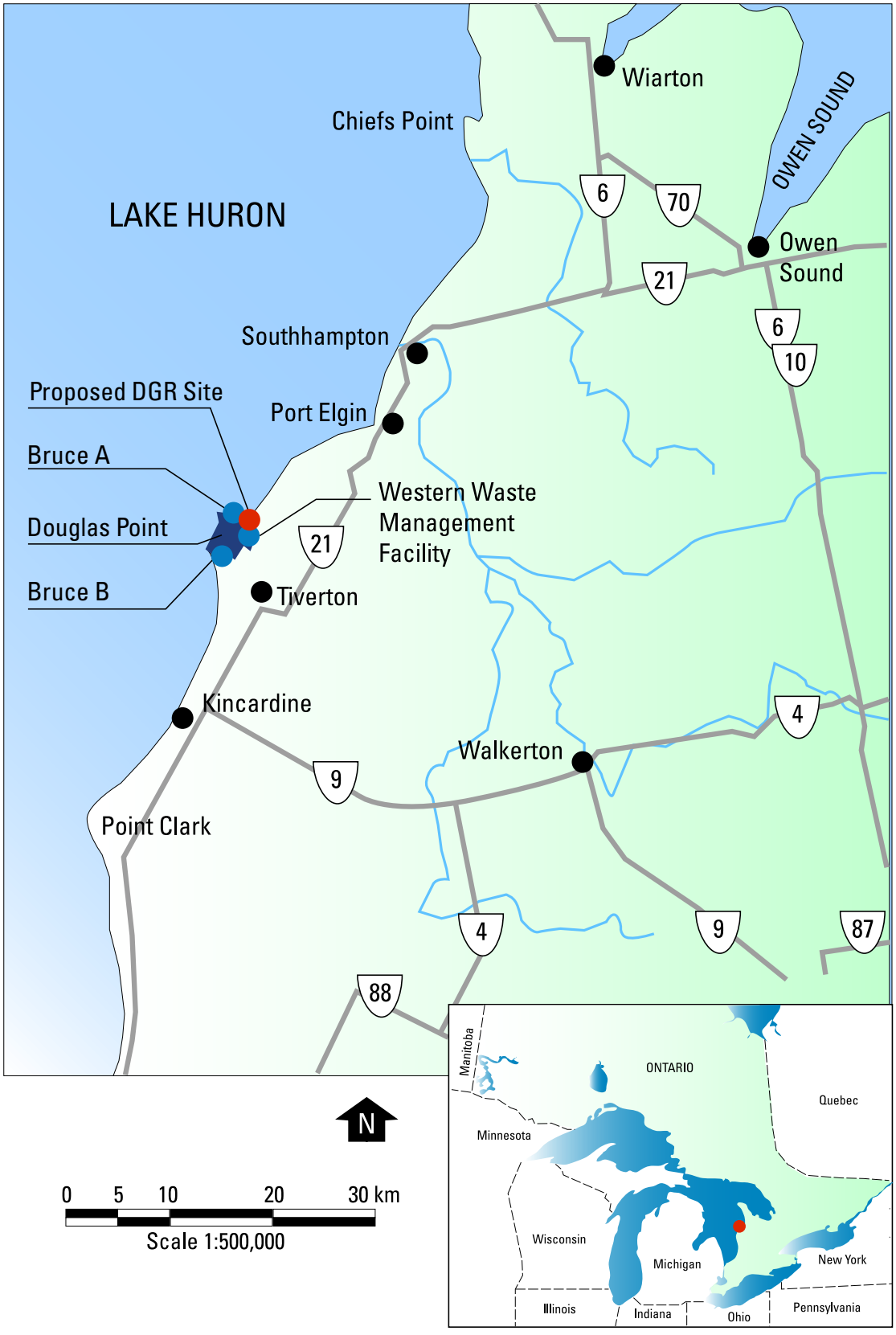
DEEP GEOLOGIC

REPOSITORY

FOR OPG's LOW & INTERMEDIATE LEVEL WASTE

ANNUAL REPORT
2008

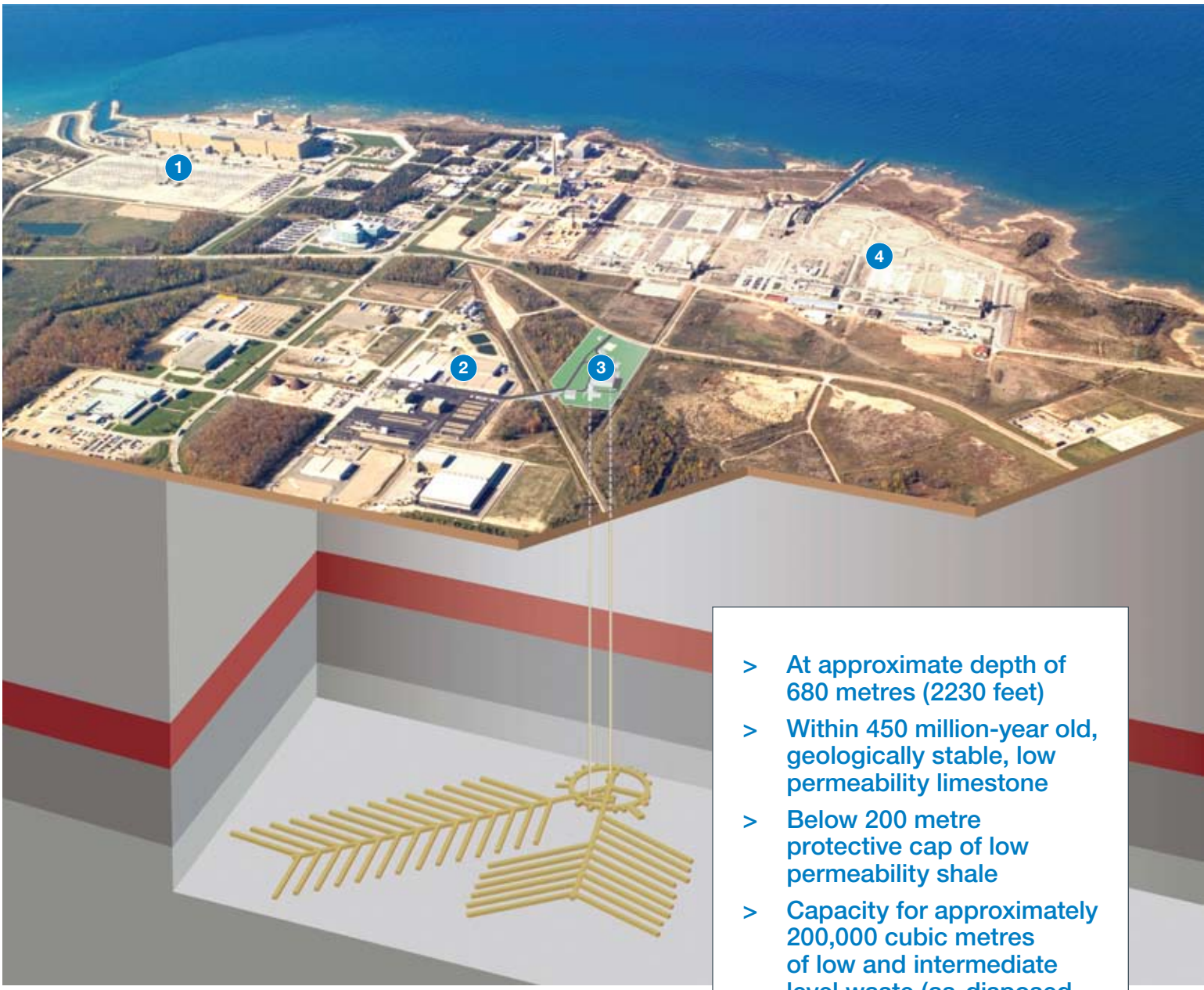
nwmo
NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES



The Deep Geologic Repository is proposed adjacent to the Western Waste Management Facility in the Municipality of Kincardine

Contents

Key Features



1: **Bruce B Generating Station**
2: **Western Waste Management Facility**
3: **DGR Project Site**
4: **Heavy Water Plant Lands**

- At approximate depth of 680 metres (2230 feet)
- Within 450 million-year old, geologically stable, low permeability limestone
- Below 200 metre protective cap of low permeability shale
- Capacity for approximately 200,000 cubic metres of low and intermediate level waste (as-disposed volume equivalent to 160,000 cubic metres as stored at WWMF)

The DGR Project

Following completion of an Independent Assessment Study undertaken jointly by OPG and the Municipality of Kincardine in 2004, a Host Community Agreement was negotiated. A telephone poll conducted within the Muncipality of Kincardine by an independent company indicated community support. Ontario Power Generation (OPG) initiated the regulatory approvals process for the proposed Deep Geologic Repository (DGR) in 2005. The project has received the support of all municipal councils in Bruce County.

In 2008, project activities related to geoscientific characterisation, repository safety analyses, environmental assessment and conceptual facility engineering design continued. These activities are being conducted in support of the regulatory approvals process, through which OPG expects to receive a site preparation and construction licence in 2012. The Project, if approved, will provide long-term management of approximately 200,000 m^3 (as-disposed volume) of low and intermediate level radioactive waste (L&ILW).

The waste, which is produced as a result of the past and ongoing operation of OPG-owned nuclear generating stations at Pickering, Darlington and Bruce, will be emplaced in rooms about 680 m (2230 feet) underground in very low permeability Ordovician age limestone that is overlain by thick and very low permeability shale. This rock has remained stable for more than 450 million years through geologic upheavals, major climate change and glacial cycles. It will provide assurance for the safe containment and isolation of the waste many thousands of years into the future.

The DGR will be comprised of surface facilities to receive the waste and to support the underground facilities which include two shafts, and underground tunnels, emplacement rooms and maintenance areas excavated in the rock. The waste will be taken underground by hoist via a vertical shaft and placed in a series of emplacement rooms.

The DGR will be located adjacent to the Western Waste Management Facility (WWMF) at the Bruce site, near Tiverton, Ontario in the Municipality of Kincardine. Much of the waste to be placed in the DGR is already located at the WWMF.

Based on the current proposed schedule, construction of the DGR will commence in 2013 subject to receiving a construction licence, an operating licence will be sought in 2017, and waste will be placed in the DGR commencing around 2017. Emplacement activities would continue for a period of approximately 40 years. Once the DGR ceases to receive waste, and after a period of environmental monitoring, regulatory approval would be sought to decommission the facility. On receiving a decommissioning licence, the DGR would be closed by sealing the vertical repository access shafts with engineered seals comprised of clay-based, asphaltic and concrete materials.

Borehole hydraulic testing trailer

Transition of the DGR Project to the NWMO

Effective January 1, 2009, OPG contracted with the Nuclear Waste Management Organization (NWMO) to undertake a number of activities on its behalf to develop the DGR. As part of the arrangement, OPG staff that had been working on the DGR project became NWMO employees.

The NWMO is a not-for-profit company established under the Nuclear Fuel Waste Act by OPG, Hydro Québec and New Brunswick Power, the nuclear power utilities in Canada, to implement a long-term solution for Canada's used nuclear fuel.

The NWMO's implementation of Adaptive Phased Management (APM) plan for the safe management of Canada's used nuclear fuel is a separate project from OPG's proposed Deep Geologic Repository (DGR) and will remain so. Combining the expertise of key staff allows them to benefit from mutual experiences and lessons learned in the application of technology for deep geologic repositories, community consultation, and the collaboration with international partners. The DGR project will benefit from skills, knowledge and relationships developed in the APM program.

OPG continues to be the sole owner of the DGR and the DGR will only accommodate OPG's low and intermediate level waste as described in the current Host Community Agreement. The NWMO will be the Project Manager for the DGR project overseeing licensing and development activities. The DGR Project will proceed as planned, while honouring all commitments in the hosting agreement with the Municipality of Kincardine.

Regulatory Approval Process

The regulatory approval process that was initiated in December 2005, continues to progress toward a site preparation and construction licence. The DGR project was referred to a review panel under the Canadian Environmental Assessment Act, in June 2007. Subsequently, in April 2008 the Canadian Nuclear Safety Commission (CNSC) and the federal Environment Minister, jointly issued draft guidelines for the Environmental Impact Statement (EIS) and the Joint Review Panel Agreement for a public review period.

After completing the public review process, which included providing participant funding to six environmental groups to assist them in participating in the process, the CNSC and Canadian Environmental Assessment Agency issued the final guidelines for the EIS and the Joint Review Panel Agreement on January 26, 2009. The next steps in the approvals process include site specific studies to verify the suitability of the Bruce site for implementation of the DGR concept and analysis of the potential effects of the project on the environment. Upon completion of the field studies and analysis of the results, the various studies will be documented in the EIS. The EIS, along with the Preliminary Safety Report, will be submitted to the Joint Review Panel in 2011. The Panel will issue the documentation for a public review period, and will also conduct its own review. The public review period will be followed by a public hearing where stakeholders will have the opportunity to present their feedback on the DGR project.

After the hearing the Panel makes a recommendation to the Minister of the Environment who takes it to Cabinet for the final decision. The EIS must be accepted before a site preparation/construction licence can be issued.

Geoscientific Site Characterisation Program

Geoscientific site characterisation activities continued in 2008 as part of a multi-phase 4-year program initiated in 2006. The geoscience work program is divided into two key areas; site-specific characterisation studies that involve, among others, a multi-disciplinary deep drilling program at the Bruce site; and a Geosynthesis program that combined with information from the site-specific studies describes the geoscientific basis for understanding the past, present and future geologic evolution of the site as it influences DGR safety.

Geoscience Activities

During 2008, key progress involved the completion of two deep vertical boreholes, DGR-3 and DGR-4, which were drilled, cored and tested through the sedimentary sequence underlying the Bruce site to depths of 860 m below ground surface. The addition of these two boreholes in combination with information from two others completed in 2007 has generated a 3-dimensional understanding of the geologic conditions and properties for the bedrock formations hosting and enclosing the DGR. The results of the current site investigations were, in part, included in the Phase I Geosynthesis and six accompanying Supporting Technical Reports, which were issued in late 2008. These peer-reviewed reports, listed below, provide a description and synthesis of regional geologic, hydrogeologic, hydrogeochemical and geomechanical information that will aid development of the DGR Safety Case.

- Phase 1 Geosynthesis
- Phase 1 Long Term Climate Study
- Phase 1 Long Term Cavern Stability
- Phase 1 Regional Geology, Southern Ontario
- Phase 1 Regional Geomechanics, Southern Ontario
- Phase 1 Regional Hydrogeochemistry, Southern Ontario
- Phase 1 Hydrogeology Modelling

These reports are available on the OPG web site at: **www.nwmo.ca/dgr**.

Geoscientific investigations of the Bruce site are scheduled for completion in spring 2010. Upon completion, the program will have benefitted from the completion of 6 deep boreholes, including, two inclined deep boreholes, DGR-5 and DGR-6, planned for 2009. These two boreholes will be drilled on an incline of about 65° to purposefully attempt to intersect sub-vertical bedrock structure of potential interest to the DGR Safety Case. A final geosynthesis document describing the site characteristics based on both regional and site-specific studies as relevant to DGR safety is scheduled for completion in the fall of 2010.

Top: **Rock core retrieved from DGR-3**

Bottom: **Workover rig hydraulic testing at DGR-4**

Top: **Geologists show keen Interest in the core from DGR-3 and DGR-4**

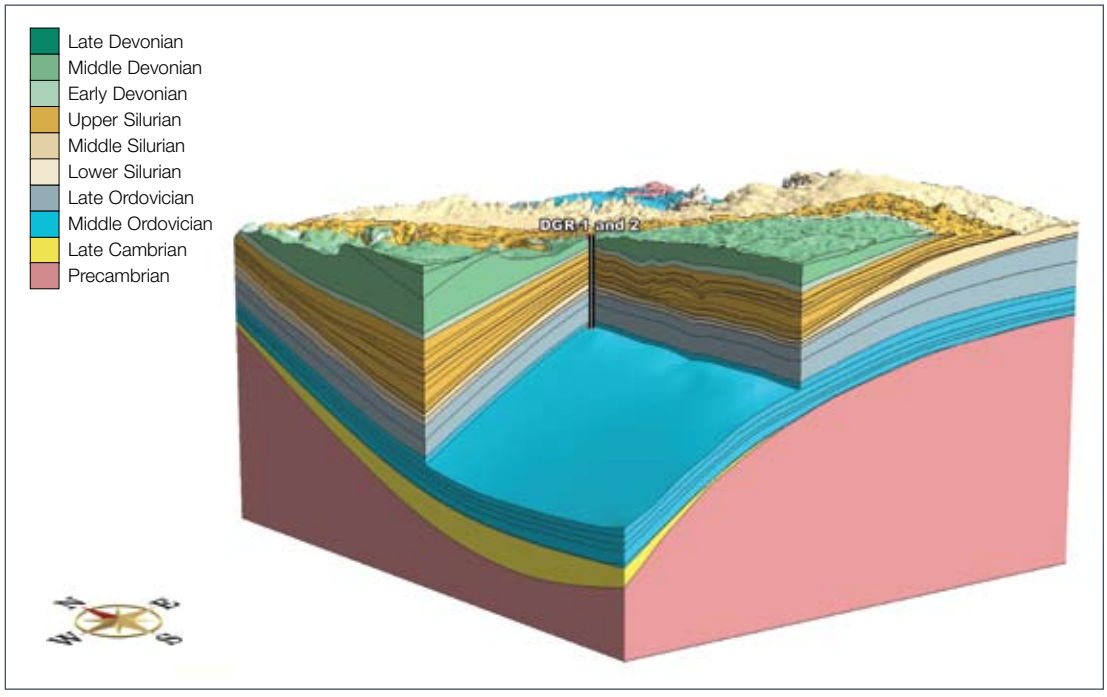
Bottom: **Technical experts gather for a DGR Geosynthesis Workshop**

An Evolving Understanding: Interim Results

The Geoscientific investigations conducted to date at Bruce site are providing useful insight as to the ability of the geologic layers hosting and enclosing the proposed DGR to safely contain and isolate the L&ILW. Specific attributes of the Bruce site that contribute to this understanding are described below.

PREDICTABILITY

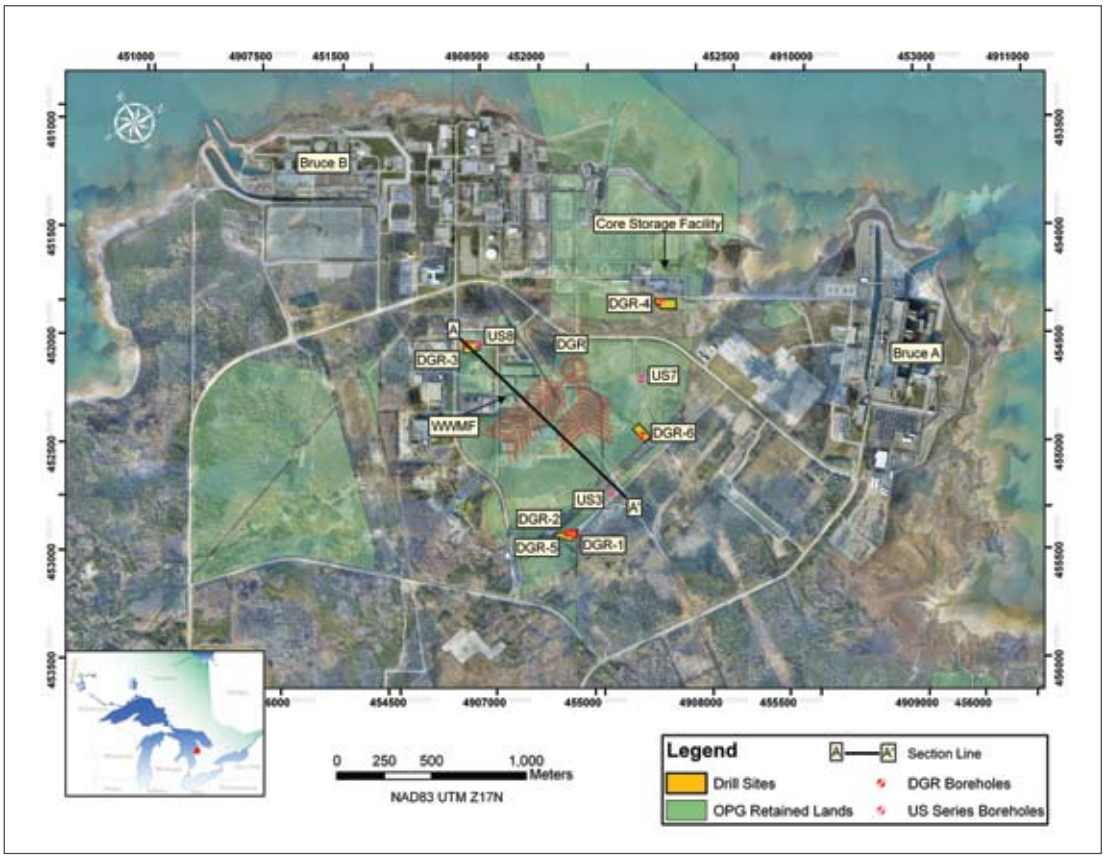
Regionally, the sedimentary bedrock stratigraphy was re-constructed using over 300 historical oil and gas well records within a 35,000 km^2 area surrounding the Bruce site. This stratigraphic model defines a near horizontally-layered, relatively undeformed and laterally extensive sedimentary sequence extending beneath Lake Huron that is comprised of carbonates, shales, evaporites and sandstones with predictable 'layer cake' geometry. Consistent with this understanding, the deep borehole program has confirmed that the sedimentary sequence beneath the Bruce site is comprised of 34 bedrock formations with a combined thickness of about 840 m. Individual formation contact elevations and thicknesses, particularly at the proposed repository horizon, have been found predictable to within metres. The repository, situated in the argillaceous limestone Cobourg Formation, is confirmed to be overlain by 200 m of shale.



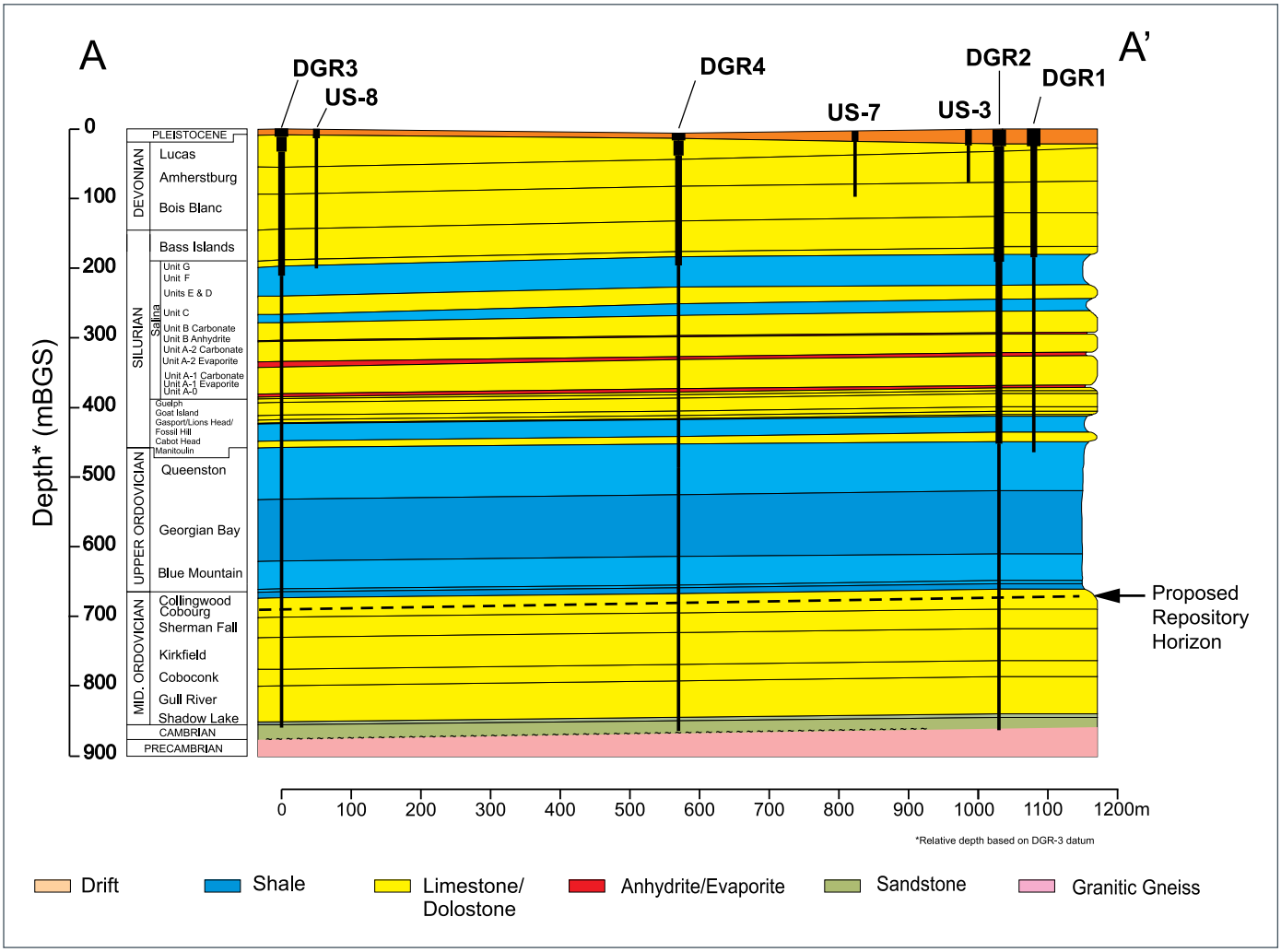
Michigan Basin – stratigraphic layering of rock

MULTIPLE NATURAL BARRIERS

The results of deep borehole testing confirm that the DGR repository horizon is under- and overlain by multiple layers of low permeability (≤10^{-12} to 10^{-14} m/sec) sedimentary bedrock. The repository is situated in a deep saline groundwater domain enclosed by Ordovician (490–443 million years) age rock formations. The overlying layers consist of three low permeability and laterally continuous shale formations (thickness 200 m). The underlying layers are limestone (thickness 150 m). A sequence of moderate to low permeability, Silurian (443–417 million years) age shales, dolostones, and evaporites (thickness 190 m) lie above these Ordovician formations within an intermediate groundwater domain. The borehole testing results are consistent with long-term borehole hydraulic monitoring data that reveal vertical groundwater pressure distributions within the sedimentary sequence. The presence of this pressure distribution can only exist with extremely low formation scale permeabilities and the absence of permeable vertical pathways.



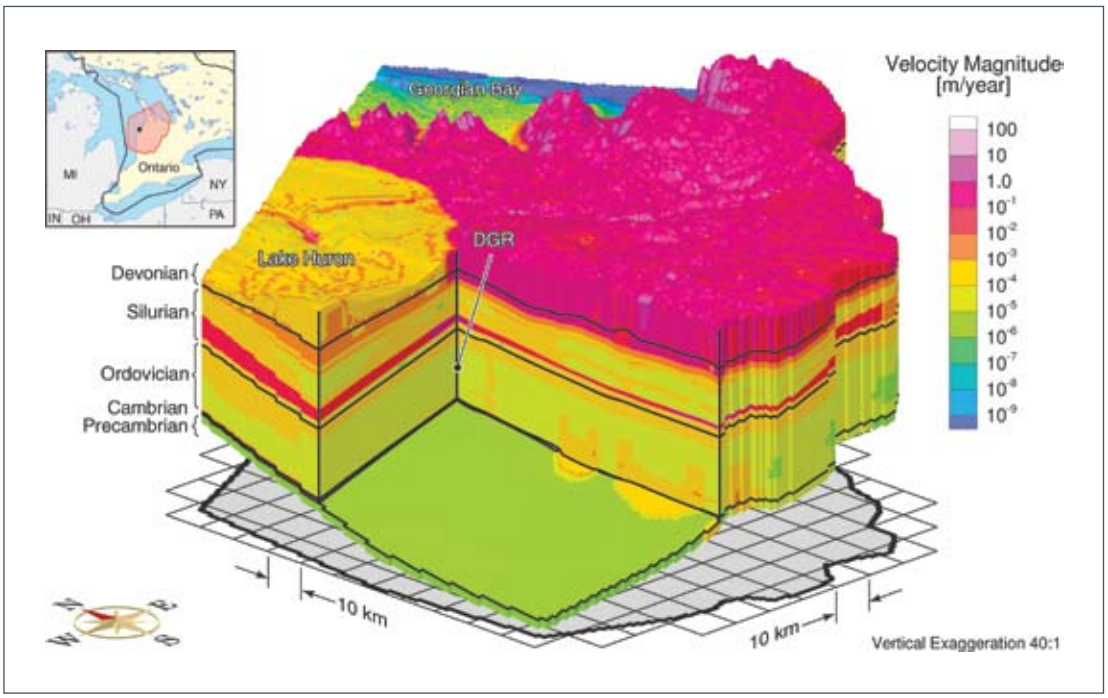
2009 Bruce Site Borehole Locations



Geologic cross-section as shown on DGR Borehole Location Plan

CONTAMINANT TRANSPORT DIFFUSION DOMINANT

The deep groundwater regime surrounding the DGR is ancient and is one in which contaminant transfer is diffusion dominated. Field and laboratory data gathered during deep borehole hydrogeologic and hydrogeochemical testing confirms this. The evidence includes the horizontally stratified, laterally continuous, low permeability sedimentary formations beneath the Bruce site and the occurrence of extremely saline (Total Dissolved Solids ≥ 250 gm/L) and chemically distinct bedrock formation groundwater and pore fluid compositions. These characteristics are all indicative of emplacement in the geologic past. This information contributes to the completion of numerical simulations of the regional and Bruce site groundwater movement. These simulations, which consider uncertainties related to past, present and future evolution of the groundwater system, consistently predict a stable diffusion dominant system enclosing the repository. It is estimated that solutes at the repository horizon would take more than 8 million years to discharge.

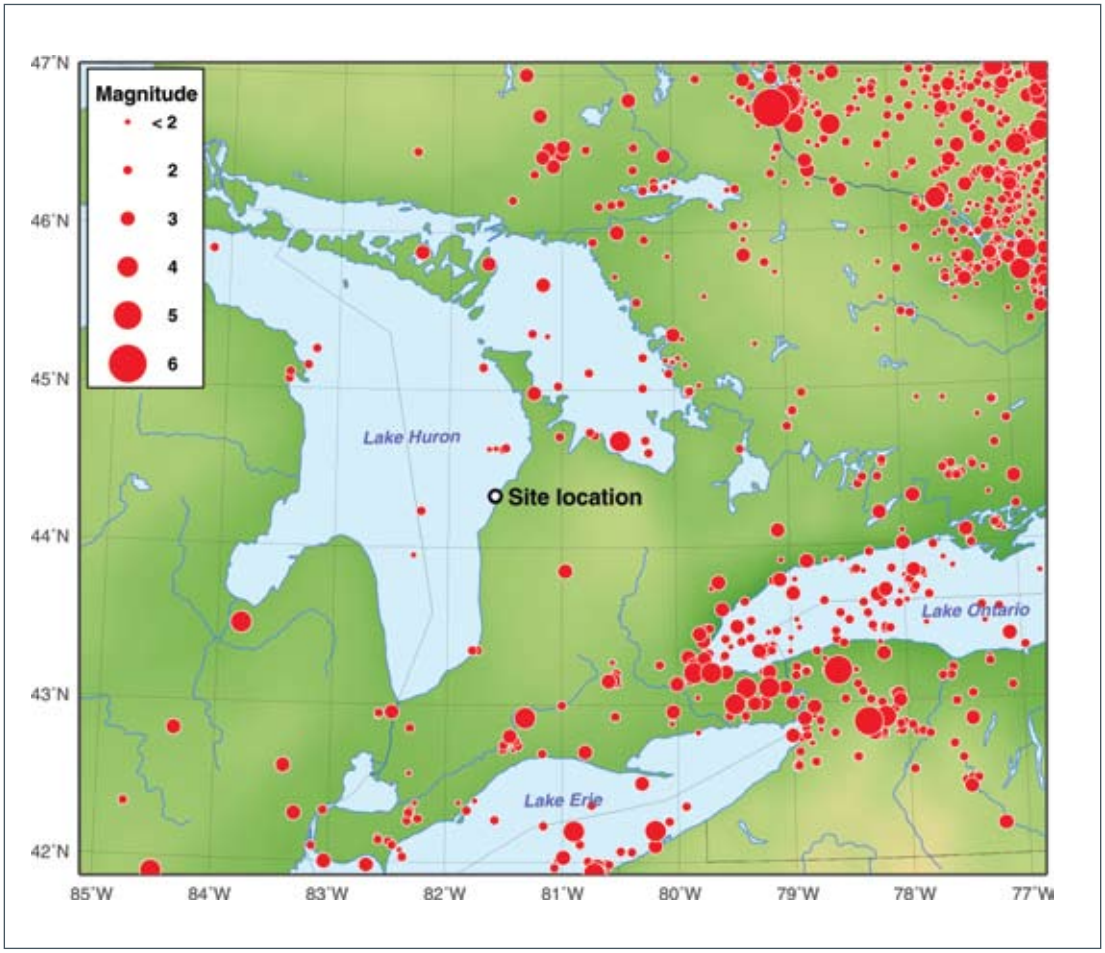


Modelling results – groundwater flow velocities
Phase 1 regional hydrogeology

SEISMICALLY QUIET SITE

The Bruce site is located within the tectonically stable interior of the North American continent, and is comparable in terms of stability to the Canadian Shield. Historic seismicity records indicate that there has not been a seismic event near Bruce site exceeding Magnitude 5 in over 180 years of observation.

A micro-seismicity borehole monitoring network was installed in the summer of 2007 to allow improved monitoring of micro-seismicity within a 50 km radius of the Bruce site. Monitoring of the new network is undertaken by the Geologic Survey of Canada's Canadian Hazard Information Service. Monitoring to date has not detected natural seismic activity greater than Magnitude 2.5 within a 150 km radius of the site. Seismic events below Magnitude 2.5 would not normally be felt at surface.



Seismic activity (start of historic records – 2007)

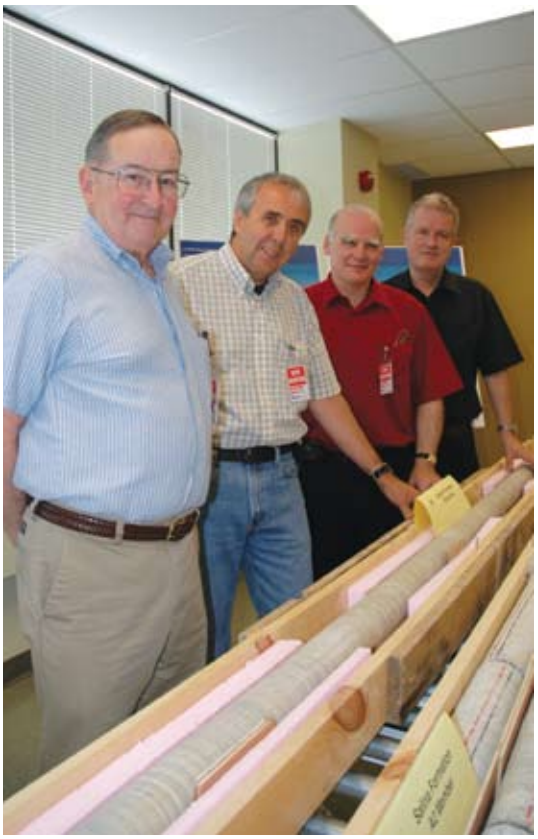
GEOMECHANICALLY STABLE HOST ROCK

The repository opening should be dry and stable. This assertion is supported by evidence gathered through review of underground construction experience within the Cobourg Formation, coupled with results from borehole permeability testing, geomechanical core testing, and numerical simulations of operational and long-term repository opening stability. A practical example of an underground opening in the Cobourg Formation includes the Darlington Nuclear Generating Station cooling water intake tunnel, which provided a stable, dry opening with little rock support only 30 m beneath Lake Ontario.

Darlington cooling water intake tunnel

NATURAL RESOURCE POTENTIAL IS LOW

The results of petroleum well drilling, and the coring and testing of the deep boreholes on Bruce site, coupled with knowledge of the geologic setting, strongly suggest that viable commercial oil and gas reserves do not exist within 40 km of the Bruce site. Commercially viable base metal deposits have not been identified in the study area.



GRG examines rock core

Geoscience Review Group

The mandate of the Geoscience Review Group (GRG), who provided guidance and oversight of the first phase of the geoscientific studies, was renewed for the second phase of the Geoscientific Site Characterisation Program. The GRG comprises internationally renowned scientists and engineers whose role on the DGR project is to ensure that information and lessons learned from their experience in similar international programs are reflected in the DGR project.

During 2008, the GRG attended workshops at which the results of the Bruce site and regionally based geosynthesis work programs were presented, and provided input and comment. The GRG also worked with the geosynthesis team to reconcile comments on the Phase 1 Geosynthesis report, issued in 2008.

Safety Assessment

The safety of the DGR during the operational phase and over the long-term, after operations have ceased and the facility has been decommissioned, are being studied. These technical studies of the operational and long-term safety of the proposed DGR will contribute to the environmental impact statement and the submissions supporting the site preparation/construction licence application. Canadian and international guidelines are being followed in the safety assessments.

Preclosure Safety

The preclosure safety assessment covers the period from the start of operations to the closure of the facility. Activities are currently focused on identifying the potential radiological impact of the DGR on workers and members of the public and developing an estimate of the radiological emissions for use in assessing possible impacts. Work is also being done to identify accidents, which could occur as a result of DGR operational failures or external hazards. The potential consequences of these accident scenarios are also assessed.

Based on experience from the WWMF operations, small amounts of tritium and C-14 are expected to be released from the DGR under normal operating conditions, dropping to zero as the DGR is closed. The potential sources of air emissions are the waste receipt building and the repository ventilation shaft. The potential sources of water emissions are the waste receipt building and the sump water pumped out of the repository.

The potential doses due to these small releases are estimated to be similar to the low doses presently observed for the WWMF, where many of the wastes are currently located. These results suggest that there are no concerns with respect to exposure to members of the public during normal operations of the DGR.

Accident scenarios were postulated for the DGR facilities, both above and below ground. These accidents were screened for likelihood and worst-case scenarios were identified for analysis. The accidents considered included breach of waste package and fire. The preliminary analysis suggests that radioactivity released from above or below ground accidents will not harm members of the public.

Future work will continue interacting with the engineering team to refine the design, and to improve the assumptions used in the safety analysis.

Postclosure Safety

The postclosure safety assessment period will start when the facility is closed and sealed, and continues to the time when the maximum dose impact is predicted to occur. The purpose of the safety assessment is to quantitatively assess the postclosure radiological and non-radiological safety of the proposed DGR. In the assessment, uncertainty in the future evolution of the site is addressed by analyzing a range of future scenarios.

Ensuring the safety assessment incorporates information from the conceptual design report

Scenarios being considered for the future evolution of the DGR system include the Normal Evolution Scenario, which describes the expected long-term evolution of the repository and site following closure, and four disruptive scenarios, which consider events with low probability that could disrupt the repository system. These include, for example, future human intrusion into the repository, as well as the effects of a very large earthquake.

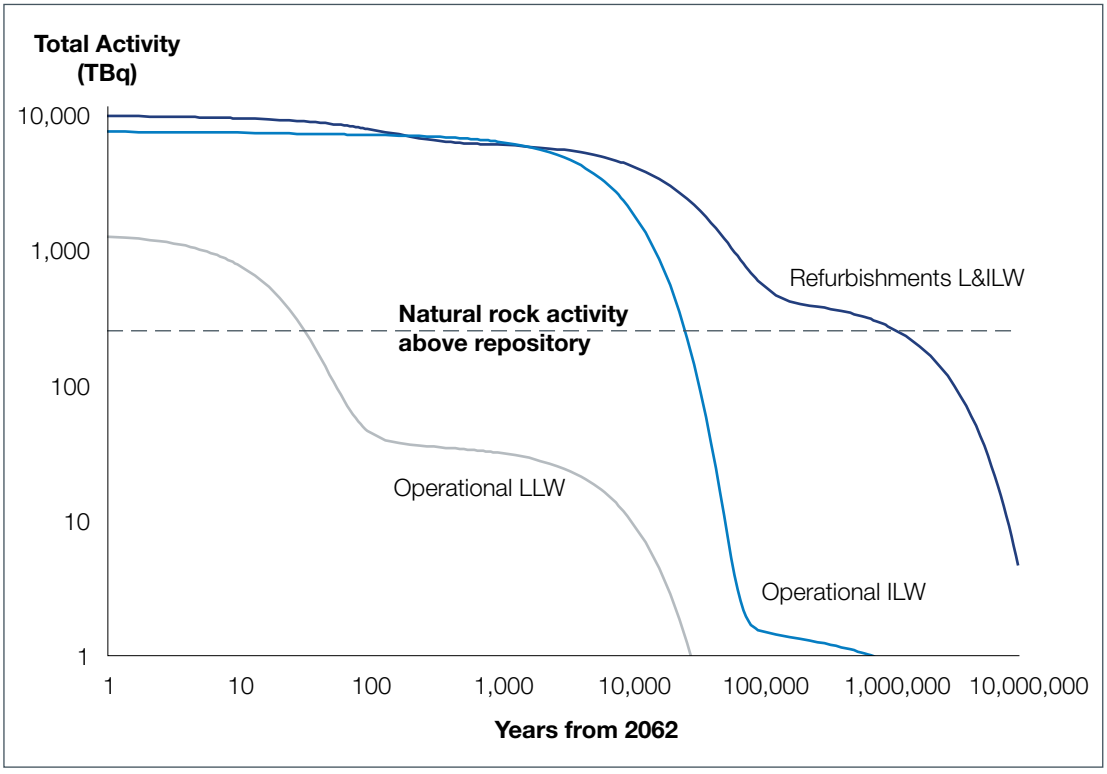
The current results of this work predict that there would be very little impact from the repository. Observations which contribute to this prediction include that the host rock is very effective in retarding movement of radionuclides, and the repository will take a very long time to resaturate. Other key observations which will be considered further in ongoing work include the importance of the sealed shaft as a potential pathway for radionuclides, and the importance of C-14 containing carbon dioxide and methane gas generated from decomposing organic and plastic waste.

Waste Inventory

The understanding of the waste inventory is based on more than 25 years of historical data. The radionuclide content has been measured and estimated using a variety of standard methods. The total estimated activity for disposal in the repository is approximately 980 PBq (9.8×10^{17} Bq) at 2017, the earliest possible start of operation. At the earliest assumed closure time (about 2062), the total activity is about 17 PBq (1.7×10^{16} Bq) (taking into account new waste being emplaced as well as decay of already stored wastes).

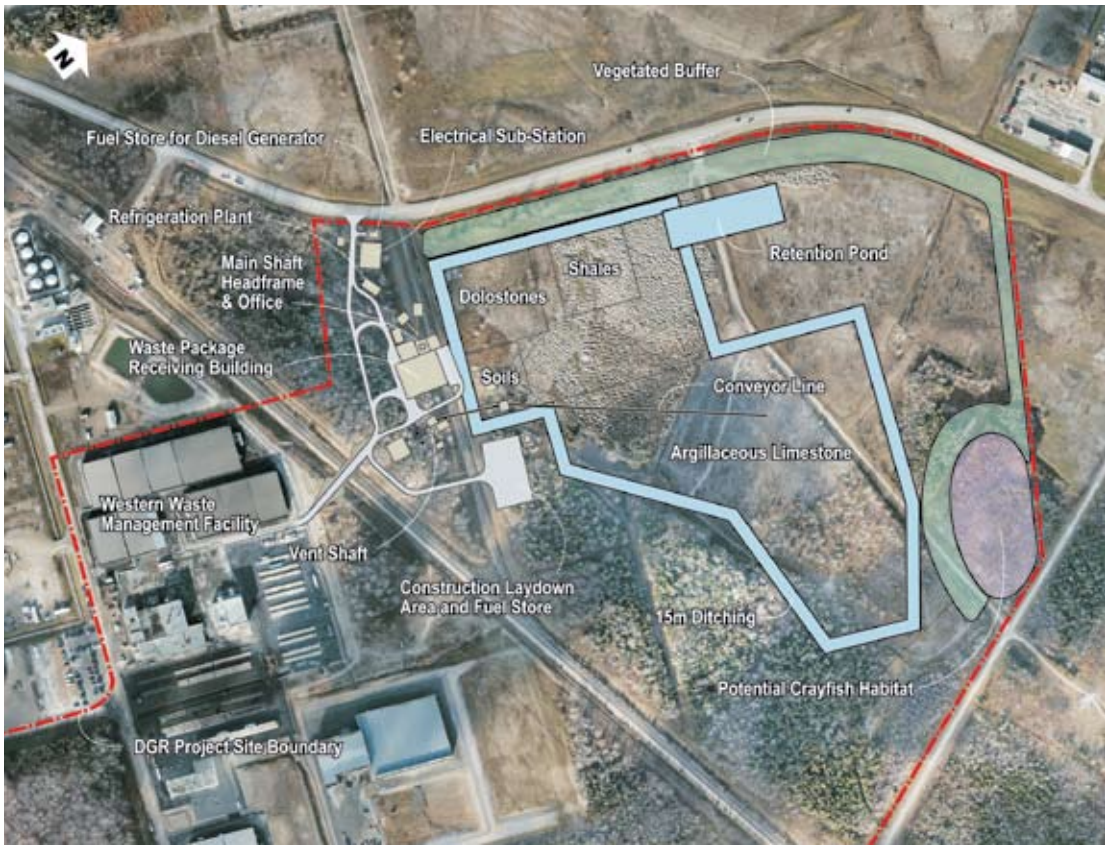
The total radioactivity will decrease with time due to radioactive decay. The following figure illustrates the radioactivity within the three major classes of waste – operational low-level waste (e.g. cleaning materials, mops), operational intermediate-level waste (e.g. water cleaning resins), and refurbishment waste (e.g. steam generators, pressure tubes). Initially, key radionuclides are tritium and C-14. At long times, the residual radioactivity is primarily due to Zr-93. For comparison, the low natural radioactivity of the host rock over the repository is also shown in the figure.

In 2008 additional work was undertaken to improve our knowledge of waste in areas of most importance to the safety case. This work included sampling of specific wastes currently stored at the WWMF. Results of this work will provide input to future safety assessment work.



Total radioactivity in the DGR as a function of time

Conceptual Design of the DGR



Conceptual layout of DGR surface facilities adjacent to WWMF

A conceptual design for the DGR was completed in 2008. This work updates and advances previous conceptual design work completed in 2004. The scope of work included all aspects of the DGR, including its construction, the receipt of waste from the WWMF and nuclear generating stations, and the emplacement of the waste in the DGR.

The surface features of the DGR include the main shaft, ventilation shaft and waste rock management area. The main shaft area will have a headframe equipped with a hoist to handle a 40-tonne payload, a waste package receiving building, and buildings housing equipment to heat and cool air to be delivered underground. The waste package receiving building and shaft office will be directly connected to the main shaft headframe building. In addition, a maintenance shop and storage area will be attached to the main shaft headframe building. The ventilation shaft area will include a headframe building with airlock, a hoist house, a waste rock bin, and an exhaust fan building.

A bridge will be constructed to provide the link between the existing WWMF and the DGR.

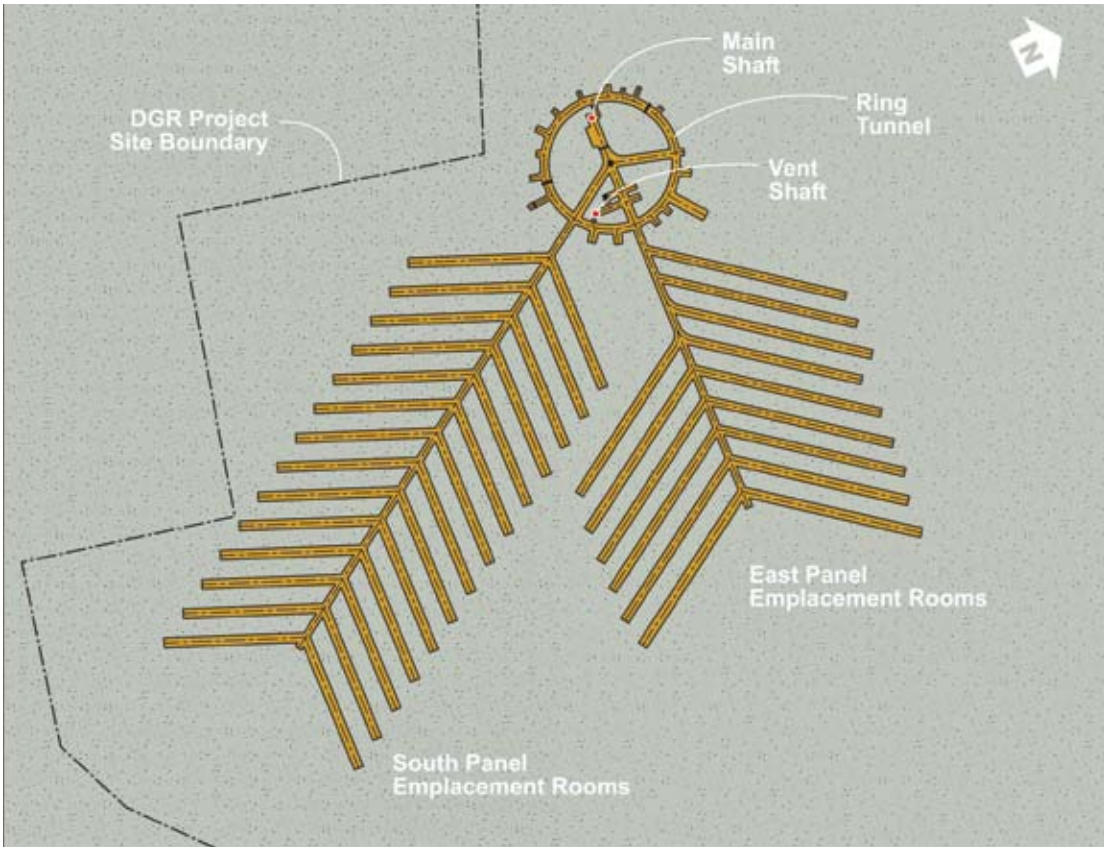
The reference capacity of the DGR is nominally 200,000 m^3 of “as-disposed” waste.

It is currently assumed that the DGR will be fully developed during initial construction.

The underground layout of the repository includes two vertical shafts located on a central ring tunnel. Two emplacement room access tunnels radiate out to the south and east, and smaller ancillary rooms will also be provided for administrative and maintenance activities off the central ring tunnel. This arrangement facilitates having all underground infrastructure near to the shafts, while keeping the emplacement rooms further from areas that are normally occupied or high activity areas.

Shafts will be excavated by traditional drill and blast methods in the harder dolostones, with vertical roadheaders currently being considered to excavate in the shales. A horizontal roadheader is the proposed excavation method for the access tunnels and emplacement rooms.

Storage for the waste rock volume, estimated to be about 700,000 m^3, will be at surface to the northeast of the two shafts.



Top: **Conceptual drawing of the surface facilities of the DGR**
Middle: **Conceptual drawing of a low level waste emplacement room in the DGR**
Bottom: **DGR underground layout**

Community Engagement

In 2008, OPG continued to take its consultation activities to locations and events where the public would already be gathering. The DGR exhibit trailer, in conjunction with staff, attended the Wiarton, Port Elgin, Walkerton and Kincardine Home Shows, the Kincardine Scottish Games, the Chippewas of Nawash PowWow, the International Plowing Match, the Port Elgin Pumpkinfest, Clarington Family Safety Day, and summer markets in Kincardine and the surrounding area.

Progress was made toward reaching agreement on a Protocol with the Saugeen Ojibway Nation (SON). In April, OPG and SON initialed a Protocol and agreed to work to finalize the schedules relating to implementing the agreement before signing the final Protocol. These discussions are expected to continue in 2009 and result in signing the Protocol. At meetings to discuss the Protocol, OPG also provided updates on the status of the DGR project.

Contact was made with two local Métis Community Councils, leading to meetings with the Saguingue Community Council and the Métis Nation of Ontario to provide an overview of the DGR project and to discuss how they would like to participate in the project. These discussions are expected to continue in 2009.

In March 2008, OPG took the opportunity to present a “Geology Rocks” workshop, based on the onsite drilling activities and the rock core, to members of the Girls in Real Life Science Club. The workshop provided a day-long discussion of careers in geology, key points about the DGR, an examination of fossils, and hands-on experience classifying rocks based on rock properties.

OPG and the DGR project also sponsored and participated in the International Plowing Match which was held in Teeswater, Ontario in September 2008. This event was attended by more than 97,000 people. Attendees were from Ontario and the world, including school children and the agricultural community, many of whom visited the exhibit to obtain information and provide feedback about nuclear waste management and the DGR project.

A series of Open Houses was held in the local communities of Kincardine, Ripley, Port Elgin, Walkerton, Wiarton, Owen Sound and Chesley during November. More than 150 people attended the Open Houses, most to receive updated information on the status of the DGR project but some to learn about the project for the first time, some to express their opposition to nuclear energy or the project, and some to discuss employment opportunities for local residents in association with the project.

Top: **A representative of the next generation attends a DGR open house**

Middle: **Girls in Real Life Science participate in the DGR Geology Rocks Workshop**

Bottom: **Fall Open House 2008**

Top: **OPG on behalf of the DGR Project sponsored and participated in the 2008 International Plowing Match**

Bottom: **OPG's DGR Exhibit participated in the Nawash PowWow**

Girls in Real Life Science participate in the DGR Geology Rocks Workshop

Throughout the year, project staff made more than 45 presentations on the DGR project to local community and service groups, and professional organizations. Many of these presentations provided updates on the DGR project to groups previously addressed, but OPG was also able to extend its network to service groups in Tobermory, Grand Bend, and to professional groups in London and Port Hope.

Three DGR Project newsletters were published and distributed by mail to nearly 25,000 local residences. The newsletters focused on the conceptual design of the DGR, the geologic model for the DGR, how the information gathered to date in the geoscientific site characterisation is contributing to the safety case, the Open Houses, and the second Rock Core Workshop.

The key comments received on the project continue to be associated with whether used nuclear fuel or waste from other producers will be stored in the DGR, the proximity of the DGR to Lake Huron and the Great Lakes, and the potential for contamination of drinking water. The community stakeholder events provided an opportunity for OPG to respond to the questions and comments that are provided.

Environmental Assessment Process

Scientists assess fish population

In January, 2009, following a public review and comment period in 2008, the Canadian Nuclear Safety Commission and the Canadian Environmental Assessment Agency released the final guidelines for the Environmental Impact Statement (EIS) for the DGR project and the Joint Review Panel (JRP) agreement. The EIS guidelines identify the information needed to examine the potential environmental effects of the proposed project as well as requirements for a licence to prepare a site and for construction. The JRP agreement deals with the establishment of an independent review panel including procedures for appointing the JRP members, the proposed terms of reference (i.e., responsibilities) for the panel and the process for conducting the reviews.

The compilation and documentation of baseline environmental data to support the EIS continued in 2008. These data provide the starting point from which the potential effects of the DGR project on the environment, including the physical, cultural, social, and economic components, will be assessed.

Left: **Wild turkeys populate the Bruce nuclear site**
Right: **Habitat assessment in winter conditions**

The information compiled to date indicates that:

- 21 species of birds were identified in the project area (lands proposed for the DGR project)
- two flocks of wild turkeys nest and live at the Bruce site
- Several varieties of frogs and turtles were sited in the local study area which includes the Bruce site and nearby surrounding lands
- there is evidence of chimney building crayfish in the project area
- white-tailed deer were sighted in the local study area.

Project Schedule

The DGR project continues to be on schedule with the geoscientific characterisation work expected to be completed in 2010. This information forms the basis for the safety assessment and the environmental impact statement, which will be submitted to the review panel early in 2011. The Panel hearing is expected to take place in 2012. If the review panel accepts the environmental impact statement, the site preparation/construction licence(s) could be issued in 2012.

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