
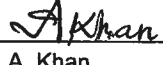
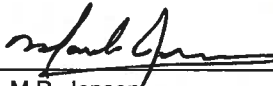

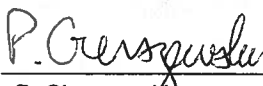




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NUCLEAR WASTE MANAGEMENT ORGANIZATION SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

ONTARIO POWER GENERATION'S DEEP GEOLOGIC REPOSITORY FOR
LOW AND INTERMEDIATE-LEVEL WASTE
PROJECT REQUIREMENTS

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Revision Summary		
Revision Number	Date	Comments
R002	22 Sept 2010	<ul style="list-style-type: none"> • Document name – changed from “System Requirements” to “Project Requirements” • General – minor changes to wording throughout for clarification • General – changed “repository facility” to “DGR facility” throughout • Sec 1.1 – removed reference to Conceptual Design Report • Sec 1.2 – updated to 1st paragraph • Sec 1.3 – update lists of structures, systems, equipment and components • Sec 1.4 – update to state glossary now available in Appendix A. • Sec 3.3 and 3.4 – clarified language around required performance as per OPG request. • Sec 4 – updated to clarify interfacing. Sec 4.2 – deleted old text and added new interfacing requirement for DGR environmental monitoring systems. Sec 4.5 reflects new OPG requirement re access for workers and visitors. • Sec 5.2 – update to clarify required payload capacity of waste handling cage. • Sec 5.3 – new requirement specifying inside dimensions of waste handling cage. Following sections renumbered. • Section 5.5 (old 5.4) – changed requirement for pillar width between rooms. • Sec 7.1 – changed words to clarify required underground location of repository • Sec 7.6 – new requirement for rock support design. Following sections renumbered. • Sec 7.10 (old 7.9) – clarified placement of LLW and ILW packages in rooms. • Sec 8.2 – clarified functions of closure wall • Sec 8.5 – new requirement stating functions of room wall. • Sec 9 – added footnote to clarify use of shaft seal system requirements. • Sec 10.5 – added new requirement regarding minimization of condensation. • Sec 11.2 – updated to clarify that operational control and monitoring will only occur at surface. • Sec 11.3 – updated to clarify application of ALARA • Sec 12.1 – updated text to clarify availability requirements for operation of DGR. • Sec 12.4 – updated requirement to specify minimum top elevation of all structures providing access to underground. • Sec 14.1 (f) – new requirement for ground water monitoring. • Sec 14.2 – updated to include reference to OSHA and OPG's RPRs. • Sec 14.4 – updated to clarify scope of inspection activities at DGR. • Sec 15.1.2 – updated to clarify • Sec 15.1.4 – reword to clarify requirement • Sec 15.2 – update list of requirements for occupational safety • Sec 18.2 (old) – removed and other sections renumbered. • Sec 19.5 – new section with electrical codes and standards; renumbered following sections

		<ul style="list-style-type: none">• Sec 19.9 – added CAN/CSA-S16.1• Sec 19.10 – removed reference to rock mass rating systems as per recommendation of TRG and replaced with a reference to use best practice.• Sec 19.12(d) – update document names• Sec 19.12(e) (new) – reference to NWMO Design Management procedure• Sec 22.2 – new requirement for records management• Sec 23 – updated list of technical references• Appendix A – added glossary
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1.0 OVERALL FACILITY DEFINITION

1.1 Introduction

Low- and intermediate-level radioactive waste (L&ILW) that is produced during the operation and refurbishment of Ontario Power Generation (OPG)-owned or operated reactors is stored centrally at OPG's Western Waste Management Facility (WWMF). OPG has initiated a project to construct a Deep Geologic Repository (DGR) on the Bruce nuclear site to provide long-term management of these wastes. The Nuclear Waste Management Organization (NWMO) is managing, on behalf of OPG, all design activities for the DGR facility. NWMO is supporting OPG in their application to obtain a Canadian Nuclear Safety Commission (CNSC) Site Preparation & Construction Licence for the DGR with OPG being licensee.

The preliminary waste acceptance criteria (WAC) have been defined for the DGR facility (hereafter referred to as "DGR WAC") [R-1].

1.2 Purpose and Scope

These Project Requirements shall direct all aspects of design work for the DGR facility. These Project Requirements establish performance standards to be met by the DGR facility. Tests will be conducted during commissioning to confirm DGR facility can meet these performance standards

Unless otherwise specified, these requirements do not apply to the structures, systems, equipment and components that would be used to retrieve L&ILW from the existing engineered storage facilities or transfer the resultant waste packages to the surface receiving area of the DGR facility.

1.3 Key Structures, Systems, Equipment and Components

The DGR facility will consist of surface and underground structures. The key surface structures will be buildings that are used to receive waste packages, to house equipment such as hoisting and ventilation equipment, and to provide space for various amenities. A key non-building structure will be the waste rock pile and associated storm water management facilities. The key underground structures will be comprised of shaft access-ways, emplacement rooms and tunnels, and any barriers or seals that would be constructed in these underground openings.

While in operation, the DGR facility will function using the following systems (representative list and not meant to be complete):

- Waste package receipt, transfer and handling
- Waste package tracking
- Personnel transfer
- Heating and ventilation
- Electrical power and lighting
- Communications including emergency communications
- Compressed air

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- Potable and non-potable water
- Conventional waste collection and handling
- Drainage (surface and underground) including storm water management
- Normal and emergency pumping and water handling
- Underground rock support and lining (for shafts, access tunnels, emplacement rooms)
- Occupational, environmental and radiological monitoring
- Rock mass monitoring (i.e., performance monitoring in context of shaft and excavation stability)
- Security
- Fire protection
- Emergency electrical power
- Fuel or energy supply for equipment (e.g., diesel)
- Emergency evacuation and emergency response

During decommissioning the DGR facility will function with all of the aforementioned systems (except those directly related to waste package handling) as well as the following system:

- Sealing material receipt, preparation, storage, handling and placement (decommissioning only)

The key equipment and components in the DGR facility are (representative list and not meant to be complete):

- Shaft hoisting equipment
- Above-ground waste package and material handling equipment
- Underground waste package and material handling equipment
- Heating and ventilation equipment and associated ducting
- Electrical power and lighting equipment
- Emergency diesel-powered electrical generator
- Compressed air equipment
- Below-ground fuel storage and transfer equipment
- Communications equipment
- Potable and non-potable water supply equipment
- Sanitary waste handling equipment
- Drainage system and pumping equipment
- Monitoring equipment including radiological monitoring equipment
- Fire detection and suppression equipment
- Refuge stations
- Underground offices and amenities
- Underground maintenance area and supplies
- Emergency sump equipment
- Above-ground offices and amenities

1.4 Definitions

A glossary is provided in Appendix A and defines selected terms used in this document. Other definitions are provided in the DGR Project Glossary [R-2]. If there

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is conflict between a definition in Appendix A and the corresponding definition in the DGR Project Glossary, the definition in Appendix A shall take precedent.

2.0 FUNCTIONAL REQUIREMENTS

- 2.1 The DGR facility shall be capable of receiving, inspecting, tracking, handling and emplacing operational L&ILW from OPG-owned or operated stations and L&ILW generated during refurbishment projects at OPG-owned or operated nuclear stations.
- 2.2 During the preclosure period, the DGR facility shall be capable of supporting all aspects of an underground geoscience verification and monitoring program. Support would include providing office space for staff, underground space for equipment including access to the rock for testing, and support services necessary to implement the sampling, testing and measurement activities.
- 2.3 During the preclosure period and following the start of waste emplacement operations, the DGR facility shall be capable of supporting all aspects of construction to create additional emplacement rooms in the repository, as necessary (e.g., mining support facilities, excavated rock stockpiles, access to repository for excavation operations and explosives transfers, and rock mucking) (related to 11.4).
- 2.4 During the preclosure period and following completion of waste emplacement operations, the DGR facility shall be capable of supporting all aspects of an extended monitoring program. The DGR facility shall be available for personnel access to all major underground service areas and open access tunnels to carry out monitoring activities and to maintain the monitoring installations.
- 2.5 The closed repository, including shaft seals, and the surrounding geosphere shall passively contain and isolate the radioactive waste so as to protect the environment, and the health and safety of persons.

3.0 PERFORMANCE REQUIREMENTS

- 3.1 The DGR facility shall be available to receive L&ILW packages at the earliest practical time commensurate with the regulatory approvals process.
- 3.2 The initial repository configuration shall have sufficient capacity to accept a total emplaced waste volume of about 200,000 m³, with waste types specified in the latest revision of [R-3].
- 3.3 The DGR facility shall be designed so that it is capable of receiving and handling LLW packages at a throughput rate of approximately twenty-four (24) packages per 8-hour shift. This performance standard is based on an assumption that only LLW packages are being handled at the DGR facility during the 8-hour shift.
- 3.4 The DGR facility shall be designed so that it is capable of receiving and handling 3 m³ resin liners at a throughput rate of approximately four (4) liners per 8-hour shift. This performance standard is based on an assumption that only resin liners are being handled at the DGR facility during the 8-hour shift.

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- 3.5 The DGR facility shall be designed, constructed and operated so that the release of potentially contaminated air (including flammable/explosive gases), water (e.g., sump water from DGR, run-off from waste rock pile), and solids (e.g., dust, particulates in water) from the facility has radiological and chemical contaminant concentrations and amounts that are below regulatory limits.
- 3.6 The repository shall be designed, constructed, operated, decommissioned and closed in such a manner that excessive subsidence of the overlying rock formations will not occur. The subsidence would be considered excessive if it adversely affects the barrier properties of the overlying Ordovician shale formations (related to 7.2 and 7.3).

4.0 INTERFACING REQUIREMENTS

- 4.1 The Waste Package Receiving Building (WPRB) shall interface with equipment transferring waste packages originating at:
- (a) WWMF storage structures; and
 - (b) Waste Volume Reduction Building (WVRB) (and any other waste processing facility constructed at the WWMF).

The DGR will not receive truck deliveries of waste packages directly from nuclear stations.

- 4.2 Environmental monitoring systems at the DGR facility shall be compatible with environmental monitoring systems at WWMF and Bruce nuclear site-wide environmental monitoring systems.
- 4.3 The DGR facility shall interface with the existing infrastructure on the Bruce nuclear site. To the degree that is practical, the DGR facility shall make use of existing services (e.g., domestic and fire water, sewage and stormwater, dosimetry, effluent monitoring, security, emergency response, and other miscellaneous services) to support construction, operation, decommissioning and closure activities. An agreement shall be established with Bruce Power through the Bruce Site Services Agreement to ensure these services will be available when needed.
- 4.4 For waste transfer, the DGR will interface with WWMF via a crossing over the abandoned railway. The headframe of the waste package-handling shaft (main shaft) shall be located as close as practical to WWMF; i.e. less than 300 m from WWMF fence line near proposed crossing location.
- 4.5 DGR staff and visitors will park at the DGR. DGR staff will have full stand-alone amenities (change rooms, lunchroom, badge rack, offices, meeting rooms), with amenities design based on same at OPG's Darlington Used Fuel Dry Storage Facility. DGR visitors will be received, badged and briefed at the DGR.
- 4.6 The heaters in the underground ventilation system shall use electrical power.
- 4.7 The DGR facility shall have a waste package tracking system and it shall be capable of interfacing with OPG's waste tracking system for the WWMF.

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5.0 DESIGN LIMITS

- 5.1 The DGR facility shall be capable of supporting waste emplacement operations for at least 100 years. This time period includes a period for extended monitoring and decommissioning following end of waste emplacement operations, as needed.
- 5.2 The waste handling cage in main shaft shall be capable of handling of a waste package or multiple waste packages with a total mass up to 35 tonnes plus mass of any transfer vehicle (e.g. rail cart) and associated attachments that may accompany waste package while being transferred underground.
- 5.3 The waste handling cage in main shaft shall be capable of receiving a payload comprised of a waste package(s) on a transfer vehicle (e.g. rail cart) which has maximum footprint dimensions of 2.65 m wide and 5.2 m long. The dimensions for the majority of waste packages to be received at DGR facility are specified in [R-3]. Final dimensions for any waste packages produced by segmentation (e.g. steam generator segments, heat exchanger segments) will be set by internal cage dimensions and/or the mass limit in 5.2.
- 5.4 To allow for uncertainties in future waste volumes, the repository layout shall be such that it is possible to increase waste capacity to a disposal volume up to 400,000 m³ with little to no change to the DGR facility infrastructure except for number of emplacement rooms and expansion of waste rock pile.
- 5.5 The width of the rock pillar between adjacent emplacement rooms shall have a dimension that is no less than twice the average effective width of the adjacent emplacement rooms¹.
- 5.6 The DGR facility shall have a ground surface area(s) for the storage of waste rock and the area(s) shall have the capacity to store all waste rock produced by the underground excavation of the repository (related to 3.2 and 5.4).

6.0 SEISMIC AND ANTHROPOGENIC VIBRATION REQUIREMENTS

- 6.1 The occurrence of a seismic ground motion event, as specified in the National Building Code (NBC) [R-5], shall not lead to a structural failure in DGR surface facilities during the operational life of the facility (related to Section 5.1).
- 6.2 The use of explosives shall not have any significant adverse impacts on the operations of any other facility on the Bruce nuclear site, and the natural environment (e.g., fish populations in nearby waters).
- 6.3 The potential for and possible impacts of rock bursts shall be assessed and, if necessary, provisions shall be included in the repository design for remedial measures.

¹ An estimate of effective emplacement room width must take into account the possible presence of highly damaged rock beyond the minimum excavation lines for rooms.

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7.0 DESIGN CONSTRAINTS

- 7.1 The underground footprint for repository with a 200,000 m³ emplaced waste volume capacity shall be located within the boundaries on the DGR Project Site (see Hatch Drawing No. 323874-DGR-602-001).
- 7.2 The repository shall be constructed in the argillaceous limestone Cobourg Formation at a nominal depth of 680 m below ground surface.
- 7.3 The repository shall be designed to have no adverse impact on the long-term integrity of natural barrier attributes of the repository site.
- 7.4 There shall be flexibility in the repository layout and design so that design and layout changes can be implemented if adverse rock conditions are encountered during construction, or if other factors require that such changes be made.
- 7.5 To the degree that it is practical and necessary, sizes of emplacement rooms and access tunnels and orientations of these openings within the in situ stress field shall be optimized so as to minimize overstressing around openings, to promote long-term stability, and to minimize rock support system maintenance requirements. (related to 8.1 and 13.4).
- 7.6 Rock support for underground openings shall be designed taking into account the expected range of rock conditions along the depth/length of the shafts and at the repository level.
- 7.7 The horizontal distance between the surface expression of any part of the repository containing L&ILW and the shoreline of Lake Huron shall not be less than 750 m, and where practical this separation distance shall be maximized. The Lake Huron shoreline position in the vicinity of Bruce nuclear site means shoreline position as shown on Hatch Drawing No 323874-DGR-602-001.
- 7.8 The ventilation discharge from the repository shall be located at a sufficient distance from the ventilation inlet and other normally inhabited areas to ensure discharge air and water are neither re-introduced into the repository nor fall-out on surface in concentrations which may be harmful to persons or the environment. Prevailing winds and their effect on the exhaust plume from the ventilation discharge shall be taken into account in determining the location of the ventilation discharge.
- 7.9 No part of the DGR surface facilities shall be constructed within 100 m of a high-voltage transmission power line or the base of a transmission tower. In planning the location of the DGR surface facilities, possible future location(s) of new transmission line corridors shall be considered.
- Ontario Regulation 213/91, Construction Projects, specifies safe approach distances when working in the vicinity of power lines.
- 7.10 The DGR facility shall be designed based on the principle that LLW packages and ILW packages should be segregated into separate rooms. However each room type may be located adjacent to each other within the repository. Exceptions to this principle will

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be allowed only if the mixing of LLW and ILW in a room will not compromise operational and postclosure safety.

- 7.11 The separation distance between any part of the repository and an existing or planned deep exploration borehole shall be no less than 100 m and where practical this separation distance shall be maximized [R-4]. The location and underground orientation of all existing deep exploration boreholes in the vicinity of proposed DGR facility is shown on Hatch Drawing No 323874-DGR-602-001.

8.0 CLOSURE WALLS, ROOM WALLS, AND PACKAGE RETRIEVABILITY

- 8.1 Once filled with waste packages, a group of emplacement rooms shall be isolated by a single closure wall that is constructed in the adjacent access tunnel (related to 13.4).

- 8.2 The functions of a closure wall are:

- (a) To minimize airflow into and out of the space that is being isolated by the closure wall;
- (b) To minimize release of potentially contaminated air (e.g., tritiated air) from the space that is being isolated by the closure wall and, in particular, from the waste-filled rooms;
- (c) To restrict entry into area that is being isolated by the closure wall; and
- (d) To contain an air blast due to a potential explosion and/or rock fall in one or more emplacement rooms².

- 8.3 Although there is no intention to retrieve waste following emplacement, it shall be possible to easily retrieve³ the emplaced waste packages until such time when a group of emplacement rooms are isolated by a closure wall.

- 8.4 If any design provisions are made to allow retrieval, they shall be designed to have no adverse effect on either operational or postclosure safety.

- 8.5 A wall or barrier will be installed at the entrance of a waste-filled room, if necessary, to:
a) control ventilation system airflow into room, b) limit spread of fire in remote event of fire inside the room, c) prevent release of potentially contaminated air, and/or d) control worker entry into the room.

² For purposes of designing the closure wall, NWMO will specify loading on closure wall due to a potential air blast.

³ Easy retrieval means that the waste packages can be removed with the same equipment and procedures used to originally emplace the packages within a room but where the procedures are applied in reverse order. Easy retrieval does not mean that it should be possible to directly access any particular waste package within a waste-filled room for purpose of retrieval from the room. It is recognized that T-H-E liners may not be easily retrievable after emplacement.

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9.0 SHAFT SEAL SYSTEMS⁴

- 9.1 The effective bulk hydraulic conductivity of the shaft sealing system coupled with annular zone of potentially damaged host rock around shaft shall be equal to or less than 10^{-10} m/s.
- 9.2 The sealing system materials and design shall be compatible with chemical and mechanical conditions within surrounding host rock and pore fluid (related to 10.4).
- 9.3 The sealing systems shall be designed so as to prevent subsidence of sealing materials.
- 9.4 Sealing systems shall be designed so that they can be constructed using existing construction technologies and materials.
- 9.5 Sealing systems shall be designed to prevent cross-formational ground water flow and mixing via a shaft (related to 19.11 (a)).
- 9.6 The shaft sealing systems shall be capable of withstanding an internal gas pressure of 14 MPa without failure of the seal systems. The gases would be generated by degradation of organic wastes and corrosion of metals within the repository after closure, and natural gases that may seep into underground openings.
- 9.7 The sealing systems shall passively maintain their function over the long-term without need for maintenance or replacement.

10.0 ENVIRONMENTAL REQUIREMENTS

- 10.1 The DGR facility shall be designed, constructed and operated in such a manner so as to create an environment that:
- (a) is safe for workers and other persons entering the facility;
 - (b) will help ensure the structures, systems, equipment and components in the repository maintain their integrity as per performance requirements;
 - (c) will help ensure waste packages retain their integrity as required to meet requirements in Section 8; and
 - (d) minimizes radiological and chemical contaminants (air, water or solids) released into the underground and surface environments.
- 10.2 The HVAC system for surface facilities and ventilation system for underground facilities shall be designed for local climatic conditions as specified in the [R-5] and as

⁴ These requirements have been used to develop the preliminary design for the shaft seal system. The full set of requirements for final design of shaft seal system design will likely be developed several decades in the future when an application for a CNSC Decommissioning Licence is submitted. The final design requirements will be based on the best knowledge about construction materials, and methodology for shaft sealing that is available at that time.

defined in the Environment Canada databases, whichever is more adverse. The ventilation system shall deliver air to the repository horizon so that temperature, humidity and quality are within the limits for underground workers in accordance with American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) (related to 19.6(b)) and American Conference of Government Industrial Hygienists (ACGIH) principles (related to 19.6(c)).

- 10.3 The DGR facility shall be designed, constructed and operated in such a manner that there is minimal contact of water (i.e., precipitation, dripping or seeping groundwater, or condensate) with the waste packages. There shall be no standing water in open emplacement rooms, access tunnels and the underground service area except in sumps.
- 10.4 The repository and its engineered features shall be designed taking into consideration the expected physical conditions (e.g., rock properties, in situ stress, ground water pressures and ambient temperature and humidity) and chemical conditions (e.g., 100 to 300 g/L pore water salinity; primarily sodium, calcium and chloride brines) within the rock mass hosting the repository.
- 10.5 The DGR facility shall be designed, constructed and operated to minimize the amount of condensation occurring within or near the exhaust ventilation shaft and surface exhaust ventilation fans. In particular condensation should be minimized where condensate contains tritium and carbon-14.

11.0 OPERABILITY REQUIREMENTS

- 11.1 The repository shall be capable of operating year-round (i.e. 365 days per year and 3 shifts per day) with specific times reserved for shaft inspections and maintenance.

The facility is expected to operate on the order of 200 days per year, one shift per day, but may operate multiple consecutive shifts during specific emplacement campaigns.
- 11.2 During DGR operations, primary operational control and monitoring of the DGR facility will be executed from the Control Room. Monitoring includes the real-time and continuous monitoring of the safety, environmental and operational status of the DGR facility, as required, per OPG monitoring standards. Local alarms shall be provided.
- 11.3 The ALARA principle will be used in design of repository and in particular design waste handling operations in the emplacement rooms so as to minimize worker dose.
- 11.4 During the operational phase, it shall be possible to perform underground construction. However, emplacement operations and underground development/rock excavation shall not be performed concurrently (related to 2.3 and 18.3).
- 11.5 The DGR facility operations shall support an on-going program to collect various types of data relevant to repository performance including data on excavation response, groundwater flow and chemistry, gas generation, seismicity, surface biosphere, and releases into surface environment (related to Section 14).

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- 11.6 Waste packages shall be handled in a manner that minimizes the possibility of accidentally being dropped, minimizes potential drop height and that maintains package integrity both aboveground and underground.
- 11.7 Waste packages shall be emplaced in a manner that maintains package integrity, optimizes use of available space, is consistent with any requirements in applicable mining, building and/or fire codes, keeps dose as low as reasonably achievable (ALARA), and does not unnecessarily impede waste package retrieval (related to Section 8).
- 11.8 Repository's underground ventilation system shall be operated so as to place workers in the fresh air supply side of each workplace, with potentially contaminated air being exhausted through areas not routinely occupied or in sealed ducting. This shall be achieved by causing the air to flow from areas of low potential contamination to areas of greater potential contamination.
- 11.9 Systems to collect water originating within the shaft and below the shaft collar shall be arranged to flow by gravity to sumps that are located at the shaft bottoms.
- 11.10 During both construction and operation of DGR facility, wastewater originating at sanitary facilities and maintenance facilities within the repository shall be directed to a sump(s) dedicated to collection of this waste water. This water will be brought to surface in containers for treatment and disposal, as required.

12.0 RELIABILITY REQUIREMENTS

- 12.1 During normal working hours, the target operational availability of main shaft hoisting system for waste transfer operations shall be 80%. This level of availability assumes scheduled inspection and maintenance activities will occur within normal working hours (i.e. within the 8-hour-per-day, 5-day-per-week operation).
- 12.2 Adequate electrical power supply shall be maintained to ensure the safety of the DGR facility and its personnel under all circumstances.
- 12.3 There shall be emergency electrical power supply to operate all required systems in the event of an interruption of the main electrical power supply.
- 12.4 The top elevation of structures providing access to the repository (e.g. shaft collars, and inlet and exhaust plenum structures) shall be set so as to minimize the probability of water ingress in the unlikely event of an extreme flood event (i.e. Probable Maximum Flood event) occurring in the vicinity of DGR facility. The maximum flood level shall be assumed to be 186.6 mASL [R-6].

13.0 MAINTAINABILITY REQUIREMENTS

- 13.1 It shall be possible to maintain and refurbish all structures, systems, equipment and components within the DGR facility, as necessary, to ensure performance as per design specifications during operating life of the DGR facility.

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- 13.2 The underground rock openings shall be designed and constructed so as to require only routine maintenance (e.g., rock scaling, replacement/repair of rock supports, shotcrete replacement/repair, concrete liner replacement/repair) during the operating life of the repository (related to 5.1).
- 13.3 The amount of installed equipment and associated maintenance requirements in emplacement rooms that are open and receiving waste packages shall be minimized so as to avoid worker radiation exposure.
- 13.4 Once filled with waste packages and isolated by a closure wall, maintenance of any structures, systems, equipment or components behind the closure wall, including within emplacement rooms and the enclosed access tunnel, shall no longer be required (related to 8.1).
- 13.5 There shall be facilities located underground for the routine maintenance of all underground equipment. It shall be possible to transfer any underground equipment to surface for replacement or major refurbishment using the same processes as was used to transfer equipment underground but in reverse.

14.0 PERIODIC INSPECTION AND MONITORING REQUIREMENTS

- 14.1 Monitoring will be carried out on DGR site starting during the initial site characterization program. Monitoring shall continue until during site preparation, construction, operations and decommissioning to gather information, as necessary, to:
- (a) establish DGR facility and environmental baseline conditions (to occur prior to start of operations);
 - (b) assess performance of various structures, systems, equipment and components relative to design specifications and baseline conditions;
 - (c) monitor changes in underground rock/excavation conditions (e.g., rock movement, stress) over time;
 - (d) assess preclosure safety and environmental performance relative to predefined standards or limits, and baseline conditions;
 - (e) provide data for analysis of postclosure performance and safety for the sealed repository; and
 - (f) monitor for any changes in groundwater quality due to the operation of the DGR facility.
 - (g) Follow-up environmental monitoring will be performed in accordance with requirements in [R-10]
- 14.2 Underground air quality shall be monitored in a manner compliant with requirements of the Ontario Health and Safety Act and its regulations, and OPG's Radiation Protection Requirements (related to 19.12(a)). The purpose of the monitoring will be to confirm

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that there is no accumulation of toxic, asphyxiating, radioactive, flammable or explosive gases in areas that are routinely occupied by workers (related to 19.6).

- 14.3 The monitoring systems, if still required after repository closure, shall be designed so that they will not compromise the passive safety of the repository in the postclosure period.
- 14.4 All waste packages will be inspected at WWMF to verify that they meet the DGR WAC before transfer to the DGR facility. Inspections at DGR's WPRB will be limited to confirming that the correct package(s) has been transferred as per a roster and that package(s) have not been damaged during transfer from WWMF.
- 14.5 Once waste packages are placed into their final position within an emplacement room, the waste packages will no longer be routinely inspected.
- 14.6 Provisions shall be made to allow monitoring of air quality within a waste-filled emplacement room during the preclosure period and prior to installation of access tunnel closure walls. This monitoring capability is required to measure concentrations of potentially explosive gases (i.e., hydrogen and methane) and other gases that would not allow safe reentry, if necessary, into a room.
- 14.7 Following decommissioning and closure of the DGR facility, which is subject to further environmental assessment and obtaining a Decommissioning Licence, continuing environmental monitoring will occur as required by the CNSC at that time.

15.0 SAFETY REQUIREMENTS

15.1 Public Safety Requirements

- 15.1.1 The design, construction, operation, decommissioning and closure of the DGR facility shall meet all applicable federal and provincial laws and regulations communicated by the CNSC, and all applicable OPG and NWMO governing documents.
- 15.1.2 During normal operations, abnormal events and accidents, and during the postclosure period, the general public shall not be exposed to releases of radioactive and non-radioactive contaminants where concentrations in the releases exceed regulatory limits.
- 15.1.3 During the operational period, the public dose limit with respect to normal operation of the DGR facility shall be 1 mSv/a. Optimization shall be applied to meet a public dose target of 1% of the dose limit, i.e., corresponding to 0.01 mSv/a (10 µSv/a) at the site boundary.
- 15.1.4 During the postclosure period, the public dose constraint with respect to normal evolution shall be 0.3 mSv/a (300 µSv/a) in order to allow for possible multiple exposure sources in the future. Optimization shall be applied to reduce the potential public dose below this constraint. The postclosure protection will be accomplished primarily through a diffusion-dominated environment to reduce contaminant migration away from the repository. Therefore the design, construction and decommissioning

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(including shaft sealing) of the repository shall support or provide such an environment where applicable (relates to 9.0 and 18.5).

- 15.1.5 The burden on future generations shall be minimized by developing a repository design which does not rely on active institutional controls to achieve the postclosure dose constraint.

15.2 Occupational Safety Requirements

- 15.2.1 Activities associated with site preparation, construction, operation, decommissioning and closure of the DGR facility shall meet all applicable federal and provincial laws and regulations, and applicable OPG and NWMO governing documents.
- 15.2.2 The occupational dose limit shall be 20 mSv/a [as per 19.1(d)]. However the facility design shall be developed based on an occupational dose constraint of 10 mSv/a.
- 15.2.3 The DGR facility shall be designed, constructed, operated, decommissioned and closed such that the radiological risk to site workers is in keeping with the ALARA principle.
- 15.2.4 The ventilation system for the repository shall prevent the accumulation of toxic, asphyxiating, radioactive, flammable or explosive gases within all accessible areas of the repository.
- 15.2.5 To prevent accidental entry, barriers will be erected at entrances of all empty emplacement rooms that are not actively ventilated. Before entering a previously unventilated emplacement room, predefined procedures for safe re-entry will be followed.
- 15.2.6 Rock support systems shall be designed to ensure safe working conditions in all accessible areas of the repository during construction, operation and decommissioning of the repository.

15.3 Fire Safety

- 15.3.1 The DGR facility shall be designed, constructed and operated so as to minimize the possibility of fire (including minimizing potential ignition sources).
- 15.3.2 Fire protection systems shall be installed in the DGR facility, as required by applicable regulations and codes. Care shall be taken in selection of these systems to ensure that they will not adversely influence other safety aspects of the DGR facility.
- 15.3.3 Flammable materials (i.e., diesel fuel, lubricants) shall be safely stored away from L&ILW materials in compliance with relevant regulations. The amount of flammable materials stored or combustible material used should be minimized.

16.0 SECURITY REQUIREMENTS

- 16.1 The DGR site shall be securely fenced to prevent unauthorized access.

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16.2 Access to the DGR facility shall be restricted to qualified and authorized personnel, and those escorted by qualified and authorized personnel.

16.3 Explosives used for the construction of the repository shall be securely stored in compliance with relevant regulations, and in a manner that will not compromise the security and safety of any CNSC-licensed facility on the Bruce nuclear site.

17.0 SAFEGUARDS REQUIREMENTS

17.1 There are no nuclear safeguards requirements applicable to the DGR facility.

18.0 CONSTRUCTABILITY REQUIREMENTS

18.1 The repository shall be constructed using conventional construction techniques. To the degree possible, the design shall not require the use of unique or special construction techniques that may require extensive development work before they can be used. Construction of repository seals, however, may require construction techniques not normally used in the mining industry.

18.2 During construction, all shafts, tunnels and rooms shall be made accessible, as necessary, to allow personnel to periodically inspect rock, conduct tests and/or gather geoscience data (see [R-11]).

18.3 Following the start of waste emplacement operations, any underground construction work shall not negatively impact waste emplacement operations (related to 11.4).

18.4 The repository shall be constructed in such a way as to preserve the postclosure safety functions of the repository and the geological barriers shown to be important by the DGR safety case.

18.5 Where practical, rock excavation techniques shall be used that minimize the excavation damage zone in any rock forming the perimeter of excavations to be permanently sealed (related to shaft seal system requirements in Section 9).

19.0 REGULATIONS, CODES AND STANDARDS

The DGR facility falls under Federal Jurisdiction. Thus, with the exception of workplace health and safety, Canadian federal acts, regulations and codes shall apply to all aspects of the DGR facility. By Canadian Federal Regulation 98-180, responsibility for workplace health and safety at all OPG nuclear facilities (including OPG nuclear waste management facilities) has been delegated to the Province of Ontario. Thus workplace health and safety during the construction and operation of the DGR facility will be regulated under the Ontario Occupational Health and Safety Act (OHSa) and its associated regulations.

Under the Nuclear Safety and Control Act and its associated Regulations, Class 1 Nuclear Facility Regulations apply, and the DGR facility is classified as a Class 1B nuclear facility under these regulations.

The design of the DGR facility shall meet the requirements of the regulations, codes and standards listed below and will incorporate guidance provided in the various guidance documents (see various documents below marked "(guidance)", as appropriate.

The latest version of all regulations, standards and codes listed in this section shall be used. In the event of any conflict or inconsistency between any requirement of the Nuclear Safety and Control Act and its associated Regulations, and any requirement of the regulations, code or standards listed in this section, the conflict or inconsistency will be directed to the CNSC for resolution.

Canadian Federal Acts and Regulations can be found at <http://laws.justice.gc.ca/> and Ontario Provincial Acts and Regulations can be found at www.e-laws.gov.on.ca.

19.1 Canadian Nuclear Safety Commission

- (a) Nuclear Safety and Control Act, Canada Gazette Part III, Vol 139, 1997
- (b) General Nuclear Safety and Control Regulations, Registration SOR/2000-202, 31 May 2000, Canada Gazette Part II, Vol 134, No. 13, 21 June 2000
- (c) Class I Nuclear Facilities Regulations, Registration SOR/2000-204, 31 May 2000, Canada Gazette Part II, Vol 134, No. 13, 21 June 2000
- (d) Radiation Protection Regulations, Registration SOR/2000-203, 31 May 2000, Canada Gazette Part II, Vol 134, No. 13, 21st June 2000
- (e) Uranium Mines and Mills Regulations SOR/2000-206, 17 June 2009 (guidance⁵)
- (f) CNSC's P-290, Managing Radioactive Waste, July 2004 (policy document)

⁵ Although this regulation does not apply because the DGR is not a uranium mine, CNSC has indicated that this regulation provides some clarity as to the types of information to be supplied in submissions to CNSC.

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- (g) CNSC's P-223, Protection of the Environment, February 2001 (policy document)
- (h) CNSC's G-320, Assessing the Long-term Safety of Radioactive Waste Management, December 2006
- (i) CNSC's G-129, Keeping Radiation Exposures and Doses As Low as Reasonably Achievable (ALARA) (Rev 1), October 2004 (guidance)
- (j) CNSC's Guide G221, A Guide to Ventilation Requirements for Uranium Mines and Mills, June 2003
- (k) CNSC's G-224, "Environmental Monitoring Program at Class 1 Nuclear Facilities and Uranium Mines and Mills, July 2004
- (l) CNSC's G-276, "Human Factors Engineering Program Plans", June 2003
- (m) CNSC's G-278, "Human Factor's Verification and Validation Plans, June 2003
- (n) CNSC's R-72, Geological Considerations in Siting a Repository for Underground Disposal of High-Level Radioactive Waste, September 1987 (guidance)

19.2 Buildings and Structures

- (a) Surface facilities (except "mine-specific") - NBC (2005)
- (a) Surface facilities - Ontario Regulation 213/91, Construction Projects (applicable to construction work to a nominal depth of 50 m below ground surface)
- (b) Surface facilities and underground waste handling - Ontario Regulation 851/90, Industrial Establishments
- (c) Underground facilities - Ontario Regulation 854/90, Mines and Mining Plants

19.3 Fire Protection System

- (a) Surface facilities (except "mine-specific") - NBC (2005)
- (b) Underground mine-specific (e.g., head frames, hoist rooms) facilities - Ontario Regulation 854/90, Mines and Mining Plants
- (c) Surface facilities – National Fire Code (2005)

19.4 Pressurized Systems

- (a) CAN/CSA Standard 285.0-08, General requirements for pressure-retaining systems and components in CANDU nuclear power plants/Material Standards for reactor components for CANDU nuclear power plants
- (b) CAN/CSA Standard B51-09, Boiler, pressure vessel, and pressure piping code
- (c) Technical Standards and Safety Act, 2000

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- (d) Ontario Regulation 220/01 for Boilers and Pressure Vessels

19.5 Electrical

- (a) Ontario Electrical Safety Code, 23th Edition, 2002
- (b) CAN/CSA-Z462-08, Workplace electrical safety
- (c) CAN/CSA-M421-00, Use of electricity in mines
- (d) CAN/CSA-B72-M87, Installation code for lightning protection systems

19.6 Repository Ventilation System

- (a) Ontario Regulation 854/90, Mines and Mining Plants
- (b) American Society of Heating Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 62.1-2004
- (c) ACGIH, Threshold Limit Values (TLVs) and Biological Exposure Indices (BEIs) available at www.acqih.org

19.7 Underground Equipment

- (a) CAN/CSA-M424.2-M90, Non-rail-bound diesel-powered machines for use in non-gassy underground mines

19.8 Environmental

- (a) All aspects of site preparation and construction of the DGR facility shall comply with NWMO's Environment Management and Protection Program (under development).
- (b) Activities associated with site preparation, construction, operation, decommissioning and closure of the DGR facility shall meet all applicable federal and provincial environmental protection laws and regulations.
- (c) All applicable permits and approvals that are required under provincial and federal legislation will be obtained.

19.9 Concrete and Steel

- (a) Surface facilities - CAN/CSA-A23.1, Concrete materials and methods on concrete construction
- (b) Surface facilities - ACI 201, American Concrete Institute's "Guide to Durable Concrete" (guidance)
- (c) CAN/CSA-S16.1, Limit states design of steel structures

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19.10 Underground Design and Construction

The design and construction of all underground openings for the repository will incorporate consideration of best engineering practice for this type of work (e.g. [R-7]).

19.11 Shaft Sealing

A sealing system design shall incorporate consideration of:

- (a) Ontario Ministry of Natural Resources, Provincial Operating Standard, "Oil, Gas, Salt Resources of Ontario", Version 2, Section 11 entitled Well Plugging [www.oqslibrary.com]
- (b) Ontario Regulation 240/00, Mine Development and Closure Under Part VI of the Act, Schedule 1: Part 1, Protection of Mine Openings to Surface

19.12 General Guidance for Waste Handling and Repository Design

- (a) OPG Radiation Protection Requirements – Nuclear facilities, N-RPP-03415.1-10001, R07, June 2001
- (b) International Commission on Radiological Protection (ICRP), Radiation Protection Recommendations as Applied to the Disposal of Long-lived Solid Radioactive Waste, ICRP Publication No. 81, Pergamon Press, 2000
- (c) CAN/CSA N292.3-08, Management of low- and intermediate-level radioactive waste
- (d) Relevant International Atomic Energy Agency (IAEA) documents shall be used as guidance in establishing additional requirements for the design of the repository, specifically the following documents or superseding documents [<http://www-ns.iaea.org/standards/>]:
 - (i) Predisposal Management of Radioactive Waste, IAEA General Safety Requirements Part 5, No. GSR Part 5, May 2009
 - (ii) Geological Disposal of Radioactive Waste, IAEA Safety Requirements, WS-R-4, July 2006 (*to be replaced by DS354, Disposal of Radioactive Waste*)
 - (iii) Siting of Geological Disposal Facilities, IAEA Safety Guide, 111-G-4.1, 1994 (*to be replaced by DS334*)
 - (iv) The Management System for Disposal of Radioactive Waste, IAEA Safety Guide, GS-G-3.4, June 2008 (*to be replaced by DS337*)
- (e) All design work shall be performed in accordance with NWMO's Design Management Procedure, NWMO-PROC-EN-0001, which complies with all relevant requirements for design work in CAN/CSA 286-05, Management System Requirements for Nuclear Power Plants.

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20.0 OTHER REQUIREMENTS

- 20.1 The DGR facility shall only accept waste packages that meet the DGR WAC [see **R-1**].
- 20.2 The DGR facility shall not accept used nuclear fuel.
- 20.3 The repository shall be developed in manner that is commensurate with the requirements as specified in this document and that minimizes the overall life-cycle cost to OPG. Present value estimates of life-cycle cost shall be based on escalation rates and discount rates as specified by OPG.

21.0 COMPARISON WITH SIMILAR SYSTEMS

- 21.1 The following operating and planned L&ILW repositories should be used as possible sources of design information, and construction and operating experience:
- (a) Sweden's Final Repository for Radioactive Operational Waste (SFR) , Forsmark, Sweden - Mined Rock Cavern in Granite.
 - (a) Olkiluoto, Finland - Mined Rock Cavern in Granite
 - (b) Waste Isolation Pilot Plant (WIPP) , New Mexico – Mined Rock Cavern in Salt
 - (c) Konrad Mine, Germany – Former iron ore mine in sedimentary rock
- 21.2 The following documents may be used as a source of design information:
- (a) The safety report for WWMF [**R-8**] and related design documents for the surface facilities and the storage structures are possible sources of design information.
 - (b) WIPP certification documentation [**R-9**].

22.0 RECORDS

- 22.1 There shall be a permanent information management system associated with DGR facility that archives essential records, samples (including rock samples) and other information about the local geosphere, the repository, and its waste package contents.
- 22.2 All records will be managed in accordance OPG and NWMO records management governance.

23.0 TECHNICAL REFERENCES

- [R-1] NWMO (2010), OPG's Deep Geologic Repository for L&ILW – Preliminary Waste Acceptance Criteria, DGR-PR-09132-0001
- [R-2] NWMO (2010), L&ILW Deep Geologic Repository – Project Glossary, DGR-LIST-00120-0001

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- [R-3] NWMO (2010), Reference Low and Intermediate Waste Inventory for the Deep Geologic Repository, NWMO Report DGR-TR-02010-04
- [R-4] NWMO (2009), DGR Borehole Respect Distance, DGR-03954-T10, 4 November 2009
- [R-5] Canadian National Building Code (2005)
- [R-6] AMEC (2011), Maximum Flood Hazard Assessment, NWMO Report DGR TR-2011-35, Toronto, Canada (in preparation)
- [R-7] Tunneling Code of Practice 2007, Workplace Health and Safety Queensland, Department of Justice and Attorney-General, Queensland, Australia
[\[www.deir.qld.gov.au/workplace/resources/pdfs/tunnelling_code2007.pdf\]](http://www.deir.qld.gov.au/workplace/resources/pdfs/tunnelling_code2007.pdf)
- [R-8] OPG (2006), Western Waste Management Facility Safety Report, OPG Report W-SR-01320-00001 Rev 01, Toronto, Canada
- [R-9] Waste Isolation Pilot Plant (WIPP) certification documentation at
http://www.wipp.energy.gov/Documents_EPA.htm
- [R-10] NWMO (2011), EA Follow-up Monitoring Plan, NWMO Report, DGR-TR-2011-10 (in preparation)
- [R-11] NWMO (2011), Geoscientific Verification Plan, NWMO Report, DGR-TR-2011-37 (in preparation)

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APPENDIX A

Glossary

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Bruce nuclear site – The 932 hectare (9.32 km²) parcel of land located within the administrative boundaries of the Municipality of Kincardine in Bruce County. Two operating nuclear stations are located on the site. The site is owned by OPG but has been leased to Bruce Power since May 2001. However, parts of the site, including land on which WWMF is located, have been retained by OPG. See also *OPG-retained lands*.

Bruce Power – The licensed operator of the Bruce A and Bruce B nuclear generating stations.

Canadian Nuclear Safety Commission (CNSC) – The Canadian federal agency responsible for regulating nuclear facilities and materials, including management of all radioactive waste in Canada.

Cage – Refers to an enclosure raised or lowered in a vertical shaft to transport personnel and freight.

Closure – The administrative and technical actions directed at a repository at the end of its operating lifetime. For example covering the waste (for a near surface repository), backfilling and/or sealing of rooms, tunnels and/or shafts (for a geological repository), and termination or completion of activities in any associated structures.

Controlled Area – A defined area in which specific protection measures and safety provisions are or could be required for controlling normal exposures or preventing the spread of contamination during normal working conditions, and preventing or limiting the extent of potential exposures.

Decommissioning – Those actions taken, in the interest of health, safety, security and protection of the environment, to retire a licensed activity/facility permanently from service and render it to a predetermined end-state condition.

Deep Geologic Repository (or DGR, or Repository) – The underground portion of the deep geologic repository facility for low- and intermediate-level waste. Initially, the repository includes the access-ways (shafts, ramps and/or tunnels), underground service areas and installations, and emplacement rooms. In the postclosure phase it also includes the engineered barrier systems. The repository includes the waste emplaced within the rooms and excludes the excavation damage zone.

Deep Geologic Repository Facility (or DGR Facility, or Repository Facility) – The deep geologic repository for low- and intermediate-level waste, and the various surface and underground support facilities. The support facilities include equipment, materials and infrastructure for receiving, inspecting and handling waste packages, for transferring waste packages from the surface to the repository horizon, for handling the waste packages in the repository, for emplacing waste packages, for excavating the repository (during operations), for constructing room shield walls, and for material storage. The repository facility excludes the waste emplaced within the rooms and any zones of damaged rock around underground openings.

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Deep Geologic Repository Site (or DGR Site, or Repository Site) – The physical location of the deep geologic repository on the Bruce nuclear site. It is characterized by such features as its proximity to other human developments, geology, hydrogeology and geotechnical conditions, adjacent land use patterns, and meteorological and seismic conditions.

Design Basis – Identifies specific functions to be performed by a system, structure, equipment, component or software; and the specific values or range of values chosen for controlling parameters as reference bounds for the design.

Design Constraint – A mandatory requirement to be fulfilled by the repository design. For example, must be located on OPG-retained land, must be constructed in suitable Ordovician limestone. See also *Design Limit, Functional Requirement and Performance Requirement*.

Design Life – The period during which a structure, system, equipment or component will perform while still meeting original design specifications, including routine maintenance but without major repair or refurbishment.

Design Limit – A limit beyond which an element or combination of repository elements is not expected to function properly. Design limits should have either “maximum” or “minimum” in the description. See also *Design Constraint, Functional Requirement and Performance Requirement*.

Emplaced Volume (Waste) – The external volume of the *waste package* for emplacement in the DGR, which includes the waste, storage container, overpack, and/or shield.

Emplacement Room – A portion of the repository into which waste packages are permanently placed. Rooms are bounded by the host rock for floor, ceiling and walls on most sides, and by a wall or access tunnel on one side.

Engineered Barrier – A physical obstruction that has been constructed to prevent or delay water seepage and/or radionuclide migration and/or migration of other materials between components in the repository, or between the repository and the surface environment.

Excavation Damaged Zone (EDZ) – The region of rock around repository openings that has been physically or chemically affected as a result of the excavation process, with significant changes in flow and transport properties (i.e., permeability of the rock increased by at least one order of magnitude). See also *Highly Damaged Zone and Excavation Disturbed Zone*.

Excavation Disturbed Zone (EdZ) – The region of rock surrounding the EDZ with possible stress or flow changes as a result of the excavation, but without significant changes in flow and transport properties (i.e. permeabilities with the rock materially unchanged). See also *Highly Damaged Zone and Excavation Damaged Zone*.

Extended Monitoring – Monitoring during the time period following completion of waste emplacement activities and prior to closure of the repository (see also *Postclosure Monitoring*). The results from extended monitoring would be used in the decision-making processes related to decommissioning and closure of the repository.

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Functional Requirements – These specify what has to be done but not how it should be accomplished. A function can be described by an action verb and a measurable noun, for example, a function of the repository is to “contain waste”. See also *Performance Requirements*.

Heating, Ventilation and Air Conditioning (HVAC) – means the heating, ventilation and air conditions equipment and associated controls that are used to maintain temperature and comfort factors in large commercial buildings and industrial settings.

Highly Damaged Zone (HDZ) – The zone of rock around an excavation where macro-scale fracturing or spalling may occur, thereby inducing changes in flow and transport through the interconnected fracture system (i.e. permeabilities within the rock increased by at least 2 orders of magnitude). See also *Excavation Damaged Zone* and *Excavation Disturbed Zone*.

In-Situ Stress – The natural or virgin state of stress in a rock mass that was derived from a pervasive force field imposed by geological perturbations such as tectonic activity.

Intermediate-Level Waste (ILW) – Radioactive non-fuel waste, containing significant quantities of long-lived radionuclides (generally refers to half-lives greater than 30 years).

Long-term – in radioactive waste disposal, refers to periods of time which exceed the time during which active institutional control can be expected to last.

L&ILW – Low- and Intermediate-Level radioactive Waste.

Low-Level Waste (LLW) – Radioactive waste in which the concentration or quantity of radionuclides is above the clearance levels established by the regulatory body (CNSC), and which contains primarily short-lived radionuclides (half-lives shorter than or equal to 30-years).

mASL – Metres above sea level.

mBGS – Metres below ground surface.

Near- field Rock – The rock adjacent to the repository that may have experienced changes in flow, mechanical, chemical or microbial characteristics as a consequence of the excavation, operation, decommissioning and closure of the repository. See also *Highly Damaged Zone*, *Excavation Damaged Zone* and *Excavation Disturbed Zone*.

NWMD – Nuclear Waste Management Division of Ontario Power Generation Inc.

NWMO – Nuclear Waste Management Organization.

OPG – Ontario Power Generation Inc.

OPG-retained Land – The parcels of land on the Bruce nuclear site for which control has been retained by OPG. This includes the WWMF, certain landfills, and the Heavy Water Plant Lands.

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Performance Requirements – The quantifiable measures of adequate performance of the deep geologic repository system. Each performance requirement should include both a measurable item or parameter and the value of that item or parameter that would identify satisfactory performance of that aspect of the deep geologic repository. See also *Functional Requirement, Design Limit and Design Constraint*.

Postclosure Phase – The period of time following closure of the deep geologic repository.

Preclosure Phase – The period of time that includes all activities from siting through to decommissioning and closure of all components of the deep geologic repository.

Ramp – An inclined excavated passageway that connects the surface with an underground workplace or connects one underground workplace to another at a different elevation. Also called inclines or declines.

Retrieval – 1) The accessing and removal of waste containers from storage facilities for the purpose of transferring to another facility (e.g. a repository).
2) The accessing and removal of waste containers from either closed emplacement rooms (i.e., prior to decommissioning and closure of the repository), or from a sealed deep geologic repository (i.e., after the decommissioning and closure of the underground excavations).

Retrievability – The ability to remove waste packages from where they have been emplaced. Conditions may necessitate the use of different equipment and procedures from those used during emplacement of waste packages.

Sealing System – A low-permeability system, typically comprising clay and/or cementitious materials, placed to fill and seal rooms, tunnels, shafts and/or boreholes when they are no longer needed, in order to inhibit groundwater movement and contaminant transport.

Shaft – A vertical or near-vertical excavated passageway that connects the surface with an underground workplace or connects two or more underground workplaces at different elevations.

Time-Dependent Deformation – Deformation that occurs slowly and continuously through time leading to gradual *strain* failure of a rock mass. Synonymous with creep and swelling. An example is the gradual inward convergence of the walls of underground openings in response to *stress*.

Underground Service Areas – Any excavations within the deep geologic repository that provide the space for the infrastructure to characterize, demonstrate, construct, operate, monitor and decommission a deep geologic repository. Service areas include all excavations in a deep geologic repository that are not classified as tunnels, shafts, ramps, emplacement rooms or boreholes.

Waste Acceptance Criteria (WAC) – Formal criteria which define the qualities of waste packages (including the waste) that are accepted for emplacement in the repository.

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Waste Package – The waste material, the container, and any external barriers (e.g. shielding material), as prepared in accordance with requirements for handling, transfer and emplacement in the repository. It is a discrete unit that can be individually identified and handled at the repository facility. See also *Waste Packaging*.

Waste Packaging – The container and any external barriers (e.g., *overpack*, shielding material), used for handling, transfer and disposal of the waste. It does not include the waste itself. See also *Waste Package*.

WPRB (Waste Package Receiving Building) – The building at the DGR surface where waste packages arrive for transfer underground.

WWMF (Western Waste Management Facility) – The centralized processing and storage facility on the Bruce nuclear site for OPG's L&ILW and for the dry storage of used fuel from Bruce nuclear generating stations.