Energy Centre (DYEC) is located to the west of the site. The DYEC is a waste management facility that produces energy from the combustion of garbage. The emissions from the combustion do not present a hazard to the station [R-17].

There are three major pipelines near the site. Two pipelines (0.56 m and 0.61 m diameter) carrying natural gas are located about 10 km from the site and one pipeline

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(0.25 m diameter) carrying refined oil products is located about 8 km from the site. Due to the distances involved, they represent no hazard to the station.

The City of Oshawa is a major centre of heavy manufacturing activity. The largest segment of this employment is associated with the automobile industry [R-17].

### 2.3.5 Local Communities

The Darlington Nuclear Site is located in the Municipality of Clarington. Other nearby municipalities include the City of Oshawa to the west and the Municipality of Port Hope to the east. The population of nearby municipalities in 2016 is presented in Table 2-1 below [R-25]. The local and regional areas have experienced strong population and economic growth over the last decade.

The demographic make-up of residents living near the Darlington Nuclear Site is not substantially different from that of the Province of Ontario as a whole. The economy within the region is founded on a diverse manufacturing base.

**Table 2-1: Population of Nearby Municipalities**

Municipality	2016
Oshawa	159,458
Town of Ajax	119,677
Town of Whitby	128,377
Clarington	92,103
Port Hope	16,753
Township of Scugog	21,617
Township of Uxbridge	21,176

OPG is a large local employer. It is estimated that about 300 local jobs are created indirectly, because of DNGS and DWMF operation. Most of the employees live in the local area.

The 10-year DNGS Refurbishment Project will help extend the operational life of the DNGS reactors to up to 2055, contributing a total of \$90 billion to Ontario's Gross Domestic Product. The Refurbishment Project will create up to 11,800 jobs annually while contributing nearly \$15 billion to Ontario's economy.

The region is well serviced and enjoys many recreational and cultural facilities. In addition, there is a full range of social and community organizations in the region. Many employees from the station are involved in these organizations and the station maintains strong links with these organizations.

### 2.3.6 Indigenous Communities

There are six First Nation communities located within distances between 50 km to 135 km of the Darlington Nuclear Site, one each in Durham Region and Northumberland County, two in southern Peterborough County, and another located

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on Georgina Island in South Lake Simcoe in York Region, and another in Quinte West. These six indigenous communities all have a historical relationship with the lands along the north shore of Lake Ontario (from Toronto east to the Bay of Quinte) and north to Lake Simcoe and Rice Lake as a result of their occupation and traditional use of these lands prior to European settlement and subsequent signing of treaties.

These indigenous communities are listed below along with their approximate locations:

- **Alderville First Nation:** 20 km southeast of Peterborough on south side of Rice Lake.
- **Curve Lake First Nation:** 15 km north of Peterborough on Buckhorn Lake.
- **Hiawatha First Nation:** 15 km southeast of Peterborough on north side of Rice Lake.
- **Mississauga's of Scugog Island First Nation:** 35 km north of Oshawa on Scugog Island in Lake Scugog.
- **Chippewa's of Georgina Island First Nation:** 10 km north of Sutton West on the southern end of Lake Simcoe.
- **Mohawks of the Bay of Quinte:** 35 km east of Belleville.

There are no Métis settlements in or near the Darlington Nuclear Site property; however, there are Métis persons residing within the regional area. The Oshawa and Durham Region Métis Council represents Métis people in Durham Region [R-26].

### 2.3.7 Community Relationships

OPG believes in open and transparent communication with the public in a timely manner, in accordance with CNSC REGDOC-3.2.1 [R-6]. As such, OPG regularly and proactively provides information to the public on its operations and projects. OPG's Corporate Relations manages communications and relationships between the nuclear facilities and the host communities by fostering healthy, open relationships and sustainable partnerships with community stakeholders, including government, media, business leaders, educational institutions, interest groups and community organizations. OPG's Corporate Relations organization adheres to the principles and process for external communication as governed by the nuclear standard N-STD-AS-0013 [R-27], Nuclear Public Information and Disclosure.

OPG conducts integrated communications and regular community liaison activities. For Darlington Nuclear Site, the community relations program proactively provides information to the stakeholders on DNGS and DWMF operation and the status of key projects, including the Darlington Refurbishment Project, and the Darlington New Nuclear Project. OPG regularly provides milestones and regular waste management updates to key stakeholders. Presentations are regularly made at the Darlington Community Advisory Committee and Durham Nuclear Health Committee. In addition,

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presentations and informal meetings are held with local elected officials and community leaders a number of times each year to provide updates on performance and other activities taking place both at the stations and waste facilities.

A major component of the site public affairs program is Darlington's Public Information Program, which includes key activities such as the Darlington Information Centre, the Darlington 'Neighbours' newsletter and the Speaker's Bureau. Of particular note was Darlington's response to the local public's concerns over nuclear safety following the nuclear incident at Japan's Fukushima nuclear power plant in 2011. A two-page insert into the Darlington Neighbors Newsletter was distributed throughout the community, explaining the roles and responsibilities of OPG and other organizations, as well as providing responses to a number of commonly asked questions following the incident. Ongoing communication of Darlington Nuclear operations is provided through these public information programs and vehicles, including social media (Facebook, Twitter, and Instagram). It is expected that the same mechanisms will be employed during the site's decommissioning phase.

In 2017, OPG conducted a one-day emergency exercise at the Darlington Nuclear to test the emergency response plans and demonstrate how the participating agencies and government work together. OPG also conducts multiple Emergency Response Organization drills throughout the year to demonstrate proficiency and capture lessons learned. OPG regularly meets with citizens and community groups in a variety of forums to discuss issues related to the Nuclear Emergency Preparedness program. Under CNSC's mandate, potassium iodide (KI) pills have been distributed by OPG to all homes and businesses within a 10 km zone surrounding Darlington Nuclear Site in 2015. New residents and businesses within the 10 km zone are sent KI pills every year based on data provided by Canada Post, and KI pills remain available to the public within 50 km around Darlington Nuclear Site through a dedicated website.

In addition to operational-related liaisons, Darlington also supports a large number of local not-for-profit organizations. Of note, OPG has worked with Bring Back the Salmon, Scientists in School, Toronto & Region Conservation Authority, Rouge Valley Health System Foundation (Ajax & Pickering Site), and the Oshawa & Durham Region Métis Council's Heritage Celebration in a corporate-wide initiative to better the local environment, education, and community.

OPG's community relations and public information program has been recognized as a strength by national international utility peers. OPG benchmarks current practices amongst other industries to ensure continuous performance improvement.

OPG's Centre for Canadian Nuclear Sustainability (CCNS) is focused on community and stakeholder communications and relationships specifically related to decommissioning. The CCNS communication program is integrated into OPG's existing public information program and focuses on research and development, innovation and collaboration in decommissioning. It holds meaningful interaction with CCNS partners, committees, Indigenous communities and the broader community through a variety of channels including social media, Neighbours Newsletter, community presentations and events, and collaboration with the Pickering Community Advisory Council. The CCNS also has its own website, [www.theccns.com](http://www.theccns.com), which

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provides online access to the general public about CCNS projects and opportunities to engage with the CCNS team.

The CCNS has also launched an Indigenous Advisory Council (IAC) that provides advice and insight to CCNS on how Indigenous communities, organizations and businesses can bring Indigenous values and content into the Centre's mandate. The IAC is comprised of Indigenous individuals and representatives of specific Indigenous organizations within Durham Region and the surrounding area.

#### **2.3.7.1 Indigenous Relations**

OPG has a board-level Indigenous Relations Policy [R-28] and active community relations program that focuses on:

- Community relations and outreach;
- Capacity building support with communities;
- Employment/business contracting opportunities; and
- OPG staff education.

Building positive, community-minded relationships with indigenous communities is important to OPG with respect to current operations and the planning of new projects. OPG recognizes close consultation with community members and leaders is an essential part of the process. OPG continues to engage in active dialogue with indigenous people on a number of issues and operational decisions related to our nuclear operations. Discussions and information sharing to build long-term mutually beneficial working relationships with indigenous communities near the nuclear host communities occurs on a regular basis [R-26].

#### **2.4 History and Future Outlook**

The first unit (Unit 2) of DNGS entered commercial service on October 9, 1990, followed by Unit 1 on November 14, 1992, Unit 3 on February 14, 1993 and Unit 4 on June 14, 1993.

OPG is currently progressing with the refurbishment of the existing DNGS units. Unit 2 has completed refurbishment and has been reconnected to the grid, with Unit 3 currently undergoing disassembly. See Section 1.5 for the refurbishment dates for Units 1-4. All four units are expected to remain in service for 30 years post refurbishment.

Since 2018, OPG (in partnership with the Laurentis Energy Partners and the BWX Technologies Inc.) have been developing a system to produce molybdenum-99 (Mo-99) at the DNGS. Mo-99 is the most commonly used medical isotope, used in over 40 million procedures a year to detect cancers and diagnose various medical conditions. DNGS will be the only source of Mo-99 in North America, ensuring a stable domestic supply of this critical product. The Mo-99 Isotope Irradiation System (IIS), also known

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as the Target Delivery System (TDS), is planned to be installed in Unit 2 during an outage in 2022.

### 3.0 PRELIMINARY DECOMMISSIONING PLAN

#### 3.1 Scope of the Decommissioning Plan

This plan describes the preliminary plan for the decommissioning of the DNGS, along with all of the associated buildings and structures located within the nuclear licensed area of the station. This includes but is not limited to the following:

- The Reactor Buildings;
- Fuelling Facilities Auxiliary Areas (both East and West including Irradiated Fuel Reception, the IFBs and the Wet Cask Handling Bays);
- The Vacuum Building;
- The Pressure Relief Duct;
- The Powerhouse (including the four Turbine Halls and the Turbine Auxiliary Bays);
- The Central Service Areas;
- The Pump Houses and Water Treatment Building;
- The Standby Generator Buildings;
- The HWMB and TRF; and
- All other small buildings, aboveground storage tanks and structures that are located inside the protected area.

A full list of buildings that has been considered when developing the cost estimates for decommissioning (as detailed in Section 5.0) is provided in Table 3-1. Refer to Figure 2-2 and Figure 2-3 for the location of buildings. This plan is considered as the site<sup>9</sup> PDP as it takes into account the interfaces of the DWMF with the DNGS, as described in Sections 2.2.8. The impact of decommissioning the DNGS may have on the DWMF is further described in Section 4.0, while the details for decommissioning of the DWMF or any buildings associated with the operation of that facility are provided in the DWMF PDP [R-1].

<sup>9</sup> Per CSA N294:19 [R-2], the site is defined as: 'the immediate area containing the nuclear facility including the exclusion zone (if any) and under the control of the operating organization'.

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This plan will be revised as appropriate to incorporate any future changes in the scope of decommissioning.

**Table 3-1: List of Buildings Considered in Cost Estimations for DNGS**

Location Str #	Building Name
0	Unit 0
1	Powerhouse
U1-4	Units 1-4
WF	West FFAA
EF	East FFAA
P1-P4	Pumphouse 1-4
WTP	Water Treatment Plant
14	Lube Oil Tanks
15	EPS Building
16	ESW Pumphouse
17	Circulating Water Discharge Structure
18	EPG #1
20	EPG #2
22	EPG Fuel Management Building
29	Reactor Maintenance Building
31	Sheet Metal Shop
32	Inactive Liquid Waste Storage
36	Standby Generators Fuel Storage
38	Standby Generator #1
39	Standby Generator Fuel Management Building #1
40	Standby Generator #2
42	D <sub>2</sub> O Management Building
41	HWMB West Annex

Location Str #	Building Name
46	Vacuum Building
50	Compressed Gas Bottle Storage
51	Service & Storage Building
54	Standby Generator #3
55	Standby Generator Fuel Management Building #2
56	Standby Generator #4
58	Island Garage
59	Standby Generators Fuel Storage
124	Hydro Transformer Substation
125	Steam Heating Boiler House
126	Steam Relief Stack
300	Auxiliary Security Building
411	OSB
415	Bill Gearing Guardhouse
416	Main Security Building
8	FPS Firehall - Building #8
63	Scaffold Storage Building
512	Radiation Kiosk
208	RPO Building
65	RFRISA Building
23	EPG 3 Building
CFVS	CFVS Buildings
10	Retube Waste Processing Building

**3.2 Objective of the Decommissioning Program**

The objective of the decommissioning program is to permanently retire the DNGS from service in a manner that will ensure that the health, safety and security of workers, the public and the environment are protected.

During the course of decommissioning, radioactive and other hazardous materials will be removed and the site will be restored to meet the radiological release criteria approved by the CNSC. Upon completion of the decommissioning program, the site will be in a condition that will support an application to the CNSC for release from

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regulatory control. OPG will retain ownership of the site and it will then be available for other OPG uses.

### 3.3 Decommissioning Phases

According to CSA N294:19 [R-4], decommissioning proceeds according to four distinct phases (see Figure 3-1):

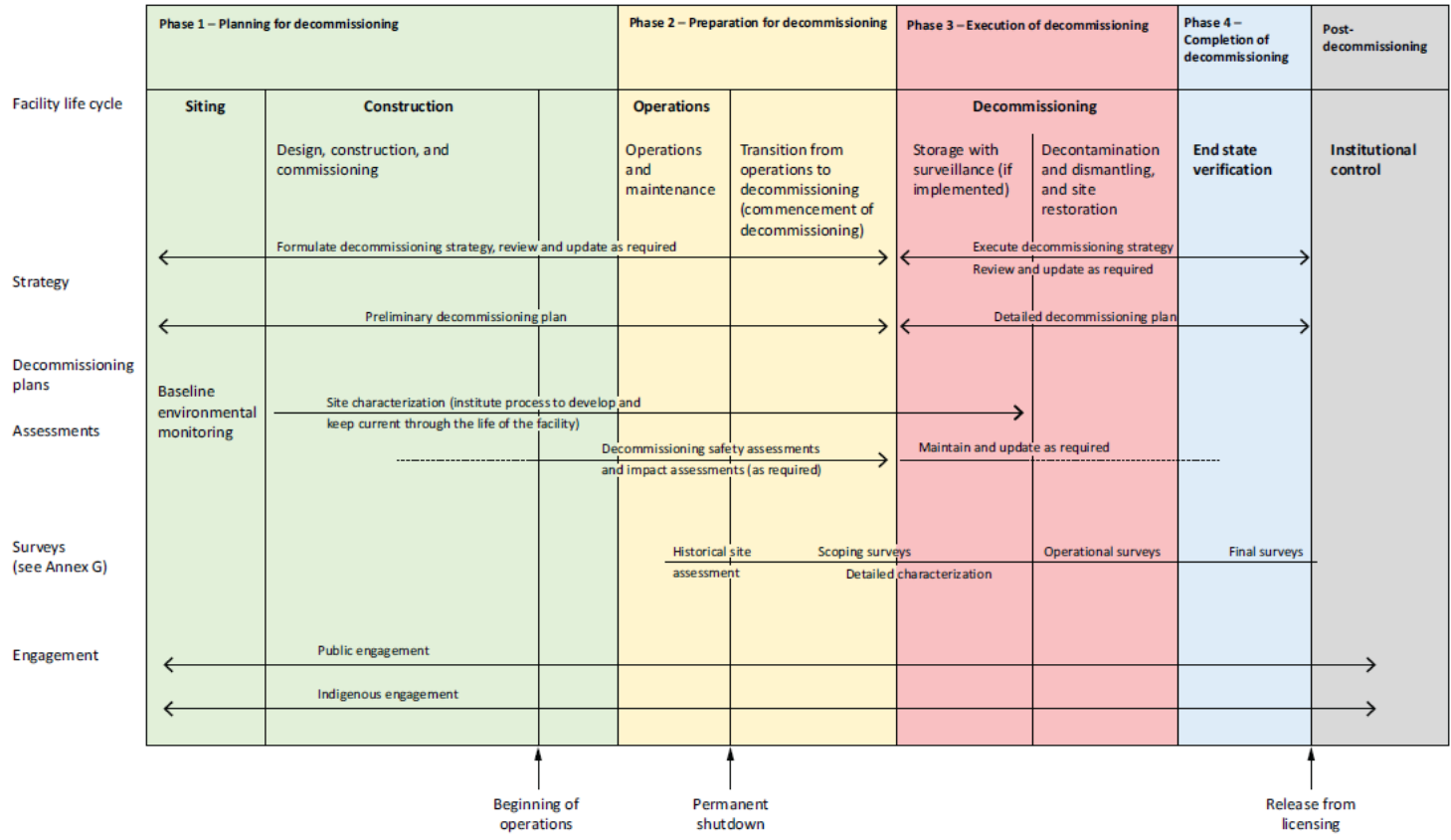
- (a) **Phase 1, Planning for Decommissioning:** This is carried out throughout the operating life of DNGS and results in the preparation of a decommissioning strategy (Section 3.4) and a PDP (i.e., this document).
- (b) **Phase 2, Preparation for Decommissioning:** For planning purposes, it is expected that units at DNGS will be shut down per the schedule in Section 1.5. After all the units in DNGS are permanently shutdown, OPG will defuel and dewater the reactor and make all the necessary modifications to the Structures, Systems and Components (SSCs) to prepare for the subsequent SWS period; this phase will end when the units enter into SWS stage. The PDP will be further developed into a DDP<sup>2</sup> to include details of the activities that would be conducted in the next phase of decommissioning.
- (c) **Phase 3, Execution of Decommissioning:** During this phase, a decommissioning licence will have been received from CNSC and the DDP that was prepared in Phase 2 will be implemented. The station will have been placed in SWS and will be monitored and maintained as deemed necessary while the radiation levels in the reactor systems decay. For planning purposes, it is assumed that the dismantling of the station will begin after a nominal 30 years of SWS. The activities under this phase also include the execution of the physical works (i.e., decontamination, Dismantling & Demolition of the facility) and site restoration.
- (d) **Phase 4, Completion of Decommissioning:** When Dismantling & Demolition and site restoration activities are completed, final surveys and an end state verification of the site will take place and release from regulatory control will be requested from the CNSC.

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Time interval shown denotes the applicability of the plans and not the time when they are developed

**Legend:**

- identifies when the activity may be performed
- identifies when an optional activity may be performed if required

**Figure 3-1: Phases of Decommissioning [R-4]**

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### 3.4 Decommissioning Strategy

#### 3.4.1 Decommissioning Strategy Adopted by Ontario Power Generation

OPG has chosen a decommissioning strategy that is considered to minimize both the occupational radiation dose to staff and the potential exposure of the public and the environment. It is known as the 'Deferred Decommissioning' strategy.

The main feature that distinguishes the decommissioning of a nuclear station from that of any other large industrial plant is the radiological hazard. At shutdown, major activation radionuclides such as H-3, Fe-55, Fe-59, Ni-63, Ni-59, Nb-95, Zr-93, Zr/Nb-95 and Co-60 will be present in the systems and equipment subject to neutron flux, but also carried to other portions of the systems not subjected to the flux (such as throughout the Heat Transport and Moderator system). Contamination fission products will also be present in the reactor cooling systems from defect fuel and tramp uranium: radioiodines, xenons, Sr-90, Tc-99, Ru-106 and Cs-137 typically. Historically fuel failure rates have been low, however some actinides may be present in the PHT from defect fuel particulate and tramp uranium. Whereas the activation radionuclides in the fixed structure of the reactors may be estimated by calculation, the contamination nuclides will need to be measured via sampling and in-situ measurements to complete the inventory.

Co-60, Zr/Nb-95 and Sb-124 are the principal gamma emitters associated with reactor surfaces. Co-60 is usually the dominant contributor to radiation levels during operation and into shutdown. Co-60 is found in activated steel structures (reactor core) and as a corrosion product in nuclear process systems. Co-60 is a strong gamma radiation emitter with a relatively short half-life of 5.3 years and remains the dominant radiological hazard for several decades after shutdown. After about 30 years of decay, the level of Co-60 activity would be reduced by a factor of approximately 60 and its contribution to the radiation fields would also be reduced.

Dismantling the radioactive parts of the stations are considered to be the most challenging and labour and cost intensive activities involved in decommissioning. Hence, reducing the amount of radiation exposure to workers, public and the environment was one of the most important factors considered when OPG was developing the strategy for decommissioning. Three decommissioning options were considered, consistent with CSA N294:19 [R-4]:

- (a) **Prompt Decommissioning**, where the reactors and stations would be decontaminated and dismantled and the site restored promptly after shutdown.
- (b) **Deferred Decommissioning**, where the reactors and stations would be safely stored for several decades after shutdown to allow radiation levels to decay prior to Dismantling & Demolition and Site Restoration.
- (c) **In-situ Decommissioning**, where the facility would be placed in a safe and secure condition, in which some or all of the radioactive contaminants will remain in-place, resulting in a waste disposal site.

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CSA N294:19 also allows a combination of the above strategies. A combination of options (a) and (b) will result in a phased decommissioning strategy, where decommissioning proceeds according to a sequence of dismantling activities and periods of SWS, according to the prevailing conditions, e.g., resource availability, safety, environmental and stakeholder conditions.

Deferred decommissioning strategy was selected on the basis of decommissioning planning studies that OPG started in the 1980s. This strategy was chosen based on the following considerations and benefits:

- Minimizes dose/radiation exposure to workers consistent with the As Low As Reasonably Achievable (ALARA) principle. This in turn reduces cost of dismantling activities due to substantially lower radiation levels. Reducing the amount of radiation exposure to workers, public and the environment was one of the most important factors considered when OPG was developing the strategy for decommissioning.
- Gives time to implement long-term disposal strategies for used fuel and L&ILW.
- Allows continued growth of the decommissioning fund to help moderate price of power as a result of future expenditures vs. expenditures in the present.
- Lower classification of radioactive waste is achieved through natural radiation decay and the ALARA goal is met. This additionally lowers waste management costs associated with handling, packaging, shielding, transporting and disposing of waste.
- Efficiencies as a result of technological development in the area of decommissioning and nuclear waste management, and benefit of industry decommissioning experience.

Studies performed by OPG showed that the ‘Prompt Decommissioning’ option would incur higher costs and result in higher occupational dose. The studies also showed that dismantling costs and occupational dose would fall over time, thus favouring the other two options: ‘Deferred Decommissioning’ and ‘In-situ decommissioning’.

However, the current post decommissioning plans for Darlington site are for OPG’s re-use, therefore In-situ decommissioning strategy was not considered further. The following subtle strategy modifications to the Prompt Decommissioning option (a) and Deferred Decommissioning option (b) were also evaluated but were not pursued further [R-29]:

- Immediate Dismantling of the Units, Deferred Dismantling of the wet bays after used fuel is transferred; and
- Deferred Dismantling where dismantling of the unit starts immediately after the removal of all used fuel from the station.

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When the three options (a) - (c) described above were compared, it was concluded that 'Deferred Decommissioning', entailing a SWS period, was currently the most suitable option for decommissioning OPG's NGSS. The duration of the SWS period was determined by balancing the reduced decommissioning cost and occupational dose achieved by allowing the residual activity to decay against the increased social and economic costs of a longer storage period. OPG has determined that a SWS period of nominally 30 years offers a reasonable time to defer dismantling and the available funding assumes a Deferred Decommissioning strategy for DNGS [R-30]. This decision will be reassessed periodically in light of experience, cost, changing technology and the possible requirement of the site for other purposes.

### 3.4.2 Stages in Deferred Decommissioning Strategy for Darlington Nuclear Generating Station

Applying the 'Deferred Decommissioning' strategy, the DNGS will pass through four distinct stages:

- (a) Preparation for Safe Storage<sup>10</sup> or Stabilization Period (also referred to a Phase 2: Preparation for Decommissioning in Section 3.3(b));
- (b) Storage with Surveillance (Part of Phase 3: Execution of Decommissioning, see Section 3.3(c));
- (c) Dismantling and Demolition and Site Restoration (Part of Phase 3: Execution of Decommissioning, see Section 3.3(c)); and
- (d) End State Verification (Part of Phase 4: Completion of Decommissioning, see Section 3.3(d)).

#### 3.4.2.1 Stage 1 – Preparation for Safe Storage

During the Preparation for Safe Storage, OPG will plan and execute the safe transition of the Darlington station from its current (electricity generating) state, to a predetermined SSS. This will take place in two sub-stages:

- (a) Planning for SWS – occurs before shutdown. Details of the project planning activities are given in Section 4.1.2.
- (b) Stabilization – execution of activities detailed in the planning phase. Details of the project Stabilization activities are given in Section 4.1.4.

The planning for SWS will consist of activities to ensure that the physical and operational condition of the facility will meet all regulatory and operational requirements, while minimizing the operational footprint of the facility to be maintained over the nominal 30-year SWS period. In preparation for the scheduled shutdown of DNGS, the design basis and safety analysis appropriate for the transition from

<sup>10</sup> Preparation for Safe Storage is also referred to as Stabilization.

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operations to decommissioning will also be reviewed and modified to reflect plant conditions and the safety concerns consistent with permanent cessation of operations.

Stabilization activities will start following shutdown of DNGS. The reactors will be defueled, and each unit will be dewatered, thereby reducing the radioactivity in the reactors by approximately 99 percent. Following defueling, used fuel transfer operations from the IFBs will resume. All unnecessary SSCs will be placed into an inactive safe state where they will be removed from the design basis, de-energized, drained of gas or fluids and isolated from operational systems. SSCs supporting continued operations will be reclassified and reconfigured, as required, to meet the operational needs of the SWS period. At the end of Stabilization, the facility will remain intact with the structures in a safe condition.

### 3.4.2.2 Stage 2 – Storage with Surveillance

The SWS stage (also referred to as Safe Storage) allows time for the decay of short-lived fission and activation products that remain in plant components. The specifics of SWS will be outlined in the SSP (refer to Sections 1.1 and 4.1.3). During this period used fuel transfer operations from the IFBs will continue until all the used fuel has been transferred to DWMF. As such there will be two distinct phases of SWS: SSS (pools) when the used fuel is still in the IFBs and SSS (dry) when the IFBs have been emptied of all used fuel.

### 3.4.2.3 Stage 3 – Dismantling and Demolition

Following SWS, Dismantling & Demolition are scheduled to occur over a nominal 2-year period for each reactor. The first reactor will be dismantled, followed in sequence by the others. Radioactive and other hazardous materials will be removed from the site and transferred to approved disposal facilities.

### 3.4.2.4 Stage 4 – Site Restoration

During the fourth stage, surveys will be conducted to verify that the site meets the release criteria agreed with the CNSC before the remaining buildings and structures are demolished. The site will be restored to a condition suitable for other OPG uses. At the conclusion of this work, OPG will apply to the CNSC for release from regulatory control.

## 3.4.3 Domestic and International Decommissioning Strategies and Experience

### 3.4.3.1 Domestic Decommissioning Strategies and Experience

Decommissioning strategies adopted in Canada for nuclear facilities are summarized below.

OPG has successful decommissioning experience at both the Bruce Heavy Water Plant (HWP) and the Spent Solvent Treatment Facility (SSTF), which are both located on the Bruce Nuclear site.

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The Bruce HWP was in continuous operation from April 1973 until March 1998, for the purpose of producing reactor-grade heavy water [R-31]. After it was no longer in operation, the Bruce HWP decommissioning project was carried out in accordance with a DDP, remediation and an Environmental Assessment (EA) and follow-up program. Demolition began in October 2004 and was completed in 2006. The buildings were demolished using standard demolition techniques. The debris was removed from the site for recycling or disposal. Bioremediation of oil-contaminated soil in the effluent lagoons was required and began in 2006. About 25% of the soil was bioremediated to below the end-state criteria and was used as clean backfill in the immediate area. Any soil that did not meet the end state criteria was disposed of off-site at a licensed facility. The radiological end state was that no nuclear substances would remain within the HWP facility boundaries and the remaining structures, equipment and grounds were free of significant radiological contamination. In order to demonstrate that this end state criterion was met, a final radiological survey was performed in 2012 using the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) methodology [R-32]. This survey found no radioactive contamination on the HWP site [R-33], [R-34] and a licence to abandon the facility was granted by the CNSC in 2014 [R-35].

From May to December 2018, OPG completed decontamination of all radiologically contaminated piping in the SSTF. As decontamination progressed, each room or section was systematically surveyed and sampled for radiation in accordance with the MARSSIM methodology. A Site Survey and Characterization report was prepared and approved by OPG in March 2019. This report concluded that radioactivity levels in the SSTF were below the site unconditional release criteria. The CNSC also concluded that OPG satisfactorily demonstrated that the SSTF was free of any contamination above the regulatory limits [R-36], [R-37] and [R-38]. This resulted in CNSC acceptance of OPG's request to remove the SSTF from licensing control [R-39]. In November 2019, demolition of the above ground structure was completed. Most of the underground infrastructure was removed in February 2020, with the exception of some Bruce Power water lines that remained. Final site grading and remediation was completed in June 2020.

Gentilly-2 Nuclear Power Plant (NPP), owned by Hydro-Québec, was shut down in 2012 and is currently in the SSS for approximately 40 years. Some of the main activities that have taken place from Gentilly-2 shutdown to reactor stabilization and transition to SWS were [R-40]:

- Placing Gentilly-2 in guaranteed shutdown state;
- Removal of the fuel from the reactor;
- Transfer of resins and tank repairs;
- Emptying and transfer of heavy water;
- Preparations, modifications, removal of systems;
- Construction of infrastructure required for dry storage; and

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- Transfer of fuel from the pool to dry storage (yearly summer campaign on site).

Hydro-Québec was granted (in June 2016) a 10-year power reactor decommissioning licence from the CNSC to continue activities related to the preparation for the decommissioning of Gentilly-2. Under this decommissioning licence the activities include, but are not limited to the following, will take place [R-40]:

- Construction of infrastructure required for dry storage, and
- Continuation of the transfer of fuel from the pool to dry storage (yearly summer campaign on site).

The Point Lepreau NGS, owned by New Brunswick Power (NBP) Corporation, has been operating since it was last refurbished in 2012. Currently, NBP has opted for the deferred decommissioning strategy.

Canadian Nuclear Laboratories currently maintains several reactors in SWS including three prototype reactors (Nuclear Power Demonstration (NPD), Douglas Point (DP) and Gentilly-1 (G-1)) and several research reactors (Whiteshell Reactor (WR-1), National Research Experimental (NRX), Multipurpose Applied Physics Lattice Experiment (MAPLE)-1 and MAPLE-2). An eighth reactor, National Research Universal (NRU), is in a permanent shutdown state after ceasing operations in 2018. CNL originally proposed a deferred decommissioning strategy for all of these but changed to In-situ decommissioning for NPD and WR-1. This strategy has been adopted for small reactors in several countries but has generally not been used for a large power reactor. The In-situ decommissioning strategy is usually limited to a small number of facilities in a given country, particularly to remote sites, in order to prevent the proliferation of waste disposal sites [R-41]. In 2019, the CNSC amended CNL's Waste Facility Decommissioning Licence into three separate licences for the NPD, DP and G-1. Under these new licences, CNL can proceed with the different decommissioning strategies and timelines for each site [R-42]. CNL is currently planning to proceed with final active decommissioning of nuclear facilities as well as continuing with its planned removal of remaining non-nuclear area facilities at the DP site [R-43], [R-44]. Both the Zero Energy Experimental Pile (ZEEP) reactor and the Pool Test Reactor (PTR) have been completely decommissioned. In addition to the reactors, CNL has been actively decommissioning legacy research and isotope production facilities and other support facilities across its sites.

Within the last 5 years, CNL has accelerated its decommissioning timelines to reduce legacy liabilities and support the larger revitalization effort of its Chalk River campus. CNL applies a graded approach to its decommissioning activities that considers the unique radiological and non-radiological characteristics of facilities. In addition, CNL is considering multiple decommissioning strategies (prompt, deferred, and in-situ) for its portfolio of reactors and research facilities. Below is an update of the decommissioning plans for CNL's eight main reactors:

- At NPD and WR-1, CNL continues to plan for in-situ disposal of the reactor and remaining systems.

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- At DP and G-1, CNL is advancing the decommissioning of non-reactor components and hazard reduction while planning for the dismantlement of the Calandrias.
- At Chalk River (NRX, NRU, MAPLE-1, and MAPLE-2), decommissioning strategies are being explored to support the revitalization of the site. Where feasible, a prompt decommissioning strategy is preferred to support construction of new Science and Technology research facilities.

OPG has an active decommissioning planning program and maintains links with other utilities on the topic of decommissioning to gain experience on other decommissioning projects.

### 3.4.3.2 International Decommissioning Strategies and Experience

Decommissioning strategies adopted by the operators of other nuclear facilities around the world vary from Prompt Decommissioning (also referred to as immediate dismantling) to a variety of different Deferred Decommissioning approaches. The choice between Prompt and Deferred Decommissioning is influenced by many factors as described in several publications prepared by the IAEA [R-45], [R-46] and [R-47].

In summary, some of the reasons to choose Prompt Decommissioning may include:

- Regulatory requirements;
- Government subsidies;
- Costs for maintaining a site in SWS;
- Retention of staff and related expertise;
- Availability of waste disposal facilities;
- Public acceptability;
- Desire for re-use of the sites; and
- Risks related to future uncertainty.

Reasons to choose Deferred Decommissioning may include:

- Reduction in radiation levels during a deferral period that will likely reduce dose to decommissioning workers and the associated cost savings with decreased complexity of the decommissioning due to the likely use of less complex robotic and remote dismantling technologies;
- Unavailability of waste disposal facilities;
- Unavailability of immediate funding and time allowed for growth of the decommissioning fund;
- Continued operation of other reactors on site;

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- Continued growth of the decommissioning fund to help moderate price of power as a result of future expenditures versus expenditures in the present; and
- Potential for making use of newly developed technologies and taking advantage of additional Operating Experience (OPEX).

A review of international practices in decommissioning [R-48] has indicated that Belgium, Germany, Italy, Spain, France and Switzerland are planning for Prompt Decommissioning, whereas Canada, Netherlands and the United Kingdom are planning for Deferred Decommissioning. Japan, Sweden, Finland and the United States are using both strategies for their reactors with strategy selection dependent upon the site-specific constraints. On average, SWS periods range from a low of 10 years (Japan) to a high of 85 years (United Kingdom) with most nations falling into a 25 to 40 year timeframe.

In the United States, the choice of decommissioning strategy is made by the station owner. Many utilities with multiple units on site choose to delay decommissioning until the final unit has ceased operation. Decommissioning may not occur until 25 to 30 years after the first unit has been shut down. This practice is similar to the OPG strategy. Owners with only one unit tend to start decommissioning within a few years of the end of operation.

Internationally, several small and some full-size power reactors have been successfully decommissioned and the sites made available for other uses. As of December 2019, 186 power reactors worldwide had been permanently shut down. Of these, 7 power reactors had been fully decommissioned and their licences terminated. Decommissioning strategies for these 7 power reactors were as follows: 3 Deferred Decommissioning, 2 Prompt Decommissioning, 1 In-situ decommissioning and 1 adopted a different decommissioning strategy. Of the remaining 179 power reactors, 63 opted for Deferred Decommissioning, 54 opted for Prompt Decommissioning, 2 opted for In-situ decommissioning, 23 opted for 'Other decommissioning strategy' and 37 have not commenced decommissioning and/or did not have a specified decommissioning strategy [R-49].

These industry experiences indicate that the strategy adopted for the decommissioning of DNGS is technologically feasible and can be completed in a manner that protects the health, safety and security of workers, the public and the environment, consistent with current international practice.

**3.5 Predicted Characteristics of the Darlington Nuclear Generating Station at Shutdown**

As the station is shut down, it will be transitioned from operations to Stabilization (Preparation for Safe Storage), then SWS, followed by Dismantling & Demolition and subsequent Site Restoration. The actual station condition will be characterized, as required, prior to each stage. However, certain conditions such as the radiological, chemical and the physical conditions of the station can already be predicted with sufficient accuracy for preliminary decommissioning planning purposes. A general description of the radiological, chemical and the physical conditions of the station at

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the time of shutdown is outlined below and more details can be found in Section 8.0 and in Appendix A.

The radiological condition of the station will depend on both the design and the operating history of the reactor units. Generally, the main sources of radiation at shutdown will be: the used fuel resident in the reactors and stored in the IFBs, the activated and contaminated sections of the reactor internals and the PHT and moderator systems. Other sources of radiation can be found in the heavy water used in the PHT coolant and moderator, in fission products in the IFBs, in the ion exchange resin and columns used in purification of the PHT and moderator systems fluids, in the fuelling machines and in the TRF.

During operations, routine radiation dose rate and contamination surveys of the accessible, normally frequented areas of the facility are performed at regular intervals. Any loose contamination discovered outside of contamination control areas is removed or the area is re-designated as a contamination control area. In addition, non-routine radiation dose rate and contamination surveys (for exposure control) are carried out whenever abnormal or changed radiological conditions are known or suspected to exist [R-50].

In preparation for the decommissioning of DNGS a Historical Site Assessment (HSA) is planned as a precursor for further site characterization activities in a Radiation Survey and Site Investigation (RSSI) process that will be maintained up to the Dismantling & Demolition stage of decommissioning as per MARSSIM [R-32].

As mentioned in Section 4.1.4.4, post-operational/scoping surveys will be performed when the station is shut down. Characterization surveys will also be performed during the preparation for or during the SWS period, prior to the start of the Dismantling & Demolition stage. The acquired site characterization field data will permit an appropriate assessment of the radiological and conventional hazards that can affect workers, the public and the environment.

The RSSI will use a graded approach for performing a site investigation and will begin by preparing an HSA and includes various surveys and sampling to assess site radiological conditions. The RSSI will conclude with a Final Status Survey, which is designed to show that residual radioactivity at the site meets regulatory approval, and which ultimately leads to final licence termination after decommissioning is completed.

The results of the radiation dose rate and contamination surveys, together with other information on the radiological hazards and conditions in the facility, are recorded in OPG's electronic database known as the Visual Survey Data System (VSDS). The information in this database will be available for use during the Preparation for Safe Storage, SWS and final preparation of the DDP. Other information on hazards that are discovered is also recorded in this database. A 'Station Condition Record' (SCR) is used to document, evaluate and correct an adverse condition related to personnel performance, procedure, or programs and an adverse condition causing or identified as a result of an event. The SCRs are recorded in an electronic database that will also be available during the preparation for decommissioning.

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Most of the hazardous materials stored on the site (flammable, cryogenic gases, oxidizers, corrosives, etc.) will be consumed during routine station operations. Some of the remaining materials will be consumed during the shutdown period. Others, such as the fuel oil for the standby generators, can be removed for use at other sites when the systems have been permanently removed from service.

Until the final shutdown of DNGS, OPG will continue to maintain and operate the station SSCs in a manner that will minimize the deterioration of these assets. It is anticipated that these SSCs will be in good working condition at the time of shutdown. Individual component condition assessments will be conducted prior to station shutdown.

### 3.6 Uncertainty and Degree of Conservatism

There are several elements of risk and uncertainty associated with decommissioning DNGS. Some of the main ones include, but are not limited to the following:

- Planning assumptions;
- Physical, radiological and non-radiological state of the facility;
- Regulatory framework;
- Technical strategy/approach for decommissioning;
- Waste disposition; and
- Stakeholder concerns.

Any risks associated with the planning assumptions supporting this PDP and the associated cost estimates have been identified, documented and are being tracked by OPG. The cost estimate is also based on a well-established methodology and takes into account a risk contingency to address problems that are likely to occur beyond the project scope (i.e., unknowns), as described in Appendix B. To further address uncertainties, relevant OPEX from other sites being decommissioned, industry best practices and the cost estimator's judgement were used for preliminary decommissioning planning.

As mentioned in Section 3.5, a comprehensive site characterization will be completed and will be used as input in the development of the DDP. This thorough site characterization based on the MARSSIM approach will reduce the uncertainties associated with execution of decommissioning by addressing the following [R-51]:

- Understanding of the conditions of facility – radiometric, chemo-toxic, biological, physical and structural;
- Defining the amount, location and composition of contaminants (radiological and non-radiological) and the associated physical parameters;

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- Categorizing the SSCs and site areas (including ground water) in contaminated, potentially contaminated and non-contaminated areas as a basis for zoning or implementation of a graded approach for clearance.

The safety assessment, which will be prepared in conjunction with the DDP (see Section 4.2.4), will take into account all identifiable uncertainties and address them as the decommissioning activities progress. The safety assessment should be conservative though not normally unduly, unless this allows the safety assessment to be simplified and gives overall benefit to the decommissioning project. Typical sources of uncertainty as identified in IAEA Safety Guide WS-G-5.2 [R-52] include:

- Source and magnitude of radiological hazards (e.g., inventory characteristics and source terms – location, dimensions, spatial distribution, constituents, quantities);
- Scenarios that could lead to these hazards, such as the frequency of occurrence, exposure pathways, assumptions required in support of the calculations of frequencies and consequences, during both normal and accident conditions;
- Predicted consequences – such as the dose rate and occupational doses; and
- The mathematical models used in the calculation of the effective doses or risks following normal and accident scenarios.

Elements of uncertainty can typically arise since:

- The quality, reliability and availability of information from the characterization of the stations may be limited, prior to the actual decommissioning; and
- Relevant supporting information, such as drawings and records of modifications, to be used as input data to the safety assessment may not be available in the detail needed.

In addition, generic data may be primarily used in the preparation of the preliminary safety assessment. There is also an uncertainty issue arising from the state of the facility during and after the SWS period, in particular, the extent to which aging may have compromised the building structures or engineered safety measures, which may affect the safety margins.

The safety assessment will be reviewed, revised or updated, as required, when additional information becomes available as compared to the earlier phases of the decommissioning project. It is also expected that the uncertainty with regard to the radioactive inventory and the condition of the facility may be reduced as decommissioning progresses.

Further details on the uncertainty associated with decommissioning safety assessment are given in [R-52].

In terms of any uncertainty related to the regulatory framework, OPG maintains a good communication protocol with the CNSC and ensures that the PDP meets the

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regulatory requirements in its licence and Licence Condition Handbook, as described in Section 1.4 and Appendix C.

This PDP demonstrates that decommissioning is feasible with existing technology. OPG will use OPEX from refurbishment projects to further reduce the uncertainty associated with execution of the decommissioning tasks.

Up until January 2020, the L&ILW Deep Geologic Repository (DGR) has been the long-term disposal strategy for OPG's L&ILW decommissioning waste. The L&ILW DGR was planned to be in-service for the purpose of receipt of decommissioning waste in 2050. On January 31, 2020, the Saugeen Ojibway Nation (SON) members voted not to support the L&ILW DGR project. Since then, OPG is not proceeding with the DGR at the Bruce site without SON support. Therefore, OPG is working on alternative long-term disposal strategy for L&ILW decommissioning waste as described in Section 4.4.1.3.

To manage uncertainty related to stakeholder perception for DNGS decommissioning, OPG has extensive public and stakeholder engagement activities, as described in Section 12.0.

To further reduce the uncertainty associated with the decommissioning project, clear endpoints will be defined to accurately determine intermediate progress and develop reliable forecasts to complete the remaining activities. This will be set up in the form of optimal selection and use of performance indicators, such as recommended in [R-53].

It is also expected that the level of uncertainty of knowledge relevant to decommissioning will decrease with maturity of the decommissioning planning [R-51], i.e., as this plan evolves from a PDP to a DDP.

**4.0 DESCRIPTION OF PLANNED DECOMMISSIONING ACTIVITIES**

This section describes the major activities that will be performed during the course of the planned decommissioning work at DNGS during each of the four stages as described in Section 3.4.2.

All timing should be considered approximate and used for planning purposes.

The anticipated major project milestones for decommissioning the DNGS are shown in Figure 4-1<sup>11</sup> [R-14]. More detailed schedules of decommissioning activities will be submitted to the CNSC as part of the DDP.

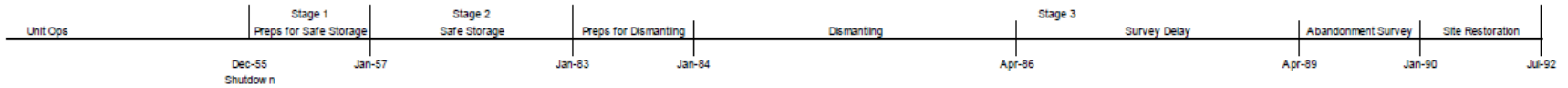
Note: Stage 3 in Figure 4-1 combines both Stage 3 (Dismantling & Demolition) and Stage 4 (Site Restoration), as described in Section 3.4.2. Also, planning for dismantling will be done during the SWS stage before dismantling starts.

<sup>11</sup> In this figure, Safe Storage is referred to as SWS, which is the terminology that has been used in this document.

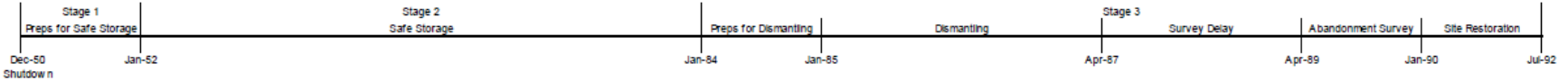
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**Darlington Unit 1**



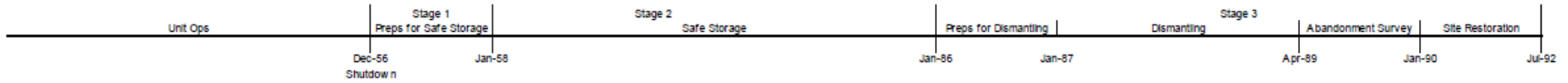
**Darlington Unit 2**



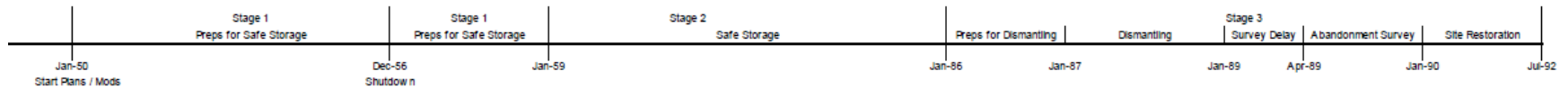
**Darlington Unit 3**



**Darlington Unit 4**



**Darlington Unit 0**



**Figure 4-1: Planned Project Milestones Related to the Decommissioning of DNGS**

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For planning purposes, the shutdown date for Unit 2 is assumed as given in Section 1.5 [R-14].

OPG will prepare and submit a DDP<sup>2</sup> to the CNSC, prior to the SWS period as part of OPG's application for a licence to perform subsequent decommissioning activities. It is anticipated that one year for each unit will be required to complete execution of stabilization for DNGS A once it has been shut down.

The SWS stage will begin upon the completion of the preparation work. The duration of the SWS period will be long enough to bring the total time from shutdown to the beginning of the Dismantling & Demolition and Site Restoration period to nominally 30 years for each unit.

OPG will prepare and submit an updated DDP for DNGS to the CNSC approximately two to five years prior to the commencement of Dismantling & Demolition, for acceptance. This revised DDP will include a description of the planned Dismantling, Demolition and Site Restoration activities, a corresponding schedule and an estimate of the expected costs. It will also address outstanding environmental impacts associated with the proposed decommissioning scenario – see Section 13.0.

Dismantling operations are assumed to begin after a storage period of nominally 30 years. After this period, Units 1 through 4 will exit SWS and enter Preparation for Dismantling in one-year intervals. The Dismantling & Demolition work for the first unit to be decommissioned (Unit 1) is expected to begin in 2083. Work on the other units will begin at intervals of one year. Component and equipment removal is sequenced such that each successive unit benefits from the lessons learned from the dismantling of the previous unit. Decontamination and dismantling activities will be coordinated at the four units to optimize the project schedule and maintain continuity in the overall process. While system removal activities are primarily sequential, building demolition activities assume parallel and concurrent scheduling across all four units. Approximately two years will be required to complete the dismantling.

As shown in Figure 4-1, the final abandonment survey for all the units will be delayed (referred to as the 'Survey Delay') until 2089, corresponding to when the last unit at DNGS, i.e., Unit 4, has been dismantled. Demolition and Site Restoration work for the station is expected to approximately take 3.5 years, including site surveys (1 year) and site restoration (~ 2.5 years). Site restoration of DNGS will take place from 2090-2092, and is expected to be complete by the year 2092.

DWMF

The DWMF will remain in operation after shutdown of the DNGS reactors and is expected to continue receiving, processing, and storing DSCs during stabilization and SWS, until all the fuel has been removed from the IFBs. Figure 4-2 shows the overall decommissioning timeline of the DNGS and the DWMF. Since both the stations and the waste facility will be dismantled concurrently, it is not anticipated that there will be any interferences.

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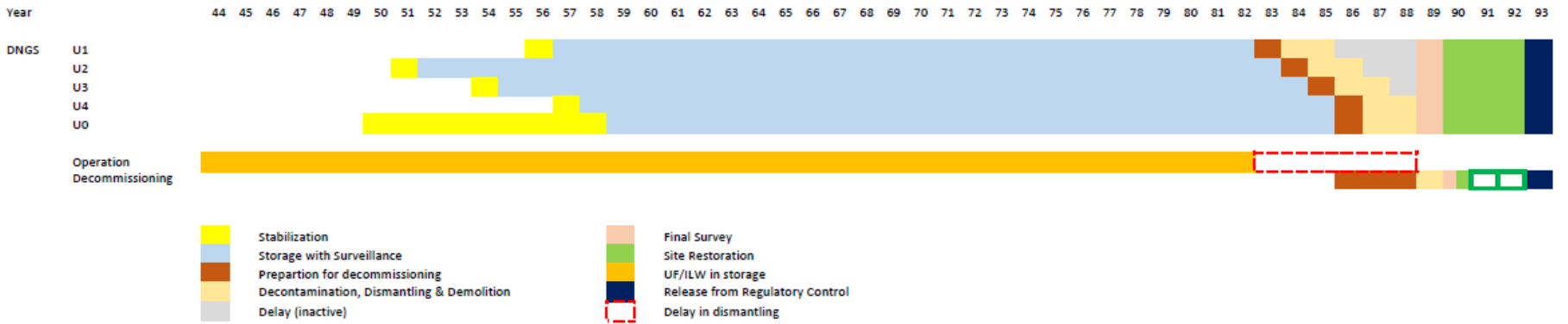
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The impact of the shutdown of the DNGS on the interfacing systems and services with DWMF, described in Section 2.2.8, will be further assessed in the DNGS SSP that will be prepared prior to SWS (see Section 1.1). System modifications will be executed to ensure the DWMF can operate safely and independently of DNGS SWS and decommissioning activities.

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Note: Green border text box indicates the possibility of site restoration being postponed by the Contractor for overall optimization

**Figure 4-2: DNGS and DWMF Decommissioning Activities Timeline**

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## 4.1 Preparation for Safe Storage

It is expected that OPG will utilize a similar approach to Pickering Nuclear Generating Station (PNGS) Preparation for Safe Storage for DNGS Preparation for Safe Storage stage while accommodating DNGS site-specific SSCs (e.g., TRF), and lessons learned will be incorporated as appropriate.

### 4.1.1 Preparation for Safe Storage Project Scope

The Preparation for Safe Storage Project will plan and execute the safe transition of the DNGS from its current (electricity generating) state to its predetermined SSS. The SSS refers to the physical, operational and administrative state in which the DNGS will be maintained for the nominal 30 years SWS period until dismantling activities commence.

The Preparation for Safe Storage Project goals and objectives include, but are not limited to:

- Defuel and removal of heavy water from systems;
- Continue to safely and securely store nuclear substances, such as irradiated fuel and heavy water on site;
- Maintain the facility in a safe and stable condition while creating no new hazards;
- Reduce the footprint of the station in preparation for the next phase of decommissioning; and
- Protect workers, the public and the environment from residual radioactive sources and hazardous materials remaining on site and maintain exposures to ALARA.

### 4.1.2 SWS Planning Activities

Work to define the SSS will take place prior to shutdown in order to confirm the physical and operational condition of the facility, which will meet all regulatory and operational requirements, while minimizing the operational footprint of the facility to be maintained over the nominal 30-year SWS period.

Project planning activities will include:

- Developing strategies as well as timeline and resource estimates for major Stabilization activities, such as defueling, dewatering and system end-stating or reconfiguration taking into account OPEX from Pickering Safe Storage, refurbishment projects, as well as international guidance referenced in Section 1.2.4.
- Confirming the regulatory and system drivers that will determine the operational demands during the SWS period.

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- Completing a Predictive Effects Assessment to proactively assess the potential environmental impacts resulting from proposed SWS activities or physical/operational changes to the station. The results of the assessment will identify environmental monitoring studies and/or mitigation measures required to manage the predicted effects.
- Reviewing and revising programs that are in place during operations to ensure that requirements for the remaining stages of decommissioning are met. Examples include, but are not limited to environmental monitoring, radiation protection, emergency response, and fire protection. The plans and protocols, developed during the detailed planning stage, for monitoring the following would be submitted to the CNSC for acceptance and implemented during the SWS period:
  - work hazards during decommissioning;
  - personnel dosimetry;
  - environmental emissions and effluents; and
  - materials, sites and structures to be cleared from regulatory control.
- Completing engineering studies to determine the most efficient and effective means of reconfiguring station systems to meet SWS requirements, such as the alternative means for supplying and distributing adequate heating and ventilation, electrical supplies and service water to the station in the SSS.
- Conducting a system by system review of the plant through end state determination reports to determine which modifications are required to the transition the plant to a SSS.
- Developing a safety assessment framework to manage the nuclear and reactor safety aspects of Stabilization activities.
- Engaging stakeholders, including the public, in SWS planning activities.

In support of the Preparation for Safe Storage Project, a safety assessment will also be completed, including controls and approvals, to facilitate the shutdown and stabilization of the station. The objectives for the safety assessment include:

- a) Demonstrate that applicable regulatory requirements are met throughout Stabilization.
- b) Demonstrate through systematic hazard analyses that the risks posed by hazards due to both Stabilization activities and for accident conditions are understood and managed.
- c) Identify necessary mitigating measures, limit controls and conditions to meet safety criteria throughout Stabilization.
- d) Quantify the hazard reduction to be achieved through Stabilization activities.

#### 4.1.3 Regulatory Submissions

Similar to PNGS, the SOP and SAP will be prepared and submitted to the CNSC as part of Preparation for Safe Storage – see also Section 1.1. In addition, a DDP will be

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prepared and submitted to the CNSC with the application for a licence to perform decommissioning activities.

The SOP will describe the arrangements and activities that ensure safe and reliable operation of the DNGS to the end of commercial operation. The SOP will cover the period starting 5 years prior to the final shutdown of the first DNGS operating unit and ending with the final shutdown of the last operating unit. The SOP provides confidence that as the DNGS approaches end of commercial operation:

- Nuclear safety is assured such that plant personnel, the public and the environment are protected;
- Systems, structures and components at the plant continue to be fit for service until its end of service life;
- Staff are qualified and competent to operate the plant, including sufficient staffing numbers;
- Impacts of plant operation to the public, workers, and the environment will continue to be of low risk and adequately mitigated, while continuing to provide the various societal and environmental benefits of plant operation;
- Transparency and appropriate public and indigenous engagements and consultations will continue;
- End of Commercial Operation is structured to align with OPG's Nuclear Management System governance framework; and
- Planning is integrated to ensure consistency in the transition from commercial operation to the next phases.

The SAP will describe, at a high level, the plan for managing arrangements and activities that will be conducted in support of the shutdown and stabilization of the DNGS across all 14 Safety and Control Areas (SCAs) of the licence. The purpose of the SAP is to ensure the safe transition of the facility from its final shutdown state to its SSS. The SAP is intended to be a living document, evolving with time and increasing in scope and definition with future submissions as planning progresses.

The DDP<sup>2</sup> will outline OPG's plan for the continued safe operation and management of the facility over the SWS period, covering all applicable SCAs of the licence, and include information on the physical, operational and administrative state of the facility in the SWS phase.

This DDP will be prepared to meet the applicable requirements of CSA N294:19 [R-4] and it will be organized to address the various stages of the decommissioning (Section 3.4.2). For the SWS period (i.e., 3.4.2 (b)), the DDP will address the following in detail:

- SSS (pools), i.e., when the fuel is still in the IFBs; and
- SSS (dry), i.e., when the fuel has been transferred to dry storage.

Future stages of decommissioning (i.e., 3.4.2 (c) and (d)) will also be addressed conceptually. The DDP will later be revised to provide additional details in preparation

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for, and execution of, Dismantling and Demolition and Site Restoration (see Section 4.2.4).

#### 4.1.4 Stabilization

The transition, or Stabilization of the station, will commence immediately following the end of commercial operations and be complete once the physical, operational and administrative transition to the SSS is confirmed.

The Stabilization activities that will be undertaken as part of the Preparation for Safe Storage Project will be carried out under the existing Power Reactor Operating Licence (PROL) and can be performed with currently available technology, while utilizing similar approach and OPEX gained from stabilization of PNGS. Some of the key Stabilization activities are outlined in the subsections below. At the end of Stabilization, an interim end state report including the End State Declaration reports for stabilization (see Section 4.1.4.3) will be produced and submitted to the CNSC to document the work that was executed. Any repurposing activities inside the protected area implemented after shutdown will not negatively impact decommissioning activities.

##### 4.1.4.1 Defueling

The first step to reducing hazards and placing each unit into its SSS will be reactor defueling. This will be completed as efficiently as possible to achieve a guaranteed defueled state using conventional defueling practices (utilizing existing fuelling machines) and is expected to take a minimum of 6 months per unit to complete. All fuel removed from the units will be transferred to their respective IFBs for storage and monitoring.

##### 4.1.4.2 Dewatering

Following the completion of defueling activities, each unit will be dewatered. The moderator system will be drained, followed by a light water flush of the moderator heat exchangers and air drying of the calandria, to reduce residual contamination. The heat transport system will be drained to Very Low Level Drain State (VLLDS) and then bulk vacuum dried. Heavy water removed from the reactor systems will be stored in a suitable storage facility.

##### 4.1.4.3 End State of Stabilization Activities

As Stabilization activities progress, systems that are no longer required to support the operation of the station will be placed into an inactive safe state. That is, they will be de-energized, drained of gas or fluids and isolated from operational systems.

Systems that will remain necessary to support continued operation in the SSS will be constructed, modified or left as is, as required to meet the SWS operational demands. A high-level overview of the anticipated system demands in the SWS phase is outlined in Section 4.2.

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The operational requirements for each individual system (or groups of related systems) will be identified and documented in the Safe Storage End State Determination Reports (ESDRs). In the case of active (or partially active) systems, ESDRs will describe the role of each system in meeting the SWS design basis. Alternatively, for inactive systems, ESDRs will provide justification as to why the system is no longer required to operate in the SSS. Collectively, ESDRs will outline, in detail, the physical and operational footprint of the facility in the SSS. The ESDRs will also define the periodic monitoring requirements for these systems.

Final end state declaration report(s) will be prepared to complete the documentation to describe the as-left Safe Storage configuration. The station end state will be declared when all the systems at DNGS achieve the conditions prescribed in the end state declaration report(s).

#### 4.1.4.4 Radiation Surveys and Decontamination

Detailed post-operational/scoping surveys will be conducted after DNGS is shut down and that will be used as input for preparation of the DDP. Radiation surveys will also continue to be performed throughout the Stabilization period to facilitate dose control and the requirements of the Radiation Protection Program [R-50]. Loose and/or fixed contamination will be removed, as required, from areas of the plant which would be accessed by personnel. Contaminated equipment located in accessible areas may be removed for decontamination or disposal, if appropriate.

Any radiation devices not required during SWS will be removed for use at another licensed facility or packaged and shipped for disposal at an approved facility.

After reactor shutdown and as part of the Preparation for Safe Storage, the PHT system will not be chemically decontaminated.

The secondary side demineralized water will be sampled to confirm that the non-radiological contaminants in the water are within the Derived Release Limits (DRLs) and discharged (as appropriate) through the inactive drainage, using similar procedures adopted during outages.

#### 4.1.4.5 Hazardous Material

In general, transient hazardous wastes will be removed as a result of Stabilization activities. Stabilization activities will include:

- Draining lubricants, coolants and other chemicals from inactive station systems, including above and below ground storage tanks and/or sumps; and
- Removing from the site hazardous chemicals or compressed chemical gases, which are no longer required.

Pre-approved pathways for hazardous material removal or disposal will be utilized for all Stabilization activities.

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#### 4.1.4.6 Site Characterization

OPG will perform characterization surveys during the preparation for or during the SWS period to investigate the amount (if any) of contamination present on the DNGS site and to identify the decontamination necessary to reduce occupational exposure for facility maintenance during the SWS period. Characterization of the radioactive contamination remaining in the station will be performed based on the results of the radiation and contamination surveys (see Section 4.1.4.4) and the existing historic information (see Section 3.5). The results of these surveys will be recorded and eventually be used when preparing the work plans for the DDP (Section 4.2.4) that will be submitted for approval to the CNSC prior to Dismantling & Demolition.

#### 4.2 Storage with Surveillance

The facility will be maintained in a safe and secure state over the SWS period to allow for the decay of residual activation and fission products that remain in the station's systems prior to commencing Dismantling & Demolition activities. For planning purposes, it is assumed that the SWS period will last for nominally 30 years from shutdown for each unit.

In order to reduce the operational footprint of the station for the SWS period, SSCs no longer required to support regulatory or system requirements will be placed into an inactive safe state, that is, they will be removed from the design basis, de-energized, drained of gas or fluids and isolated from operational systems. SSCs that remain necessary to support continued operations (i.e., in active safe state) to meet operational demands will be modified or reconfigured, as required during Stabilization. Based on the planning efforts to date, systems required to satisfy operational and regulatory requirements in the SWS period include:

- IFBs (including sufficient cooling, purification, monitoring equipment, Emergency Mitigating Equipment<sup>12</sup> and the means to continue to transfer spent fuel to dry fuel storage containers);
- The DWMF, including the ability to continue to receive, package, process and store DSCs containing spent fuel (Note: The DWMF is included here for completeness, however it is not included in the scope of the DNGS PDP – See Section 2.2.8);
- Select heavy water storage tanks located at various locations across the facility for interim storage of the tritiated heavy water (if required);
- Spent resin storage and handling systems;
- Environmental monitoring equipment for intermittent (or continuous) monitoring of selected atmospheric emission and liquid effluent streams;
- Active and inactive drainage systems, including the means to collect, store, treat and discharge liquid waste streams;

<sup>12</sup> Emergency Mitigating Equipment or other equivalent equipment will be available to provide fuel cooling in the bays in case of Beyond Design Basis Events.

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- Heating and ventilation systems to maintain minimum temperatures in all in-service (or partially in-service) areas of the facility, as required;
- Radiation monitoring equipment;
- Select fire protection equipment;
- Security systems;
- Auxiliary systems that will be required to support the above noted operational systems including, but not limited to, power (including back-up power) supplies, air supplies, service water, domestic water and demineralized water supplies;
- Low and intermediate level waste management systems, including the means to collect, store, package, and ship low and intermediate level waste generated on site; and
- An (alternative) central monitoring and control station.

Essential facilities will have necessary heating and lighting during the SWS period.

Administratively, programs that will continue to support station operations, organized by SCAs, will include:

- Management System;
- Human performance management, including training;
- Safety Analysis;
- Physical Design;
- Fitness for Service (including aging management and preventative maintenance programs);
- Radiation protection;
- Conventional health and safety programs;
- Environmental protection and environmental monitoring;
- Emergency management and fire protection;
- Waste management;
- Security;
- Safeguards and non-proliferation; and
- Packaging and transport.

Other matters of regulatory interest such as that stipulated in CNSC REGDOC-1.1.3 [R-54] will continue to be addressed during the SWS:

- Reporting that meets the requirements of CNSC REGDOC-3.1.1 [R-55];
- Public and Indigenous engagement that meets the requirements of CNSC REGDOC-3.2.1 [R-6] and CNSC REGDOC-3.2.2 [R-7], respectively; and

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- Financial guarantee that meets the requirements of CNSC REGDOC-3.3.1 [R-56] (which supersedes the CNSC Regulatory Guide G-206<sup>3</sup> [R-5]).

In all cases, the programs and procedures will be adapted to meet regulatory requirements, while remaining commensurate with the complexity and risks of the SWS operations and any revisions to these programs and procedures will require acceptance by the CNSC, where applicable.

Activities involved in removing intermediate level operational waste generated prior to the stations entering SWS will also continue into the SWS period. Contaminated solid waste generated from periodic surveys, inspections and maintenance activities at DNGSs during SWS will be processed at the Western Waste Management Facility (WWMF) until it is shutdown. OPG will also maintain the IFBs and associated systems while the fuel remains in the bays, up until the fuel is transferred to the used fuel disposal facility.

During the SWS phase, OPG will perform continuous monitoring and surveillance of the facility to ensure that worker, public and environmental safety is maintained.

The SSP (see Section 4.1.3) will be implemented during the SWS period to ensure that:

- The station remains safe;
- Any release of materials to the environment is controlled;
- Inadvertent entry of unauthorized persons in the facility is prevented; and
- Any biological hazards, that may result from any animals, plants, fungi or their detritus in the building or from the growth of moulds on exposed surfaces that may appear over time, are mitigated.

The radiological monitoring and survey plans approved by the CNSC (see Section 4.1.2) will also be implemented during the SWS.

An effluent monitoring program, consistent with CSA N288.5 [R-57], will be carried out during the dormancy period to ensure any radiological and non-radiological emissions to the environment are controlled and monitored. Appropriate emergency procedures will be established and initiated for releases that could exceed prescribed limits. An environmental monitoring program, consistent with CSA N288.4 [R-58], will be maintained.

Routine radiological monitoring of contaminated structures and systems will also be performed. Procedures for responding to unanticipated changes in the radiological environment of the site and potential releases to the environment will be prepared and implemented, if required.

Adequate level of security will be provided during SWS. Security during the SWS period will be conducted primarily to prevent unauthorized entry due to the presence of spent fuel on the site. Once all the spent fuel has been shipped off-site to the used fuel disposal facility, there will be a case for reducing the security presence on site.

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Security will be provided by the security fence, sensors, alarms, surveillance equipment, etc., which will be maintained in good condition for the duration of this period. Fire and radiation alarms are also to be monitored and maintained. A small group of plant staff will be available during this period to support the maintenance, inspection and surveillance programs.

#### 4.2.1 Used Fuel Transfer Operations

The used fuel transfer operations will continue during Preparation for Safe Storage and extend into the SWS period.

Fuel will be transferred to dry fuel storage at the end of the cooling period and stored in DSCs at DWMF, which will remain in operation during SSS (dry). Consequently, the IFBs will remain in operation through the first part of the SWS period. In order to comply with CNSC and IAEA requirements, safeguard arrangements will be maintained until all of the used fuel has been removed from the IFBs.

Used fuel will be transferred from the IFBs to the used fuel disposal facility, (i.e., Adaptive Phased Management (APM)) which will be available no earlier than 2043. Once all waste has been removed from the IFBs, the following will be carried out:

- Conduct surveys to confirm that no fuel particles remain in the IFBs; if fuel particles are found, the water will be treated to remove such particles;
- Collect samples of the IFB water and analyze it to confirm that it meets the radiological and chemical clearance levels that have been established;
- Drain the IFBs and dispose of the water in accordance with the applicable regulatory requirements;
- Remove ion exchange resins for disposal;
- Survey and decontaminate the surfaces of the IFBs;
- Mitigate any remaining hazards to workers through the erection of barriers and posting of warning signs;
- Perform a site characterization survey of the empty fuel bays and surrounding areas to confirm safe state;
- Secure the IFBs for the remainder of the SWS period; and
- With the approval of the CNSC, shut down and remove the safeguard monitoring equipment.

By the end of the SWS period, all used fuel is assumed to have been removed from the site to the used fuel disposal facility.

#### 4.2.2 Planning for Dismantling & Demolition and Site Restoration

Towards the end of the SWS period, OPG will make detailed preparations for the dismantling of the remaining SSCs and the disposal of the waste. The DDP will be revised and submitted to the CNSC for acceptance (see also Section 4.2.4). The end-

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state objectives for decommissioning will be developed to the guidance in CSA N294 Annex F [R-4]. A plan will be developed for the orderly progression from SWS to Dismantling & Demolition operations, including staff augmentation and any required plant system re-activation. Detailed work plans will be prepared to ensure that they remain appropriate in light of any improved knowledge of the condition of the site and the hazards that might be encountered during the course of the dismantling. Decommissioning Contractor(s) will be hired to manage and perform the Dismantling & Demolition and Site Restoration. The activities performed by the Decommissioning Contractor(s) will include, but not be limited to, updating procedures for the characterization surveys, dismantling work, waste packaging, disposal, site restoration and final surveys. The Dismantling & Demolition operations will be designed to accomplish the required tasks while maintaining all doses ALARA. The procedures will also address the continued protection of the health, safety, security of workers, the public and the environment.

During this stage of the work, OPG staff and/or Decommissioning Contractor(s) will:

- Develop a detailed schedule of activities – sequential planning of activities to minimize conflicts with simultaneous tasks;
- Review the results of the site characterization (Section 4.1.4.6) and address any gaps or deficiencies in the information required to plan the decontamination, dismantling, demolition and disposal;
- Prepare the work packages for Decontamination, Dismantling & Demolition and disposal activities;
- Prepare the detailed work procedures for the decontamination of SSCs and procure decontamination equipment, which may include high-pressure sprays, chemical mixing tanks, decontamination solvent injection and treatment components, grit-blasting and abrasive jets devices, components for the scarification and spalling of concrete surfaces, chemical applicators, etc.;
- Prepare the detailed work procedures and sequences for the removal of systems and components;
- Perform a safety assessment to evaluate the processes for decontamination and dismantling the station, including waste handling, conditioning and on-site processing;
- Evaluate the options for the disposal of the calandria and its internals;
- Evaluate the options for the removal, handling and disposal of other large radioactive components such as steam generators etc.;
- A graded approach will be taken in reviewing and revising station drawings, consistent with the need to maintain configuration control of the facility;
- Design, procure and test the tooling and equipment (including remotely operated equipment) that will be used during the dismantling work;
- Procure Dismantling & Demolition equipment:

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- Heavy equipment, which may include lifting gear (cranes, hoists and rigging), material transfer equipment (fork lifts and trucks), and demolition equipment (demolition hammers, cutting torches, saws);
- Small tools, which may include hand and power tools such as drills, circular and band saws, slings, small cutters and power hack saws, etc.; and
- Pipe cutting equipment, which may include plasma arc torches, track cutters, milling machines, band saws, etc.;
- Procure or design and fabricate shielding and contamination control envelopes in support of removal and transportation activities;
- Develop the procedures for occupational dose control, contamination control, industrial safety, environmental protection, fire protection and emergency response;
- Develop/revise the emission monitoring program;
- Develop/revise the waste management program so that it covers the following processes, as applicable:
  - Characterization;
  - Classification;
  - Minimization;
  - Segregation;
  - Clearance;
  - Handling;
  - Volume reduction;
  - Treatment;
  - Packaging;
  - Storage;
  - Transportation; and
  - Final disposition.
- Develop a waste management plan, which typically includes but is not limited to:
  - Develop a plan for both the short term and, where possible, the long term, for managing all decommissioning waste;
  - Develop the procedures for processing radioactive waste such as resins, filter media, metallic and non-metallic waste generated during the dismantling work;
  - Determine the transport and disposal container requirements for radioactive materials and hazardous wastes including the requirements for shielding and stabilization of the waste;

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- Procure and test the transportation and disposal containers for radioactive materials and hazardous waste;
  - Prepare the detailed procedures for the packaging, removal and disposal of radioactive materials, hazardous waste and construction debris; and
  - Assess/investigate decontamination methods such as chemical cleaning, electro polishing, mechanical abrasion or melting. These decontamination methods may be used to decontaminate scrap metal if the reduction in the volume of the scrap is sufficient to justify further processing. Depending on the efficiencies achieved, metals will be considered as either radioactive wastes for controlled disposal, lightly contaminated (or activated) for consideration for re-use within the controlled nuclear environment or metals that are decontaminated to levels below the clearance levels will be released for recycling in the open market;
- Prepare plans for site remediation; and
  - Obtain any additional licences, permits or approvals that may be required and complete any other regulatory processes that may be applicable.

An Impact Assessment (IA) and safety assessment for the intended Dismantling & Demolition processes will also be performed as required by prevailing regulations prior to Dismantling & Demolition. Refer to Sections 4.2.4 and 13.0 for additional details on the safety assessment and IA, respectively.

Acceptable site radiological release criteria and clearance levels for decommissioning waste will be developed prior to Dismantling & Demolition. The guidance provided in CSA N292.5 [R-15] will be followed for the application of exemption quantity and clearance level criteria for the release of materials containing, or potentially containing, radioactive nuclear substances, and the activities necessary to demonstrate compliance with these criteria [R-15].

Based on the identified requirements and needs for Dismantling & Demolition appropriate subcontractors will be identified and selected to support the various phases and project deliverables.

### 4.2.3 Building and Site Preparation

Building and site preparation work will include activities to prepare the site for subsequent Dismantling & Demolition work. The preparation work will be performed towards the end of the SWS period.

In preparation for dismantling, the following activities will be initiated:

- Prepare any required site support and storage facilities including a Central Waste Processing Area that will be used to process and package waste;
- Complete a comprehensive characterization survey to determine the extent of site contamination (see also Section 4.1.4.6);

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- Clean all plant areas of loose contamination and process all liquid and solid wastes;
- Use survey data to develop packaging and transportation requirements and procedures;
- Determine transport and disposal container requirements for activated materials and/or hazardous materials, including shielding and stabilization. Fabricate or procure such containers;
- Procure required transportation packages from suppliers;
- Reactivate, refurbish and/or procure essential plant services necessary for dismantling;
- Develop procedures for occupational exposure control, control and release of liquid and gaseous effluent, processing of radioactive waste including resins, filter media, metallic and non-metallic components generated in dismantling, site security and emergency programs and industrial safety; and
- Conduct radiation surveys of work areas, major components (including the calandria and internals), sampling of internal piping contamination levels and primary shield cores.

### 4.2.4 Detailed Decommissioning Plan

As mentioned in Section 1.1, a DDP will be prepared and submitted approximately two to five years for CNSC acceptance prior to the SWS period. Towards the end of the SWS period, the DDP will be revised to describe OPG's detailed plan for managing the arrangements and activities that will be conducted in support of Dismantling & Demolition and Site Restoration phase. The DDP will be prepared to meet the requirements of CSA N294:19 [R-4].

The DDP will establish the criteria (clearance levels) that will be used to determine if the material is suitable for uncontrolled release from the site. The DDP will also establish the clearance levels and end-state criteria that will be used to determine if the site itself is suitable for release from further regulatory control.

The original DDP that was prepared prior to SWS (see section 4.1.3) will be revised to include a detailed description of the decontamination, dismantling and demolition work that will be performed, broken down into a multi-volume document by Decommissioning Planning Envelopes, which will be integrated with an overall plan to ensure the work is done efficiently with safety being the top priority. The Decommissioning Planning Envelopes may include:

- Reactor Vault;
- Reactor Building;
- Vacuum Building and Pressure Relief Ducts;
- Reactor Auxiliary Bay;
- Turbine Hall;

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- Turbine Auxiliary Bay;
- Central Service Area;
- Pump House and Water Treatment Building; and
- Standby Generator Buildings, fuel storage tanks and other small buildings (machine shops, garages, etc.) in the fenced area.

Additional details of the site restoration work will also be included in the DDP.

However, a decision may be taken to dismantle some of the conventional plants in the above list during the SWS period to reduce the ‘footprint’ of the site and in the interest of maintaining a safe shutdown state.

A detailed safety assessment of the work to be performed during Dismantling & Demolition as well as Site Restoration will also be prepared and submitted along with the DDP or included in the DDP. The decommissioning safety assessment will address potential radiological hazards to workers, the public, and the environment, from both routine decommissioning activities and credible accidents during decommissioning. The decommissioning safety assessment will also identify the mitigating methods to address the risks associated with these hazards and any residual risks to the public once decommissioning is complete [R-4].

#### 4.2.5 End State of SWS Stage

By the end of the SWS period, all used fuel, including all defected fuel and all waste in the IFBs, is planned to have been removed from the station. Radioactive decay will have substantially reduced the residual contamination levels throughout the station and reduced the dose rates surrounding the calandria and calandria internals. Station systems (except for those in use during the SWS period) will remain in a drained, de-energized and secure state. The station will remain intact with the structures and systems maintained in a safe condition. An interim end state report indicating the current status of the facility will be prepared at the end of the SWS period for submission to the regulatory body.

#### 4.3 Dismantling & Demolition and Site Restoration Period

Dismantling work will begin after the detailed planning has been completed and the necessary permits and approvals have been obtained. The work in this phase can be divided into a series of conceptual steps:

- Prepare the buildings and site;
- Decontaminate and dismantle systems;
- Decontaminate and dismantle structures;
- Dismantle non-nuclear systems;
- Demolish buildings;
- Manage and dispose of the waste; and

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- Restore the site.

Work in the different steps may occur in parallel. Remedial action support surveys for radioactive and other hazardous materials will be performed throughout the dismantling work, up to the final survey.

#### 4.3.1 Dismantle Nuclear Systems

Dismantling activities are anticipated to involve the following:

- (a) Construct temporary facilities, modify existing storage facilities, erect and place scaffolding in and around components to be dismantled to support the dismantling and decontamination activities. These may include a cutting station (for boilers and other large components), additional change rooms and contaminated laundry facilities for increased work force, establishment of laydown areas to facilitate equipment removal, upgrading roads to facilitate hauling and transportation, and modifications to the reactor building to facilitate access of large/heavy equipment;
- (b) Remove the irradiated fuel stacking frames from the fuel wet storage bay. Frames will be disassembled, decontaminated with high-pressure water (to the extent possible) and packaged for off-site disposal;
- (c) Design and fabricate shielding and contamination control envelopes to support removal and transportation activities. Specify and/or procure special tooling and remotely operated equipment. Modify containment to support segmentation activities and prepare rigging for segmentation and extraction of heavy components, such as the steam generators;
- (d) Conduct decontamination of components and piping systems as required to control (minimize) worker exposure. Remove, package and dispose of all piping and components that are no longer essential to support dismantling operations. It is anticipated that radioactive corrosion products on inner surfaces of piping and components will not have decayed to levels that will permit unrestricted use or allow conventional removal. These systems and components are surveyed as they are removed and disposed of in accordance with the radiological clearance levels that have been developed (see Section 4.2.2);
- (e) Remove the steam generators and pressurizer for shipment and controlled disposal. A potential method for removal (and the one used as the basis in this PDP for cost estimating) is the one-piece vertical extraction of the generators through openings in the steam generator compartment roof slab and the reactor auxiliary bay roof deck. Assuming this method is used, sections of the shield walls and floor grating in the compartment will be removed to allow for the vertical lift of the generators through the roof openings. The generators will be disconnected from the surrounding piping and supports and prepared for removal. The exterior surfaces of the steam generators will be decontaminated as required, the interior volume will be filled with low-density cellular concrete for stabilization of the internal contamination, and openings (nozzles, inspection

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hatches and other penetrations) will be welded shut. When this stage has been completed, the generator will be removed from the building in a vertical lift and placed on a temporary cradle mounted on a multi-wheeled transporter and moved to an on-site segmentation area to await final packaging, and finally to an on-site storage area. Final packaging preparations will be completed and the segmented generator loaded onto a transport cradle mounted on a multi-wheeled transporter. The segmented generator will remain on the transporter until it is unloaded at the disposal site. The remaining steam generators will be removed and packaged using the same techniques [R-14];

- (f) Remove the pressurizer, moderator heat exchangers and bleed cooler intact from the reactor vault and prepare for transport and disposal to serve as their own container in a manner similar to the steam generators. All nozzles and other openings will be welded closed for containment of the internal contamination. Segmentation and packaging for these components will be completed similar to the work done on the steam generators;
- (g) At each calandria face, remove the fuelling machine bridge structure and insulated feeder cabinet which encloses the PHT headers and feeder tubes;
- (h) Remove the PHT and moderator piping and pumps. Any fuel cladding failure that has occurred or may occur during operation of the plant is assumed to have released fission products at sufficiently low levels that the build-up of quantities of long-lived isotopes (e.g., Cs-137, Sr-90, or transuranics) has been prevented from reaching levels exceeding those that permit the major PHT and moderator system components to be shipped as Surface Contaminated Object or Low Specific Activity waste and to be emplaced within the requirements of the long-term disposal facilities for respective Low Level Waste (LLW) and Intermediate Level Waste (ILW) (see section 4.4.1.3);
- (i) Package the piping in transportation packages. The pumps are sealed with steel plates to serve as their own containers. Segment those components that are considered as large object waste that exceed the waste disposal facility size guidelines. Ship piping and pumps for disposal;
- (j) Install calandria segmentation system in reactor vault and test;
- (k) Segment the calandria/shield tank structure in-situ with a remote cutter and remove the ILW first. Work is directed from a shielded work platform installed overhead in the reactor vault. Parts of the calandria and internal components are expected to be classified as decommissioning LLW and will be packaged in B-25 waste containers. The ILW will be packaged in Modular Shielded Containers (MSCs). Major activities as part of this work will include the following:
  - Install temporary shielding as necessary;
  - Remove all horizontal and vertical control elements and their associated drive mechanisms;
  - Remove all reactivity housing mechanisms (vertical and horizontal);

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- Cut annulus bellows and remove end fittings and pressure tubes from calandria; cut into lengths to fit MSCs for disposal;
  - Cut welds and remove calandria tubes from calandria structure; cut into lengths to fit MSCs for disposal;
  - In parallel with the pressure tube and calandria tube removal, begin removal of the end shield balls in the calandria faces. Shot removal must be coordinated with pressure tube and calandria tube removal to minimize area doses to segmentation crew;
  - Transport all waste in suitable containers to the transportation staging area; and
  - Segment the balance of the calandria structure.
- (l) Remove the balance of the systems and equipment from the reactor vault. These components will be segmented prior to disposal;
- (m) Remove systems and associated components as they become non-essential to the vessel removal operation, related decommissioning activities, or worker health and safety (e.g., waste collection and processing systems, electrical and ventilation systems, etc.);
- (n) Remove activated concrete biological shield and accessible contaminated concrete. Remove those portions of the associated enclosures necessary for access and component extraction;
- (o) Remove contaminated equipment and material from the Central Service Area, Fuelling Facilities Auxiliary Areas, D<sub>2</sub>O and TRF facilities and Vacuum Structure. Remediate contaminated surfaces until radiation surveys indicate that the structure can be released for unrestricted access;
- (p) Remove all remaining L&ILW along with any remaining hazardous materials. Material removed in the decontamination and dismantling of the nuclear units will be routed to an on-site central processing area. Material that meets clearance criteria will be released for unrestricted disposition, e.g., as scrap, recycle or general disposal. Contaminated material will be characterized and packaged for controlled disposal at the long-term disposal facilities for respective LLW and ILW (see section 4.4.1.3);
- (q) Remove remaining components, equipment and plant services in support of the area release survey(s); and
- (r) Conduct final radiation surveys to ensure that all radioactive materials in excess of permissible residual levels have been remediated.

All dismantling work performed on contaminated nuclear systems will be conducted in a manner that will minimize the spread of contamination and in accordance with OPG's Radiation Protection Program [R-50]. Appropriate contamination control techniques, including the use of portal monitoring systems at controlled egress points, temporary

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enclosures, local ventilation, Personal Protective Equipment (PPE) and contamination monitoring, will be used when the work is performed.

#### 4.3.2 Dismantle Contaminated Structures

Contamination will be removed from the surfaces of structures wherever possible in order to reduce waste volumes. Any contaminated paint, coatings, steel or other materials will be removed from the walls and floor. Removal can include surface scarification or physical dismantling depending upon the depth of contamination/activation. If required, removal of surface structures will be pursued to sub-surface contaminants that have migrated to inaccessible locations over the operating life of the facility. Contaminated concrete will be removed by scarifying (needle de-scaling, scabbling or hammering), concrete shaving or drilling and spalling. The contaminated debris will be collected and packaged for disposal as radioactive waste.

Concrete waste will be packaged in steel containers, at an average waste density of approximately 1,400 kg/m<sup>3</sup>.

Contamination may be removed from surfaces with chemical cleansers or by mechanically removing material from the surface (by planing, scarifying or drilling and spalling).

Large structures will be removed and segmented into smaller pieces at the station using commercially available equipment, e.g., diamond wire sawing or other alternative technologies available at the time.

Metals will be decontaminated in place (if practical) or removed by dismantling or cutting. The scrap metal will be sent to the Central Waste Processing Area for further processing. Metallic waste will be packaged in steel containers, at an average waste density of approximately 1,000 kg/m<sup>3</sup>. Contaminated metal may be packaged for disposal as radioactive waste. However, chemical cleaning, electro polishing, mechanical abrasion or melting might be used to decontaminate scrap metal if the reduction in the volume of the scrap is sufficient to justify further processing. Depending on the efficiencies achieved, metals will be considered as one of the following three:

- Metals that are decontaminated to levels below the clearance levels will be released for recycling in the open market;
- Lightly contaminated (or activated) for consideration for re-use within the controlled nuclear environment; and
- Radioactive wastes for controlled disposal.

Structures designated as “internally clean” but located within potentially contaminated areas are treated as though they are contaminated and disposed of as LLW.

All decommissioning work performed on contaminated structures will be conducted in a manner that will minimize the spread of the contamination. Appropriate

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contamination control techniques will be used when the work is performed. This may include the use of temporary enclosures, local ventilation, PPE and contamination monitoring.

This work will continue until surveys confirm that contamination levels have been reduced to below the clearance level established in the DDP, after which the structures will be treated as non-contaminated (see Section 4.3.5 below). It is assumed that demolition would be delayed until after all radioactive materials in excess of release levels have been removed.

#### 4.3.3 Dismantle Non-Nuclear Systems

The non-nuclear systems will be dismantled using conventional demolition techniques, surveyed for radioactivity and other contamination, and prepared for disposal. Components and equipment located outside the Radiological Controlled Area will be removed. Material deemed to be free from contamination (i.e., below the established clearance level) may be released for recycling or disposal. Dismantling activities are likely to include, but may not be limited to, the following:

- Remove secondary circuit steam cycle components (assumed to be within the clearance for free release);
- Cap-off the condenser cooling water inlet and outlet ducts and remove the condensers;
- Remove the turbines, generators and ancillary equipment;
- Remove the condenser cooling water pumps and associated piping;
- Remove the de-aerator; and
- Remove the feed water heaters, piping and other equipment.

The following are anticipated to be dismantled in conjunction with the last unit on site:

- Water Treatment Plant;
- The remaining standby generators and EPGs;
- Above-ground storage tanks (after draining, purging, and decontaminating); and
- Remaining offices, workshops, laboratories and storerooms.

#### 4.3.4 Dismantle the Heavy Water Management Building and the Tritium Removal Facility

The Immobilized Tritium Containers (ITCs) remaining in the TRF vault will be removed prior to dismantling the TRF/HWMB.

It is anticipated that the relevant activities described in Section 4.3.1 will also be undertaken at the HWMB and the TRF. In addition, the following systems are expected to be removed:

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- Vault in the basement of the TRF/HWMB;
- Front-end process systems such as the Feed and Product Storage System, Feed Treatment System, Vapour Phase Catalytic Exchange and Dryer Unit;
- Cryogenic refrigeration system;
- Absorber Unit;
- Other auxiliary systems such as the Recombiner System, Drain and Purge System, Deuterium Makeup System and Sampling Systems, Liquid Collection System;
- Tritium Immobilization System; and
- Tritium Clean-up System such as the Air Clean-up System and Glove Box Clean-up System.

Any systems and structures that are found to be contaminated will be dismantled according to Section 4.3.2 and those that are free of contamination will be dismantled using conventional demolition techniques (Section 4.3.3).

#### 4.3.5 Demolition

Once contaminated systems, structures and non-nuclear systems have been dismantled and final surveys (see Section 4.3.8) have confirmed that the remaining structures are below radioactive and hazardous materials release limit, demolition activities may begin.

Efficient removal of the contaminated materials and verification that residual radionuclide concentrations are below regulatory limits will result in substantial damage to many of the structures. The reactor auxiliary bays, reactor vaults, fuelling facilities auxiliary areas, and central service area will be demolished. Remaining buildings, such as above ground structures, including the turbine halls, vacuum building, and other site structures, will be removed using conventional demolition techniques.

Blasting, coring, drilling, scarification (surface removal), and the other decontamination activities will substantially damage power block structures including the reactor, service and ancillary service buildings. Internal floors and walls will be removed from the lower levels upward, using controlled blasting techniques. Verifying that subsurface radionuclide concentrations meet site release requirements may require removal of grade slabs and lower floors, potentially weakening footings and structural supports. This removal activity will be necessary for those facilities and plant areas where historical records, when available, indicate the potential for radionuclides having been present in the soil, where system failures have been recorded, or where it is required to confirm that subsurface process and drain lines were not breached over the operating life of the station.

Any remaining structures (including buildings that were not contaminated and temporary structures) will be demolished by general demolition crews by drilling and controlled blasting or other conventional demolition techniques. The waste blocks will be sized so that they can be handled and moved by the available technologies. All foundation and exterior walls will be removed to the nominal one meter removal depth

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below grade whenever possible. At-grade foundation slabs exceeding one meter in thickness will be abandoned in place and covered with a one meter thick layer of backfill. Concrete rubble and clean fill produced by demolition activities are used on-site to backfill voids. Suitable materials will be used on site for filling; otherwise the rubble will be trucked off-site for disposal as construction debris.

Underground metal and concrete piping will be excavated and removed for survey. Any piping that exceeds the site release criteria will be removed and disposed of appropriately. Clean metal piping will be considered scrap or will be recycled. Clean concrete piping will be used as backfill. Crushed concrete from demolition of the onsite facilities that is below the clearance level can also be used to backfill voids below grade. Clean piping, subterranean tunnels, chases, etc., will be abandoned in place unless deemed a hazard from collapse and subsidence. Circulating water intake and discharge tunnels will be exposed and the roof of the tunnels collapsed with the exception of the portion that runs under the station IFB. This portion will be abandoned in place and backfilled from each end of the tunnel segment. Shallow portions of the concrete circulating water closed-loop piping will be exposed and the roof of the piping will be collapsed. Deeper portions of the piping will be capped and abandoned in place. OPG will investigate the requirements for capping the underground piping and utility lines while maintaining consistency with provincial and/or national regulations at the time of dismantling/demolition. Road and parking areas with asphalt or concrete surfacing will be broken up and the rubble will be used for backfilling on site if needed.

Once demolition is complete, an interim end state report will be prepared for submission to the regulatory body.

#### 4.3.6 Waste Processing

All material removed during the decontamination and dismantling of the nuclear units will be routed to a Central Waste Processing Area, which will characterize and prepare the material for release or shipment to an appropriate waste disposal, storage or recycling facility. The estimated maximum size of the packaged decommissioning waste, including any required shielding, is 2.65 m x 5.2 m x 14 m and the estimated weight criterion is 35 Mg (as required by transportation regulations [R-59]). Radioactive, hazardous and conventional wastes will be managed as described in Section 4.4.

#### 4.3.7 Restore the Site

Depending on the nature of the future activities that will be carried out on the site, restoration work may include:

- Removing or remediating contaminated soil to meet the regulations for clearing the site as 'brownfield'<sup>5</sup>;
- Breaking up road and parking areas covered with asphalt or concrete surfacing and using the rubble for backfilling, if needed;
- Cleaning the site to remove any remaining inactive waste and debris;

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- Covering the filled excavations with gravel (for drainage) and topsoil;
- Abandoning water drain holes at the bottom of all subgrade structures;
- Restoring the lake front property (including the water inlets and outlets) to inhibit erosion and potential detrimental impacts on fish, fowl or other wildlife;
- Exposing shallow portions of the concrete circulating water closed-loop piping and collapsing the roof of the piping. Deeper portions of the piping will be capped and abandoned in place;
- Grading the area to prevent ponding and inhibit the re-floating of subsurface material; and
- Establishing a covering of vegetation to prevent soil erosion.

The existing electrical switchyard will remain after decommissioning in support of the utility's electrical transmission and distribution system [R-14].

Soil and structural surfaces that are within authorized limits may remain at site following Dismantling & Demolition activities. The Darlington site will be shown to meet the final clearance levels in support of release from further regulatory control.

### 4.3.8 Surveys

A series of surveys for radioactive and other hazardous materials will be performed throughout the course of the Dismantling & Demolition work. MARSSIM-like survey, surveys such as those based on Annex G of CSA N294:19 and any other surveys based on guidelines available at the time of decommissioning will be performed [R-4], [R-32] and [R-60]. Several different types of surveys should be performed at different stages of the decommissioning:

- A scoping survey – to determine facility status;
- A characterization survey – to evaluate remediation options and perform risk assessments;
- Operational surveys during the various decommissioning phases – pre- and post-SWS, and Remedial Action support surveys during Dismantling & Demolition operations – to control the spread of contamination, assess wastes for category and determine levels of site remediation achieved;
- Final surveys (also referred to as the abandonment survey, as shown in Figure 4-1) during Site Restoration to provide evidence that a declared end state has been achieved; and
- A verification survey by an independent party may be requested by the regulator – to provide compliance monitoring and to ensure that agreed site remediation levels have been achieved, that will then be used as the basis for removal from regulatory control.

According to international experience, scoping and characterization surveys (also referred to as post-operational surveys) should be performed as early as possible, prior to the start of decommissioning. Scoping surveys will be performed in order to

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identify contaminants, impacted and non-impacted areas and provide an estimate of the variability of the contamination (Annex G, [R-4]). Characterization surveys will be performed to provide a complete description of the nature, extent and variability of the contamination in each area of the site/facility (Annex G, [R-4]). Both of the surveys mentioned above will assist with the planning of the decontamination work.

Operational surveys and Remedial Action support surveys will be performed throughout the dismantling and decontamination process in order to guide and monitor the decontamination work. They are also used to help control the exposure of decontamination workers to radiation and hazardous materials. Operational surveys are typically based on simple measurements such as contact radiation dose rates or direct contamination checks. More extensive surveys may be required in order to measure subsurface contamination. This may require the removal of grade slabs and lower floors, particularly where historical records indicate that process failures have occurred or where it is necessary to confirm that subsurface vessels or pipes have not leaked.

The final survey will be performed to verify that the facility has been remediated to such an extent that all remaining buildings, components and the site itself now have residual activity levels that are below the established end state criteria. A final survey plan will be developed before any of the final survey work begins. The survey plan will describe the survey work that will be performed, the schedule for that work, the methods that will be used to collect and analyze the data and the structure of the final report that will be produced. This plan will also set out the performance criteria for the measurements and analyses that will be performed and the acceptance criteria for data from other sources, such as previous survey work, that will be incorporated into the final survey. The end state criteria set out in the DDP will be reviewed to confirm that they remain appropriate and they will be revised if necessary.

Although the final survey is described as though it were a single activity performed at a well-defined stage of the decommissioning process, this will probably not be the case. The final surveys will likely be performed in stages and at different times in different units or different work areas within a unit. In order to ensure that the surveys are thorough, they will be performed when the remaining structures and materials are still accessible. However, the surveys will be performed as expeditiously as possible after the completion of the decontamination work since the remaining structures may be unstable and could present a hazard to the decommissioning staff working in or around these structures. Any residual contaminants identified in the survey will have been remediated. Administrative and/or physical controls will be in place to isolate the surveyed areas and prevent recontamination. Demolition work (see Section 4.3.5) may proceed once the final surveys have confirmed that the residual contamination levels in a work area or unit are below the established clearance levels and the results of these surveys have been accepted by the CNSC and other regulatory agencies.

The final stage of the survey will be performed after all demolition work is complete to ensure that no residual contamination remains on the site. Periods of deferral (called 'survey delays') may be incorporated into the decommissioning schedule (see Figure 4-1) to ensure that all decommissioning work has been completed before this final stage of the survey work begins.

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A report on the final release survey will be prepared upon completion of all survey work. The report will present a description of the methods used to collect and analyze the data. The results of the analyses that were performed and the results of the analysis of the data will include the following [R-4]:

- The criteria used to define the end-state;
- The methods and procedures used to ensure that the criteria were met; and
- The measurement data, including appropriate statistical analysis and systematic approaches.

Data from other surveys performed at earlier stages of the decommissioning process, such as the characterization survey and the remedial action surveys, may be incorporated in the final survey if they meet the acceptance criteria that were set out in the final survey plan. The results of the analyses will be compared to the end state criteria and the conclusions drawn from that comparison will be included in the report.

Regulatory agencies may wish to perform additional surveys or a verification survey by an independent survey organization may be requested by the regulator to assess any residual activity on site and this will form the basis for the release of the site from further regulatory control. This possibility will be provided for in the DDP.

All of the surveys will be performed according to approved procedures that will be based on the recognized standards and guidelines applicable at the time [R-4], [R-32] and [R-60]. The procedures will describe:

- The sampling strategies and methods that will be employed during the survey;
- The instruments and laboratory methods that will be used;
- The statistical techniques that will be used to analyze and interpret the data;
- The documentation that will be prepared and retained; and
- The Quality Assurance (QA) and quality control program that will be in place.

#### 4.3.9 Final End State

By the end of the Dismantling & Demolition and Site Restoration period, the site will be free of industrial and radiological hazards. All of the station SSCs will have been dismantled and all non-essential buildings and site facilities will have been demolished to a depth of one meter below grade. The switchyard will remain for continued use.

All radioactive contamination in excess of the established clearance levels and all other hazardous materials will have been removed from the site. It is expected that the clearance level used for the clean up of the site will not require institutional controls after the release from regulatory control. All of the station systems will have been dismantled and all of the buildings demolished. Subsurface structures will have been drained and de-energized. These subsurface structures will also have been surveyed for contamination, decontaminated, if required, and dismantled to a nominal depth of one meter below grade (consistent with international practices), backfilled with clean concrete rubble and/or soil and graded over. The remaining site will have been

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backfilled to prevent future subsidence and restored to a state suitable for other OPG uses. By the end of this stage, the end-state objectives defined in the DDP will be verified to have been achieved and the site will meet the criteria to release from regulatory control.

#### 4.3.10 Release from Regulatory Control

Upon completion of decommissioning, the Darlington Nuclear Site will be in a condition that will support its removal from regulatory control. A final end state report (or site abandonment plan) on the decommissioning program will be prepared. The final report will describe the decommissioning work that has been performed and the outcome of that work, the results of the final surveys that were performed and the interpretation of those results (i.e., whether the results meet the end-state objectives defined in the DDP). Any other information required by the applicable regulations will also be included in the report. The final report will be submitted to the CNSC as part of the request for a release from regulatory control. Institution controls are not expected to be required.

#### 4.4 Waste Management

Waste management is governed by OPG's Management of Waste and Other Environmentally Regulated Materials standard [R-61], which includes the instruction that all waste generators follow the concept of reduce, reuse and recycle in the waste management activities. All radioactive waste generated during decommissioning will be characterized as per CSA N292 series of Standards, consistent with OPG's Nuclear Waste Management program [R-62]. Transportation of decommissioning waste will be carried out per OPG's Radioactive Materials Transportation program [R-63], which includes the Radioactive Shipments procedure [R-64] that addresses consultation with the waste receiver per the transportation regulations. Non-radioactive waste packaging and transportation will be carried out according to OPG's Management of Waste and Other Environmentally Regulated Materials standard [R-65].

##### 4.4.1 Radioactive Waste Management

###### 4.4.1.1 Radioactive Waste Inventory

The radioactive material inventory of a reactor at the time of shutdown will depend on both the design and the operating history of the unit. The inventory will decrease over time due to the removal of activity by any decontamination work that is performed and the natural decay of the radioactive material. Estimates of the activity that will remain at DNGS at the end of the SWS Period are shown in Table 4-1. These estimates are based on the assumption that the units have been in service for approximately 30 years, followed by 3 years of refurbishment and operation for at least another 27 years, after which the radioactivity will be allowed to decay for 30 years after shutdown [R-66]. However, it is important to note that the current estimates of radioactivity may need to be updated post targeted site characterization activities at the DNGS site.

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**DARLINGTON NUCLEAR SITE PRELIMINARY DECOMMISSIONING PLAN****Table 4-1: Residual Induced Radioactivity at DNGS**

Radionuclide	Residual Activity		Half-life (years)	Percentage (%)
	Type	(Bq)		
C-14	$\beta$	$6.4 \times 10^{13}$	5,730	0.22
Fe-55	$\gamma$	$1.4 \times 10^{14}$	2.73	0.58
Ni-59	$\gamma$	$1.9 \times 10^{14}$	76,000	0.66
Co-60	$\beta$ - $\gamma$	$2.0 \times 10^{15}$	5.27	7.6
Ni-63	$\beta$	$2.6 \times 10^{16}$	100	89.6
Zr-93	$\beta$ - $\gamma$	$1.4 \times 10^{13}$	1,530,000	0.06
Nb-94	$\beta$ - $\gamma$	$3.0 \times 10^{14}$	20,300	1.2
TOTAL		$2.8 \times 10^{16}$		

Estimates of the volume of L&ILW that will be generated during the decommissioning have been prepared and are shown in Table 4-2 [R-14].

**Table 4-2: Estimated Volumes of L&ILW Generated During the Decommissioning of DNGS**

DNGS Unit	Low-Level Radioactive Waste (m <sup>3</sup> )	Intermediate-Level Radioactive Waste (m <sup>3</sup> )
Unit 1	8,947	836
Unit 2	8,813	836
Unit 3	8,799	836
Unit 4	8,788	836
Unit 0 (common services)	11,469	205
<b>TOTAL*</b>	<b>46,816</b>	<b>3,547</b>

\* May not add due to rounding

The radioactive wastes generated during the decommissioning will consist mainly of those wastes generated during dismantling. Wastes generated during Preparation for Safe Storage are likely to include:

- Filters and ion exchange resins;
- Wastes from decontamination activities; and
- Routine radioactive waste from the Stabilization period.

The radioactive waste generated during the Dismantling & Demolition and Site Restoration period will consist of process components and structural materials contaminated with residual activity. The principal sources generated during dismantling are:

- Component parts of the reactor assembly;
- Calandria and shield tank;

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- PHT system pumps and other smaller pumps;
- Steam generators;
- Piping and valves;
- Heat exchangers;
- Fueling machine; and
- Other components of active systems, e.g., TRF.

Demolition will generate large amounts of concrete wastes.

A single unit inventory of plant system equipment and components was taken as the base inventory for all four units. Modifications performed to one or two units are likely to be performed on the other units.

Material quantities for plant structures (i.e., concrete, steel, etc.) may vary from unit to unit due to the differences in the arrangement and location of exterior walls.

#### 4.4.1.2 Management of High-Level Waste

During the operating life of the station, used fuel from the reactors is initially stored in the IFBs for cooling. Used fuel from DNGS, that has been stored in the IFBs for the required minimum cooling period, is then loaded into DSCs and then transported to the interim used fuel storage facility, i.e., the DWMF.

When the station is shut down, all of the used fuel resident in the four reactor units will be transferred to the IFBs for an initial cooling period. All the support programs for fuel (including monitoring, security, safeguards and criticality safety) will be maintained while fuel is on the DNGS site. It is anticipated that all the used fuel remaining in the IFBs will be transferred to the APM. The transfers will continue for 10 to 15 years after station shutdown. Once all of the used fuel has been removed, the IFBs will be decontaminated and secured for the remainder of the SWS period. It is not anticipated that any activity will remain in the IFBs after the decontamination is complete. Although decommissioning of IFBs is addressed by this PDP, the used fuel transfer activities from the IFBs or the DWMF are not part of DNGS decommissioning scope. Although the life cycle plans of the DNGSs and the DWMF are separate from each other, interdependencies were considered (see Section 2.2.8 and Figure 4-2, while decommissioning planning for the DWMF has been documented in a separate PDP [R-1].

The Government of Canada passed the Nuclear Fuel Waste Act in 2002. The legislation required nuclear energy corporations to establish the Nuclear Waste Management Organization (NWMO) to study the options available to recommend a long-term management approach for used fuel.

The NWMO has issued a study report 'Choosing a Way Forward - The Future of Canada's Used Nuclear Fuel', in 2005 [R-67]. This report was intended to assist the federal Government in defining the approach for the long-term management of Canada's nuclear fuel waste. On June 14, 2007, the Government of Canada selected

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the APM as the best plan for Canada for safeguarding the public and the environment over the very long time in which used nuclear fuel must be managed [R-68]. The APM involves the containment and isolation of used nuclear fuel in a DGR in a suitable rock formation. By the end of the SWS period and before dismantling begins, all used fuel is assumed to have been removed from the site to the used fuel disposal facility (i.e., APM).

#### 4.4.1.3 Management of Low- and Intermediate-Level Waste

Radioactive wastes will be treated (e.g., by volume reduction where foreseeable) and packaged on site by the Decommissioning Contractor(s) in order to reduce worker exposure, to meet the regulatory requirements for waste transport and disposal and to minimize waste. Liquid waste will be generated from decontamination activities, cutting operations in the PHT system, selective decontamination of laundry, personnel showers, etc.

All processing and packaging of decommissioning waste will be performed on site by the Decommissioning Contractor(s) and not by OPG. The following waste treatments are assumed for planning purposes:

- Decontamination using aggressive cleaning solutions and/or using decontamination equipment described in Section 4.2.2;
- Dewatering of waste slurries either by removing the activity from the liquid (using filters and resins) or by evaporating the liquid from the waste;
- Waste processing units, which are usually self-contained and portable, are delivered on skids, from which hook-ups are made to the plant's waste collection tanks;
- Waste immobilization by solidifying concentrated liquid wastes; and
- Volume reducing low-density materials by compaction and packaging.

The waste treatment processes will be reassessed in more detail during the preparation of the DDP.

The decommissioning of the DNGS will produce a relatively large number of components such as pumps, vessels, motors, concrete, structural steel, construction debris, etc., which will need to be packaged for disposal as LLW. Large components will be segmented and packaged as such (e.g., steam generators as described in Section 4.3.1). Other large components (e.g., calandria) will be processed and packaged in suitable containers. Other smaller components and equipment will be cut to fit and be placed in standard waste containers. Contaminated concrete (e.g., surface contaminated concrete from the IFBs) will be broken up, loaded into disposal containers and shipped to a licensed long-term LLW disposal facility. The remaining concrete that meets the clearance criteria will be crushed, graded, and used on-site as backfill.

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Wastes will be packaged for transport and disposal according to the requirements of the applicable federal and provincial regulations. It is assumed that the waste produced in the decommissioning of the nuclear units will be moved by truck or multi-wheeled transporter to the waste disposal facility. The necessary packages will be identified, designed, tested and procured prior to the decommissioning project. The required licences, approvals and certifications will also be obtained before the packages are put into service.

Although OPG owns and operates the WWMF on the Bruce Power site for interim storage of radioactive waste generated during the operating phase of OPG owned NGSs, there are no plans to store or dispose decommissioning waste from any of OPG's nuclear facilities at the WWMF. Any loose contamination removed by Operations prior to stations entering into SWS will continue to be sent to the WWMF and waste from DNGS during SWS will be processed at the WWMF until it is shutdown.

OPG had planned to dispose of L&ILW from its owned generating stations in a DGR at the Bruce Nuclear Site. Early in 2020, the L&ILW DGR Project was cancelled. OPG is exploring options and remains committed to the permanent and safe disposal of its operational waste as well as future decommissioning waste.

OPG is also participating in Natural Resources Canada (NRCan)'s work in public engagement on the existing Radioactive Waste Policy to ensure OPG is meeting international best practices. The NWMO was asked to lead a dialogue to develop an integrated strategy for Canada's radioactive waste through close collaboration among waste owners and producers (including OPG), indigenous people and other interested Canadians. Any progress in regard to the Policy and Integrated Strategy will be taken into consideration in OPG's decommissioning waste disposal strategy.

Note: For financial planning purposes, the L&ILW generated during decommissioning is assumed to be transferred to long-term disposal facilities for respective LLW and ILW [R-14].

#### **4.4.2 Hazardous Waste Management**

##### **4.4.2.1 Hazardous Waste Inventory During Operation**

Designated Substances are defined in the Regulations made pursuant to the Ontario OH&S Act. An assessment of the Designated Substances used at the DNGS has been previously completed as required. The results of the assessments indicate that three designated substances are likely to be found in the stations at the time of shutdown:

- (a) Asbestos – DNGS is free of asbestos-containing thermal pipe insulation. However, it is known that some asbestos-containing products are in use at the station. These may include valve gaskets, packing, vehicle brake shoes and linings. It is likely that many of these items (particularly the brake shoes and linings) will be replaced with other materials before the decommissioning begins;

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- (b) Lead – Lead is found at DNGS in structural materials such as radiation shielding, lead bricks and some painted surfaces and equipment. Lead is also used as radiation shielding for equipment both internally and externally. Lead is found in a number of products such as solder, wire, sheeting, shot, thread lubricant, cartridges for fastening tools, grit and lead-acid batteries [R-69]. Lead has never been melted or poured at DNGS and there is no bulk storage of lead on the site. The number of lead-containing products is being reduced through the Hazardous Materials approval process [R-69]. Lead handling activities are performed in accordance with the Management of Designated Substances Other Than Asbestos (OPG-PROC-0125) [R-70]; and
  
- (c) Mercury – Mercury was not used as a construction material. However, mercury is present at DNGS predominantly as a component of manufactured articles, such as in some equipment and instruments such as thermometers, manometers, hygrometers, mercury-wetted relays (flasher relays in airlocks, relays in watchdog timer cards/digital output cards), magnetol, mercoid switches, vacuum pump temperature switches, transformer deluge systems, sealed batteries and various types of lamps (fluorescent, mercury vapour, metal halide, etc.) that present no exposure hazard [R-71]. Free mercury is not stored or used at the station.

Small quantities of some other designated substances, such as benzene and isocyanates, are occasionally used during projects, but they are not routinely stored at the station. Limited quantity of silica-containing products are used at DNGS (primarily for radiation protection shipping, civil and mechanical maintenance) [R-72]. Silica-containing materials are not used as decontamination (sandblasting) agents within the Protected Area of the station; however, they may be used in workshops outside of the Protected Area. There is also one solid product that contains very low level of vinyl chloride (0.3% max) [R-73]. Lastly a very small quantity of arsenic is also present in SSC at DNGS, such as in batteries [R-74].

Most of the hazardous materials stored on the site (flammable, cryogenic gases, oxidizers, corrosives, etc.) will be consumed during routine plant operations. It is anticipated that the inventories will be reduced as the units are successively shut down so that only small quantities will remain after the last unit is shut down. Some of the remaining materials (e.g., welding gases) will be consumed during the Preparation for Safe Storage period. Others, such as the fuel oil for the standby generators, can be removed for use at other sites. Tanks will be cleaned by flushing or steam cleaning as required prior to disposal [R-14].

A number of other materials used during routine station operations are potentially harmful to workers or the environment. The inventories of these materials will be reduced as the station approaches shutdown so that only small quantities should remain at the start of the decommissioning. These hazardous materials include:

- (a) Compressed gases including welding gases, oxygen, nitrogen, helium, carbon dioxide and compressed air:

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- Compressed gas cylinders are stored in a small building located to the south of Unit 3 (Building 50);
  - A trailer carrying compressed hydrogen cylinders is stored south of Unit 2 and another trailer is stored outside the Protected Area (west of the station); and
  - Compressed helium is stored in the Protected Area south of the station;
- (b) Cryogenic gases including liquid hydrogen, liquid nitrogen and liquid carbon dioxide. Liquid hydrogen and carbon dioxide are stored within the Protected Area west of the station and liquid nitrogen is used and stored in the TRF and in laboratories around the site;
- (c) Flammable liquids including fuel oils and organic solvents used as decontamination agents:
- Four large above-ground oil storage tanks are located south of the station (two south of Unit 1 and two south of Unit 4); these are associated with the Standby Generators;
  - Three lube oil tanks are located north of Unit 1;
  - Industrial-sized containers (e.g., 200 L drums) of flammable liquids are stored in the Low Flashpoint Storage Area of the Service Maintenance and Flammable Stores Building (Building 51);
  - A waste oil storage sump is located in the Service Maintenance and Flammable Stores Building (Building 51);
  - An oily water storage tank is located at the Water Treatment Plant north of Unit 0; and
  - Small volumes of other flammable liquids are stored in special storage cabinets located in laboratories and workshops around the station;
- (d) Corrosives:
- Sulphuric acid, sodium hydroxide and sodium hypochlorite are used in the Water Treatment Plant located north of Unit 0;
  - Sodium hypochlorite is currently used for zebra mussel control, although it is expected that it will be replaced by ozone or some other non-chlorinated compound before decommissioning begins;
  - Hydrazine is added to the condensate to remove dissolved oxygen (morpholine is not used at DNGS); and
  - Ammonia (at a concentration of 20 percent) is stored at each unit;

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- (e) Oxidizers such as hydrogen peroxide are used during cleaning of the steam generators and heavy water upgrader; hydrogen peroxide is also used as a biocide in the IFBs;
- (f) No Polychlorinated Biphenyls (PCBs) are currently used in electrical transformers or stored on the site and there are no fluorescent light ballasts containing PCBs at DNGS [R-75];
- (g) Ozone depleting substances are used in chillers and air conditioners, but these were replaced by less detrimental refrigerants. Halon fire suppression systems and dry cleaning solvents have already been removed from the site; and
- (h) Pesticides and herbicides are applied by licensed contractors when required to control weeds, insects, rodents and other pests, but they are not routinely stored on the site.

Small quantities of other chemicals are used in the active and inactive laboratory in the Central Service Area, the laboratory in the TRF and in workshops located around the station. Appendix A shows the types, quantities and locations of hazardous materials found at DNGS.

#### 4.4.2.2 Hazardous Waste Inventory During Decommissioning

Hazardous waste that does not form part of the station's SSCs is not included as part of decommissioning activities. All operational waste will be removed prior to decommissioning.

Hazardous wastes removed during the Preparation for Safe Storage period will include oils, lubricants and refrigerants. Many of these wastes can be recycled.

Other hazardous wastes likely to be generated during the SWS period are the decontamination agents used during the decontamination of the IFBs and associated equipment. The volume of hazardous waste generated during this phase of the project is expected to be minimal.

Hazardous wastes generated during the Dismantling & Demolition and Site Restoration period of the decommissioning will likely be limited to hazardous materials originally used as building materials. Volumes of these wastes are likely to be small since very few hazardous materials were used in the construction of the plant. Dry active waste such as combustibles (paper, cloth, wood, filter cartridges) could also be generated in the removal of plant systems.

Hazardous materials that might be used during the decommissioning, such as welding gases, petroleum products (e.g., gasoline and diesel fuel) and organic solvents, are anticipated to be similar to materials used during station operations and maintenance.

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#### 4.4.2.3 Management of Hazardous Waste

DNGS is already registered with the Ontario Ministry of the Environment, Conservation and Parks (MECP)<sup>13</sup> as a generator of hazardous wastes. The waste generator registrations will be reviewed prior to beginning the decommissioning project to ensure that all of the wastes that will be generated are registered.

Appropriate disposal facilities for hazardous wastes will be identified prior to the beginning of the decommissioning project. Hazardous wastes will be packaged for transport and disposal according to the requirements of the applicable provincial regulations. All hazardous wastes, including non-radioactive hazardous wastes, will be transferred to an appropriate, licensed waste management facility for storage or disposal at approved disposal facilities. Waste manifests will be prepared and submitted as required by provincial regulations. Mixed waste (i.e., radioactive waste mixed with clean waste that is also hazardous) will be transferred to an appropriate long-term disposal facility.

#### 4.4.3 Other Wastes

The bulk of the non-hazardous waste materials generated during decommissioning will be produced during the Dismantling & Demolition and Site Restoration period of the decommissioning although some are likely to be produced during the Preparation for Safe Storage period. Non-hazardous wastes that meet the established clearance levels will be re-used or recycled wherever possible or disposed of at approved disposal facilities.

If the volume or value of the contaminated scrap metal generated during the decommissioning is sufficient to justify further processing, chemical cleaning, electro polishing, mechanical abrasion or melting might be used to decontaminate scrap metal. Any metals that are decontaminated to levels below the clearance levels established in the DDP will be released for recycling or disposal.

Clean concrete rubble may be used on site for fill. Other non-contaminated materials will be released for disposal according to the applicable regulations.

### 5.0 DECOMMISSIONING COST ESTIMATE AND FINANCIAL GUARANTEE

This section deals with the costs associated with decommissioning the DNGS and provision of a financial guarantee for the accumulated liability.

<sup>13</sup> In 2022, MECP is poised to hand over oversight of the Provincial hazardous waste program to Resource Productivity and Recovery Authority.

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## 5.1 Cost Estimates

The decommissioning cost estimate update was prepared by the TLG Services LLC (TLG), on behalf of OPG.

The cost associated with decommissioning the DNGS is estimated at \$3.994 billion (2022 Dollars) for this financial guarantee period (2023-2027) and covers the activities as detailed in Section 3.0 of [R-14]. The aforementioned decommissioning cost is accurate as of the time of PDP approval. As OPG is currently in the process of finalizing its 2022 Ontario Nuclear Funds Agreement (ONFA) Reference Plan Update, this decommissioning cost may change pending further reviews by the Province.

A summary of the cost estimate for decommissioning the DNGS can be found in Appendix B. The cost estimate will be updated when changes to the DNGS planning assumptions occur. These changes may include the addition of or removal of facilities, systems and equipment or other changes to planning assumptions such as shutdown dates.

The costs associated with the management of used fuel including interim storage, transportation and disposal from the DNGS are not included in this estimate. Plans and cost estimates for these activities are described in separate documents.

OPG will continue to provide an annual status report to the CNSC staff detailing amounts accumulated in the applicable segregated funds for decommissioning and management of used fuel. The report will also identify any material changes in decommissioning plans or cost estimates, which may affect the financial liability incurred.

Only facilities and land within the licensed/protected area are covered by the decommissioning segregated funds.

## 5.2 Financial Guarantee

For the 2023 - 2027 Financial Guarantee liabilities calculations, the TLG cost estimates will be adjusted to incorporate costs from the Financial Guarantee year onwards and will include oversight costs specific to the OPG decommissioning program. The OPG Financial Guarantee liabilities calculations process allows for managing/evaluating changes that may be required if the shutdown dates are affected.

## 6.0 HUMAN AND ORGANIZATIONAL FACTORS

The term 'Human Factors' (HF) refers to those factors that influence human performance as it relates to the safety of a nuclear facility or activity over all phases, including design, construction, commissioning, operation, maintenance and decommissioning. The term 'HF engineering' refers to the application of knowledge about human capabilities and limitations to facility, system and equipment design. HF engineering ensures that the design of the equipment, human tasks and work environment is compatible with the sensory, perceptual, cognitive and physical

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attributes of the personnel who operate, maintain and support the facilities, systems and equipment. The goal in any phase of station life, including decommissioning, is to achieve productive, error-free and safe system performance.

Unique Human and Organizational Factors issues can occur during the decommissioning phase and that do not exist during the design, construction or operational phases of an NPP. The Human and Organizational Factors issues that may arise during the decommissioning of DNGS can be split into the following three categories [R-76]:

- (a) Work Environment, which may include:
  - Activities that may be hazardous to personnel and the environment;
  - Material that may be in less than optimal condition at the facility; and
  - Incomplete documentation and records from operation that can create uncertainty among decommissioning staff;
- (b) Work Planning, which may include:
  - Activities unique to decommissioning that can impose burdens on development and maintenance of staff skills and technical knowledge;
  - The long timeframe of decommissioning that can pose difficulties to organizational continuity, culture, staffing and knowledge;
  - Complications in decommissioning planning due to the potential for the need to replace obsolescent systems and work practices; and
  - Unique issues with human performance resulting from new tasks;
- (c) Work Execution, which may include:
  - Adaptations to the decommissioning work plans due to unexpected findings ('discovery work');
  - Impacts of a declining staffing resource as the decommissioning program proceeds; and
  - Complications with control over monitoring remote and automated operations as well as overseeing less knowledgeable contract staff.

Prior to decommissioning, OPG will establish a Human Factors Engineering Program Plan (HFEPP) for the decommissioning of DNGS according to the recommendations of CNSC REGDOC-2.5.1, 'General Design Considerations: Human Factors' [R-77], REGDOC-2.2.1 'Human Factors' [R-78], lessons learned from decommissioning of PNGS and international OPEX. The details of the HFEPP will be included in the DDP. The following items should be included in the HFEPP:

- Human-machine interface system;
- Human-machine allocation of function;

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- Human reliability;
- Job design;
- Operating experience review;
- Physical working environment;
- Activities with potentially hazardous human interactions;
- Procedures development;
- Shift-work systems;
- Staffing; and
- Validation and verification.

Decommissioning work will also comply with requirements of the HF in design and any other guidelines available at the time of decommissioning. HF in design applies to nuclear safety, protection of the environment, health and safety of persons, security, productivity, and economics [R-79].

## 6.1 Transition to Decommissioning

The period of transition from operations to decommissioning poses different Human and Organizational Factors challenges to OPG than during the operational phase because of the complex process and the long time frame required to complete decommissioning. There are many HF issues that are unique to decommissioning that are not encountered during the commissioning or operational phases. Human and Organizational Factors issues that arise during transition to decommissioning may include [R-80]:

- Loss of personnel expertise during the transition from operations to decommissioning;
- Immediate reduction in the number of employees working at the station;
- Reliance on contractors during decommissioning instead of knowledgeable and experienced station staff;
- Decommissioning activities, such as Preparation for Safe Storage, will occur while other units on site continue to operate;
- The maintenance of safety culture of the station during the transition from operations into decommissioning;
- The change of mission from operations to decommissioning;
- The change in management and organizational structure;
- The morale of station personnel, both as the station nears scheduled shutdown and after shutdown; and

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- The impact of delaying the Dismantling & Demolition of the station and the duration of the SWS period, e.g., reduction in staff numbers.

The Human and Organizational Factors issues listed above will have a major impact on the course of the decommissioning project. OPG will ensure that Human and Organizational Factors issues are considered throughout the planning and execution of the project. Special attention will be given to staffing and training in order to minimize potential problems resulting from the loss of experienced personnel over time. Furthermore, a plan to manage staff reductions during the period following shutdown will be implemented.

As mentioned in Section 3.6, the risks associated with the decommissioning activities will be managed as per OPG's risk management process to ensure these risks are identified, analyzed, documented and appropriate measures are put in place to mitigate these risks.

### 6.2 Administration

OPG will retain responsibility for the station throughout the course of the Preparation for Safe Storage period of the project. OPG staff will perform the work in this period although contractors may be retained to provide specialized services under the supervision of OPG staff.

OPG will also retain responsibility for the station throughout the course of the SWS period of the project and OPG staff will perform the work required during this phase of the project, such as equipment maintenance, inspection activities and routine service.

It is anticipated that the organization required to oversee the decommissioning program will be assembled from available OPG station staff and outside resources as needed. Decommissioning Contractor(s) will be retained to perform the Dismantling & Demolition and Site Restoration work. OPG will provide the necessary oversight during this time period. The Decommissioning Contractor(s) will be a company or consortium selected on the basis of factors such as decommissioning experience, safety record, overall approach and cost. OPG will remain the owner and licensee of the DNGS throughout the course of the decommissioning, but the Decommissioning Contractor(s) will be given charge and control of the site during the Dismantling & Demolition and Site Restoration period. Other contractors may also be given charge and control of designated portions of the site during the earlier phases of the decommissioning. During these periods, the contractor will become the 'Constructor' for the decommissioning work as defined by the Construction Safety Regulations made pursuant to the OH&S Act. The Decommissioning Contractor(s) and sub-contractors will be required to comply with OPG procedures related to Nuclear Energy Workers and other federal and provincial regulations.

### 6.3 Staffing

The staffing numbers for each phase of decommissioning can be found in [R-14] and have been estimated based on activities in each phase, schedule, work difficulty factors, industry experience, etc.

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The numbers should be considered preliminary (i.e., for cost estimating purposes only). Business plan staffing numbers have not yet been established and will be determined at a later date.

#### 6.4 Training

OPG will ensure that all workers are qualified to perform the work assigned to them. They will be provided with training on the hazards associated with their work and the procedures that may be used to protect against those hazards. All workers will be provided with the training through OPG's training program [R-81]. This will include training in:

- Radiation protection;
- Construction safety;
- Workplace Hazardous Materials Information System;
- Emergency procedures; and
- Any other topics that may be deemed appropriate at the time.

Long term fleet staffing plans, which include clearly defined training requirements, are being developed to cover a 10-year rolling window and these plans will be refreshed yearly. The staffing plans, and associated training requirements, will ensure training can be delivered within the specified timeframe to ensure capability is maintained, and that sufficient resources are available for safe and reliable operation.

Details of the training program for SWS will be provided in the DDP (or a separate SSP). Detailed descriptions of the required training for Dismantling and Demolition will be included in the DDP that is expected to be available prior to the entering this phase.

#### 7.0 POTENTIAL ENVIRONMENTAL AND SOCIO-ECONOMIC EFFECTS

An IA is not required for the transition period. In consultation with the CNSC and to comply with all applicable laws and regulations, OPG will determine the requirements for performing an IA, if required prior to Dismantling & Demolition. Section 13.0 provides further information on the IA process. This section is only intended to highlight some of the major effects on the natural and socio-economic environment that might occur over the course of the decommissioning work. The listing in this section is not intended to be exhaustive.

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## 7.1 Natural Environment

### 7.1.1 Air Quality

The decontamination and dismantling of nuclear systems could release airborne radioactivity. The impact of these releases will be minimized through the use of temporary containment structures and local filtered ventilation.

The heavy construction equipment and the vehicles used for transport of waste and other materials will release particulates (dust) and exhaust gases into the atmosphere. The nature and extent of these releases will depend on the type of equipment in use at the time of the decommissioning. Dusts, fumes and other emissions from cutting or blasting operations, particularly during the dismantling operations, may have some impact on air quality. Emissions from these activities are common in many other industrial activities and the impact can be reduced through proper equipment maintenance and currently available dust suppression technologies.

Traffic resulting from the movement of heavy vehicles to and from the Darlington Nuclear Site during decommissioning may have an impact on the surrounding community but the additional impact on the environment should not be significant. Shipment of radioactive waste and used fuel from the site is governed by the Radioactive Materials Transportation program [R-63] and will be subject to strict application of the following transportation regulations [R-59], [R-82] and [R-83].

As described in Section 7.2.2, there may be noise pollution resulting from use of heavy equipment, but this should be limited to a small number of distinct events during the Dismantling & Demolition work.

### 7.1.2 Surface Waters, Groundwater and Soil Quality

Some increase in turbidity of the water along the lakeshore may result from filling and sealing the station's water inlets and outlets as well as from runoff during the Dismantling & Demolition and Site Restoration work.

As indicated in Section 2.3.2.3, tritium contamination has been found to exist in groundwater at DNGS, but it appears to be limited to one area of the site. The groundwater plume flows into the nearby Forebay Channel, which ultimately discharges to Lake Ontario. No significant impact upon decommissioning is likely as the tritium plume's concentrations are decreasing and are likely to significantly decrease due to dispersion and radioactive decay from now through the end of the SWS period [R-84].

Potentially contaminated soil that has become contaminated with activation and fission products are likely to be found in soil relatively close (within a few meters) to the underside of the structure or components from which the leakage occurred. The longer half-life radionuclides (Cs-134, Cs-137, Sr-90 and Co-60) are typically found in contaminated soil.

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Annual reports on the monitoring and remedial work are being submitted to the CNSC [R-19].

Remediation would likely entail excavation of the affected soil, with off-site disposal of the soil as radioactive waste.

Decommissioning is also a potential source of soil and groundwater contamination, through spills of heavy water, oils and chemicals. The impact of possible releases will be minimized through the reduction of inventories immediately following the end of operations or during Preparation for Safe Storage and through the use of good practices as well as appropriate mitigating actions. More details regarding mitigating actions, such as runoff control measures, will be provided in the DDP.

### 7.1.3 Vegetation

It is not anticipated that the work performed during Preparation for Safe Storage period would have any impact on the vegetation in the immediate vicinity of the site beyond that caused by normal station operations.

The reduced level of activity on site during the SWS period might permit increased growth of the vegetation on the site. However, it is anticipated that the growth of vegetation inside the security fence would be controlled to prevent the areas from becoming naturalized habitat prior to dismantling.

As mentioned in Section 2.3.1, there are some plant species of conservation concern that have been identified on the Darlington Nuclear Site and that would need to be protected during the Dismantling & Demolition activities.

The most heavily vegetated areas of the site are not likely to be impacted during the course of the decommissioning work but the dust produced during the Dismantling & Demolition and Site Restoration period may have a temporary impact on some of the vegetation in the immediate vicinity of the site.

### 7.1.4 Wildlife

The warm water from the condenser cooling water outlets and the nets across the forebay have created feeding grounds and resting places for a variety of other water birds including ducks, geese and gulls. Shutting down the station will change the habitat of these birds. Removing the warm water source during decommissioning will change the water environment which may impact fish and waterfowl species.

Within the Darlington Nuclear Site, there are also several birds and bats that are listed under the Endangered Species Act (ESA) [R-85]. Changes to the site during dismantling and site restoration work will change the surrounding environment, which may impact these birds and bats that are protected under the ESA and their habitats. Mitigation and offset plans will be taken into account to protect these bird species.

Some locations around the Darlington Nuclear Site, that are not routinely used, have naturalized and thus become a habitat for wildlife. A variety of species of mammals,

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birds, reptiles and amphibians have been observed in these areas. These populations may increase during the SWS period since there will be little activity on the site.

The increased level of activity during the Dismantling & Demolition and Site Restoration period, along with the noise and dust generated has potential to affect species inhabiting the Darlington Nuclear Site and direct surrounding areas. Increased vehicular traffic during some phases of the decommissioning may have a potential to impact wildlife.

### 7.1.5 Aquatic Life

A number of amphibians and other forms of aquatic life have been observed in the marsh areas to the east and west of the station. It is not anticipated that the work performed during Preparation for Safe Storage period would have any impact on local aquatic populations beyond that caused by the operating stations. The local aquatic populations may increase during the SWS period since there will be relatively little activity on the site.

Changes in runoff from the site during Dismantling & Demolition and Site Restoration period may impact some species found on the site and this will require discussion and consultation with the Department of Fisheries and Oceans. The impacts of the runoff from the work areas will be further assessed and mitigation measures put in place prior to Dismantling & Demolition. Some increase in turbidity of the water along the lakeshore may result from filling and sealing the station's water inlets and outlets as well as from run-off during the Dismantling & Demolition and Site Restoration work. The potential impacts of turbidity will be assessed and appropriate mitigation strategies will be put in place prior to Dismantling & Demolition. All feasible measures will be taken to prevent sedimentary discharges reaching local water bodies from the decommissioning site.

If part of the decommissioning plans requires in-filling of the intake channels and forebay, then mitigation and off-set commitments may be required under the Fisheries Act [R-86].

## 7.2 Land Use and Noise

### 7.2.1 Land Use

It is expected that the site itself will continue to be utilized for other OPG uses.

Decommissioning itself is anticipated to have minimal impact on the use of the surrounding lands.

### 7.2.2 Noise

Heavy construction equipment and blasting may be used during the Dismantling & Demolition work towards the end of the decommissioning project. This work may produce localized elevated noise levels during the Dismantling & Demolition work. Site workers and wildlife may be temporarily impacted by the increased noise. The potential

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impacts of demolition noise will be assessed prior to Dismantling & Demolition and appropriate mitigation strategies will be put in place, such as not using certain demolition methods.

### 7.3 Human and Socio-Economic Environment

#### 7.3.1 Purpose

The Regulatory Guide G-219 specifies that a PDP should include the “identification of any features of the surrounding... social environment that could be significantly affected by the decommissioning process” [R-2]. This section will focus on the potential for socio-economic impacts at the local community and regional level associated with the decommissioning of the stations.

This section does not attempt to assess or evaluate what impacts may actually result at the time when decommissioning actually occurs. The impacts resulting from the decommissioning process will be assessed in an IA, if required to comply with all applicable laws and regulations prior to Dismantling & Demolition, and their significance will be determined at that time.

#### 7.3.2 Scope

If an IA is required per the IAA [R-9] which came into force in 2019, the scope of the socio-economic assessment considerations would include the other planned activities occurring in the same time period, such as decommissioning of DWMF, which when taken together with the planned decommissioning of the DNGS may have the potential for cumulative impact on the local communities. For more details on the IA, refer to Section 13.0.

Aspects to be considered include:

- Direct economic impacts – employment (local/non-local), skill groups required, labour supply, etc.;
- Indirect economic impacts – employee expenditure, suppliers, labour markets, etc.;
- Demographics – changes in population size and characteristics (long and short term);
- Housing; and
- Other local services – police, health, social, education, etc.

#### 7.3.3 Definitions

Socio-economic impacts are defined as changes in people’s well-being and/or changes in significant aspects of their communities as a result of a development or project.

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Socio-Economic Impact Assessment (SEIA) is a process designed to identify and evaluate the potential social, cultural and economic effects of a proposed project, policy, program or plan on people, organizations, institutions, communities and social systems. The purpose of SEIA is to recommend impact management measures that would improve a project by reducing negative community effects and enhancing community benefit.

Impact management involves the coordinated application of measures designed to mitigate, enhance, compensate, plan for contingencies, monitor and ensure continuing liaison. Measures could also include formal impact agreements.

SEIA and impact management improve projects by identifying and managing the costs and benefits and by facilitating decision-making. A SEIA would be undertaken as part of the EA of decommissioning, if required.

### 7.3.4 Temporal Considerations

Shutting down the station and the four phases associated with decommissioning (i.e., Planning, Preparation, Execution and Completion Phases) will each have discrete activities that will result in effects on local communities. As a part of the planning activities, the local communities will be engaged throughout the process. This results in a number of socio-economic effects taking place. For planning purposes, it is assumed that these effects will commence for DNGS in 2050 and extend until decommissioning is complete for the site in 2092 (see Table 7-1).

**Table 7-1: Planning Schedules Affecting Socio-Economic Conditions for the Decommissioning of DNGS Site**

Stage	DNGS Dates	Total Time Required	DWMF Dates	Total Time Required
Preparation for Safe Storage including shutdown <small>Notes 1&amp;2</small>	2051 – 2052	1-year	–	–
SWS <small>Notes 1&amp;2</small>	2052 – 2084	32-years	–	–
Preparation for & activities associated with Dismantling, Demolition and Site Restoration and release from regulatory control <small>Notes 1&amp;2</small>	2084 – 2093	9-years	2086 - 2093	7-years
<b>Total Duration at Site</b>	<b>2051 – 2093</b>	42-years	2086 - 2093	7-years

Note 1: For Unit 2 as it will be shut down first in December 2050.

Note 2: All dates are nominal.

The scheduled phases of decommissioning are almost continuous and overlapping, extending for a total period of over 40 years. Actual activities associated with these planned phases will be intermittent; however, it is important to understand the overall flow of activities, as these will be the major source of potential socio-economic impacts.

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### 7.3.5 Preparation for Decommissioning/Shutdown/Preparation for Safe Storage

The most significant source of community effect will be the changes in the size of the workforce when the station is shut down. Prior to the shutdown, there would be approximately 2,000 workers at the Darlington Nuclear Site. Approximately 7 years will be needed to complete the transition activities from operations to SWS for all four units. After the Preparation for Safe Storage, including station shutdown, most of the established workforce will no longer be required. The reduction of staff would probably be staggered, as the units are shut down. See Section 6.3 for further details on the staffing needs during this decommissioning phase. A preliminary workforce estimate is presented in [R-14]. Some displaced workers and their families may not move away from the community and may or may not find employment locally. Other workers and their families may move away from the community. The loss of jobs, income and population will affect the local communities in a variety of ways, including effects on the housing market, services, consumer spending and social aspects.

Local traffic patterns would change, as the numbers of staff will be reduced at the station. Any nuisance effects associated with worker traffic would change.

L&ILW generated by the decommissioning in the Preparation for Safe Storage period will be transported by truck to long-term disposal facilities for respective LLW and ILW, as described in Section 4.4.1.3.

The closure of the station will change the pattern of local expenditures and tax payments. Local and regional purchases of goods and services associated with the operation of the station would cease. There may be some spending associated with the shutdown activities. It is possible that indirect economic effects would occur. Under current assessment legislation, tax monies will continue to be paid on buildings and structures until the structures are removed. For planning purposes, it is assumed that the amount will vary as the work progresses through each phase of decommissioning.

### 7.3.6 Storage with Surveillance

The SWS period will extend for nominally 30 years for each unit. Over that period, a small workforce will be required, which may represent opportunities for local employment and consumer spending. Towards the end of the SWS period and during preparation for Dismantling & Demolition, the staff complement will increase to accommodate the planning activities and mobilizing for Dismantling & Demolition and Site Restoration. See Section 6.3 for further details on the staffing needs during this decommissioning phase. A preliminary workforce estimate is presented in [R-14].

### 7.3.7 Dismantling, Demolition and Site Remediation

When Dismantling & Demolition begins, the workforce will increase at DNGS. See Section 6.3 for further details on the staffing needs during this decommissioning phase. The Dismantling & Demolition activities will extend over approximately 5 years. Consequently, some of these workers may move into the community. There may be local spending associated with the Dismantling & Demolition activities. It is possible

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that local contractors and suppliers will benefit. These changes will affect the local and regional community.

Other activities associated with Dismantling & Demolition will also be a source of effects. Most of the waste generated by the Dismantling & Demolition will not be radioactive. Of this waste, the concrete-based materials are anticipated to be used for filling at the site. The availability, proximity and cost of the disposal and any impacts related to haulage may potentially affect community services and infrastructure. L&ILW would be transported by truck to long-term disposal facilities as described in Section 4.4.1.3. The volume of these wastes would be substantial (~50,000 m<sup>3</sup>, per Table 4-2), so it is currently expected that the number of truck trips would be considerable, i.e., more than the present transportation trips for operational waste from the Darlington Nuclear site to the WWMF on the Bruce Nuclear site.

At the conclusion of the Dismantling & Demolition period, the site will be restored for other OPG use(s). During Site Restoration, the workforce will decrease significantly at the DNGS. All of the visual effects of a large industrial plant in the midst of a generally rural area will be eliminated. The site will remain under the control of OPG and the input of a broad cross-section of stakeholders will be sought for the future use of the site. Under current assessment legislation, tax monies will continue to be paid on buildings and structures until the structures are removed. It is assumed that the tax amount paid will vary as the work progresses through each phase of decommissioning. The amount of taxes paid after the Dismantling & Demolition of all buildings will depend on the new land uses.

## **8.0 POTENTIAL HAZARDS AND HEALTH & SAFETY**

### **8.1 Hazard Assessment**

A thorough assessment of the radiological, chemical and construction safety hazards that might be encountered in the course of the decommissioning project will be performed during the preparation for decommissioning. A preliminary assessment of some of the hazards likely to be encountered during the course of the decommissioning of DNGS is summarized in Table 8-1. This preliminary hazard assessment is not exhaustive. Other potential hazards may be identified during the course of decommissioning planning and these will be addressed as appropriate.

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**Table 8-1: Preliminary Hazard Assessment for the Decommissioning of DNGS**

Hazard	Most Likely Source(s) of Hazard	Description/Comments
<b>Radiation Hazard</b>	<b>Preparation for Safe Storage</b> <ul style="list-style-type: none"> <li>Handling used fuel, tritiated heavy water, filters and resins.</li> <li>Performing decontamination work (including the chemical decontamination).</li> <li>Working in gamma radiation fields produced by fission and activation products in station systems and components.</li> </ul>	
	<b>Storage with Surveillance</b> <ul style="list-style-type: none"> <li>Storage of used fuel in the facility.</li> <li>Radiation fields will exist in other parts of the facility throughout SWS.</li> <li>Residual tritium in TRF.</li> </ul>	<p>Used fuel will continue to be stored in the facility for an initial cooling period after shutdown and the work required to transfer this fuel to a used fuel disposal facility will continue.</p> <p>At the beginning of this phase, the radiation fields will primarily be due to short-lived activation products such as tritium and cobalt-60 and these fields will decay significantly over the course of the SWS period.</p>
	<b>Dismantling &amp; Demolition and Site Restoration</b> Internal and external radiological hazards include: <ul style="list-style-type: none"> <li>Radiation fields produced by the fission and activation products that remain in station systems and components.</li> <li>Hot spots from radioactive particles.</li> <li>Radiation fields produced by the radionuclides in the waste.</li> <li>Loose surface contamination (including alpha emitting radioisotopes) on tools, equipment and systems that are opened during the work.</li> <li>Airborne contamination generated during the decontamination work or the packaging of the waste.</li> <li>Tritium contained in TRF.</li> </ul>	<p>All of the radiological hazards will be removed by the end of the decontamination and disposal work during Dismantling, Demolition and Site Restoration period.</p>
<b>Chemical Hazard</b>	<b>Preparation for Safe Storage</b> <ul style="list-style-type: none"> <li>Draining and cleaning of water treatment facility tanks, etc.</li> <li>Handling the cleaning agents used during decontamination work.</li> <li>Transporting bulk/waste chemicals.</li> </ul>	

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Hazard	Most Likely Source(s) of Hazard	Description/Comments
	<p><b>Storage with Surveillance</b></p> <ul style="list-style-type: none"> <li>No unusual chemical hazards are expected during this phase.</li> </ul>	Chemical storage during SWS and decommissioning will include appropriate storage requirements including separation of chemicals where required to avoid potential chemical hazards/explosions in case of spills or common mode event (earthquake).
	<p><b>Dismantling &amp; Demolition and Site Restoration</b></p> <ul style="list-style-type: none"> <li>Handling the cleaning agents used during decontamination work.</li> <li>Transporting bulk/waste chemicals.</li> <li>Concrete dust generated during the dismantling work.</li> </ul>	
<b>Industrial and Construction Hazards</b>	<p><b>Preparation for Safe Storage</b></p> <ul style="list-style-type: none"> <li>Similar hazards to those encountered in an operating station during a routine maintenance outage.</li> <li>Airborne hazards necessitating the use of supplied breathing air or Powered Air Purifying Respirator (PAPR).</li> </ul>	
	<p><b>Storage with Surveillance</b></p> <ul style="list-style-type: none"> <li>Similar hazards to those encountered in an operating station during a routine maintenance outage.</li> <li>Airborne hazards necessitating the use of breathing air or PAPR.</li> </ul>	
	<p><b>Dismantling &amp; Demolition and Site Restoration</b></p> <ul style="list-style-type: none"> <li>Airborne hazards necessitating the use of breathing air or PAPR.</li> <li>The operation of heavy construction equipment in close proximity to workers.</li> <li>Fires caused by cutting torches and grinders.</li> <li>The collapse of equipment or structures during dismantling.</li> <li>The use of blasting and other techniques to demolish concrete structures.</li> <li>Falls, lifting heavy objects, falling objects, use of hand tools and the other hazards routinely encountered during construction work.</li> <li>Working at heights inside the station.</li> <li>Hazards from decontamination activities (mechanical/chemical).</li> <li>Hazards from concealed or hidden services.</li> </ul>	
<b>Biological Hazards</b>	<p>Biological organisms and materials that might be found on the site during the decommissioning could also produce hazards that include:</p> <ul style="list-style-type: none"> <li>Stings and bites from insects, rodents, birds or other animals that might live or nest inside accessible buildings.</li> <li>Toxins and antigens produced by moulds and other fungi that might grow on surfaces (particularly those made of biological materials).</li> </ul>	

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Hazard	Most Likely Source(s) of Hazard	Description/Comments
	<ul style="list-style-type: none"> <li>Infections or adverse reactions resulting from exposure to organisms living in decaying biological material (such as carcasses and droppings) or their by-products.</li> </ul>	
<b>Motor Vehicle Accidents</b>	<ul style="list-style-type: none"> <li>Highway travel/shipments.</li> <li>Vehicle/pedestrian collisions.</li> <li>Vehicle/wildlife collisions.</li> </ul>	
<b>Inclement Weather</b>	<ul style="list-style-type: none"> <li>Temperature extremes (hot/cold).</li> <li>Lightning.</li> <li>High winds.</li> </ul>	Workers at the above-grade structures face the greatest risk of lightning strike.
<b>Work around Open Water</b>	<ul style="list-style-type: none"> <li>Work around the forebay and Pump Houses.</li> </ul>	
<b>Work at Heights</b>	<ul style="list-style-type: none"> <li>Work on the meteorological tower, stacks and other tall structures.</li> </ul>	
<b>Fire/Explosion</b>	<ul style="list-style-type: none"> <li>Hot work (e.g., cutting torches, etc.).</li> <li>Storage of flammable liquids.</li> </ul>	
<b>Flying/Falling</b>	<ul style="list-style-type: none"> <li>Objects falling from heights.</li> </ul>	Pipes, walkways and other equipment will fall to the ground after it is cut.
	<ul style="list-style-type: none"> <li>Objects falling off buildings/structures as they are demolished.</li> </ul>	Objects could fly off buildings and structures as they are being demolished.
<b>Sharp/Heavy Objects</b>	<ul style="list-style-type: none"> <li>Heavy objects.</li> </ul>	Objects will be cut to the size required by recyclers, etc. Most objects will be too heavy to lift by hand.
	<ul style="list-style-type: none"> <li>Sharp objects.</li> </ul>	Metal objects that are cut or torn may have sharp corners/edges.
<b>Confined Spaces</b>	<ul style="list-style-type: none"> <li>Work in confined spaces.</li> </ul>	Little work will be performed in confined spaces.
<b>Power/Hand Tools</b>	<ul style="list-style-type: none"> <li>Working with power tools and hand tools.</li> </ul>	
<b>Heavy Equipment</b>	<ul style="list-style-type: none"> <li>Working around heavy equipment.</li> </ul>	
<b>Excavations</b>	<ul style="list-style-type: none"> <li>Work in or near below-grade structures.</li> </ul>	There are open, below-grade concrete structures on the site.
	<ul style="list-style-type: none"> <li>Work in or near excavation in soil.</li> </ul>	
<b>Demolitions</b>	<ul style="list-style-type: none"> <li>Working near buildings and structures under demolition.</li> </ul>	
<b>Noise</b>	<ul style="list-style-type: none"> <li>All conventional industrial processes.</li> </ul>	PPE will be used.
<b>Work around Live Services</b>	<ul style="list-style-type: none"> <li>Work near live above-ground services.</li> </ul>	Due to the tight footprints of a four unit site, the logistics for safe work areas, laydown areas and access for heavy lifts, etc. need to be planned,
	<ul style="list-style-type: none"> <li>Work near live underground services.</li> </ul>	Live electrical and water lines are buried below the site.

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### 8.1.1 Occupational Dose Estimate

A preliminary occupational dose estimate for the decommissioning of the four DNGS units has not been prepared. However, a preliminary assessment of the occupational dose for the decommissioning of Bruce Nuclear Generating Station (BNGS) A was conducted in 1986 [R-87]. This will serve as OPEX and as a guide for future studies and to what may be expected during the decommissioning of DNGS. According to this analysis, the total estimated dose for the decommissioning of BNGS A is 5.15 person-Sieverts (515 person-rem). This estimate was based on 40-years of continuous operation of the BNGS A units followed by 30-years of decay. The design of the DNGS units is different from that of the BNGS A units so the occupational dose for the decommissioning of DNGS may also be different. However, for preliminary planning purposes, it is assumed that the occupational dose estimate for BNGS A will also be applicable to the DNGS.

An Occupational Dose Estimate for the decommissioning of the DNGS will be prepared prior to Dismantling & Demolition. The Occupational Dose Estimate will be prepared by:

- Reviewing the work breakdown to identify those decommissioning tasks that will result in an occupational exposure to workers;
- Determining the location of the work that will be performed and the number of person-hours required to complete each task;
- Using survey results or numerical models to estimate the radiation dose rates that will be encountered in each location during the performance of each task; and
- Calculating the anticipated occupational dose that will result from the performance of each task.

### 8.1.2 Hazards to Workers

Primary hazards to workers throughout the decommissioning will be from conventional (non-radiological) hazards, particularly through the Dismantling & Demolition and Site Restoration period. Radiological hazards will be significantly reduced by removal of contamination and/or sealing of contamination in the Preparation for Safe Storage and through the SWS period with the removal of the used fuel from the IFBs. Further details on the hazards that are likely to exist during decommissioning are provided in Table 8-1.

### 8.1.3 Hazards to the Public

It is currently assumed that throughout the decommissioning project, radiological hazards to the public are most likely to result from accidents during the off-site transport of radioactive wastes. The bulk of the off-site transport is expected to occur during the Dismantling & Demolition period. Since this activity is scheduled to occur nominally 30 years after the final station shutdown, OPG will perform an in-depth

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analysis closer to the end of SWS period. This will allow OPG to take advantage of the technological advances and industry experience, further minimizing any radiological risks to the public.

## 8.2 Radiological Safety

All decommissioning activities will be carried out in accordance with the ALARA principle and the Radiation Protection Program of OPG [R-50]. The procedures set out in the Radiation Protection Program with respect to dose control, contamination control and so forth will continue to be followed until they are suspended or modified in consultation with the CNSC. Some of the actions that will be taken to help ensure the radiological safety of workers during the different phases of the decommissioning program are described in Sections 8.2.1 through 8.2.3 below. Where required, Radiation Work Plans and detailed procedures will be prepared before work begins.

Throughout the decommissioning phases, qualified personnel will be selected to perform the work assigned to them using approved procedures to mitigate/eliminate hazards and any potential releases.

### 8.2.1 Preparation for Safe Storage Period

OPG station staff will perform the defueling and dewatering activities, along with contractor(s) performing decontamination activities during the Preparation for Safe Storage period. The decontamination work that will be performed at this time should further reduce the radiation dose rates in the station. When these activities are completed, the portions of the station that still contain radioactivity will be sealed off and all systems and services essential to caretaking will be kept in service.

Routine radiation surveys to help ensure public, environmental and personnel safety will be performed throughout this phase of the decommissioning. Environmental monitoring will be continued in order to confirm that radioactive emissions to the environment are kept ALARA. Surveys of work area contamination and radiation levels will also be routinely conducted and documented. The results of surveys performed at the end of this phase will be used to more accurately predict the radiation levels that are likely to exist during later phases of the work.

### 8.2.2 Storage with Surveillance Period

Used fuel transfers will continue during the SWS period for up to 10 years after station shutdown. Used fuel stored in DSCs at the DWMF will also be transferred to the used fuel disposal facility during the same timeframe. OPG staff will perform this work.

Radiation fields will exist in parts of the facility throughout the SWS period. At the beginning of the phase, the fields will primarily be due to short-lived activation products such as tritium and cobalt-60 and these fields will decay over the course of the SWS period. During this phase of the decommissioning, surveillance, inspection and maintenance of the buildings and site will be carried out in order to ensure that the nuclear building structures and system envelopes retain their integrity. Tritium may remain in the TRF systems. Hence, routine radiation surveys to help ensure public,

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environmental and personnel safety will be performed throughout this phase of the decommissioning. Consequently, employee exposure to the remaining fields and the resulting dose will be limited.

Environmental monitoring of the site and surrounding area will be maintained in order to confirm that radioactive releases are being controlled. Periodic gamma dose rate surveys will be carried out and documented to more accurately predict the radiation fields that will exist during Dismantling, Demolition and Site Restoration period.

### 8.2.3 Dismantling & Demolition and Site Restoration Period

In order to minimize radiation doses during the Dismantling & Demolition process:

- Radiation surveys will be performed and dose estimates will be prepared before work begins;
- Work plans that make allowance for the difficulty of the work to be performed will be prepared (the cost and duration estimates will make allowance for the difficulty of the work by adjusting for respiratory protection, protective clothing, work breaks and radiation protection/ALARA);
- Workers will be qualified in radiation protection and trained to perform the work. The level of training will be commensurate with the work being performed;
- The most active part of the station, the reactor calandria and associated systems, will be dismantled using remotely-controlled cutters and manipulators. The operators will remain in a shielded control room and the resulting wastes will be packaged by remotely controlled manipulators;
- Where possible, components will be removed in one piece without dismantling;
- Because of the potential for airborne activity, temporary containment envelopes will be erected and many dismantling operations will be carried out by workers using approved PPE and respiratory protection;
- Contamination control procedures will be strictly observed; and
- Regular contamination and dose rate surveys will be performed and documented.

Procedures will be implemented to ensure that all persons, packages or flasks leaving the site satisfy the radioactive material transport or clearance levels. Environmental monitoring of the site and the surrounding area will be maintained throughout dismantling and waste transport operations. On completion of these operations, the final surveys will be performed to confirm that all prescribed substances have been removed to the extent specified in the DDP.

### 8.3 Chemical and Demolition Safety

OPG will ensure that all decommissioning work is conducted in accordance with the requirements of the applicable federal and provincial OH&S regulations. OPG currently has a comprehensive OH&S program that meets the requirements of the OH&S Act of Ontario [R-88]. This program recognizes:

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- The right of employees to know of the hazards associated with their work;
- The right of employees to participate in decisions related to health and safety; and
- The right of employees to refuse to perform work that is considered to be unsafe.

As described in Section 6.2, Decommissioning Contractor(s) will be retained to perform the decommissioning work on behalf of the owner during the Dismantling & Demolition and Site Restoration period of the decommissioning project. The Decommissioning Contractor(s) will be given charge and control of the work area (or designated parts of the work area) as the “Constructor”. The Decommissioning Contractor(s) will be responsible for:

- Registering the Construction Project with the Ontario Ministry of Labour as required by the Construction Safety Regulations made pursuant to the OH&S Act; and
- Providing the personnel, equipment, procedures and training required for the protection of workers, the public and environment.

OPG will provide oversight of the Decommissioning Contractor(s) to ensure that the work is performed in accordance with the requirements of the decommissioning licence, OPG policies and the contract.

#### 8.4 Emergency Response Planning

During the preparation of the DDP, OPG will prepare an assessment of the potential hazards to workers, the public and the environment. During stabilization, while there is still fuel in the reactors, it is anticipated that the emergency situations that might occur will be similar to those that might occur in an operating station during a routine maintenance outage. It is also anticipated that the emergency response plans and resources required to deal with these situations would be similar to those required in an operating station during an outage and, on this basis, it will be necessary to maintain the operational emergency response capability until the reactors are defueled and dewatered. For example, provision of Emergency Mitigating Equipment or equivalent will still be retained for backup fuel cooling in the bays to respond to emergencies (such as Total Loss of On-Site Power). Subsequently, the response may be reduced to address spent fuel stored in IFBs. For example, distribution of KI pills to residents in the vicinity of Darlington site (see Section 2.3.7) will no longer be required.

As the project progresses (particularly after all of the radioactive materials have been removed from the site), the potential emergency situations will come to more closely resemble those that might occur during the course of a major construction project.

At all stages of the project, OPG will ensure that:

- The required emergency response plans and procedures are in place;

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- The plans are reviewed and exercised regularly;
- An adequate number of personnel are available to respond to any emergency situation that may occur;
- The emergency response personnel receive the training required to respond appropriately to any emergency situation that may occur; and
- The necessary equipment and supplies are available for use by emergency response personnel.

OPG will coordinate its response to a real or potential emergency situation with the appropriate federal, provincial, regional and municipal agencies.

## 9.0 SECURITY AND SAFEGUARDS

### 9.1 Security

During decommissioning, OPG will continue to comply with the CNSC regulations on the physical security of nuclear facilities. OPG will be responsible for the security of the site throughout the course of the decommissioning project.

OPG will ensure the security of the site and the Decommissioning Contractor(s) and sub-contractors will be required to comply with licensing conditions and OPG procedures regarding the physical security. During decommissioning of DNGS, the DWMF would already have been shut down. Even though they are two different facilities that are under two separate licences, the same security staff will be responsible for both facilities.

### 9.2 Safeguards

In accordance with an agreement between the Government of Canada and the IAEA, nuclear safeguards are implemented at OPG's NGSs. These international safeguards apply to used fuel management.

The existing safeguards arrangements for used fuel will continue until modified or terminated by agreement with the CNSC.

## 10.0 QUALITY ASSURANCE

OPG has QA programs for its operations, which is detailed in the Nuclear Management System [R-10] and that meet the requirements of national (i.e., CSA N286) and international standards. A QA program for the decommissioning work will be prepared and revised at the time of the DDP and will meet the requirements of the QA program of OPG.

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The Decommissioning Contractor(s) and all sub-contractors will be required to have a QA Plan that meets the standards established by OPG's QA Plan. OPG may perform audits to ensure that they perform their work in accordance with the requirements of their QA Plans.

## 11.0 RECORDS

The IAEA Technical Report [R-89] states that operational records should be retained in order to meet the needs of future decommissioning. It is recognized that there is a potential for information about the DNGS to be lost as work transitions through the stages of decommissioning, and staff numbers decrease. It is therefore necessary that measures are taken to preserve and improve the existing records database, capturing all potentially relevant information. Records filing and retention are governed by OPG's Information Management program [R-90], which identifies records relevant to decommissioning are permanent records. Decommissioning-related documentation will also be managed and maintained in accordance with CSA N294:19 [R-4]. The IAEA documents on record keeping (e.g., Technical Reports Series No. 411 [R-89]) will also be consulted to provide additional guidance. These records will contain historical information that may be required in the future in order to update this PDP, prepare the DDP and ultimately facilitate successful decommissioning. They will include, but are not limited to:

- (a) The DDPs and Storage with Surveillance Plans;
- (b) Interim end-state reports;
- (c) Design of facilities and buildings included in the decommissioning plan;
- (d) Licences and permits required for the decommissioning work;
- (e) Details of the operating history of the reactors;
- (f) Details of the initial design and configuration of station systems and the maintenance and modifications made to that configuration over the course of the station's operating lifetime including records of:
  - Updated drawings and photographs taken from inspections, modifications, and repairs to SSCs;
  - Details of materials used;
  - Special repair or maintenance activities and techniques; and
  - Details of the design, material composition and the history and location of all temporary modifications and devices;
- (g) Records of routine and extraordinary radiation dose rate and contamination surveys that are performed throughout the station (these records are stored in an electronic database called the VSDS);

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- (h) Records of worker and contractor doses received during the course of the station's operating lifetime;
- (i) Descriptions of the nature and location of any hazardous materials in the station and the disposition of any hazardous materials that have been removed;
- (j) Reports and other documents that describe the criteria used to define radioactive and hazardous materials and to distinguish contaminated from uncontaminated materials:
  - (1) the criteria used to define the final contamination status of the facility;
  - (2) the principles and models used in deriving the criteria in Items a) and b);
  - (3) the residual radionuclide inventory after decontamination;
  - (4) the amounts of radioactive and hazardous materials removed and the disposition method;
  - (5) waste management and transfer records;
  - (6) the equipment and materials removed from the facility for recycling or use elsewhere, their treatment prior to removal from the site, and the disposition method;
  - (7) the survey methods and the types of instruments used;
- (k) The equipment, nuclear and non-nuclear materials, and structures remaining at the end of decommissioning;
- (l) Details of any spills or releases of radioactive materials or environmentally hazardous substances that may have occurred over the course of the station's operational lifetime;
- (m) Records of any unplanned events or unusual occurrences;
- (n) Site characterization and environmental review or Impact Assessment; and
- (o) Public and Indigenous engagement/communications records.

Records pertinent to the shutdown of the station will also be maintained. The progressive shutdown of the operational units is very similar to the commissioning of a station. Record keeping during shutdown will be similar to record keeping during commissioning. Records from Stabilization such as the system end-stating activities, scoping and characterization surveys, etc. (see Section 4.1.4) will be well documented and be properly archived so that they can be readily available at the time of Preparation for Dismantling and Demolition. OPG will document the progress of decommissioning in a traceable manner.

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Furthermore, during the course of the decommissioning, OPG will retain records of:

- The plans and procedures used in decommissioning;
- The progress achieved in meeting the schedule for the decommissioning;
- The implementation and results of the decommissioning, including the residual radionuclide inventory after decontamination;
- The results and interpretations of environmental monitoring programs;
- The manner in which and the location where any nuclear or hazardous waste is managed, stored, disposed of or transferred (i.e., waste management and transfer records);
- The name and quantity of any radioactive nuclear substances, hazardous substances and radiation that remain at the nuclear facility after completion of the decommissioning;
- The amount of radionuclides discharged via airborne and liquid pathways;
- Occupational dose records, i.e., records of worker and contractor doses received during the decommissioning phases;
- The status of each worker's qualifications, re-qualification and training, including the results of all tests and examinations completed in accordance with the licence;
- Any deviations from plans and procedures;
- The quality assurance records;
- The final radiological and hazardous materials surveys;
- Final end-state reports; and
- The land remediation undertaken, including the results of verification analyses as compared to criteria used or derived for soil and water quality (defined in the DDP), and the disposition of any affected media.

At the completion of decommissioning, all appropriate records will be retained for the purpose of:

- Confirmation of completion of decommissioning activities;
- Recording the disposition of wastes, materials and premises; and
- Responding to possible liability claims.

Decommissioning records will be kept in the storage medium in standard use at the time of the decommissioning. All records will be assembled and maintained in accordance with the document and record management process and governance. Because of the long time frame anticipated for the decommissioning, records will be periodically checked to ensure their preservation and protection from loss, deterioration and destruction.

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## 12.0 PUBLIC AND STAKEHOLDER ENGAGEMENT PROGRAM

A public and stakeholder engagement program along with an Indigenous relations program will support the development of the DDP, an IA (if one is required – see also Section 13.0) and to support consultation for future uses of the site. The program will include both information and consultation opportunities. They will be designed to involve a broad cross-section of stakeholders employing a variety of methods that will meet the needs of the participants and the objectives of the business.

The program will identify issues and concerns; ensure opportunities for involvement; ensure that all inputs were considered in decommissioning planning and/or in the environmental risk assessment, and include the documentation of the process and results. The program will also support the development of an integrated community impact management plan.

The public and stakeholder engagement programs will comply with the applicable requirements of REGDOC-3.2.1, Public Information and Disclosure [R-6] and REGDOC-3.2.2, Indigenous Engagement [R-7].

## 13.0 IMPACT ASSESSMENT

The IAA came into force in 2019 and is the legal basis for the federal EA process in Canada, now known as IA [R-9]. In consultation with the CNSC and to comply with all applicable laws and regulations, OPG will determine the requirements for performing an IA, if required, prior to Dismantling & Demolition to ensure that adequate provisions for the protection of the environment and the health and safety of persons are made during decommissioning. Some of the effects on the natural and socio-economic environment that might occur over the course of the decommissioning work are described in Section 7.0.

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## Appendix A      Types, Quantities and Locations of Hazardous Materials Stored at Darlington Nuclear Generating Station

Material / Type	Estimated Quantity	Location on DNGS Site (Building numbers refer to Figure 2-2 and Figure 2-3)
Ammonia (20%)	Two 1000-litre totes in each Unit	Chemical Addition Station in each Unit
Carbon Dioxide (Liquid)	2,700 litre storage tank in each Unit	Annulus Gas System in each Unit
Compressed Gases (including welding gases, oxygen, nitrogen, helium, carbon dioxide and compressed air)	Typically, 425-475 cylinders	Compressed Gas Cylinder Storage Area (Building #50)
Fuel Oil	Maximum capacity is 330,000 litres (6 tanks holding up to 55,000 litres each)	EPG Fuel Management Building (Building #22)
	Maximum capacity is 2,000,000 litres (there are four tanks of 1,000,000 litres per tank)	Standby Generator Fuel Storage Tanks (Building #36 and #59)
Hydrazine (35%)	Two 1000-litre totes in each unit	Chemical Addition Station in each Unit
Hydrogen	Each system consists of a storage trailer, a storage module and 4 generators, with capacities of: <ul style="list-style-type: none"> <li>• Trailer: 1,133 m<sup>3</sup></li> <li>• Storage Module: 1,420 m<sup>3</sup></li> <li>• Generators: 900 m<sup>3</sup> each</li> </ul>	Hydrogen Trailers (Building #T44 and #T204)
	The capacity of the trailer at the TRF is 1,100 m <sup>3</sup> with up to 700 m <sup>3</sup> in the TRF system	TRF Annex (Building #42)
	6 cylinders with a capacity of 197 ft <sup>3</sup> each in each Unit	Hydrogen Addition Station in each Unit
Hydrogen Peroxide (50%)	One stainless steel tote with a capacity of 400 litres	TRF (Building #42)
Lubricating Oil	Three tanks with a total capacity of 650,000 litres: Tank #1: 130,000 litres Tank #2: 260,000 litres Tank #3: 260,000 litres	Outdoor Oil Tank Area (Building #14)
	One lube oil tank with a capacity of 33,050 litres for each Standby Generator	Standby Generators (Building #38 and #40)
	One tank with a capacity of 107,000 litres in each unit	Lube Oil Tanks (Elev. 107 in each Unit)
Nitrogen	Bulk nitrogen is stored south of the TRF	South of TRF (Building #42)
Sodium Hydroxide (Caustic Soda)	Maximum of 46,335 litres	Water Treatment Plant (Building #WTP)
Sodium Hypochlorite (7%)	Maximum of 40,000 litres (two tanks with a capacity of 20,000 litres each)	Water Treatment Plant (Building #WTP)
	Typically, 4,000 litres	Chlorine Addition Station (ESW Pump House, Building #16)

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Material / Type	Estimated Quantity	Location on DNGS Site (Building numbers refer to Figure 2-2 and Figure 2-3)
Sulphuric Acid	Maximum of 36,240 litres	Water Treatment Plant (Building #WTP)
Flammable Liquids	200 L Drums	Service Maintenance and Flammable Stores Building (Building #51)
Miscellaneous Hazardous Materials	This building houses up to 500 different chemicals, typically 50,000 litres of liquids and 750 Kg of solids	Hazardous Materials Storage Facility (Building #138)
	This building houses a variety of liquid wastes, typically contained in 45-gallon drums	Inactive Waste Chemical Storage Building (Building #32)
	Small quantities of lubricants, paints, solvents, adhesives, cleaning supplies and other potentially hazardous chemicals are used and stored in laboratories and workshops throughout the station.	

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**Appendix B Executive Summary “Decommissioning Cost Study for the Darlington Nuclear Generating Station” [R-14]**

**EXECUTIVE SUMMARY**

This study prepared for OPG by TLG estimates the decommissioning cost of the DNGS at \$3.994 billion (2022 CAD). The major contributors to the overall decommissioning cost are shown in Table B-1. The cost is based on several key assumptions, regarding regulatory requirements, estimating methodology, allowance requirements, low and intermediate-level radioactive waste, disposal site availability for radioactive waste management and site restoration requirements. A complete discussion of the assumptions used in this estimate is presented in Section 3 of [R-14].

NOTE: for the 2023 – 2027 Financial Guarantee liabilities calculations, the TLG cost estimates will be adjusted to incorporate costs from the Financial Guarantee year onwards and include oversight costs specific to the OPG decommissioning program.

The estimate includes a SWS period prior to the initiation of dismantling operations. Decontamination and dismantling activities are coordinated at the four DNGS units to optimize the project schedule and maintain continuity in the overall process.

Regulations

Guidance on nuclear station decommissioning in Canada is found in Regulatory Guide G-219, “Decommissioning Planning for Licensed Activities,” [R-2] promulgated by the CNSC. This document provides guidance regarding the preparation of decommissioning plans for activities licensed by the CNSC.

The CNSC summarized the statement on decommissioning in G-219 as follows: ‘The CNSC requires that an acceptable preliminary decommissioning plan be filed as early as possible in the life cycle of a licensed activity...The main roles of the preliminary decommissioning planning process and plan are to:...2) document a preferred decommissioning strategy which, in light of current knowledge, represents a technically feasible, safe and environmentally acceptable approach; and 3) provide a structured and dynamic outline for establishing and maintaining an acceptable financial guarantee program and preparing a detailed decommissioning plan.’

This statement is similar in philosophy to the U.S. Nuclear Regulatory Commission’s position on decommissioning: that adequate funds will be collected over the operating life of a nuclear facility, such that, at the end of its useful life, the facility may be removed from service safely, without endangering the health and welfare of the public. The basic intent of this requirement is the same for both Canada and the U.S.: that the estimates for performing this future work be reviewed and updated periodically to capture economic trends, technical advances in the performance of any field-related activities that would affect final decontamination and dismantling of a facility and changes in facility configuration or conditions.

This study addresses all activities necessary to comply with the applicable CNSC requirements, and includes those decommissioning activities and work stages defined by the CSA’s N294:19 ‘Decommissioning of facilities Containing Nuclear Substances’ [R-4].

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### Methodology

The methodology used to develop the decommissioning cost estimates for OPG follows the basic approach originally presented in the cost estimating guidelines<sup>14</sup> developed by the Atomic Industrial Forum (now Nuclear Energy Institute). This reference describes a unit cost factor method for estimating decommissioning activity costs. The unit cost factors used in this study reflect site-specific costs and the latest available information about worker productivity in decommissioning. The experience gained in the Shippingport Station Decommissioning Project, completed in 1989, as well as from TLG's involvement in the decommissioning planning and engineering for the Vermont Yankee, Chrystal River, Gentilly-2, Shoreham, Yankee Rowe, Trojan, Rancho Seco, Pathfinder, Big Rock Point, Maine Yankee, Oyster Creek, San Onofre-1 and Cintichem reactor facilities, is reflected in this estimate.

An activity duration critical path is used to determine the total decommissioning program schedule required for calculating the carrying costs, which include program management, administration, field engineering, equipment rental, and support services such as QA and security. This systematic approach for assembling decommissioning estimates has ensured a high degree of confidence in the reliability of the resulting costs, in line with CSA N294:19 requirements.

### Allowance

Consistent with accepted cost estimating practice, allowances are applied to the decontamination and dismantling costs developed as "specific provision for unforeseeable elements of cost within the defined project scope, particularly important where previous experience relating estimates and actual costs has shown that unforeseeable events which will increase costs are likely to occur."<sup>15</sup>

The cost elements in the estimate are based on ideal conditions and maximum efficiency; therefore, the types of unforeseeable events that are almost certain to occur in decommissioning, based on industry experience, are addressed through a percentage allowance applied on a line-item basis. This allowance factor is a nearly universal element in all large-scale construction and demolition projects. It should be noted that allowance, as used in this estimate, does not account for price escalation and inflation in the cost of decommissioning over the remaining operating life of the station and subsequent storage period.

The use and role of allowances within decommissioning estimates are not a safety factor issue. Safety factors provide additional security and address situations that may never occur. Allowance funds, by contrast, are expected to be fully expended throughout the program. The inclusion of allowance is necessary to provide assurance that sufficient funding will be available to accomplish the intended tasks.

### Low- and Intermediate-Level Radioactive Waste Disposal

The contaminated and activated material generated in the decontamination and dismantling of a commercial nuclear reactor is classified as low- and/or intermediate-level radioactive waste

<sup>14</sup> T.S. LaGuardia et al., "Guidelines for Producing Commercial Nuclear Power Plant Decommissioning Cost Estimates," AIF/NESP-036, May 1986.

<sup>15</sup> Project and Cost Engineers' Handbook, Second Edition, American Association of Cost Engineers, Marcel Dekker, Inc., New York, New York, p. 239.

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(LLW and ILW). OPG has developed both 'fixed' and 'schedule-sensitive variable unit' disposal charges for both classifications of waste based on disposing of these products at the long-term disposal facilities described in Section 4.4.1.3. Refer to Section 3.4.5 of the DNGS Decommissioning Costing Study [R-14] for a description of the applicable Darlington waste management disposal rates. Note: disposal fees include transportation to the waste facility, the applicable tariffs, fees and mileage-related expenses.

### High-Level Radioactive Waste

The disposition of high-level radioactive waste is limited to the used fuel generated from operations. This study includes the direct cost of removing fuel from the calandria to the fuel bays as a decommissioning expense after permanent cessation of operations. Other used fuel management costs are not considered and are accounted for separately by OPG.

### Site Restoration

Site restoration, which includes the demolition of "clean" structures, will occur promptly after the radioactive material has been removed from the station (site meets radiological release criteria).

Consequently, this study assumes that site structures within the restricted access area are removed to a nominal depth of one meter below the local grade level wherever possible. Foundation grade slabs greater than one meter in thickness will be abandoned in place and covered over with a layer of backfill. The site is then graded and stabilized.

### Summary

This study provides an estimate for decommissioning the DNGS under current requirements and is based on present-day costs and available technology. Tables are provided at the end of this section that summarizes the decommissioning costs by category and the costs organized by Work Breakdown Structure (WBS) element. The categories as used in the summary table include:

- Decontamination – The cost of decontaminating systems and structures.
- Removal – The cost of removing systems and structures.
- Packaging – The cost of packaging contaminated material for disposal.
- LLW and ILW Transportation and Disposal – The cost of transporting and disposing of contaminated material.
- Project Management – The cost associated with managing and supporting the decommissioning work activities.
- LLW and ILW long-term disposal facilities – Incremental decommissioning-related costs associated with the capital expenditures and decommissioning of the long-term disposal facilities (allocated among NGSs).

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- Management of Heavy Water – The costs associated with the long-term management of heavy water after station shutdown.
- Other – Those costs not directly associated with the cost categories described above, including – defueling, dewatering, any IA, energy, taxes, fees, insurance, overheads, etc.
- Allowance – The cost allocated to project allowance. This cost is applied to each WBS element and varies by element.
- Risk Contingency – The costs associated with decommissioning circumstances not included within specific WBS elements of the estimate. The risk contingency is included to address problems that are likely to occur beyond the project scope (i.e., unknown unknowns).

This information is extracted from the detailed WBS for each reactor unit and common systems/structures provided in Appendix C of the cost estimate [R-14]. The schedule and sequence of decommissioning activities are identified in Section 4 of the cost estimate [R-14]. A detailed breakdown of the major cost contributors to the decommissioning cost estimate is reported in Section 6 of the cost estimate [R-14].

This cost analysis is designed to provide OPG with sufficient information to assess its financial obligations, as they pertain to the eventual decommissioning of the DNGS. It is a cost estimate prepared in advance of the detailed engineering preparations required to carry out the decommissioning and is based upon current industry experience.

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Table B-1: Summary of Decommissioning Cost Estimate

Work Category	Costs Estimate 2022\$ CAD <sup>2</sup> (thousands) [R-14]
Decontamination	44,166
Removal	580,484
Packaging	187,090
LLW and ILW Transportation and Disposal	182,570
Project Management (Utility & DOC <sup>6</sup> )	755,117
L&ILW Disposal Facilities	162,294
Management of Heavy Water	117,869
Other <sup>1</sup>	1,123,590
<b>Sub-Total Direct Cost</b>	<b>3,153,180</b>
Allowance <sup>3</sup>	579,890
<b>Sub-Total Direct Cost with Allowance</b>	<b>3,733,070</b>
Risk Contingency <sup>4</sup>	261,315
<b>TOTAL</b>	<b>3,994,385</b>

**Note:**

- (1) Other includes: Engineering and preparations, insurance, taxes, energy, facility maintenance, defueling, dewatering costs, etc.
- (2) The column may not add due to rounding.
- (3) Allowance as a Percent of Direct Costs.
- (4) Risk Contingency as a Percent of Direct Costs with Allowance.

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**Appendix C Compliance Matrices with CSA N294:19 Annex A and this Plan**

**Table C-1: Compliance Matrix between CSA N294:19 and this Plan**

Section in CSA N294:19	Requirement in CSA N294:19	Section in This PDP
4.1	The owner of a nuclear facility shall be responsible for planning, executing, and funding all phases of decommissioning.	1.3 5.2
4.2	Decommissioning activities shall be planned and executed in accordance with relevant regulations and standards and in keeping with relevant guides.	1.2 1.4
	Responsibilities for decommissioning, preparing documents, and recordkeeping shall be clearly established throughout the life cycle of a facility. This responsibility includes planning and preparing for, executing, and completing decommissioning (i.e., until the final end-state objective has been achieved, all documentation completed, and all requirements satisfied).	1.3, 6.1, 6.2 11.0
4.3	Responsibility for the funding of the decommissioning shall be identified and financial guarantee shall be established to ensure adequate funding for decommissioning.	1.3, 5.2
	The owner shall consider the requirements of CSA N286 when executing decommissioning works, including the following: (a) protecting the health and safety of workers and the public; (b) protecting the environment; (c) complying with requirements of the AHJ; (d) keeping radiation exposures as low as reasonably achievable (ALARA); (e) managing all radioactive and hazardous materials generated by the decommissioning; (f) security; and (g) safeguards.	10.0 8.0, 8.2, 8.1.2, 8.1.3 7.0, 8.2.1 - 8.2.3, 8.3, 8.4 & 13.0 1.4 8.2 4.3.5, 4.4 9.1 9.2
4.4	Programs shall be developed and implemented to support decommissioning.	4.1.2, 4.1.4, 4.2, 4.2.3 This pertains to the execution phase.
5.1.1.3	A financial guarantee for decommissioning shall be established to ensure that adequate funding is available at the time of decommissioning. The financial guarantee for decommissioning shall be maintained throughout the life cycle of the facility.	1.3 5.2
5.1.6	The final end-state shall be considered reached when the end-state objectives as set in the DDP are verified to have been achieved (Annex F describes how to establish the end-state objectives).	4.3.9
5.1.7	The party accountable for decommissioning shall identify the applicable institutional control requirements following decommissioning as well as the available administrative processes in the jurisdiction in which they are located.	This will be done as part of preparing the DDP (see Section 4.2.4) 4.3.9, 4.3.10
5.2.5	Decommissioning records shall include, as applicable, a) the DDP(s);	11.0

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Section in CSA N294:19	Requirement in CSA N294:19	Section in This PDP
	<p>b) public and Indigenous engagement/communication records (as per CNSC REGDOC-3.2.2);</p> <p>c) if required by the AHJ, an impact assessment or environmental review in accordance with applicable legislation;</p> <p>d) licences and permits required for the decommissioning work;</p> <p>e) the plans and procedures used in decommissioning;</p> <p>f) reports and other documents that describe</p> <ul style="list-style-type: none"> <li>i) the criteria used to define radioactive and hazardous materials and to distinguish contaminated from uncontaminated materials;</li> <li>ii) the criteria used to define the final contamination status of the facility;</li> <li>iii) the principles and models used in deriving the criteria in Items i) and ii);</li> <li>iv) the residual radionuclide inventory after decontamination;</li> <li>v) the amounts of radioactive and hazardous materials removed and the disposition method;</li> <li>vi) waste management and transfer records;</li> <li>vii) the equipment and materials removed from the facility for recycling or use elsewhere, their treatment prior to removal from the site, and the disposition method;</li> <li>viii) the survey methods and the types of instruments used;</li> <li>ix) the equipment, nuclear and non-nuclear materials, and structures remaining at the end of decommissioning; and</li> <li>x) land remediation undertaken, results of verification analyses as compared to criteria used or derived for soil and water quality, and the disposition of affected media;</li> </ul> <p>g) reports, other documents, and photographs describing findings from inspections, modifications, and repairs to SSCs;</p> <p>h) reports and other documents that describe unplanned or unusual occurrences;</p> <p>i) results and interpretations of environmental monitoring programs;</p> <p>j) occupational dose records;</p> <p>k) deviations from plans and procedures;</p> <p>l) quality assurance records;</p> <p>m) storage-with-surveillance plans;</p> <p>n) facility inspection, maintenance, and equipment records;</p> <p>o) the final radiological and hazardous materials surveys; and</p> <p>p) interim and final end-state reports.</p>	<p>This pertains to records following the completion of decommissioning.</p>
<b>5.4.2</b>	The facility shall be characterized. See Annex G for guidance.	3.5 4.1.4.6, 4.3.8
<b>5.4.3</b>	All radioactive waste generated shall be characterized as per the CSA N292 series of Standards.	4.4
<b>5.5.1</b>	A strategy shall be developed for the management of all radioactive, hazardous, and conventional waste that will be generated throughout the course of the decommissioning. The	4.4

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Section in CSA N294:19	Requirement in CSA N294:19	Section in This PDP
	strategy should be based on good management practices including the waste hierarchy.	
<b>5.6</b>	A hazard assessment commensurate with the tasks to be performed shall be completed prior to decommissioning.	8.1
<b>5.8.1</b>	A quality assurance program shall be implemented.	10.0
<b>6.1.1</b>	A decommissioning strategy should be developed early in the life cycle of a facility (normally during the siting phase) and should be reviewed and updated as new information is obtained. The strategy should contain a high-level approach and rationale for decommissioning the facility, which will be further developed in decommissioning plans. The owner shall demonstrate that, under the strategy selected, the facility will be maintained in a safe configuration at all times.	1.3 3.4.1
<b>6.1.2.2</b>	In such cases where the end-state for in-situ decommissioning results in a waste disposal site, an applicant shall satisfy all regulatory requirements for a radioactive waste disposal facility and demonstrate safety via a safety case and post-closure safety assessment of a disposal facility. In-situ decommissioning is an acceptable practice for uranium mines and mills. Additionally, in-situ decommissioning may be considered a viable solution under exceptional circumstances (e.g., following a severe accident) or for legacy sites for which decommissioning was not planned as part of the design, and which will remain under institutional control for the foreseeable future. In order to align with international best practice, in-situ decommissioning should not be considered a reasonable decommissioning option for situations where removal is possible and practicable. Note: Legacy sites (in the Canadian context) specifically refer to research and demonstration facilities dating back to the birth of nuclear technologies in Canada for which decommissioning was not planned as part of the design.	N/A
<b>6.2.1</b>	For sites with more than one facility, a site decommissioning plan shall be developed to ensure that interdependencies are taken into account.	2.2.8 3.1 4.0
<b>6.2.3</b>	Cost estimates shall include all decommissioning activities from operations, during shutdown to the final release from regulatory control.  The cost estimate for decommissioning shall address the cost of the following principal activities, if applicable: a) preparation for final shutdown; b) site characterization, site surveys; c) facility shutdown activities; d) additional activities for safe enclosure; e) decontamination and dismantling activities; f) processing, storage and disposal of all waste including used fuel; g) project management, engineering, and site support; h) site clean-up, landscaping, and restoration; i) long-term management of radioactive waste and used fuel; j) long-term monitoring and maintenance of the site and institutional control; k) licensing costs; and	5.1 Appendix B

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Section in CSA N294:19	Requirement in CSA N294:19	Section in This PDP
	l) miscellaneous expenditures.	
<b>7.1.1</b>	Preparation for decommissioning shall include a) an assessment of the records from the previous life cycle stages and the state of the facility (e.g., baseline configuration) at the time of shutdown; b) an impact assessment or environmental review in accordance with applicable legislation, if required; c) a safety assessment for decommissioning; d) ensuring that there is a sufficient number of qualified staff to ensure safe operation during the approach to shutdown; e) further development of the PDP into the DDP; f) placing a facility in a permanent shutdown state; and g) any additional requirements specified by the AHJ.	4.1, 3.5 11.0  13.0  3.6, 4.1.2, 4.2.4, 8.1  4.1.3, 6.4  1.1, 3.3 4.1 (4.1.1 - 4.1.4) 1.2.1, 4.1
<b>7.1.2</b>	The owner shall ensure that processes, systems, and personnel are in place to maintain the facility in a safe state during the transition to decommissioning.	4.1, 8.2.1
<b>7.4.1.1</b>	To ensure a smooth transition from operation to decommissioning, the facility shall be prepared to complete stabilization activities as soon as practical after the permanent shutdown date.	4.1.4
<b>7.4.3</b>	During the transition period between shutdown and decommissioning, surveillance and maintenance shall be conducted to ensure the health and safety of persons and the protection of the environment.	4.1.1, 4.1.2, and 4.1.4
<b>7.5.1</b>	An assessment of the state of the facility shall be performed to provide baseline information for evaluating the hazards to be controlled during decommissioning. A thorough field survey shall be performed and supplemented by a review of existing records, as required.	3.6, 4.1.2, 4.1.4.3, 4.3.8, 8.1  3.5, 4.1.4.4, 4.1.4.6, 4.3.8, 8.2.1, 11.0
<b>7.5.2.1</b>	The following hazards shall be investigated and assessed: (a) radiological hazards; (b) biologically, chemically, and physically hazardous materials; (c) hazards from concealed or hidden services; and (d) structural hazards.	8.0, Table 8-1
<b>7.5.2.2</b>	Historical information shall be preserved that is relevant to the eventual decommissioning of the facility.	11.0
<b>7.6.1</b>	A DDP shall be developed for nuclear facilities, in accordance with Annex C and regulatory requirements, and submitted to the AHJ for acceptance.	1.1, 4.1.3, 4.2.4 These requirements pertain to the preparation for the Dismantling & Demolition phase.  Relevant for the DDP not the PDP.
<b>7.6.2.1</b>	The DDP shall meet the content provisions of Annex C.	4.1.3, 4.2.4

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Section in CSA N294:19	Requirement in CSA N294:19	Section in This PDP
<b>7.6.3</b>	<p>If deferred decommissioning is the preferred decommissioning strategy, in addition to a DDP, a SWS plan shall be developed.</p> <p>If a SWS plan is standalone, it shall be submitted to the AHJ.</p>	1.1, 4.1.3
<b>7.6.4</b>	<p>A safety assessment shall be performed to identify potential hazards to workers, the public, and the environment, from both routine decommissioning activities and credible accidents during decommissioning.</p> <p>The assessment shall describe the relative importance of the potential hazards and identify the methods for mitigating the risks associated with such hazards.</p> <p>If fissile material is involved, a criticality safety assessment and the planned actions involving fissile material shall be included.</p> <p>The assessment shall also address the residual risks to the public, if any, after decommissioning is completed.</p> <p>In-situ decommissioning may result in a waste disposal site. In such a case, an applicant shall satisfy all regulatory requirements for a radioactive waste disposal facility and demonstrate safety via a safety case and post-closure safety assessment of a disposal facility.</p>	<p>3.6, 4.2.4, 4.4.1.2, 8.0, Table 8-1</p> <p>N/A</p>
<b>7.6.5.1</b>	<p>The strategy for managing all wastes from decommissioning shall include a management plan covering both the short term and, where possible, the long term.</p>	<p>These requirements pertain to the preparation for the Dismantling &amp; Demolition phase.</p> <p>Relevant for the DDP, not the PDP</p> <p>4.2.2 4.2.4</p>
<b>7.6.5.2</b>	<p>The waste management program shall cover the following processes, as applicable:</p> <ul style="list-style-type: none"> <li>a) characterization;</li> <li>b) classification;</li> <li>c) minimization;</li> <li>d) segregation;</li> <li>e) clearance;</li> <li>f) handling;</li> <li>g) volume reduction;</li> <li>h) treatment;</li> <li>i) packaging;</li> <li>j) storage;</li> <li>k) transportation; and</li> <li>l) final disposition.</li> </ul> <p>Transportation requirements and the waste receiver's acceptance criteria shall be reviewed to ensure that the waste is appropriate for shipment and acceptable to the waste receiver.</p>	<p>These requirements pertain to the preparation for the Dismantling &amp; Demolition phase.</p> <p>Relevant for the DDP, not the PDP</p> <p>4.2.2 4.2.4 4.4</p>

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Section in CSA N294:19	Requirement in CSA N294:19	Section in This PDP
8.1.2	The work to be performed during the decommissioning shall be described in a DDP.	1.1, 4.1.3, 4.2.4
8.1.3	The physical work to be carried out shall be defined in terms of work packages and work procedures to the level of detail required for safe, effective, and efficient decommissioning.	These requirements pertain to the execution phase and are, as such, not applicable for this PDP. 4.2.2
8.1.7.1	Where decontamination is being used as part of decommissioning, the following shall be identified: <ul style="list-style-type: none"> <li>(a) the areas, locations, and equipment to be decontaminated;</li> <li>(b) the objectives of the decontamination (e.g., decontamination of equipment for salvage and reuse, decontamination of metals for recycling, decontamination of building foundations that are to remain in place, decontamination for clearance of materials to be disposed of as non-radioactive);</li> <li>(c) the decontamination methods to be employed; and</li> <li>(d) the residual level of radioactivity that is to be achieved.</li> </ul>	4.2.2, 4.3.1, 4.3.2, 4.3.3, 4.3.5, 4.3.7
8.1.8.1	A demolition plan shall be prepared.  The equipment and structures to be dismantled or demolished shall be identified.  The equipment and structures that are to remain at the completion of decommissioning shall also be identified.  Procedures for dismantling and demolition shall take into account the associated hazards.	4.2.4 4.3.1 - 4.3.5
8.1.8.2	The following factors shall be considered when selecting dismantling/demolition methods: <ul style="list-style-type: none"> <li>a) availability of professional competence associated with the operations of the chosen equipment;</li> <li>b) the equipment should be simple to operate, decontaminate, and maintain;</li> <li>c) remaining structural elements shall be kept in a physically stable state;</li> <li>d) measures to prevent unintentional releases to the environment;</li> <li>e) planned discharges to the environment shall be controlled as per licence conditions and previous commitments;</li> <li>f) when underwater dismantling and cutting is used, provisions shall be made to process the water to promote and assist in effluent treatment;</li> <li>g) the effect of dismantling tasks on adjacent systems and structures and on other work in progress shall be evaluated;</li> <li>h) waste containers, handling systems, and routes shall be defined before the start of dismantling work; and</li> <li>i) federal, provincial/territorial and/or municipal requirements.</li> </ul>	These requirements are relevant for detailed decommissioning planning and execution, as such, not applicable for this PDP.  4.2.2, 4.2.4
8.1.9.1	Surveys during decommissioning shall be performed to comply with <ul style="list-style-type: none"> <li>(a) worker occupational safety and radiation protection programs;</li> </ul>	4.3.8

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	(b) environmental monitoring criteria; and (c) processes to release materials and equipment from the site.	
<b>8.1.9.2</b>	At the completion of a decontamination or dismantling work package, a survey shall be performed, if required, to demonstrate that the planned end-state has been achieved.  The results of the survey shall be documented in a report that includes a) the criteria used to define the end-state; b) the methods and procedures used to ensure that the criteria were met; and c) the measurement data, including appropriate statistical analysis and systematic approaches.	4.3.8, 4.3.10
<b>8.2</b>	Where decommissioning of the facility is to take place in discrete stages, an interim end-state report shall be prepared when each planned interim end state is achieved.	4.1.4, 4.2.5, 4.3.5
<b>8.3</b>	A plan for surveillance, monitoring, physical protection, and maintenance of the facility during such periods shall be developed and implemented to (a) maintain the facility in a safe state; (b) control the release of materials to the environment; and (c) prevent access by unauthorized persons; and (d) mitigate infestations of vermin and other organisms.	4.1, 4.2, 4.3
<b>8.4</b>	Lands associated with a facility or a standalone site that might have been impacted by previous nuclear activities shall be remediated to the degree required to meet the end-state criteria.	4.3.7, 4.3.9
<b>8.5</b>	At the completion of this phase, final surveys of residual radioactive and hazardous materials shall be performed and documented to demonstrate that the final end-state for remaining equipment, structures, and the site has been achieved in accordance with the criteria specified in the DDP.  The results of the final survey shall be documented in a report that includes a) the criteria used to define the end-state; b) the methods and procedures used to ensure that the criteria were met; and c) the measurement data, including appropriate statistical analysis and systematic approaches.	4.3.8
<b>9.1</b>	Following the completion of decommissioning, a final end-state report shall be prepared and retained.  Where a decommissioning program involves completing a number of separately approved decommissioning projects, interim end-state reports shall be submitted for each project.	4.1.4, 4.2.5, 4.3.5, 4.3.10

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Table C-2: Compliance Matrix between CSA N294:19 Annex A and this Plan

Section in CSA N294:19 Annex A	Requirement in CSA N294:19	Section in This PDP
<b>A.2 (a)</b>	A PDP may include the following: a description of the location of the facility, including (i) a map of the facility and its specifications; (ii) geographic information; (iii) details regarding the surrounding environment; (iv) land uses; and (v) illustrations and maps of the facility in relation to the municipality;	Figure 2-1, Figure 2-2 2.1 2.3 2.1, 2.3.4 7.2
<b>A.2 (b)</b>	purpose and description of the facility, including (i) primary components and systems; (ii) building type and construction, including location of any hazardous building materials (e.g., asbestos, PCBs); (iii) building services (e.g., power, heating, ventilation, sewer, water, fire protection); (iv) laboratories and other hazardous handling areas; (v) type, quantity, and form of radioactive and hazardous materials stored, produced, or used during operation; and (vi) design features used to reduce the spread of contamination and facilitate decontamination and dismantling;	2.2 Figure 2-2, Figure 2-4 2.2, 4.4.2.1, Appendix A 2.2.4 2.2 Appendix A, 2.2.5
<b>A.2 (c)</b>	post-operational conditions, including (i) a summary of the shutdown process, including planned removal of stored inventories of hazardous materials or radioactive materials; (ii) the predicted nature and extent of contamination remaining in the primary systems and components (in list or table format with reference to applicable illustrations); (iii) the predicted nature and extent of contamination on floors, walls, work surfaces, ventilation systems, etc.; and (iv) the identification of any separate planning envelopes; and (v) an overview of the principal hazardous conditions anticipated to exist	4.1, 4.1.4, 4.1.4.5  3.5, Table 4-1 Appendix A, 3.5, 4.1.4.6 3.4.2, 4.2.4  8.0
<b>A.2 (d)</b>	the decommissioning strategy, including (i) the final end-state objective; (ii) rationale for (1) the decommissioning strategy selected; (2) interim end states; (3) periods of storage with surveillance; and (4) in-situ decommissioning concepts; (iii) the requirements for long-term institutional controls; and (iv) the assessment of alternative strategies (or a rationale for why alternatives do not exist or do not warrant consideration);	3.2 3.4 3.2, 4.3.9  3.4.1  N/A: No long-term institutional controls will be established. 3.4.1, 3.4.3
<b>A.2 (e)</b>	a plan of the decommissioning work, including i) a work breakdown structure; ii) a summary of the main steps for decontamination/disassembly/removal of each of the systems (preferably grouped into work packages);	4.0, 4.3.1 - 4.3.4 Appendix B

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	<ul style="list-style-type: none"> <li>iii) for each work package, identification of those types of activities that could pose a significant hazard to workers, the public, or the environment;</li> <li>iv) the role of existing operational standard procedures for radiation protection, hazardous materials handling, industrial safety, and environmental protection in managing hazards;</li> <li>v) specific activities for which additional protection/mitigation procedures will be required at the detailed planning stage;</li> <li>vi) a summary of the final dismantlement of the structures; and</li> <li>v) a conceptual schedule showing the approximate year of facility shutdown and the approximate sequencing and duration of the decommissioning work packages and, where relevant, storage periods;</li> </ul>	<p>Table 8-1, 8.2, 8.3</p> <p>4.1, 8.2, 8.3</p> <p>4.2.2, 4.2.4</p> <p>4.3.9, 4.3.10</p> <p>4.0</p> <p>Figure 4-1</p>
<b>A.2 (f)</b>	<p>radiological monitoring and survey commitments, including</p> <ul style="list-style-type: none"> <li>(i) a program for conducting periodic contamination surveys and the recording of contamination events during facility operation;</li> <li>(ii) a commitment to conduct detailed post-operation surveys in support of DDP development;</li> <li>(iii) a commitment to develop plans and protocols acceptable to the AHJ at the detailed planning stage for monitoring                             <ul style="list-style-type: none"> <li>(1) work hazards during decommissioning;</li> <li>(2) personnel dosimetry;</li> <li>(3) environmental emissions and effluents; and</li> <li>(4) materials, sites, and structures to be cleared from regulatory control;</li> </ul> </li> </ul>	<p>4.2.3, 4.3.8</p> <p>4.1.4.4, 4.1.4.6, 4.3.8</p> <p>4.1.1, 4.2, 8.0, 8.1.1, 8.2.1 - 8.2.3, 8.2</p> <p>4.3.6, 4.3.7</p>
<b>A.2 (g)</b>	<p>a waste management strategy specifying</p> <ul style="list-style-type: none"> <li>(i) the approximate quantities and characteristics of radioactive and chemically hazardous wastes expected to arise from the decommissioning (tied to specific work packages, if possible);</li> <li>(ii) the anticipated final disposition of radioactive and chemically hazardous materials; and</li> <li>(iii) a commitment to segregate as much material as possible for reuse and recycling;</li> </ul>	<p>4.4, 4.4.1, 4.4.2, Table 4-2</p> <p>1.5, 4.3, 4.3.1, 4.3.2, 4.3.3, 4.3.5, 4.4.3</p>
<b>A.2 (h)</b>	<p>a commitment to prepare a DDP for regulatory approval prior to dismantling and demolition;</p>	<p>4.2.4</p>
<b>A.2 (i)</b>	<p>a commitment to prepare a DDP or final decommissioning plan for regulatory approval prior to decommissioning and, if possible, one year prior to the scheduled shutdown of the facility;</p>	<p>1.1</p>
<b>A.2 (j)</b>	<p>the physical state of the facility at</p> <ul style="list-style-type: none"> <li>(i) the end of operations; and</li> <li>(ii) the start of decommissioning;</li> </ul>	<p>3.5</p> <p>4.0, 4.1</p>
<b>A.2 (k)</b>	<p>the records required for decommissioning, including a description of the facility operational records that will be maintained to periodically update the PDP and prepare the DDP(s); and</p>	<p>11.0</p>
<b>A.2 (l)</b>	<p>a public consultation plan, including a public information program and avenues for public participation.</p>	<p>12.0</p>
<b>A.2 (m)</b>	<p>an Indigenous engagement plan as per the requirements and guidance of CNSC REGDOC-3.2.2; and</p>	<p>12.0</p>
<b>A.2 (n)</b>	<p>the cost and a financial guarantee, specifying</p> <ul style="list-style-type: none"> <li>i) an estimate of the total present-value cost of the decommissioning;</li> <li>ii) a reasonable basis for how cost estimates were derived; and</li> </ul> <p>a description of how the required funds will be provided;</p>	<p>5.1, 5.2</p> <p>Appendix B</p>

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**Table C-3: Compliance Matrix between CSA N294:19 Annex I and this Plan**

Item	CSA N294:19 Annex I	Section in this Plan
<b>I.2.2</b>	When the decision is made to permanently shut down and physically decommission the reactor, a planned process shall be followed to render the reactor to a predetermined final end state condition, release the reactor from licence control, and implement any required institutional controls.	1.1, 4.0
<b>I.3.2</b>	The management accountable for each life-cycle phase shall (a) consider the impact of their activities on the eventual decommissioning; (b) ensure that the reactor conforms to the design basis; and (c) preserve documents and records relevant to decommissioning.	4.0 11.0
<b>I.4.3.1</b>	The level of planning detail builds up through the life cycle. During operation a stand-alone plan is required. Management shall perform the necessary planning, based on the results from assessments, the design and the safety analysis, to establish the objectives, the strategies and the cost estimates for the decommissioning of the reactor.	3.2 3.4 3.4.2.1 5.0 Appendix B
<b>I.4.3.2</b>	In addition to Clause 6.2.1, the plan shall include a) a description of the site, including all of the facilities on the site and adjacent to the site; b) a description of the reactor and its auxiliary facilities; c) a description of the common and interdependent SSCs and work; d) identification of i) the planning assumptions; ii) proposed end-state criteria; iii) uncertainty and degree of conservatism; and iv) the planned decommissioning strategy; e) an outline of the proposed scope of work and schedule to complete the decommissioning. This includes a description of the proposed start date, end date, and milestones. There should be a broadly scoped and generally described work breakdown structure that will require further detailed planning as described in Clause I.4.4; and f) identification of the expected inventory of waste and surplus items that will result from decommissioning and their final disposition.	2.1, 2.2, 2.2.8  2.2.2, 2.2.3 2.2.4, 2.2.5, 2.2.6, 2.2.7 1.5 4.3.9 3.6 3.4  4.0  4.4.1.1, 4.4.2, 4.4.3
<b>I.5.1.1.1</b>	The reactor shall be safely shut down and its SSCs shall be placed in a safe state in preparation for decommissioning.	4.1, 4.2
<b>I.5.1.1.2</b>	During final shutdown, the following actions shall be performed: (a) Implementing the defueling, dewatering and waste management plan; (b) Establishing operating controls for the SSCs that will remain in operation during the remaining stages of decommissioning (e.g., the used fuel system); (c) Placing each SSC in a pre-defined interim end-state.	4.1 (4.1.1 - 4.1.4)
<b>I.5.1.1.4</b>	Additionally, programs in place during operations shall be reviewed, revised, and/or eliminated to ensure that requirements for the remaining stages of decommissioning are covered. Such examples include, but are not limited to, environmental monitoring, emergency response, and fire protection.	4.1.2 4.2
<b>I.5.1.2.1</b>	SWS (sometimes referred to as “storage with surveillance”) shall include the period when the reactor is under surveillance while the radioactivity decays and/or until the prerequisites for dismantling and demolition are achieved.	4.2

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<b>Item</b>	<b>CSA N294:19 Annex I</b>	<b>Section in this Plan</b>
<b>I.5.1.2.2</b>	During this stage, the following actions shall be performed: (a) Conducting planned surveys; (b) Removing the nuclear fuel from the spent fuel bay to dry storage; (c) Placing the spent fuel bay and auxiliaries in a pre-defined end state for future decommissioning; and (d) Ongoing removal of radioactive waste.	4.2 4.2.1 4.2.2
<b>I.5.2</b>	During this stage, the reactor shall be subjected to the planned decontamination, dismantling and demolition, and any resulting materials will either be a) decontaminated to meet release criteria; or b) disposed of into a waste facility.	4.3, 4.3.5 4.3.1 4.3.2 4.3.3 4.3.5, 4.4.1.1, 4.4.1.2, 4.4.1.3
<b>I.5.3</b>	Site restoration shall include a) disposing of hazardous substances; b) restoring the topography (for example, by restoring the landscape); c) restoring vegetation; d) removing the licence and making the site available for other use; and e) preparing the final end-state report in accordance with Clause 9.1 and Annex E.	4.4.2.3 4.3.7 4.3.9