OPG's DEEP GEOLOGIC REPOSITORY FOR LOW AND INTERMEDIATE LEVEL WASTE PROJECT DESCRIPTION – DESIGN & CONSTRUCTION

D. Wilson, J. van Heerden and R. Heystee
Nuclear Waste Management Organization
Toronto, Ontario, Canada

ABSTRACT

Ontario Power Generation (OPG) is planning to construct a Deep Geologic Repository (DGR) for the long-term management of operational and refurbishment Low and Intermediate Level Radioactive Waste (L&ILW) at the 932-ha Bruce nuclear site. The Bruce nuclear site is located approximately 225 kilometres northwest of Toronto near Tiverton, Ontario. The project is currently in the regulatory approvals phase. OPG's proposed underground repository will be comprised of horizontally-excavated emplacement rooms arranged in two panels with access provided via two vertical concrete-lined shafts. The emplacement rooms will be constructed at a depth of about 680 m below surface within limestone. This limestone formation is laterally extensive and is directly overlain by 200 m of shale which acts as a low permeability cap rock. The underground repository will be supported by a surface infrastructure comprised of two headframes, an office building and various ancillary facilities. It is estimated that it will take about five to six years to construct the DGR facility.

1. INTRODUCTION AND BACKGROUND

Ontario Power Generation (OPG) is proposing to build a Deep Geologic Repository (DGR) for Low and Intermediate Level Waste (L&ILW) near the existing Western Waste Management Facility (WWMF) at the Bruce nuclear site in the Municipality of Kincardine, Ontario. The Nuclear Waste Management Organization (NWMO), on behalf of OPG, has prepared the Environmental Impact Statement and Preliminary Safety Report for the proposed repository. The DGR project involves investigation of the site's geological and surface environmental characteristics, facility design and construction, and safety assessment. More detailed information on the DGR Project can be found in companion papers [1-7].

This paper describes the proposed design of the DGR facility. Background information about the types of waste to be emplaced in the underground facility and the geologic setting is also presented.

2. L&ILW FROM REACTOR OPERATIONS AND REFURBISHMENT

Low and intermediate-level radioactive waste that is produced during the operation of Ontario's reactors is stored centrally at OPG's WWMF. Although current storage practices are safe, OPG's long-term plan is to transfer these wastes to a long-term management facility because some of the wastes remain hazardous for thousands of years.

OPG's L&ILW is generated primarily by the operation of 20 nuclear reactors at Pickering, Bruce and Darlington stations and the waste is sent to WWMF for interim storage (Figure 1). Approximately 5,000 m^3 to 7,000 m^3 of new waste is received at the WWMF each year, resulting in 2,000 m^3 to 3,000 m^3 of additional stored waste following volume reduction. In the future, L&ILW will also be generated during the decommissioning of the reactors and the associated nuclear waste storage facilities.

2.1. Operational Low Level Wastes

LLW consists of common industrial items that have become contaminated with low levels of radioactivity during routine clean-up and maintenance at the nuclear generating stations. It consists of mops, rags, paper towels, temporary floor coverings, floor sweepings, protective clothing, and hardware items such as tools. Where possible, the LLW is processed by either compaction or incineration to reduce volume and the space required for storage and disposal.

Figure 1. Aerial view of OPG's Western Waste Management Facility (July 2009): 1) Low-Level Storage Buildings, 2) In-ground Containers for ILW, 3) Refurbishment Waste Storage Buildings, and 4) Western Used Fuel Dry Storage

LLW is stored in a variety of stackable carbon-steel containers and these containers are stored in warehouse-like structures, known as Low-Level Storage Buildings (LLSBs) (Figures 1 and 2).

2.2 Operational Intermediate Level Wastes

ILW, because of its physical condition and greater levels of radioactivity, is not processed for volume reduction. ILW consists of ion exchange resins, filters and irradiated reactor core components. These wastes are stored in concrete/steel-lined in-ground structures and concrete above-ground structures (these latter structures are no longer receiving waste). About five per cent of all waste (excluding used nuclear fuel) received at WWMF is classified as ILW.

2.3 Refurbishment Waste

Ontario's reactors are either under-going refurbishment or there are future plans for reactor refurbishment. The refurbishment activities include replacement of motors, valves, instrumentation, fuel channels and steam generators. About 26,000 m^3 of radioactive waste will be generated from the planned refurbishment activities.

The irradiated fuel channel wastes are being stored in reinforced concrete containers with inner and outer steel shells. The loaded containers are disposal-ready and weigh about 30 Mg. Steam generators removed during refurbishment are being transferred intact to a storage building and may be transferred into the DGR. Because of their weight and size, these steam generators will need to be size reduced to allow transfer into the DGR.

Figure 2. Containers stacked inside Low-Level Storage Building

2.4 Future Decommissioning Wastes

Following permanent shutdown, the reactors at Pickering, Bruce and Darlington will be decommissioned generating additional L&ILW. The decommissioning LLW will be comprised of metals and concrete, and when sent to a repository would take the form of boxed wastes and various large objects. In addition, ILW comprised of reactor components, filters and resins wastes would be generated. OPG is currently not seeking approval to dispose of these future decommissioning wastes in the DGR.

3. GEOLOGIC SETTING AND REFERENCE REPOSITORY DEPTH

The geologic conditions beneath the Bruce site have been evaluated through an on-site drilling and testing program [4]. The site is underlain by approximately 850 m of relatively undeformed, and nearly horizontal carbonates, shales and evaporates formations. It is proposed that the repository be constructed within this sedimentary sequence at a depth of about 680 m in the low permeability argillaceous limestone Cobourg formation.

The stratigraphic sequence is comprised of an upper 400 m of Devonian and Silurian age dolostones with some shale and evaporate layers. Within this upper sequence of rocks, the near-surface dolostone formations (about 180 m) has enhanced permeability. The lower half of the sequence is Ordovician in age and is comprised of an upper 200 m of shales and a lower 200 m of limestones. The entire sedimentary sequence rests on the crystalline Precambrian basement (Figure 3).

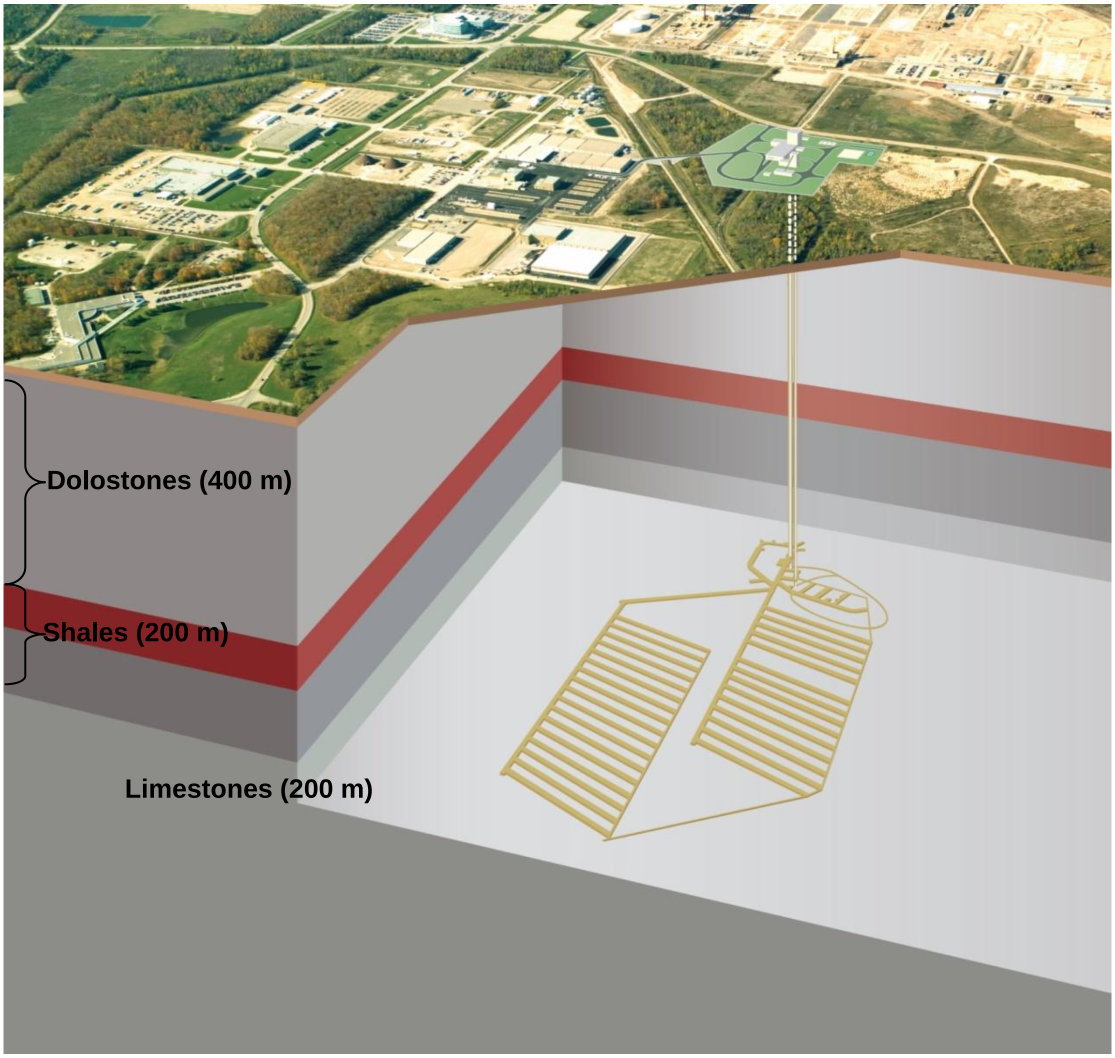

Figure 3: OPG's Deep Geologic Repository for L&ILW at Bruce nuclear site

4. LAYOUT AND CONSTRUCTION

The underground repository layout, as depicted in Figures 3 and 4, will provide sufficient capacity for a nominal 200,000 m^3 of operational and refurbishment L&ILW. The DGR layout is subject to minor changes as the design of the facility progresses. The DGR facility will be centrally located on the 900-ha Bruce site. The underground repository design consists of a series of emplacement rooms arranged in parallel rows on either side of central access tunnels. Access to the repository is through two vertical concrete-lined shafts. The DGR surface facilities are comprised of the Main Shaft and Waste Receiving Building, Ventilation Shaft Headframe Building, and various ancillary facilities. Additional information about waste capacity and size of the proposed repository is presented in Table 1.

4.1 Shafts

The Main Shaft and the Ventilation Shaft will be excavated using drill and blast methods to the repository horizon which is located nominally 680 m below surface. Controlled drilling and blasting methods will be used to minimize excavation damage to the rock. The Main Shaft is concrete lined and has a 6.5-m finished inside diameter. Its primary functions are to provide primary access to the underground repository for personnel and waste packages, and to provide access for delivery of various services including fresh air (Figure 5). The Ventilation Shaft is also concrete lined and has a 5-m finished inside diameter. Its functions include providing emergency access for staff to and from the repository, routing for exhaust air from the repository, delivery of various services and removal of excavated rock materials during repository construction.

The two DGR shafts will be excavated through 180 m of potential water-bearing dolostone formations near the top of sedimentary sequence. Excavation grouting will be used to condition rock formations to limit water inflow during construction, and then the shafts will be concrete-lined to further limit potential water inflow.

4.2 Underground Tunnels and Ventilation System

Access to the emplacement rooms from the underground waste package receiving area near the Main Shaft will be via two tunnels. All tunnels and emplacement rooms will be excavated by controlled drill and blast methods. Both access tunnels have a poured concrete floor and the Panel 1 tunnel has rails mounted flush to the floor surface into the first two rooms to allow movement of rail cars loaded with large and heavy packages.

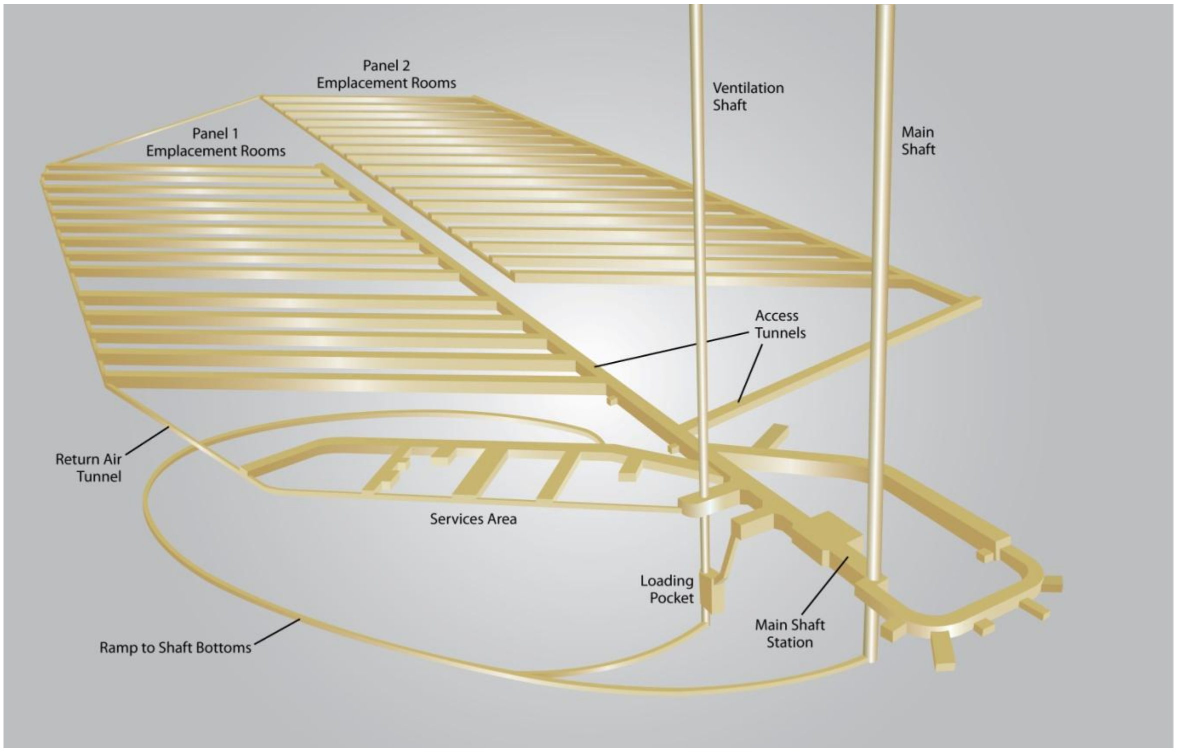

Figure 4. Underground layout of the repository for OPG's L&ILW

A ventilation system is required to support repository construction activities (i.e. flush gases and dust from rock excavation activities) and to deliver fresh air during waste emplacement operations. Ventilation of the underground repository will be by a pull-system of underground fans located near the ventilation shaft with fresh air introduced via the Main Shaft and then exhausted by the Ventilation Shaft. Fresh air will be delivered to working areas within the repository via the access tunnels and in such a manner that underground workers are always in fresh air. The exhaust air will be directed to the Ventilation Shaft via the return air tunnels. In the winter months the air will be heated prior to delivery to the underground repository.

4.3 Emplacement Rooms

All emplacement rooms will have appropriate ground control and a poured concrete floor to allow access by rubber-tired forklifts. In Panel 1 two emplacement rooms will have rails embedded flush to the floor surface to allow rail carts carrying heavy ILW packages to travel into these rooms. The access tunnels leading to all emplacement rooms will be designed to allow closure walls to be erected once a group of rooms are filled with waste.

Underground openings have been excavated in similar limestone formations and geologic settings elsewhere in Ontario and the United Sates [8, 9]. Based on experience in these underground openings, it is expected that there will be no visible seepage into the proposed emplacement rooms and tunnels of the DGR.

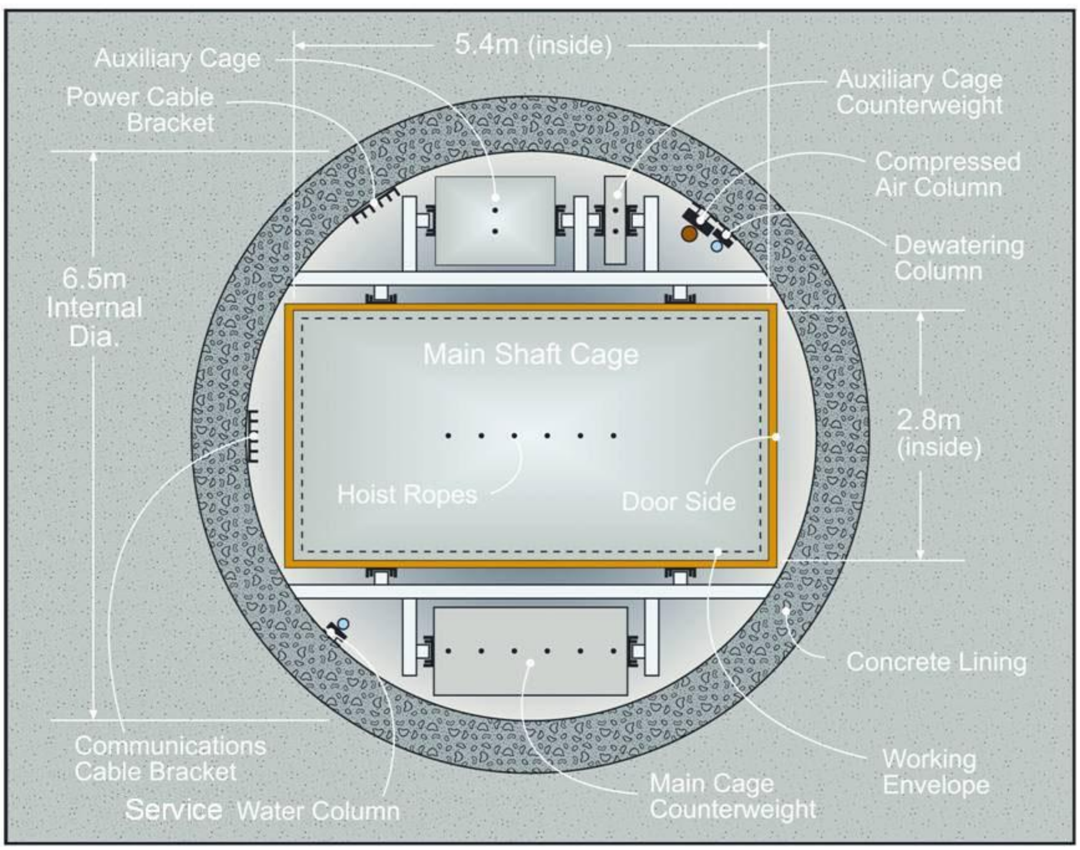

Figure 5. Conceptual layout of DGR Main Shaft

4.4 Underground Services Area

Adjacent to Main Shaft and Ventilation Shaft there will be excavations to house the underground office and amenities (Figure 4). A refuge area will be located in this area and will be equipped with emergency supplies of fresh water, compressed air, a fireproof door and sealing materials, and a communications link with surface. The maintenance area will be used for servicing of all underground equipment.

4.5 Surface Facilities

Surface buildings and other ancillary facilities will be constructed and integrated into the existing infrastructure at the WWMF (Figure 6). The Main Shaft Headframe will be used to house the Koepe hoisting system. Waste Package Receiving Building will used to receive waste packages in a disposal-ready state. An adjoining Amenities Building will provide space for offices, change rooms, lunch room and other services. The Ventilation Shaft Headframe Building is located above the second smaller shaft, and houses the access/emergency man-hoist equipment. Nearby will be buildings housing intake and exhaust fans, heating equipment, electrical substation, emergency generator, and other ancillary facilities.

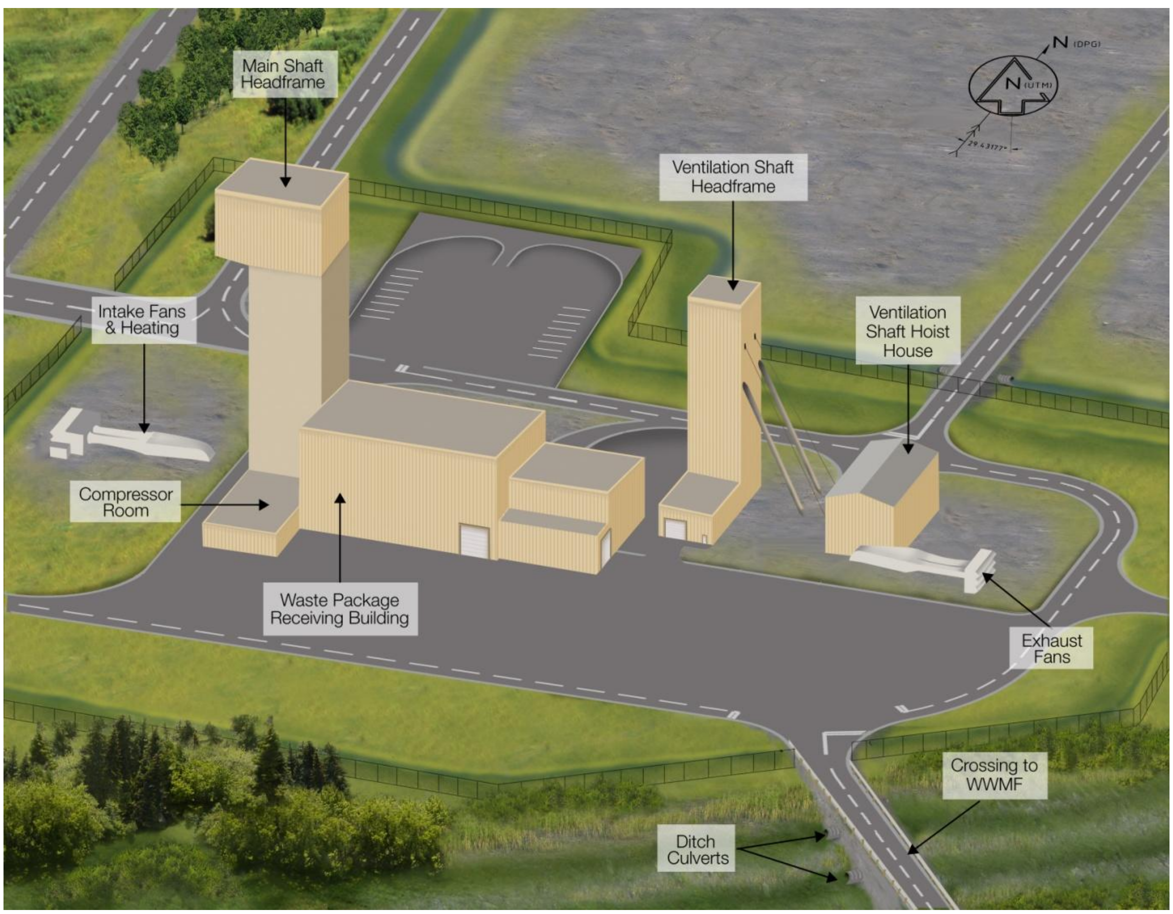

Figure 6 – DGR Surface Facilities

It is currently assumed that all waste rock from underground excavations will be transferred to the disposal area located on the Bruce nuclear site and within the DGR Project Site boundaries. It is estimated that approximately 830,000 m^3 (bulked) of waste rock will be produced during the underground development program and placed in the 9-ha disposal area to a height of about 15 m.

4.6 Future Design Modifications and Improvements

The layout of the underground repository is based, by necessity, on assumptions about future waste quantities, form in which wastes will be received, nature of the deep rock conditions and preferred methods to handle waste packages in access tunnels and emplacement rooms. As new information is gathered and assumptions are updated, the layout and design of the underground repository will be modified and improved.

5. REPOSITORY OPERATION

L&ILW retrieved from various storage structures at the WWMF will be received at the Waste Package Receiving Building and then transferred into the underground repository.

5.1 LLW Package Handling

It expected that the majority of LLW packages will be transferred "as is" to the DGR. However all LLW packages will be inspected at the WWMF and if any are found damaged, have high radiation levels, or are otherwise unacceptable for emplacement in the underground repository, they will be placed into an overpack container. The waste packages will be delivered by forklift or truck to the DGR waste package receiving area and then loaded into the Main Shaft cage. The packages will be unloaded from the cage and then transported by forklift to the LLW emplacement rooms. The LLW packages will be stacked in the rooms in a manner similar to current practice within LLSBs (Figures 2).

5.2 ILW Package Handling

ILW is currently stored in structures that provide shielding against gamma radiation. In order to provide continuous shielding for workers during handling, the various ILW containers will be placed directly into concrete shields after removal from storage structures. The shields remain in place during movement to the repository, as well as after emplacement. Depending on the type of ILW and the size of the storage container, the full weight of a shielded ILW package is expected to be in the range of 5 Mg to 35 Mg. A large number of the ILW packages will be in the form of two 3-m^3 resin liners stacked inside a cylindrical concrete shield. This type of shield will have a 250-mm-thick wall with a nominal outside diameter of 2 m, an overall length of 5 m, and a full weight of 30 Mg.

At the repository level most ILW packages are transferred by heavy-duty forklift to the emplacement rooms. Some large and heavy ILW packages will be transferred by rail cart to an emplacement room. Once in an emplacement room, a gantry crane is used to unload these ILW packages from the rail car and to place the packages into position within the room.

5.3 Repository Development and Expansion

The repository shown in Figure 4 has a modular design that would allow repository capacity to be expanded, as required, to match the L&ILW disposal needs of Ontario's nuclear power program. It is expected that the geologic conditions at the Bruce site will allow lateral expansion of the repository, if required.

During initial repository construction and prior to start of waste emplacement operations, a sufficient number of emplacement rooms will be constructed to accommodate 200,000 m^3 of waste (as-disposed volume). Should a future decision be made to expand beyond this capacity, waste receipt and emplacement operations would cease to allow the construction of additional rooms. During this construction campaign, the waste-filled rooms would be isolated to protect the construction workers. While excavating new emplacement rooms, the access tunnels and shafts will be converted to non-radiological working areas to facilitate construction activities. Any future expansions of the repository to increase capacity beyond the current proposed capacity would require regulatory approval.

5.4 Room Isolation and Repository Shaft Sealing Systems

Walls will be erected at room entrances, as required, to isolate waste-filled rooms from the active emplacement rooms, access tunnels and the return air tunnel. The walls will be designed to limit release of tritiated air, natural and waste-generated methane, and other off-gases from waste packages (e.g. H_2 and CO_2). The wall will have provisions to allow venting should monitoring indicate contaminant concentrations in air exceed levels that would not allow safe reentry. Although there is no intention to reenter the emplacement room following sealing, provisions to allow venting and safe reentry are required.

A conceptual sequence of shaft sealing has been developed and includes the stripping of the concrete liners and any excavation-damaged rock on the shaft walls, followed by placement of the clay-based and concrete seal materials. The time-dependent deformation characteristics of the Ordovician shale may cause "squeezing" of the seals, further enhancing the effectiveness of the shaft sealing systems. It is expected that these clay-based sealing systems will maintain their integrity in the long-term.

6. DGR PROJECT SCHEDULE

The DGR is currently in the regulatory approvals phase. It is currently assumed that a CNSC Site Preparation and Construction Licence would be received in 2013. L&ILW receipts at the DGR are expected to start in 2019, and span several decades depending on future developments in Ontario's nuclear generation program.

ACKNOWLEDGEMENTS

The preliminary design described in this paper is largely based on work completed by Hatch Limited on behalf of NWMO.

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