

**DEEP GEOLOGIC REPOSITORY FOR LOW  
AND INTERMEDIATE LEVEL RADIOACTIVE WASTES**

**PROJECT DESCRIPTION**

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## 1.0 INTRODUCTION

This project description document outlines Ontario Power Generation's (OPG's) plans for developing a Deep Geologic Repository (DGR) on the Bruce site in the Municipality of Kincardine, Ontario. The DGR would receive low and intermediate level radioactive waste (L&ILW) currently in storage on the Bruce site, as well as that produced from the continued operation of OPG-owned generating stations at Bruce, Pickering and Darlington, Ontario. Much of the waste is currently stored in interim facilities at the Western Waste Management (WWMF) facility on the Bruce site and the remainder will be produced over the remaining lives of the nuclear power stations.

Disposal in the sedimentary bedrock beneath the Bruce site was selected following extensive technical and community reviews of alternative long-term waste management technologies. The DGR project would employ technology and radioactive waste management practices currently used by several industrialized countries, including Sweden, Finland and the United States. These international projects are described in Appendix A.

The DGR project has the support of the Municipality of Kincardine. Following completion of an Independent Assessment Study (IAS)(Golder, 2004) and negotiation of a Host Community Agreement in 2004, a clear majority of the residents in the host community supported the establishment of a DGR facility for the long-term management of low and intermediate level waste at the WWMF. The Host Community Agreement makes provision for emplacement of decommissioning waste in the DGR however the environmental assessment (EA) for the proposed DGR would not seek approval for emplacement of that waste in the DGR. An environmental assessment may be required at the time when decommissioning is proposed but, at this time, there are no detailed decommissioning plans for any of Ontario's nuclear reactors.

It is anticipated that the first wastes would be emplaced in the DGR in approximately 2017. In the intervening period, waste will continue to be received, processed and stored at the WWMF. Construction and operation of the DGR will follow an extensive program of field studies, geophysical analysis, modeling, engineering design, safety assessment, and community consultation. Regulatory approvals are also required for the facility. The completion of the environmental assessment is an early and crucial part of the planning process.

## 1.1 PURPOSE OF THIS PROJECT DESCRIPTION

The purpose of this document, prepared by OPG, is to provide the project description information required from the proponent in accordance with the *Federal Coordination Regulations* of the *Canadian Environmental Assessment Act* (CEAA) (Canadian Environmental Assessment Agency, 1997). This information is intended to:

- i. Allow the Canadian Nuclear Safety Commission (CNSC) to determine the need for, and its role in, a federal EA for the DGR project, under the CEAA
- ii. Enable other federal authorities, pursuant to the Federal Coordination Regulations, to determine their responsibilities or interests in the DGR project, under the CEAA
- iii. Provide the basis for the CNSC to consult with provincial EA authorities to determine any need for harmonization of the EA process with that of other jurisdictions
- iv. Assist in early identification of potential environmental issues that should be considered in preparing the scope document (EA Guidelines).

Submission of this document to the CNSC is expected to meet the requirements of a project description initiating the environmental assessment that is required under the CEAA. Under CEAA, the scope of the project and the scope of the factors to be considered in the environmental assessment are determined by the Responsible Authority (RA), based on the information in the project description document.

In accordance with guidance from the Canadian Environmental Assessment Agency (CEAA, 2000), the following information is included in this document:

- Information indicating the location of the DGR project and the areas potentially affected by the project (see sections 2,3 and 4)
- A summary description of the DGR project (see section 2)
- A summary description of the physical, biological and social environments within the areas potentially affected by the DGR project (see sections 3 and 4); and
- Programs to manage radiation and environmental risks (see Appendix C).

In addition, though not explicitly indicated by the Canadian Environmental Assessment Agency, because of the potentially controversial nature of any nuclear waste management project, a



description is also provided of the community communications and consultation program that led to the selection and siting of the DGR in the Municipality of Kincardine (see section 5).

## 1.2 OVERVIEW OF THE PROPOSED PROJECT

The DGR project includes the site preparation, construction, operation and long-term performance of above- and below-ground facilities for the long-term management of OPG's low and intermediate level radioactive waste. The DGR would be constructed in competent sedimentary bedrock beneath the Bruce site. The surface facilities for the DGR would be located on OPG-owned land at the Bruce site near to the existing WWMF. The underground facilities will be comprised of access-ways (shafts, ramps and tunnels), emplacement rooms and various underground service areas and installations. All surface and underground facilities are expected to be located within the boundaries of the Bruce site.

OPG-owned nuclear generating stations at Pickering, Darlington and Bruce produce used nuclear fuel, and low and intermediate level radioactive waste. Used nuclear fuel is stored and managed within licensed facilities at each of the respective nuclear generating stations. The development of a long-term facility for used fuel is the responsibility of a federally-mandated organization, the Nuclear Waste Management Organization (NWMO), and is not the subject of this project.

The L&ILW is currently processed and stored at OPG's WWMF on the Bruce site in the Municipality of Kincardine. The L&ILW is transported by truck from Pickering and Darlington to the WWMF, and by truck on-site from the Bruce stations.

OPG's nuclear waste management operations are regulated under the *Nuclear Safety and Control Act* and regulations under that Act. OPG has in past and continues to operate in compliance with those regulatory requirements. The WWMF is operated by OPG under Waste Management Facility Operating Licence No. WFOL-W4-314/2007, issued by the CNSC. A description of the WWMF and the wastes received and stored at that facility is provided in Appendix B and section 2.3.2.

The DGR project is planned to be implemented near to the WWMF. The WWMF has safely received, processed and stored L&ILW for over 30 years. Shipments of L&ILW to the WWMF from

Pickering and Darlington are also subject to the *Nuclear Safety and Control Act*, including the regulations under the Act, and to Transport Canada regulations.

### **1.3 NEED FOR THE PROJECT**

The existing facilities at the WWMF were designed as interim storage for Ontario's existing fleet of twenty nuclear reactors. These facilities have an excellent safety record and could be relied upon to protect the health and safety of the public and the environment provided institutional controls exist. OPG is proposing to develop a facility, the DGR, capable of safely isolating the wastes from people and the environment over the hundreds and thousands of years that the wastes remain radioactive.

The DGR is proposed for the following reasons:

- It is consistent with best international practice
- It provides a permanent storage method for current waste streams from Ontario's twenty nuclear reactors, which will protect health, safety and the environment, and if necessary, will do so in the absence of institutional controls
- It provides a greater margin of safety than the existing facilities
- It is preferred by the host municipality over the other technical options that have been evaluated, including the existing facilities

### **1.4 SUITABILITY OF THE BRUCE SITE**

The sedimentary rock formations beneath the Bruce site occur in predictable, near-horizontal layers that "blanket" one another and extend for hundreds of kilometres. Within this layer-cake sequence of rock formations, the DGR would be excavated into limestone and shale formations that possess extremely low permeabilities and in which groundwater flow is expected to be virtually stagnant – an extremely effective factor in containing radioactive material. The configuration and thickness of these sedimentary rock units offer a natural barrier, isolating the repository and protecting the near-surface groundwater.

Over the years, underground openings such as mines and tunnels have been excavated through some of the same rock formations being proposed for the DGR. These facilities, some as far away as Cleveland, Ohio, provide practical evidence of deep underground openings in limestone formations remaining dry and stable. The geologic parallels between these openings

and the geologic setting beneath the Bruce site indicates that similar favourable repository conditions exist for the proposed DGR.

## 1.5 COMMUNITY ACCEPTANCE OF THE PROPOSED PROJECT

In 2002, recognizing that long-term management of L&ILW produced by Ontario's nuclear generating stations would be required, the Municipality of Kincardine approached OPG seeking to enter into an agreement to study options for long-term management of L&ILW. Those discussions led to the signing, in April 2002, of a Memorandum of Understanding (MOU) between OPG and the Municipality of Kincardine.

The outcome of the MOU was the identification of the DGR as the preferred long-term management approach for L&ILW at Kincardine. This conclusion followed site visits by Municipal officials to international waste management facilities and completion of an Independent Assessment Study (Golder, 2004), based on existing regional information, for the DGR concept and alternative management methods. In April 2004, Council passed *Resolution #2004 - 232*,

*that Council endorse the opinion of the Nuclear Waste Steering Committee<sup>1</sup> and select the "Deep Rock Vault" [DGR] option as the preferred course of study in regards to the management of low and intermediate level radioactive waste.*

Passage of this resolution paved the way for OPG and the Municipality of Kincardine to initiate discussions leading to the development of a Host Community Agreement (Municipality of Kincardine and OPG, 2004). The Agreement sets out the terms and conditions under which the Municipality of Kincardine would continue to support the DGR.

Although the Agreement is formally between OPG and the Municipality of Kincardine, OPG received letters of support for the Agreement from each of the four municipalities which would also receive benefits under the Agreement.

Residents of the Municipality of Kincardine participated in a Municipality-wide poll in January and February 2005 on whether or not to support Council's resolution and proceed with the regulatory approvals process for developing the DGR in Kincardine. A clear majority of residents voted to support the project.

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<sup>1</sup> The Nuclear Waste Steering Committee was a sub-committee of the Kincardine Municipal Council and consisted solely of members of the Kincardine Council and Municipal staff.

## 1.6 PROJECT PROPONENT

OPG is the proponent for the DGR project. Within OPG, the Nuclear Waste Management Division (NWMD) is responsible for the project. To obtain further information about the proposed project, please contact:

### Environmental Assessment

Mr. Angelo Castellan  
Director, Nuclear Waste Programming &  
Environmental Assessment  
Nuclear Waste Management Division  
Ontario Power Generation  
700 University Avenue  
Toronto, Ontario M5G 1X6  
Tel: 416-592-5409  
Fax: 416-592-7051  
Email: angelo.castellan@opg.com

### Technology and Safety Assessment

Mr. Frank King  
Director, Nuclear Waste Engineering &  
Technology  
Nuclear Waste Management Division  
Ontario Power Generation  
700 University Avenue  
Toronto, Ontario M5G 1X6  
Tel: 416-592-2862  
Fax: 416-592-7336  
Email: frank.king@opg.com

## 1.7 REGULATORY ENVIRONMENT

### 1.7.1 Canadian Environmental Assessment Act

The CNSC is responsible for the regulation of nuclear facilities in Canada. Approval by the CNSC, under the *Nuclear Safety and Control Act* (NSCA), is required before OPG may proceed with site preparation, construction, operation or decommissioning of the DGR at the Bruce site. Based on previous experience and preliminary discussions with the CNSC, OPG understands that a request for CNSC approval to undertake site preparation and construction for the DGR would trigger a requirement for an environmental assessment under the CEAA, as defined in Sections 5 and 7. The proposed project is listed under Part VI, Section 19 (g)(iii) of the Comprehensive Study List Regulations; therefore, subject to a determination by the CNSC, OPG expects to prepare and submit an environmental assessment study report in support of the comprehensive study report.

The CNSC is expected to be the lead Responsible Authority (RA) for the DGR project. At this stage no other likely RAs have been identified. The DGR project is not expected to require additional federal authorization or approvals other than those issued by the CNSC. Further, no federal lands are involved and the project is not receiving federal funding. A number of federal departments, including Environment Canada, Health Canada, Natural Resources Canada, Indian Affairs and Northern Development, and Fisheries and Oceans Canada may have a role

as Federal Authorities (FAs) for the project, through the provision of specialized expertise, advice and review of the EA studies.

### **1.7.2 Other Regulatory Requirements**

OPG will comply with the provincial *Environmental Protection Act*, the *Ontario Water Resources Act*, the *Nuclear Safety and Control Act*, and all other pertinent federal and provincial legislation, including regulations under these and other Acts.

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## 2.0 DESCRIPTION OF THE DGR

The DGR project includes the site preparation, construction, operation and long-term performance of above- and below-ground facilities for the long-term management of L&ILW. The waste to be emplaced in the DGR includes the L&ILW currently stored at the Bruce site, as well as future L&ILW waste produced as a result of the continued operation of OPG's nuclear reactors. The Host Community Agreement makes provision for emplacement of waste resulting from the decommissioning of the OPG-owned reactors in the DGR however, that waste is not included in this proposal or this environmental assessment. The DGR will not accept used nuclear fuel.

The underground facilities would be comprised of access-ways (shafts, ramps and/or tunnels), emplacement rooms and various underground service areas and installations. The surface facilities required consist of the underground access and ventilation buildings, associated temporary or permanent buildings, and related infrastructure. All surface facilities for the DGR would be located on OPG-owned land at the Bruce site near to the existing WWMF, and the underground repository would be entirely within the boundaries of the Bruce site. Operation of the DGR would be co-ordinated with the existing WWMF.

Following the operational phase of the DGR, the facility would be decommissioned.

There is no intent to retrieve the waste from the DGR at any time in the future however, during the period prior to the decommissioning of the DGR, it would be possible to retrieve waste from the repository.

## 2.1 LOCATION OF THE DGR

The Bruce site is located about mid-way between Kincardine and Port Elgin, at a longitude of 81°30' west and latitude 44°20' north. The location of the 932-ha Bruce site is shown in Figure 2-1. Although OPG is the owner of the Bruce site, the majority of the site is controlled under a leasing agreement with the current operator, Bruce Power. Bruce Power also controls all access to the site. As a result of the leasing agreement between OPG and Bruce Power, OPG has retained control of the portion of the Bruce site encompassing the WWMF and surrounding lands. The WWMF is used for the interim storage of L&ILW from the Pickering, Darlington and Bruce reactors



FIGURE 2-1: LOCATION OF BRUCE SITE



and used nuclear fuel from the Bruce reactors. A description of the current WWMF L&ILW operations and a site plan is provided in Appendix B.

The DGR would be located on the Bruce site. Figure 2-2 shows the general extent of the OPG-controlled lands centred on the WWMF. The operating Bruce B nuclear generating station is evident in the top of the photograph on the shore of Lake Huron; Bruce A, though not shown on the photograph, is located to the right (north). The WWMF consists of the buildings and structures in the left centre of the lands, approximately one kilometre from the lake shore. The



**FIGURE 2-2: BOUNDARY OF OPG-CONTROLLED LAND ON BRUCE SITE**

*Note: Boundaries are approximate. Another smaller parcel of OPG-controlled land located to south (left) and one to the east are not visible on this figure.*

DGR is expected to be constructed in the area near to the WWMF. The estimated size of the surface facilities for the DGR is approximately 15 hectares, including the construction laydown area and rock pile. The footprint of the underground facilities is approximately 30 hectares.

The exact location of the DGR within the Bruce site will be determined after consideration of a number of factors, including geotechnical and hydrogeological conditions, construction impacts, traffic, material flows, interaction with current operations, and potential environmental impacts. The siting process will be described as a part of the EA.

## **2.2 DGR CONCEPT**

An artist's rendering of a DGR concept is shown in Figure 2-3, including the principal surface buildings, access and ventilation shafts, and the underground emplacement rooms for L&ILW. In this concept, the underground repository would consist of a series of horizontal emplacement rooms, arranged at right angles to a central tunnel, excavated at a nominal depth of 500 to 700 m below surface. A ventilation tunnel may be excavated around the perimeter of the emplacement rooms. Access to the repository would be either by concrete-lined vertical shaft or inclined ramp. (Access by vertical shaft only is shown on Figure 2-3).

Waste packages would be lowered to the emplacement horizon by a hoist or taken via an access ramp and then stacked within the emplacement rooms. When each emplacement room is full, it would be isolated by an interim seal. Once all the waste has been emplaced, and following an interim monitoring period, the entire DGR repository would be sealed by placing low permeability plugs in all access-ways. Until such time as the seal is placed for the entire DGR, the waste will be retrievable. There are no plans to retrieve the waste however, it would be possible up to the time when the access is sealed.

The proposed DGR concept is similar to facilities in operation in Sweden, Finland and the United States. These are described in greater detail in Appendix A.

## **2.3 WASTES TO BE PLACED IN THE DGR**

The DGR would be designed to receive L&ILW produced by OPG-owned nuclear generating stations through the remainder of their operating lifetimes as well as L&ILW currently in interim storage at the Bruce site. The estimated volume of low and intermediate level waste to be placed in the DGR, excluding decommissioning waste, is 160,000 cubic metres (m<sup>3</sup>). This volume estimate is based on a number of assumptions about reactor life, refurbishment and effectiveness of volume reduction. These assumptions will be reviewed from time to time and may change the resulting estimate of the volume of L&ILW.

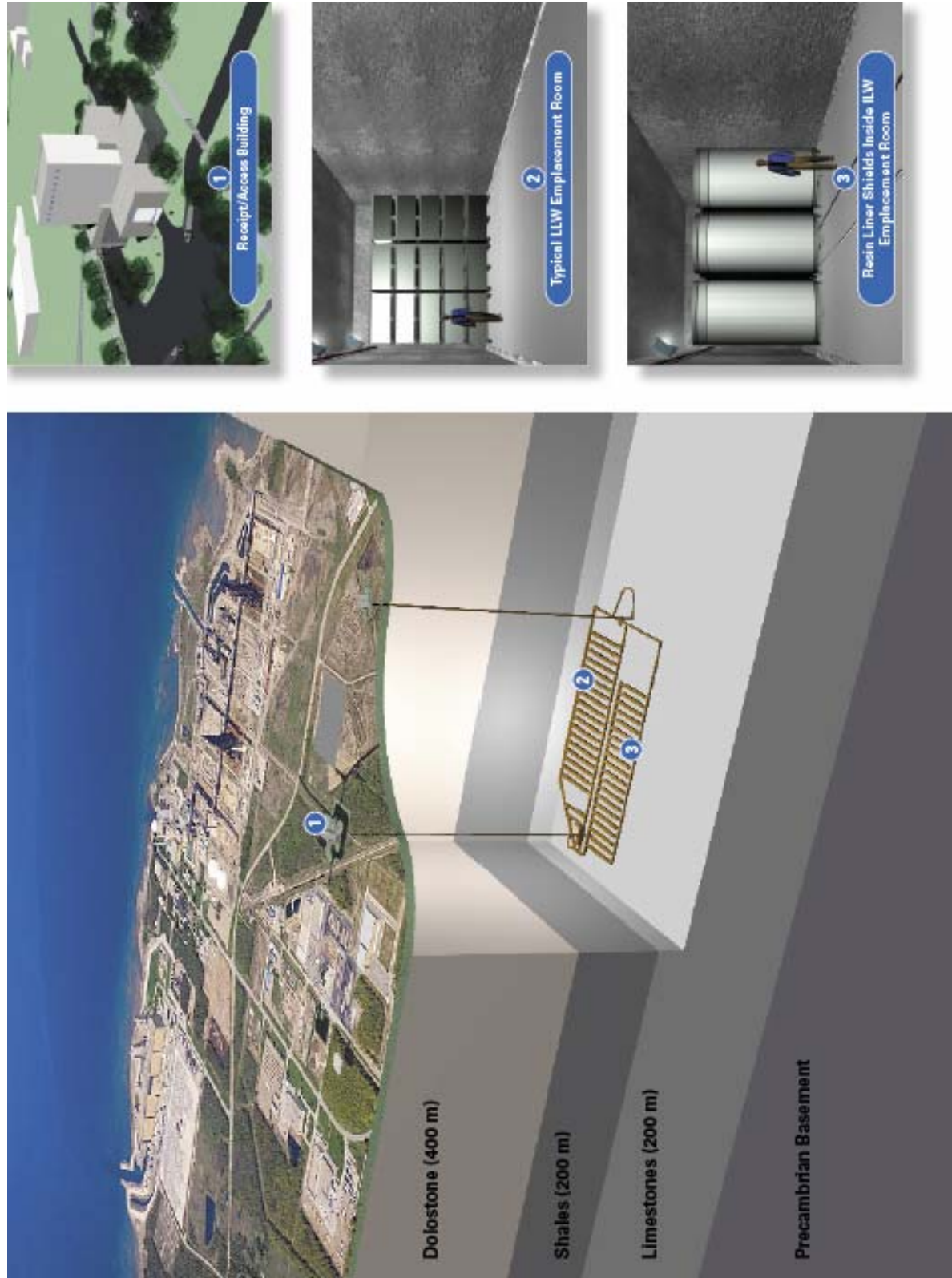


FIGURE 2-3 ARTIST'S RENDERING OF A DGR AT THE BRUCE SITE

Wastes to be emplaced in the DGR will be similar to those currently received, processed and stored at the WWMF. Accordingly, a description of the current wastes received, processed and stored at the WWMF provides an accurate prediction of the wastes that would be placed in the DGR. Further, most wastes will continue to be received and processed at the WWMF prior to being emplaced in the DGR, although some waste packages may be suitable for direct emplacement. A Waste Acceptance Criteria document would be developed to control what waste can be placed into the repository and these criteria would be consistent with the safety assessment supporting the operating licence for the repository.

OPG currently has approximately 67,000 m<sup>3</sup> of low and intermediate level waste in storage at the WWMF. Future annual waste receipts are expected to vary from year to year, depending on the operation and maintenance programs at the nuclear generating stations. It is anticipated that between 4,000 and 6,000 m<sup>3</sup> of L&ILW will be received each year for processing and packaging prior to emplacement in the DGR. Following incineration or compaction, the amount of waste requiring emplacement in the DGR is expected to be approximately 3000 m<sup>3</sup> per year, similar to that currently stored annually in surface facilities at the WWMF. These wastes are expected to be emplaced in the DGR following processing. Some wastes may be emplaced in the DGR without processing.

Similar to current practice at the WWMF, the small volume of intermediate level waste, estimated at 290 m<sup>3</sup> per year, would be emplaced in the DGR without processing for volume reduction. ILW is currently stored at the WWMF in quadricells, in-ground containers, trenches, and tile holes. A description of current storage practices is provided in Appendix B. Wastes currently in interim storage at the WWMF would be transferred to the DGR as time and resources permit.

Although the total volume of operating wastes to be emplaced in the DGR is expected to be approximately 160,000 m<sup>3</sup>, the interior volume of the DGR could be approximately 35 per cent larger. This is a result of unused space between the waste packages as they are packed into the emplacement rooms. If at some time in the future decommissioning waste is emplaced in the DGR, the waste volume would increase.

The Host Community Agreement signed by the Municipality of Kincardine and OPG includes provision for decommissioning waste to be emplaced in the DGR. Decommissioning waste is not included in this project because there is no definitive plan for decommissioning at this time or for

the management of decommissioning waste. An environmental assessment is expected to be required for the decommissioning activities for each of the generating stations and the management of the decommissioning waste could be addressed through that process.

### 2.3.1 Classification of Radioactive Waste

Wastes to be emplaced in the DGR will be classified similarly to those currently received and stored at the WWMF. Wastes currently received at the WWMF are classified as Type 1, Type 2 or Type 3, depending on the contact dose rate, as shown in Table 2-1. Type 1 wastes have the lowest radiation levels and Type 3 the highest. As shown in the table, the majority of wastes received and to be emplaced in the DGR, by volume, are Type 1 low level waste. The majority of the radioactivity is contained in the small volume of Type 3 intermediate level waste.

WASTE TYPE	DOSE RATE <sup>2</sup> (mSv/h)	AVERAGE ANNUAL WASTE RECEIVED AT WWMF (m <sup>3</sup> )	AVERAGE ANNUAL VOLUME STORED AT WWMF (m <sup>3</sup> )	PER CENT OF TOTAL ACTIVITY
<b>TYPE 1</b>	<b>&lt; 2</b>	<b>5,860</b>	<b>3,000</b>	<b>&lt;1</b>
<b>TYPE 2</b>	<b>2 TO 150</b>	<b>250</b>	<b>250</b>	<b>~2</b>
<b>TYPE 3</b>	<b>&gt;150</b>	<b>40</b>	<b>40</b>	<b>~98</b>
<b>TOTAL</b>	<b>N/A</b>	<b>6,150</b>	<b>3,290</b>	<b>100</b>

<sup>2</sup> A Sievert (Sv) is a measure of effective radiation dose. It is commonly expressed as mSv (1/1000 of a Sievert) or  $\mu$ Sv (1/1,000,000 of a Sievert)

**TABLE 2-1: LOW AND INTERMEDIATE LEVEL WASTE RECEIVED ANNUALLY AT THE WWMF**

### 2.3.2 Description of Radioactive Waste

Most atoms are stable and do not change, although they may interact with other atoms to form different chemical compounds. However, some atoms are not stable and will change or "decay" to a different type of atom. In doing so, they release energy through various processes. This process is called radioactive decay. These unstable atoms are often called radionuclides. The amount of decay occurring at any given time is called radioactivity, and is measured in units of Becquerels (Bq).

One key characteristic of radioactivity is the half-life for decay. The half-life is the amount of time it takes for half of the radioactive atoms of a certain type to decay. For example, the half-life of tritium is about twelve years. This means that, in a given quantity of tritium, half will have decayed (changed to helium in this case) after twelve years, while the other half has not changed. After another twelve years, only half of that number will remain as tritium - that is, one quarter of the original quantity. This will continue until eventually all the original tritium atoms have become stable helium atoms. As the amount of tritium decreases, so does the radioactivity since there is less tritium left to decay.

Another key characteristic of radioactivity is the way in which the atoms decay and release energy. The energy emitted from decaying atoms is often referred to as radiation. Radiation includes energetic subatomic particles such as alpha or beta particles, or energetic photons such as X-rays and gamma rays. The amount or "level" of radiation at some location can be characterized in different ways. One method is to characterize the radiation level in units of sieverts per hour (Sv/h).

More information on radioactive decay and radioactivity can be obtained from a variety of sources, including the CNSC website (CNSC, 2002).

### **2.3.2.1 Low Level Waste**

As noted in Table 2-1, Type 1 low level waste (LLW) accounts for approximately 95 per cent of the total volume of L&ILW received annually at the WWMF. LLW consists of industrial items that have become slightly contaminated with radioactivity and are of no further use, such as mops, rags, paper towels, temporary floor coverings, floor sweepings, protective clothing and hardware items such as tools.

There is approximately 58,000 m<sup>3</sup> of LLW currently stored at the WWMF. Approximately 3,000 m<sup>3</sup> of LLW is currently placed into storage each year.

The primary radionuclides found in LLW are cobalt-60, cesium-137, tritium, and others with half-lives generally equal to or less than 30 years. Cobalt-60 is a type of cobalt atom that is unstable and decays with a half-life of 5.27 years. Cesium-137 has a half-life of 30.3 years. For example, after 30 years, most of the cobalt-60 (98%) would have decayed, while about half of the cesium-137 would have decayed.

Overall, the total amount of radioactivity associated with LLW will decay to approximately 1/10<sup>th</sup> of the original amount after 50 years. After 250 years, the amount of radioactivity will have decayed to about 1/50<sup>th</sup> of its initial amount (Golder, 2004).

Average radiation levels at the surface of the containers are less than 0.01 mSv/h for about half of the LLW on receipt at the WWMF, and less than 0.25 mSv/h for most of the remaining half. These radiation levels will decrease in time in a similar manner as the total radioactivity decreases.

As described below, LLW is classified as incinerable waste, compactable waste or non-processible waste depending on how it is processed prior to storage or emplacement in the DGR.

#### ***Incinerable Waste (Type 1)***

This consists primarily of cellulosic materials, such as paper and cotton, which can be incinerated. Ash from the incineration of these materials is packaged in metal containers and placed into storage buildings at the WWMF. The levels of radioactivity are such that it may be safely handled by workers using normal industrial practices and equipment without any special radiation protection.

#### ***Compactable Waste (Type 1)***

This consists of waste material that can be compacted, such as polyvinyl chloride (PVC) and fluoroethylene plastics, vermiculite, fiberglass, metal pieces, etc. These wastes are generally low in radioactivity. Compacted waste is stored in metal containers in storage buildings at the WWMF.

#### ***Non-processible Waste (Type 1)***

These wastes consist of materials that are not readily incinerated or compacted and generally include metal components such as tooling, pipes, valves, and other metal hardware components from reactor maintenance. The radioactivity differs from item to item, but is generally of low level. This waste is also stored in buildings, either in metal containers or as is, in the case of large items.

### **2.3.2.2 Intermediate Level Waste**

Intermediate level waste (ILW) consists primarily of used nuclear reactor components, and the ion-exchange (IX) resins and filters used to purify reactor water systems. ILW is more radioactive than low level waste and requires shielding to protect workers during handling.

In addition to short-lived radionuclides, the radionuclides of interest in ILW include carbon-14 on the IX resins, and nickel-59 and nickel-63 on the irradiated core components. It also contains greater quantities of longer-lived radionuclides such as iodine-129, chlorine-36, technetium-99 and other radionuclides with half-lives greater than 30 years.

The total amount of radioactivity associated with ILW will decay to approximately half of the original amount after 50 years. After 250 years the amount of radioactivity will have decayed to approximately a third of the original amount (Golder, 2004).

The dose rates for ILW are higher than for LLW, with an average dose rate less than 200 mSv/h for more than eighty per cent of disposal containers, and more than 47,000 mSv/h for the remaining containers.

There is approximately 9,000 m<sup>3</sup> of ILW currently in storage at the WWMF and approximately 290 m<sup>3</sup> of ILW is placed into storage each year.

#### ***Ion Exchange Resins (Type 2 or 3)***

Spent ion exchange resins originate from various radioactive process systems and from the radioactive decontamination of systems and equipment. In some cases this waste contains longer-lived radionuclides, including carbon-14. In the case of ion exchange resins from the moderator system, the activity of carbon-14 is in the range of 4 to 6 TBq/m<sup>3</sup>. Resins are stored in metal containers, mostly in in-ground containers at the WWMF.

#### ***Irradiated core components (Type 2 or 3)***

Irradiated core (retube) components typically result from reactor refurbishment activities. These retube component wastes include pressure tubes, calandria tubes, end fittings and shield plugs, spacers, flux detectors, and other related or similar wastes. They are stored in in-ground containers.



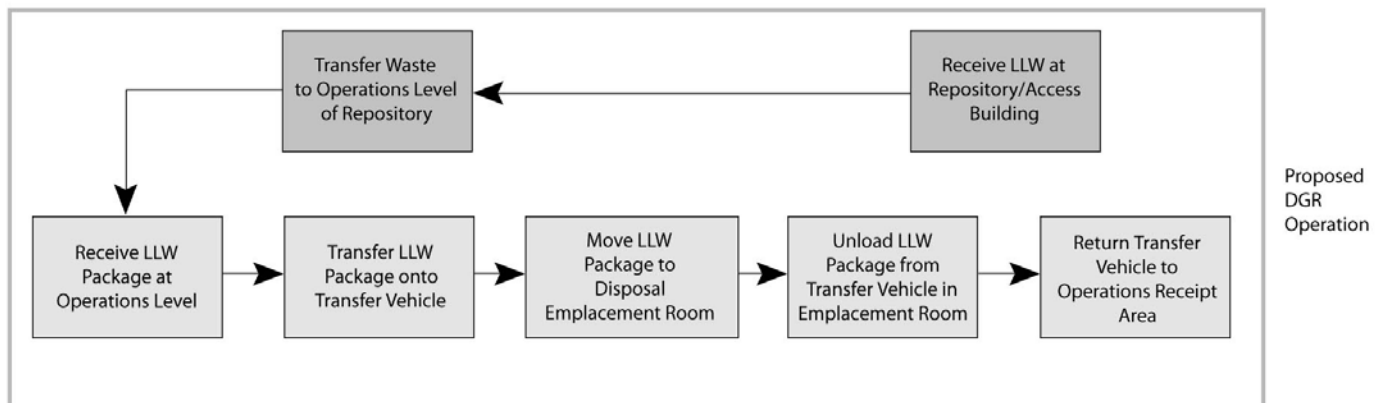
### 2.3.3 Waste Handling and Packaging

#### 2.3.3.1 Waste Handling

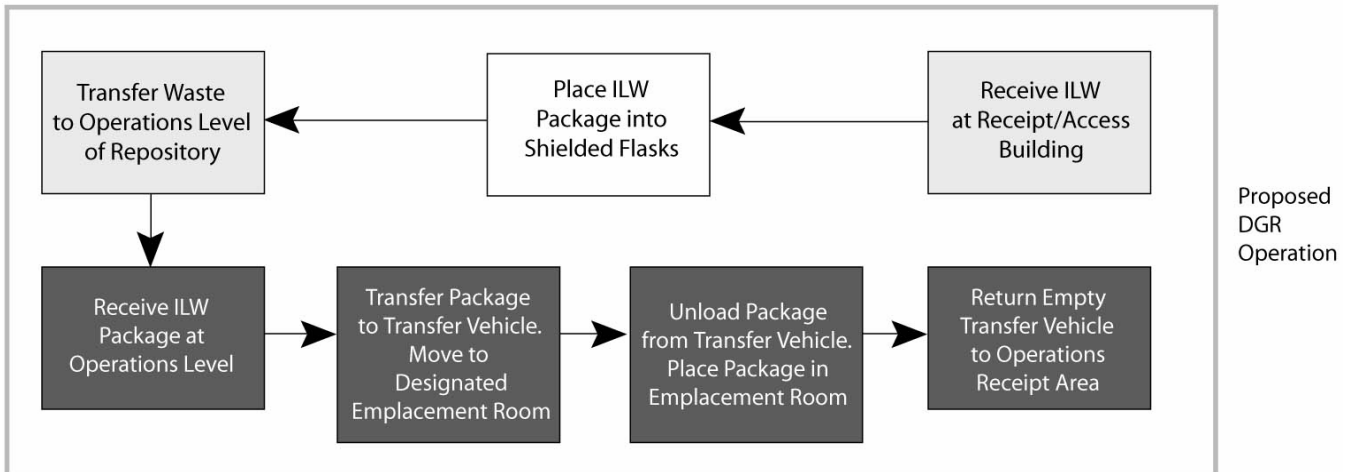
A significant portion of the wastes to be emplaced in the DGR is currently stored at the Bruce site in buildings, trenches and structures at the WWMF. Retrieval will follow proven methods designed to retrieve the waste packages intact, limit the radiation dose to workers and avoid the release of radioactivity to the environment.

A typical handling process for LLW at the DGR is presented in Figure 2-4. Handling and of ILW at the DGR is shown in Figure 2-5.

Preparation for emplacement in the DGR includes monitoring the condition of the waste, attaching bar code tags, and logging data into a waste tracking database. Only containers or packages that are suitable for use in storage and handling will be placed in the DGR. In addition, some wastes are expected to be too large to be placed in a container and may comprise their own waste packages. A small number of the large objects may be too large or of a shape that does not permit them being placed as-is in the DGR. These objects would be cut into smaller sizes using equipment such as diamond wire saws. These activities would take place in a controlled work area.



**FIGURE 2-4 TYPICAL HANDLING PROCESS FOR LLW AT THE DGR**



**FIGURE 2-5 TYPICAL HANDLING PROCESS FOR ILW AT THE DGR**

### 2.3.3.2 Low Level Waste Packaging

LLW would be received at the access building of the DGR in containers such as those currently used at the WWMF or containers similar to them, for placement in the DGR. The containers can typically be handled without shielding. Most of the LLW containers are stored in buildings; a small portion of the LLW is stored in concrete trenches which are not in buildings. A description of containers currently used for storage of LLW follows.

#### *Standard Steel Containers*

Almost all of the LLW is stored within standard containers comprised of stackable metal boxes stored in buildings at the WWMF as described in Appendix B. The metal containers can be easily handled and are amenable to an efficient placement and retrieval by a forklift. Retrieval and transfer of the containers to the DGR would be relatively straight-forward because the containers are currently stored inside. Containers may be transferred directly to the DGR or temporarily stored in a building at the WWMF prior to transfer.

It is expected that if a container exhibits surface contamination or damage, it would be placed in a new, larger container (known as an "overpack", see following paragraph). If the container surface radiation level is greater than criteria which will be established to identify waste that requires shielding to minimize radiation dose to workers, it would be placed within a

prefabricated shielded flask of a similar size to a standard low-level waste container. Placing wastes in overpacks would be carried out within a storage building close to its storage location.

### ***Overpacks***

Overpacks are new larger metal containers used to assist in the handling, stowage and carriage of one or more packages. An overpack may also be used to secure a potentially deteriorating container or to contain a standard container with surface contamination that cannot be readily removed.

### ***Shielded Flasks***

A shielded flask, which may consist of a prefabricated concrete box marginally larger than a standard container overpack, will be used as the waste package for emplacement in the DGR when the standard container has a surface radiation level greater than the established criteria. The standard container will be placed inside a sealed and shielded flask. The closed flask would be handled similarly to a standard container.

### ***Non-Standard Waste***

A number of large and irregularly shaped objects are stored in buildings at the WWMF. These consist of metal equipment such as heat exchangers. Most of these would be emplaced "as-is" in the DGR and can be handled using a forklift. If the surface of a large object cannot be decontaminated, it would be segregated for special handling. Similarly, objects with radiation levels higher than the established criteria would be segregated and a specific plan developed for each of the objects to ensure that they are managed safely.

### ***Refurbishment Waste***

Steam generators, pre-heaters, heat exchangers and similar large waste packages arising from the proposed and anticipated refurbishment activities at OPG-owned reactors would be emplaced in the DGR. Steam generators and other large objects are not expected to be stored in waste containers. The external surface will be free of loose contamination prior to transfer to the DGR, which depending on when the waste is produced may be temporarily stored in a Refurbishment Waste Building or emplaced directly in the DGR.

### ***Concrete Trenches***

A small portion of the LLW at the WWMF is stored in concrete trenches. Some of LLW in trenches may be amenable to processing by compaction or incineration. Other items in trenches may be too large for transfer directly to the DGR. In both cases, these wastes would be processed prior to emplacing them in the DGR.

A temporary weather structure/enclosure would be erected over each trench area as it is being emptied. Items that can be processed further by compaction or incineration would be transferred to the Waste Volume Reduction Building at the WWMF.

Containers that are suitable for direct emplacement in the DGR would be checked for surface contamination and inspected for damage or degradation. Any containers that are damaged would be placed in a concrete box or the contents transferred to a new container. Any items in the trenches that are too large for transfer directly to the DGR would be cut into smaller pieces and repackaged as described in the previous section.

### **2.3.3.3 Intermediate Level Waste Packaging**

ILW to be retrieved from storage for emplacement in the DGR includes containers of ion exchange resins (known as "resin liners") that are currently stored in above-ground concrete shielded "quadricells" or in below-ground "in-ground containers" at the WWMF (see Appendix B). Because of radiation levels, these resin liners cannot be handled without shielding and, as such, would be placed in shielded flasks suitable for transport and emplacement within the DGR.

ILW is also contained in below ground vertical concrete pipes known as "tile holes" (see Appendix B). However, because most of this waste has been stored for up to 30 years, the radiation levels have declined substantially and the use of concrete boxes may not be required.

Retrieval of the resin liners and other ILW would occur outdoors and would likely involve moving heavy objects with a crane. Accordingly, it may be done primarily in favourable weather conditions during the warmer months of the year.

All ILW transferred to the DGR would be in suitable containers or overpacks designed to limit the radiation dose rate on the outside of the containers to within specified limits. A description of current storage containers for ILW follows.

#### ***Quadricells***

A quadricell is an above-ground concrete structure designed to contain and isolate the resin liners. Quadricells include four removable concrete shielding containers each holding a stack of two resin liners. The shield containers and resin liners would be emplaced in the DGR together.

Shield containers that do not meet the criteria for emplacement in the repository would be returned to the quadricell structure and specific plans would be made for their modification and handling.

### *In-ground Containers*

In-ground containers are below-ground steel-lined columns designed to provide storage capacity for Type 2 and Type 3 radioactive wastes. The diameter and depth of the containers can be altered to suit any special waste storage needs. The current design of choice is the IC-18, some configured as tile hole equivalents (T.H.E.) IC-18 and others fitted for resin storage. Each in-ground container structure possesses an outer liner, into which waste is placed in separate inner liners. The number of inner liners depends on the size of the in-ground container. Each in-ground container structure is equipped with a heavy concrete lid or shield plug. The inner liners can be retrieved.

If a liner meets the established acceptance criteria, it would be transferred to the DGR using a low-bed trailer. Liners which do not meet the criteria that would allow them to be emplaced in the DGR would be returned to the in-ground container and specific plans would be made for their modification and handling.

Irradiated core components with high radiation levels are also stored in in-ground containers. The steel liners containing the components are stacked within a T.H.E. reserved for that purpose. The containers would likely be placed into a concrete box and the lid bolted in place. The package would be lowered onto a low-bed trailer and transferred to the DGR.

Filter vessels, ion exchange columns, filters, filter canisters and other materials are also stored in T.H.E. in-ground containers. Each T.H.E. in-ground container contains seven smaller-diameter steel liners, which are considered to be the container for the waste, aligned radially within the T.H.E. Prior to removal, each liner may be filled with concrete for shielding and to allow retrieval of the waste. As the concrete filled liners are removed they would be placed in a shielding box which would be sealed and transferred to the DGR.

### *Tile Holes*

Waste in the majority of the tile holes is packaged in removable steel liners. Concrete or grout would likely be added to the liner to keep the contents in place and provide shielding. The concreted/grouted liner would be retrieved from the tile hole and would be placed on a low-bed trailer. After inspection, the package would be transferred to the DGR.

Some tile holes at the WWMF do not have liners. However, these tile holes are equipped with internal reinforcing cages to facilitate grouting and removal. Concrete or grout would likely be used to fill the empty spaces within the tile hole and to form a single solid structure. The concreted/grouted tile hole would be removed and placed on a low-bed trailer. After inspection, the package would be transferred to the DGR.

### *Retube Waste Containers*

Retube waste, such as pressure tubes, calandria tubes, end fittings and shield plugs and spacers resulting from proposed and anticipated refurbishment of OPG-owned reactors are expected to be stored in retube waste containers. These containers would be rectilinear in shape and constructed of heavy concrete, lined internally and externally with stainless steel. Depending on when these wastes are generated they may be stored temporarily in the Refurbishment Waste Buildings or emplaced directly in the DGR.

## **2.4 COMPONENTS OF THE DGR**

The DGR consists of underground excavations and workings to accommodate approximately 160,000 m<sup>3</sup> of L&ILW along with the necessary surface facilities and infrastructure for constructing and operating the facility.

A general site plan showing a conceptual layout and positioning of the DGR facilities is shown in Figure 2-6. This figure shows a conceptual plan of the various surface facilities expected to be required to construct and operate the DGR, including buildings, roads excavated rock pile, construction laydown area and fences. Figure 2-6 also shows a possible DGR surface facilities location across a disused railway right-of-way, adjacent to the WWMF.

Surface facilities are expected to consist primarily of a receipt/access building, a ventilation shaft headframe building and various temporary and permanent facilities needed to support the DGR project. Site infrastructure consists of roads, waste rock pile, electrical services and fencing. Access to and availability of infrastructure and services for the DGR would be simplified by its possible location near to the WWMF. Further, some wastes would continue to be received, processed and packaged at the WWMF prior to transfer to the DGR.

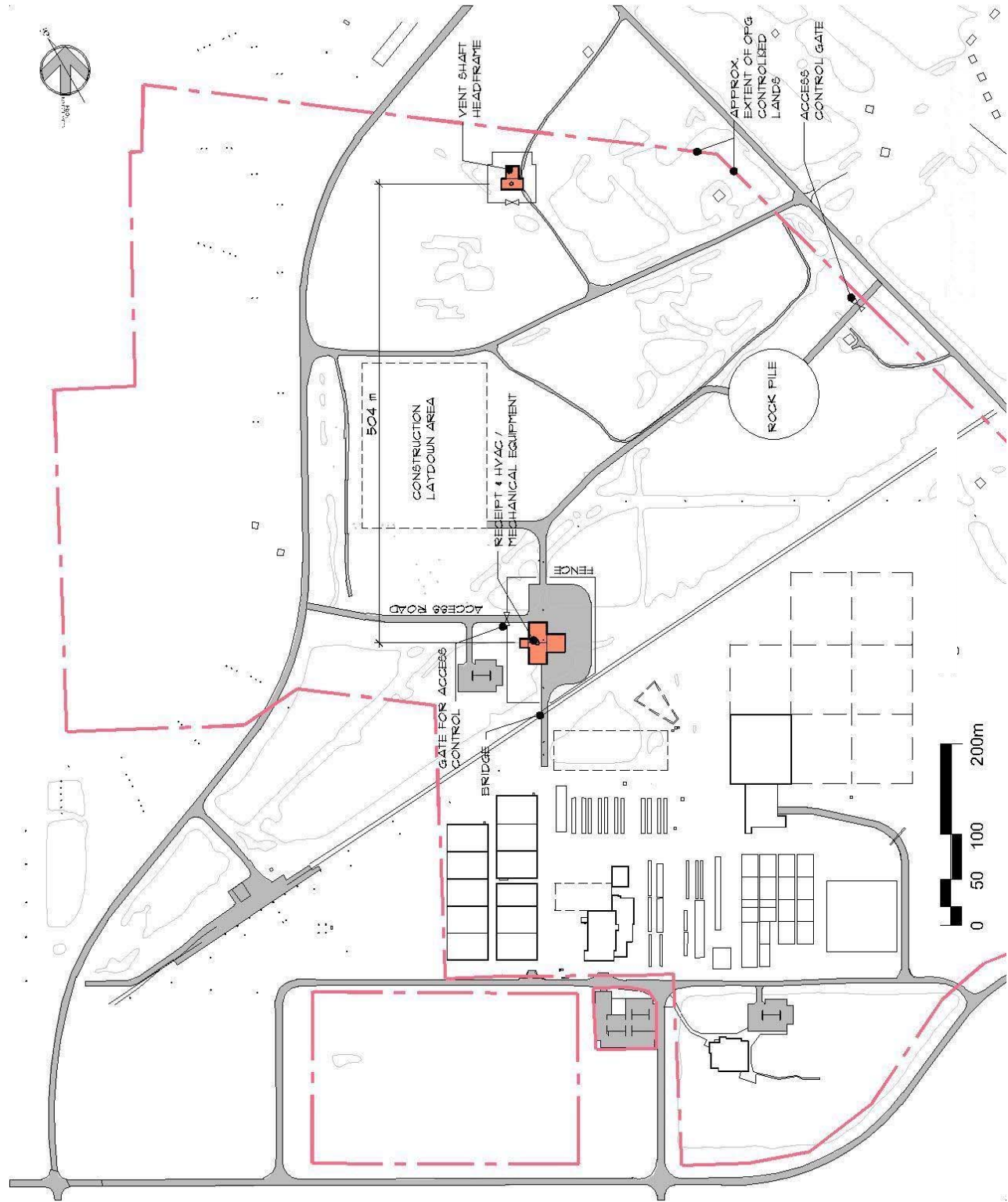


FIGURE 2-6 GENERAL SITE PLAN FOR DGR SURFACE FACILITIES

Underground facilities would include underground access, either by shaft or ramp, underground tunnels, emplacement rooms and various ancillary facilities, including facilities for receiving wastes, maintenance facilities, and services and support for underground mining and waste emplacement operations. It is currently envisaged that the underground emplacement rooms would be constructed in stages with a set of rooms being constructed initially and further rooms excavated subsequently in several construction campaigns. No waste emplacement is planned during excavation of the emplacement rooms.

### **2.4.1 Surface Facilities**

It is currently envisaged that two permanent buildings, and perhaps additional temporary or permanent buildings and related ancillary facilities, would be required to support construction and operation of the DGR. These buildings are expected to be operated in association with the existing infrastructure at the WWMF. As indicated on Figure 2-6 and described in the following paragraphs, the principal structures are expected to consist of a receipt/access building and a ventilation shaft headframe building.

#### **2.4.1.1 Receipt/Access Building**

This building would contain the facilities for underground access by either a ramp or shaft and to receive and handle L&ILW and excavated rock spoils. If access is by shaft, the receipt/access building would include the hoist/headframe/cage. If access to underground is by ramp, it would include the ramp access. It would also provide support space and facilities for staff and crews, including a control room, change rooms and coffee room. The building is expected to be a single storey structure, approximately 2,000 m<sup>2</sup>, tall enough to accommodate the shaft headframe and all hoisting equipment and electrical controls, if required. The structure would be similar to a prefabricated industrial building, with concrete slab-on-grade, and concrete column footings. The mechanical system would likely require powered ventilation and drainage systems, as well as stack monitoring. The heating ventilation air conditioning (HVAC)/mechanical equipment for the underground ventilation could be incorporated into the receipt/access building, or may be housed in a separate facility which would likely be a small medium-height, single storey structure.

The initial underground excavation operation for a shaft access facility would require construction of a stand-alone headframe building which may be integrated into the larger receipt/access building and expanded for use in staging of waste materials. The headframe would also be used for waste transfer into the DGR and future stages of construction.



L&ILW would be received at the receipt/access building and staged for transfer to the operational level of the DGR. Waste handling would require space for a transport vehicle and unloading equipment in addition to space for waste storage while in transit. The receipt/access building would also be used for transfer and removal of excavated rock during underground excavation activities.

#### **2.4.1.2 Ventilation Shaft Headframe Building**

The function of the ventilation shaft headframe building would be to:

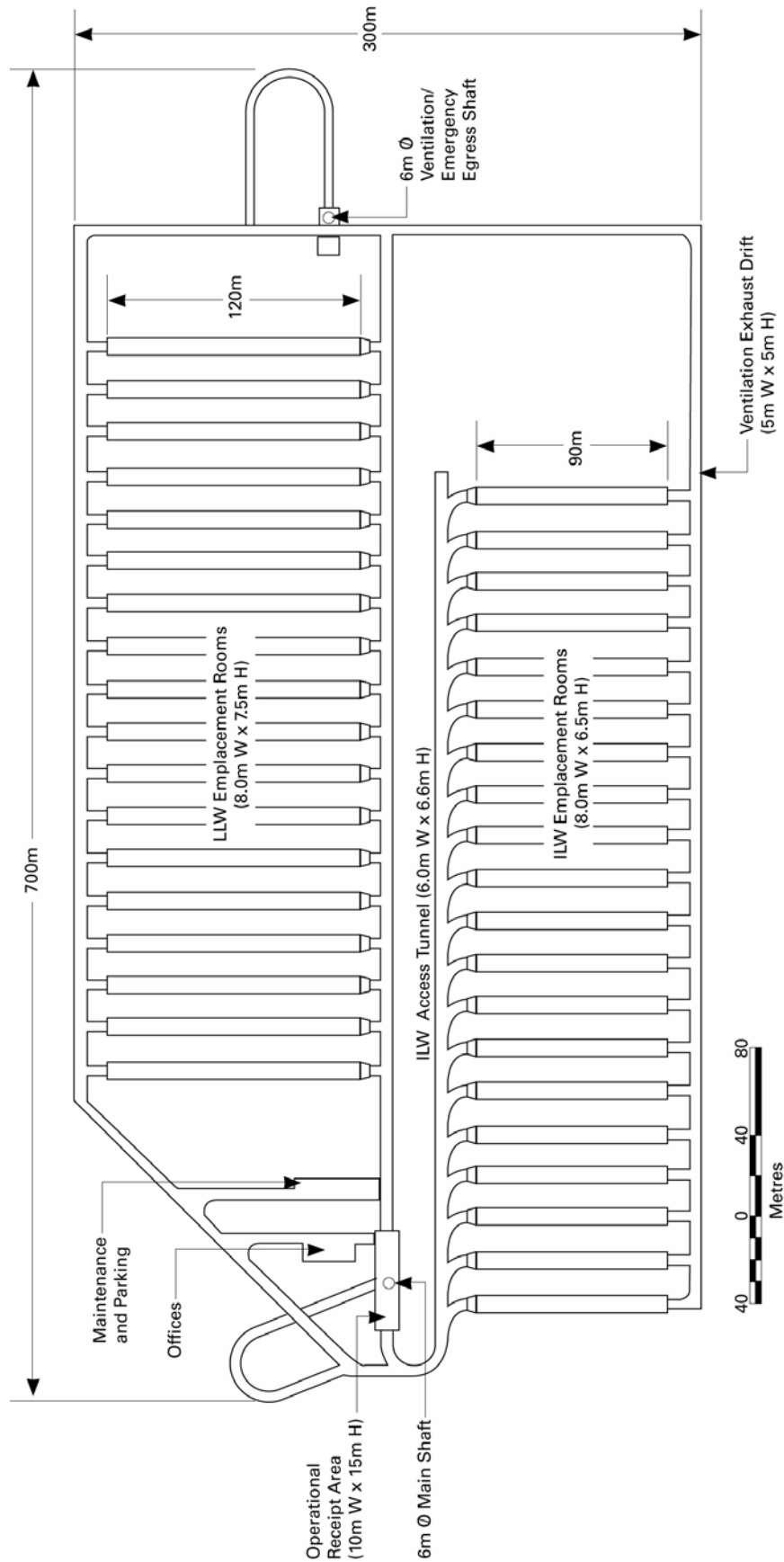
- Provide cover to the ventilation shaft.
- Contain the access/emergency hoist and associated mechanical and electrical systems.
- Contain a pair of exhaust fans working in parallel in conjunction with the HVAC system forced air fans to ventilate the underground repository.
- Contain sampling and/or monitoring devices to assess the quality of exhaust air from the repository horizon.

The ventilation shaft headframe building would house the equipment used to monitor the exhaust gases from the repository for both radiological and conventional contaminants.

### **2.4.2 Underground Facilities**

Access to the underground facility would be by ramp or shaft excavated through the upper 400 m of the sedimentary sequence to the Ordovician bedrock. Bedrock stratigraphy beneath the Bruce site is discussed in further detail in section 3.3. Within the upper 400 m of the rock sequence, the permeability of the dolostone and shale rock formations may vary considerably. Permeable rock formations intersected by the excavated opening would be grouted, and possibly lined, to limit any water inflow. This technique has been successfully used at a nearby deep salt mine. At depths below 400 m the low permeability of the Ordovician sediments is expected to yield negligible groundwater inflow. The grouting in the DGR shaft and the thick low permeability formations directly overlying and hosting the repository would result in negligible water inflows into the DGR via the shafts.

If the selected access method is a ramp, it would be excavated through the same rock formations, with excavation grouting used to condition rock formations to limit water inflow. The ramp tunnel would be concrete lined, where needed, to further limit water inflow during operation. A conceptual layout of the underground facilities is shown in Figure 2-7. Each of the major components is described below.



**FIGURE 2-7: CONCEPTUAL LAYOUT OF DGR UNDERGROUND FACILITIES**  
 NOTE: LAYOUT AND NUMBER OF ROOMS MAY DIFFER IN FINAL DESIGN

### **2.4.2.1 Ramp or the Main Shaft**

The main shaft, if selected as the access method, would be excavated to the repository horizon through the sedimentary rock using a drill and blast method. The shaft would extend an additional depth to provide a sump for emergency underground water collection. The main shaft would provide primary access to the DGR operations level for people, materials and wastes. Rock excavated during the development and operation of the DGR would be hauled to surface via the main shaft. The main shaft would also support the major services for the repository operational level, including fresh air and power.

A ramp, if selected as the preferred access method would be tunnelled into the rock and would likely be a spiral formation, similar to the configuration used in multi-level parking garages, though much deeper. A shaft for personnel access may also be provided if a ramp is constructed.

The associated surface facilities required to support the underground access and operation, including the buildings, are described in section 2.4.1.

### **2.4.2.2 Ventilation Shaft**

The ventilation shaft would allow routing air from the operational level using a once-through ventilation process whereby air enters the DGR through the ramp or main shaft and is exhausted through the ventilation shaft. It would also serve as the necessary emergency egress from the operational level for workers, and may be used for hauling excavated rock to surface. The ventilation shaft would be excavated either by the drill and blast method or the raise bore method.

A HVAC plant, located in or near the receipt/access building, would condition the fresh air prior to delivery to the operational level.

During winter month operation, the HVAC system would heat the air to ambient rock temperature (expected to be about 18°C). The air would be conditioned to assure humidity levels are below the dew point. Controlling the humidity level in the air would also reduce the potential for corrosion of various metal components including the metal waste containers. The HVAC system would be designed and operated to help ensure air concentrations of potential contaminants are below acceptable limits throughout the accessible areas of the DGR and at the surface discharge point.

### **2.4.2.3 Underground Tunnels**

Access to the emplacement rooms from the receipt area at the operational level would be via horizontal tunnels. The access tunnels, which may be up to 700 m in length, would likely have concrete floors.

A ventilation exhaust tunnel may be located around the entire perimeter of the emplacement rooms and would direct air that has first flowed through the working areas to the Ventilation Shaft.

### **2.4.2.4 Emplacement Rooms**

As discussed in section 2.3, the proposed DGR would provide capacity for approximately 160,000 m<sup>3</sup> of L&ILW. All waste would be contained within horizontal emplacement rooms excavated in the sedimentary rock. The typical size of an emplacement room for LLW is expected to be approximately 7.5-m high by 8-m wide by 120-m long, and for ILW is expected to be about 6.5-m high by 8-m wide by 90-m long. Similar underground openings have been excavated elsewhere in Ontario and the United States (Raven, et al, 1989), (Byerly, 1975). Figure 2-8 shows a tunnel excavated in similar limestone in southern Ontario.

The emplacement rooms would have exposed rock walls and a concrete floor to allow access by transfer vehicles. Wastes would be delivered to the operational level by hoist or by truck from the surface, depending upon the access method chosen. Once at the operational level, they would be moved to the designated emplacement room by transfer vehicle. The entrance and exit tunnels to the emplacement rooms would be designed to allow interim sealing of the rooms once they have been filled with waste.

### **2.4.2.5 DGR Operational Level Office, Amenities and Maintenance Areas**

The underground office and amenities will be constructed immediately adjacent to the operational level receipt area at the bottom of the main shaft or ramp (Figure 2-7). The maintenance area would be used for servicing of all underground equipment. It would also serve as the terminus and distribution point for services brought to the operational level via the main shaft or ramp.



**FIGURE 2-8 TUNNEL EXCAVATED IN LIMESTONE IN SOUTHERN ONTARIO**

Refuge areas would be located throughout the operations level of the repository and would be equipped with emergency supplies of fresh water, compressed air, a fireproof door and sealing materials, and a communications link with surface.

### **2.4.3 Site Infrastructure**

Access to the site would be controlled and monitored. The buildings and paved areas surrounding the receipt/access building would be within a dedicated fence. The ventilation shaft headframe building would be within a separate fenced area (due to its distance from the receipt/access building) with remote monitoring from the receipt/access building.

#### **2.4.3.1 Power**

Electrical power would be supplied to the facility by a high voltage (44 kV) transmission line from the Hydro One substation at Douglas Point. An emergency standby generator would be

provided to assure safety in the event of a failure of off-site power, including that necessary for personnel safety and to maintain overall conditions in a satisfactory state.

#### **2.4.3.2 Sanitary Sewer System**

Sanitary sewage from surface facilities would be conveyed by gravity or pumping from washrooms, sinks, floor drains and drinking fountains to the existing site sewerage system. Effluents may also include non-radioactive drainage from process equipment such as compressors and HVAC equipment. Sewage generated from the operational level facilities would be stored in portable tanks and would subsequently be treated in the existing site sewerage system.

#### **2.4.3.3 Potable Water**

The domestic water system would supply potable water for both surface and operational level facilities for use in washrooms, sinks, drinking fountains, decontamination areas, maintenance areas, janitor rooms, and emergency shower/eyewash stations, etc. The water supply would be provided from the existing water supply system on site.

#### **2.4.3.4 Storm Water System**

The storm water management system for the surface areas of the DGR facility would likely consist of three main components:

1. **Waste Handling Areas:** Waste handling areas (e.g. roads, turning/parking areas) would be paved and graded to lined surface ditches or storm drains, which would lead surface water runoff to a lined retention pond. Water in the retention pond would be tested and, if uncontaminated, released to the Bruce site drainage system. If sediment levels in the surface runoff exceed regulatory guidelines, retained water would be pumped to a WWMF sample station and treated prior to release.
2. **Temporary Excavated Rock Stockpile:** The temporary stockpile for excavated rock would be graded to a lined surface ditch, which would lead surface water runoff to a lined retention/sedimentation pond, or similar treatment process. Water from the pond or treatment process would be tested and, if uncontaminated, released to the Bruce site drainage system. If contaminated, retained water would be treated prior to release.

3. General Site Area: The remainder of the site would be graded to surface ditches, which would lead surface water runoff to a sedimentation pond, or similar treatment process, which would, in turn, discharge to the Bruce site drainage system.

#### **2.4.3.5 Subsurface Drainage**

Small volumes of water would be generated in the operational level workings as a result of condensation and possible infiltration. There would be sumps located at the access-way and the ventilation shaft to collect and contain this water. The sump water would be pumped, or delivered in tanks, to the surface and monitored and, if necessary, treated prior to release.

#### **2.4.3.6 Construction Laydown Area**

An area would be designated as a laydown and construction yard for sub-contractors to use while repository excavation is being carried out. This area would be leveled and graded and have a gravel road connection between the main road, lay-down area and receipt/access building. The area would be fenced for security and access reasons. The site would require connections for water, sewer, power and telephone.

Portable buildings/offices would be in place during the construction phase of the DGR and possibly during the periodic construction campaigns following the start of operation.

#### **2.4.3.7 Access Roadways**

The DGR would require a dedicated roadway to provide controlled access from within the Bruce site. This new access roadway would lead to a parking lot located near the receipt/access building. Additional access roads to the excavated rock storage pile and the ventilation shaft would be needed during both construction and operation. A possible general layout of these roads is shown on Figure 2-6.

All security requirements would be met using existing site security.

#### **2.4.3.8 Fencing**

The buildings and the laydown yard would be within a secure licensed area with some of the spaces within radiologically zoned areas, similar to the existing WWMF site. Correspondingly, there would be a fence surrounding these areas with specific access control points for personnel, equipment and materials.

### **2.4.3.9 Excavated Rock Pile and Associated Roads**

The site would have a dedicated area for excavated rock, which must be large enough to accommodate the excavated materials from surface preparation and the waste rock from underground excavation. A roadway to access the waste rock pile from the receipt/access building and from surrounding site roads would also be provided. A facility for treatment of runoff from the waste rock may also be required.

Site preparation would include clearing of up to 15 hectares of immature mixed forest and removal of stumps. The wood and stumps may be chipped and stored on site for future use. Boulders and soil would be stockpiled within the Bruce site.

During construction of the DGR, a large volume, estimated to be more than 500,000 m<sup>3</sup> of soil and rock would be excavated from the shaft and operational level. If a ramp is the preferred means of underground access, it would more than double the volume of soil and rock excavated compared with a shaft. The material excavated from the lower portions of the shafts and the emplacement rooms would be high quality aggregate grade material which is suitable for construction purposes. OPG plans to release this material from the site to the local construction market.

### **2.4.3.10 Security**

Bruce Power is responsible for maintaining the security of the Bruce site and specifically the security of the WWMF under a written agreement with OPG. Bruce Power has a trained security force and procedures are in place to limit access to the site to authorized persons. Bruce Power security staff is assisted in their duties by the Ontario Provincial Police.

The Bruce site is entirely surrounded by a perimeter fence that restricts access to the site from land or water. The only access to the Bruce site is via controlled checkpoints. Only authorized personnel and vehicles are allowed on site. Security clearances are obtained for all employees and contractors.

The WWMF, including the Western Used Fuel Dry Storage Facility (WUFDSF), is also contained within fenced restricted areas. Security procedures for these areas include staff training, positive identification of personnel, verification of documentation, physical searches, visitor escorts and background checks. Physical barriers, monitoring devices and surveillance systems constrain and monitor activity at the WUFDSF.



Similar security measures and infrastructure would be applied to ensure the security of the DGR.

#### **2.4.4 Integration with Existing WWMF Operations**

Operation of the DGR would be fully co-ordinated with that of the WWMF, including routine movement of people, materials and wastes between the two facilities. A roadway would be developed linking the DGR to the existing WWMF for the purposes of transferring waste. It is likely that this would consist of a bridge across an existing abandoned rail spur line. This would require a structural bridge or culvert to maintain the existing habitat in the so-called "railway ditch" as well as maintain the security perimeter of both WWMF and DGR.

### **2.5 HEALTH AND SAFETY**

OPG has a system for managing worker and public health and safety in place at its existing waste management facilities. This system is based on a set of documents that guides management action and controls facility operation. These systems and documents, with revisions as necessary, would apply to the construction and operation of the DGR. These systems are described in more detail in Appendix C.

### **2.6 PROJECT SCHEDULE**

The DGR would be constructed in phases, commencing with the surface facilities, access to the operational level (by shaft or ramp), excavation of underground tunnels and an initial number of the emplacement rooms. Following the construction of an initial set of emplacement rooms, additional rooms would be constructed as needed. During the construction of additional emplacement rooms, routine waste handling and emplacement operations of the DGR would likely be suspended.

Identification of the DGR project has occurred following four years of concept development and feasibility studies, including extensive community consultation. The next steps in the development of the DGR involve the environmental assessment and licensing process which are expected to occur over a period of approximately six to seven years.

### 2.6.1 Environmental Assessment and Licensing

Under the *Nuclear Safety and Control Act*, licences are required from the CNSC for site preparation, construction, operation, and decommissioning of the DGR. The CNSC is responsible for determining the type, scope and schedule of the environmental assessment and licencing process of the DGR project. The CNSC has a well-defined process for the conduct of environmental assessments, including delegation of the necessary environmental assessment studies to the proponent. A preliminary schedule for the completion of the EA process has been developed based on OPG's experience with the CNSC process and procedures.

Table 2-2, below, provides a general indication of the time OPG expects to be required to complete the principal steps in the EA process that must be completed prior to the CNSC issuing the necessary licences to bring the DGR into operation. The milestone dates shown in Table 2-2 are based on OPG's assumed in-service date of 2017 for the DGR. To meet this schedule, a licence(s) for site preparation and construction would be needed in early 2012. The identified milestone dates for the environmental assessment have been determined from these dates, based on experience with other environmental assessments. The schedule is subject to change as required to ensure that the necessary site investigations and safety assessments are completed.

ACTIVITY	PROJECTED DATE
LETTER OF INTENT AND PROJECT DESCRIPTION SUBMITTED TO CNSC	NOV 2005
OPG RECEIVES DRAFT EA GUIDELINES	MAR 2006
OPG RECEIVES FINAL EA GUIDELINES	JUL 2006
OPG BEGINS PREPARATION OF EA STUDY REPORT	2006
OPG SUBMITS DRAFT EA STUDY REPORT TO THE CNSC	2007
OPG SUBMITS FINAL EA STUDY REPORT TO THE CNSC	2008
COMPREHENSIVE STUDY REPORT ISSUED FOR PUBLIC COMMENT	2008
DECISION BY THE MINISTER ON THE ACCEPTABILITY OF THE EA	2009
OPG RECEIVES SITE PREPARATION AND CONSTRUCTION LICENCE(S)	2010-2011
OPG BEGINS CONSTRUCTION OF THE DGR	2012

**TABLE 2-2 DGR PROJECT MILESTONES**

### **2.6.2 Site Preparation**

Site preparation would begin after receipt of a site preparation licence, and would include clearing of a portion of the site, approximately 15 hectares of which is wooded, and removal of the stumps. The wood and stumps may be chipped and piled on the site for future use. Boulders and soil removed may be stockpiled within the Bruce site. The cleared land would be used for construction laydown as well as a stockpile area for rock removed during the mining of an access shaft, or ramp if required, and the repository. Roads would be developed to provide access to sites such as the rock stockpile, the site of the receipt/access building and ventilation shaft, construction laydown area, and other areas of the site as needed.

Site preparation for the proposed project is expected to last approximately six to twelve months.

### **2.6.3 Construction**

Construction of the surface facilities, the access to the repository and the underground excavation of the emplacement rooms is included in this phase. Construction would start after receipt of the construction licence.

This phase of the proposed project is expected to last approximately five years.

### **2.6.4 Operation**

The operation of the DGR would commence following completion of construction and commissioning and receipt of an operating licence. Operation involves emplacement of the low and intermediate level waste in the DGR, and may also include several construction campaigns during which emplacement activity would likely be suspended while additional emplacement rooms were excavated. The DGR is expected to operate for the period required to emplace waste from OPG-owned generating stations and would include a monitoring period to confirm that the DGR is performing as expected.

### **2.6.5 Decommissioning and Long-term Performance**

Additional environmental assessment work may be required prior to initiating decommissioning of the proposed DGR. The decommissioning phase occurs after the operation phase has ended and after a decommissioning licence has been received to seal and close the underground facilities. In this phase, the repository and shafts and ramp, if used, would be sealed. This phase

is expected to take approximately three years. The decommissioning activities would be followed by a period of monitoring to confirm that the DGR is performing as expected.

Subsequent regulatory approvals may require institutional controls to prevent public access to the site for some period of time, and monitoring may take place however, at a reduced level.

### 3.0 DESCRIPTION OF SITE AND SURROUNDING AREA

This section provides a summary of the physical, biological and social environments within the areas potentially affected by the DGR project. The physical environment is characterized in terms of the atmospheric environment, surface water, geology and hydrogeology. The biological environment is described for the aquatic and terrestrial environments. The social environment is characterized in terms of land use, socio-economic conditions, physical and cultural heritage, and Aboriginal interests.

The 932-ha Bruce site, described in section 2.1 is occupied by the Bruce A and Bruce B nuclear generating stations, currently owned by OPG and operated by Bruce Power, and the WWMF, owned and operated by OPG.

Extensive information from recent studies on the environment, including and surrounding the Bruce site has been compiled and evaluated as part of seven environmental assessments of facilities planned or operating at the Bruce site (OH, 1997; OH, 1998; OPG, 2000a; OPG, 2002; Bruce Power, 2002; OPG, 2003; OPG, 2004b; OPG, 2005b) . In addition, the recently updated WWMF Safety Report (OPG, 2004c) provides the information necessary to support the WWMF Operating Licence. The annual Bruce Power Radiological Environmental Monitoring Program Report (Bruce Power, 2005a) also provides recent information about the Bruce site.

### 3.1 ATMOSPHERIC ENVIRONMENT

The Bruce site is located on the eastern shore of Lake Huron (see Figure 2-1) and is subject to lake meteorological effects. The mean annual temperature measured at the site is 8.2°C. The mean daily temperature falls below 0°C during December through March. The coldest month is January, having a mean daily temperature of -3.4°C. Summer mean daily temperatures average 19°C. Precipitation is consistent throughout the year, with annual precipitation nominally between 944 and 1154 mm.

Prevailing winds are from the westerly direction about half the time. There is also a strong south-westerly component that occurs about 11 per cent of the time. The average measured wind speed at the 10 m level of the on-site 50 m tower was 3.45 m/s for the years 1998 to 2000. In 2003, calm winds (wind speed <1.5 m/s) were reported 17 per cent of the time and low to moderate wind speeds (1.5 to 3.0 m/s and 3.0 to 5.0 m/s respectively) had frequencies of 33 and 32 per cent, respectively.

Air quality at the Bruce site is typical of the general air quality in Southwestern Ontario. Air quality impacts are dominated by substances resulting from the industrial and transportation activity at the Bruce site associated with the operation of the Bruce A and B generating stations and the WWMF, for example, carbon monoxide, nitrogen oxides, volatile organic compounds, sulphur dioxide, and particulate matter. Historically, there were emissions from the Steam Plant, the Heavy Water Plant and the incinerator at the WWMF. The Steam Plant was decommissioned in the early 2000s, but not demolished. It has been replaced by a smaller steam plant. The Heavy Water Plant was closed in 1998 and is currently being decommissioned. The original incinerator operated from 1977 to 2001 and was dismantled in 2002. A new incinerator was installed at the WWMF in 2003.

Existing off-site noise levels reflect a rural sound environment, dominated by the sounds of nature. The Bruce site makes small contributions of dust and noise to the local atmosphere.

## **3.2 AQUATIC ENVIRONMENT**

### **3.2.1 Surface Water Environment**

The Bruce site is situated on the shores of Lake Huron. Lake Huron is a cold, deep oligotrophic lake with low nutrient levels (relative to Lakes Ontario and Erie). There are no major rivers or lakes in the vicinity of the site other than Lake Huron. A former tributary of the Little Sauble River, named Stream "C", drains into the southwest corner of the Baie du Doré to the north and the Little Sauble River empties into Inverhuron Bay to the south. Under most prevailing current conditions, there is little circulation in Baie du Doré. The Baie appears to be more heavily influenced by wind and wave action than by broad circulation patterns in the lake.

The overland flow patterns in the catchments on the Bruce site are influenced by the extensive network of roads, railways and associated culverts and ditches. Overland flow generally radiates from the centre of the site towards Lake Huron. Typical of any industrial site, the Bruce site drainage system has an extensive storm water infrastructure, including a network of sewer lines, catchbasins, manholes, open ditches, culverts and outfalls to Lake Huron (Bruce Power, 2005a).

A stormwater control study of the Bruce site was undertaken by Ontario Hydro in 1997. The study delineated 16 different drainage areas within the site. A subsequent study conducted by Parsons and Marshall Macklin Monaghan (2000), slightly refined some of the drainage areas

(areas J, K and L) defined in the 1997 study. The drainage areas as delineated by these two studies are illustrated in Figure 3-1.

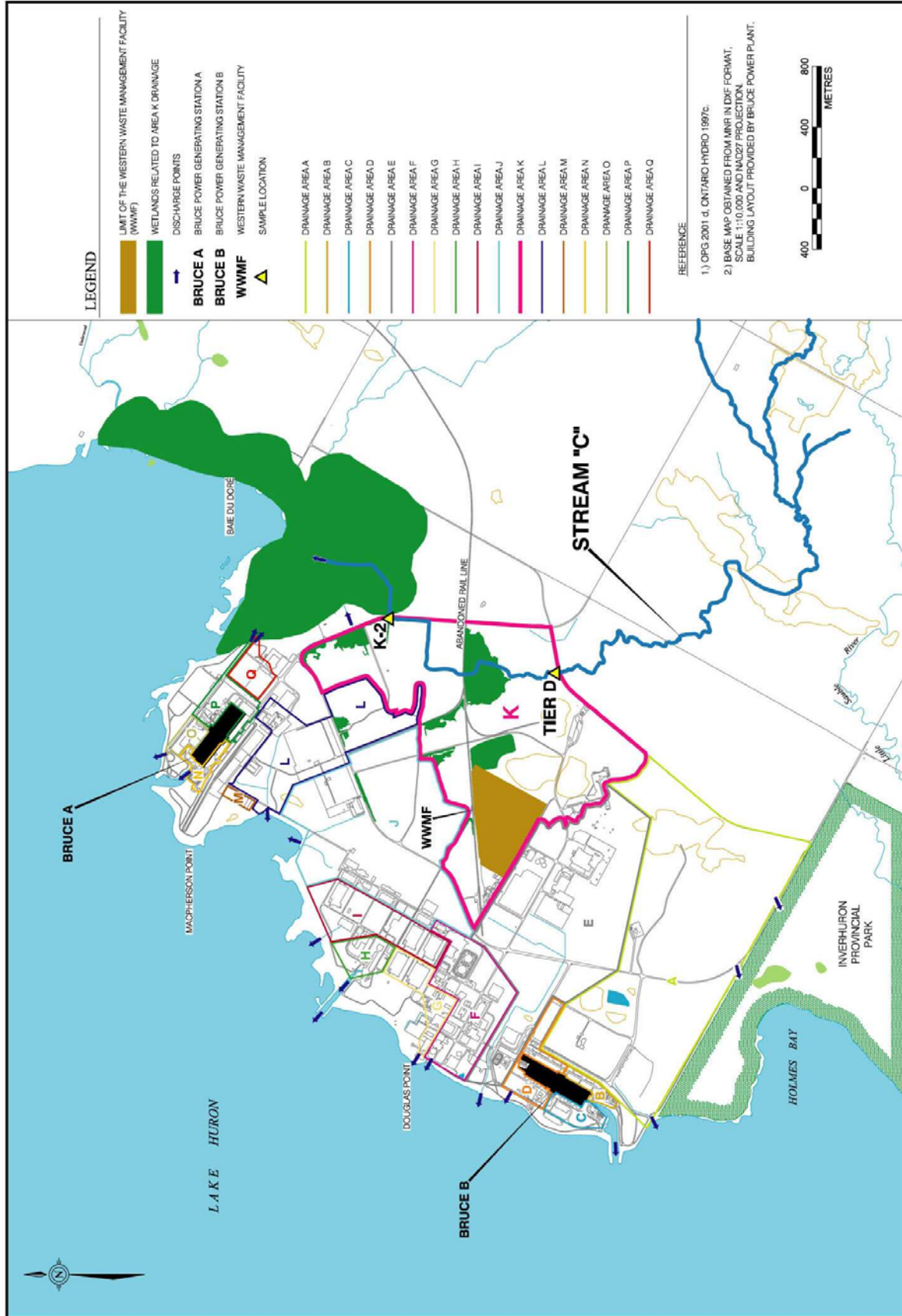
The stormwater control study (Ontario Hydro, 1997b) reported the total drainage area of the Bruce site as 738.7 ha. The WWMF and the surrounding lands, including those on the north side of the railway ditch, shown in Figure 3-1 are included in drainage area K. Area K has a total area of 196.7 ha (Parsons and MMM, 2000) and is relatively flat having an average slope of 0.29%. It is drained primarily by ditches constructed along roadways and railways.

The WWMF (19 ha) and the immediate surrounding area has a drainage area of approximately 25 ha (OPG 2001), that discharges to the Railway Ditch and a wetland immediately east of the site. The WWMF site drainage is provided by a system of catchbasins and underground storm sewers. Surface runoff from the LLSBs and the Waste Volume Reduction Building is collected to control oil and sediment loadings and sampled prior to release.

The upstream Railway Ditch receives drainage from the former Spent Solvent Treatment Facility, potential runoff from the Sewage Processing Plant, and the Waste Chemical Transfer Facility (OPG, 2005b). The Railway Ditch also receives drainage from approximately 12.5 ha of the WWMF including the areas of the in-ground containers, trenches, and some undeveloped land. The Railway Ditch also intercepts groundwater and is wet throughout the year (OPG, 2005b). The ditch is approximately 3 m wide and 1.5 m deep with a shallow slope to the east (0.09% to 0.15% grade). Between storm events the water depth in the ditch is approximately 0.15 to 0.2 m, with sluggish flow. The ditch has become naturalized over time, with cattails dominating most of its length, which contribute to the low flow velocity. The Railway Ditch flows around the north edge of the on-site wetland and has minimal contact with water in the on-site wetland. The Railway Ditch drains to the east side of Siding Road via a culvert and then to Stream "C".

In the vicinity of the Used Fuel Dry Storage area, drainage is collected by a storm sewer system which drains to a wide grassy swale east of the area. The swale drains to an existing wetland immediately east of the WWMF.

The Steel Yard, an area located to the north of the Railway Ditch adjacent to the WWMF, has drainage of the southern portion to the Railway Ditch, and of the northern portion to the culvert on the west side of the Siding Road and then to Stream "C". The on-site wetland, located immediately east of the WWMF and west of Siding Road receives drainage from an



**FIGURE 3-1 SITE AND SURFACE DRAINAGE**  
(OPG, 2005b)



approximately 25-ha area. The wetland experiences fluctuations in water levels from season to season and occasionally has areas of open water. The wetland area is covered with thick pockets of cattails, intermixed with standing dead wood.

The drainage path from the WWMF to Stream "C" is illustrated in Figure 3-2.

Parsons and MMM (2000) summarize stormwater quality data collected at locations along Stream "C". Data collected in the late 1980s in Stream "C" at the point where it enters the Bruce site and again at the discharge to Baie du Doré show that concentrations of Kjeldahl nitrogen and total phosphorous decrease across the Bruce site.

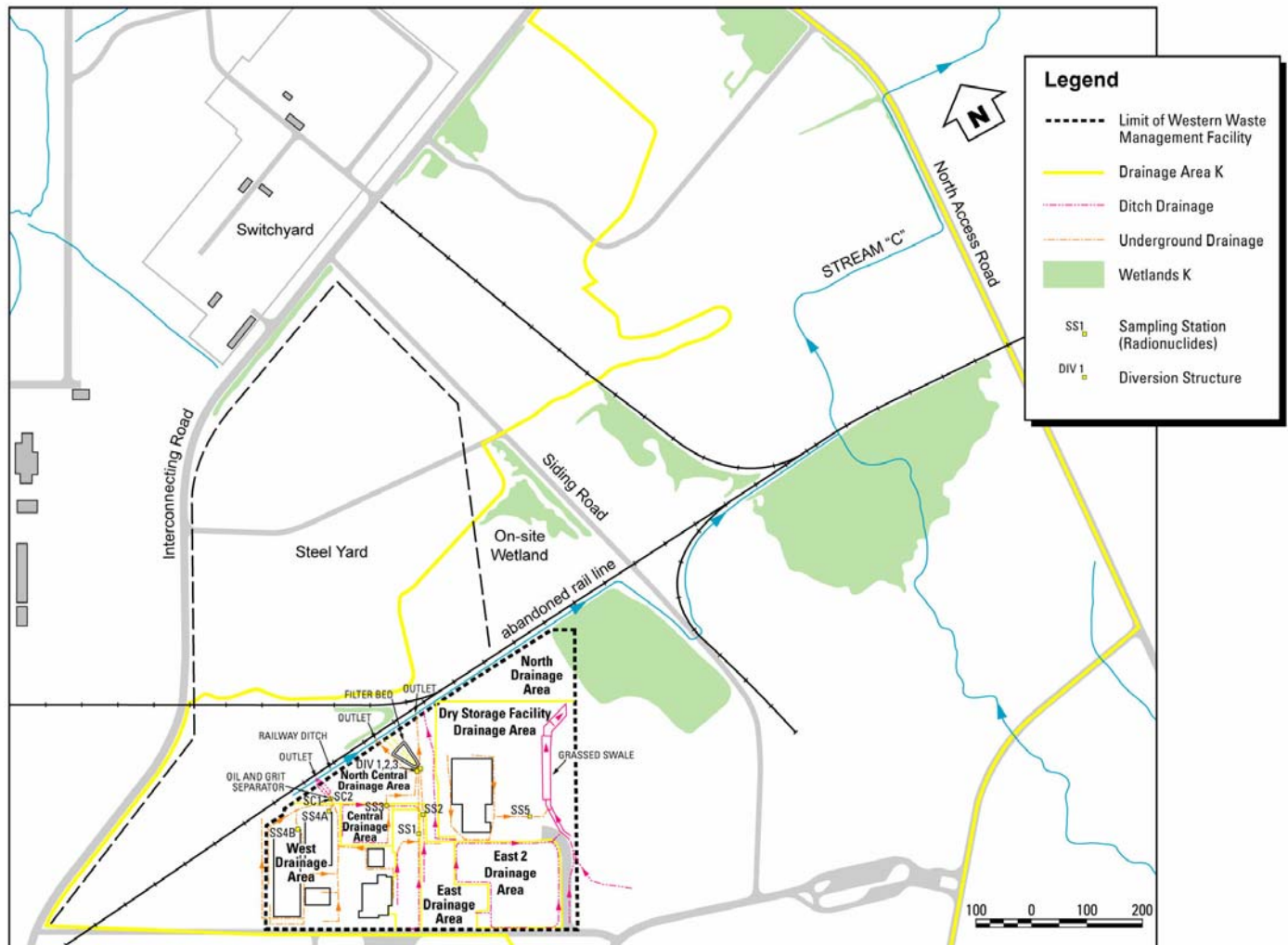


FIGURE 3-2: WWMF SITE DRAINAGE AND SURFACE FEATURES

Based on sampling in 1996 of four representative storm events, it was determined that the quality of water discharging from Stream "C" at the point of discharge to Baie du Doré was acceptable, since the average concentration of suspended solids was low. However even though the overall concentration was low, the sediment loading was quite high due to the large volume of water at the outlet.

### 3.2.2 Aquatic Habitat

Aquatic habitat conditions in the nearshore of Lake Huron around the Bruce site can be divided into two main zones: the area north of the former Douglas Point Generating Station discharge, and the area south of the discharge. The habitat conditions depend upon the types of substrate, wave action and water temperature, which vary with depth. Near shore conditions within the northern portion is characterized by an exposed shoreline of rock and bedrock, extending out into the lake to approximately 9 m depth. This area has the potential to be used by migratory fish species as a spawning area. South of the Douglas Point Generating Station for approximately 2 km, the nearshore area is characterized by a narrow shelf and a steep slope that extends into the lake to a 9 m depth within 1,000 m of the shoreline. This southerly area does not provide extensive habitat for warmwater fish or coldwater fall spawning fish, given an absence of the necessary shoals and banks.

East of the WWMF, the railway ditch runs for approximately 550 m from the WWMF to the wetland and an additional 450 m from the wetland to Stream "C", which in turn flows approximately 1,400 m north into the Baie du Doré (ESG and BEAK, 2000). Stream "C" is a cold-water stream that provides spawning and nursery habitat for brook trout, rainbow trout, brown trout and Chinook salmon. At Baie du Doré there is a provincially significant wetland.

#### Lake Huron

Fish community monitoring has been conducted within Lake Huron in the area surrounding the Bruce site since 1961. A total of 85 species have been recorded, comprising two major types: those that range broadly throughout the region and Lake Huron, and use the area on an occasional basis; and those that are confined to nearshore areas for most of their life stages. The latter fish community includes yellow perch, smallmouth bass, northern pike, spottail shiner and bowfin.

The lake-wide fish community includes species that prefer open lake or deep coastal habitats such as round whitefish, lake whitefish, lake trout, and deepwater sculpin. These fish spawn at depths greater than 2 m and make use of the nearshore area most frequently for spawning, but also for foraging and nursery function.

### Baie du Doré

Baie du Doré, located along the northern portion of the Bruce site, is an embayment within the Local Study Area. It is characterized by shallow depths and rock outcrops. The habitat of the bay is protected from Lake Huron by two major shoals. Nevertheless, the shoreline remains subject to wave action and ice scour. Wetland areas (approximately 95 ha) exist at the head of the bay and are set back from the shoreline. However, they are connected to the bay through outflow channels. These wetlands provide a very productive nursery and spawning habitat for many Great Lake species and are very productive. Average water temperatures in Baie du Doré are generally 2°C warmer than those in the open lake, but it is often much more than 2°C warmer during the summer.

Baie du Doré is regionally significant for waterfowl staging for a number of species and is an important stopover area for migratory passerine birds and shorebirds. It also provides spawning habitat for Chinook salmon, bass and carp.

The Baie du Doré wetland is home to several provincially significant animal species including the spotted turtle, horned grebe, pied-billed grebe, great egret, canvasback, redhead, caspian tern and common tern. Provincially significant plant species found in the wetland include spike rush and ridged yellow flax (Bruce Power 2002). In a bioinventory study of the Bruce site in 2000 and 2001, LGL (2002) noted that the most notable habitat for rare plant species within the Bruce site is the Baie du Doré wetland.

### Stream "C"

Stream "C" is a cool water stream that is located east of the WWMF boundary and flows in a northerly direction to Baie du Doré. The stream was constructed by redirecting a former tributary of the Little Sauble River through the Bruce site.

Stream "C" is characterized as a slow flowing stream with riffle and pool habitat throughout. The stream has a mean width of 3.0 m with maximum depths ranging from 0.15 to 0.8 m. Aquatic

vegetation is plentiful throughout the reach consisting primarily of submergents and a small emergent component. Riparian vegetation is dominated by overhanging grasses that provide some shade to the stream. Substrate is composed of a mix of boulder/cobble (30 percent), sand/gravel (10 percent) and clay/silt (60 percent).

The fish community within Stream "C" is composed of a diverse assemblage of coldwater and warmwater species including rainbow trout, brown trout, smallmouth bass, white sucker, rainbow darter, bluntnose minnow, creek chub, longnose dace, northern redbelly dace, finescale dace, emerald shiner, central mudminnow and brook stickleback (OPG 2000a). Spawning activity of rainbow trout, brown trout, brook trout and Chinook salmon have all been recorded through past studies (LGL 2002).

#### Railway Ditch

The Railway Ditch is approximately 5 m wide at the top of the bank with a wetted width of 3 m and a mean water depth of 0.15 m. The Railway Ditch is naturalized and the side slopes of the ditch are stabilized with natural vegetation cover including grasses, trees, shrubs and cattails. The presence of cattails throughout much of the ditch provides a highly stable ditch bed and serves to reduce water velocity, thus minimizing erosion and increasing the rate of settling for sediments. Other aquatic vegetation found in the ditch includes sedge, pondweed, watercress, water plantain, bulrush and arrowhead. Dense mats of muskgrass thrive in the open pool areas of the ditch along with filamentous green algae.

Fish community investigations identified that the Railway Ditch supports a warmwater fish community consisting of bluntnose minnow, fathead minnow, northern redbelly dace, central mudminnow, brassy minnow, and brook stickleback. All of the fish sampled are hardy species that thrive in slow flowing, boggy conditions with extensive aquatic vegetation growth (Parsons and MMM 2000). Common minnow, redbelly dace, creek chub, five-spined stickleback and the central mudminnow have also been observed in open water ponds along the ditch (Kinectrics 2005).

#### Wetland

There is a small wetland (4 ha) located east of the WWMF boundary. It is not a provincially significant wetland. The Railway Ditch flows around the edge of the wetland and continues into Stream "C" beyond the wetland. The wetland has experienced yearly fluctuations in water

levels and occasionally has small areas of open water. A local beaver population sometimes influences water levels in the wetland as the outflow culvert is periodically blocked with branches and other debris. Evidence of muskrat activity is also sometimes visible in the wetland and wetland discharge area (Parsons and MMM, 2000). The wetland area is covered with thick pockets of cattails intermixed with standing deadwood.

Fish community investigations identified hardy species that thrive in slow flowing, boggy conditions with extensive aquatic vegetation growth (Parsons and MMM 2000). These include bluntnose minnow, fathead minnow, northern redbelly dace, central mudminnow, brassy minnow and brook stickleback. It is likely that the fish in the wetland originate from Stream "C".

### **3.3 SUBSURFACE ENVIRONMENT**

The site characteristics and descriptive conceptual geosphere model described below are based on knowledge of regional and site-specific geology, hydrogeology, hydrogeochemistry and geotechnical conditions (Golder, 2003a; Mazurek, 2004). The description of the geologic environment for the deep bedrock formations is based on geologic extrapolation of conditions elsewhere within the Michigan Basin. A more detailed description of the Bruce site with respect to geologic, hydrogeologic and geomechanical conditions is provided in Appendix D.

#### **3.3.1 Geological Setting**

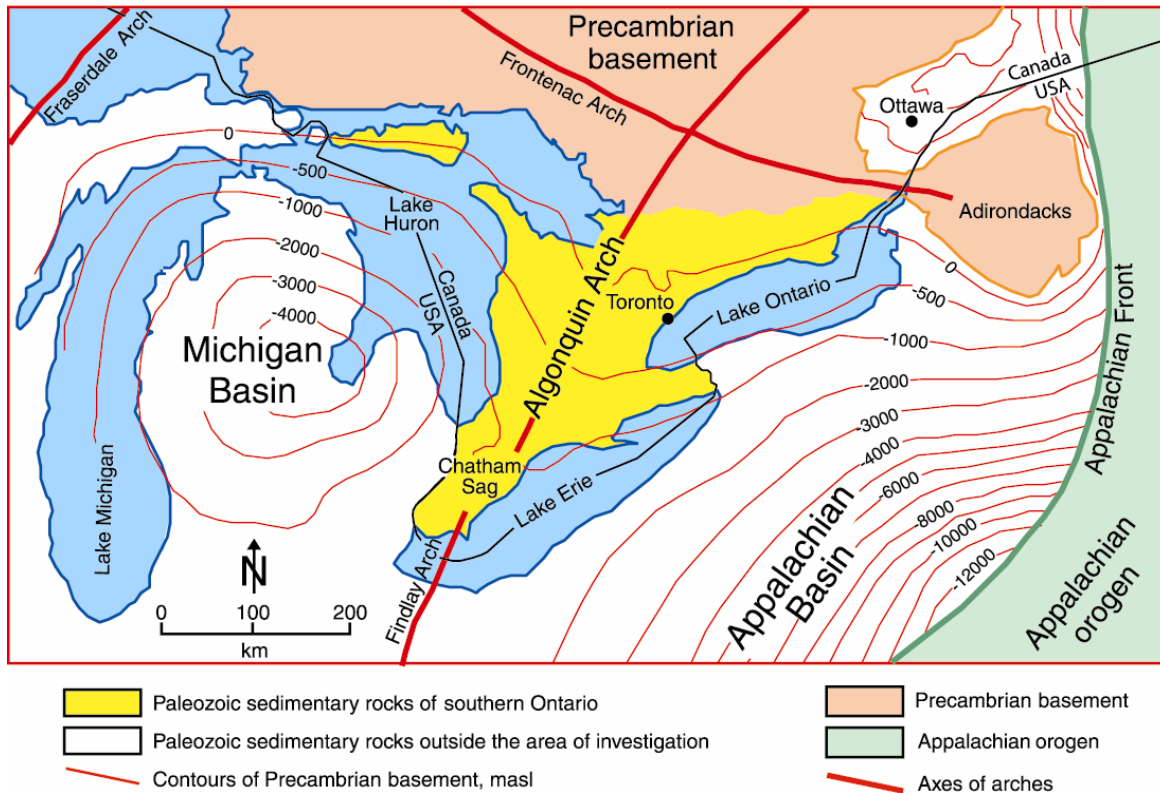
The Bruce site is located in Southern Ontario along the southeastern rim of the North American Craton. The crystalline basement rocks in this area are overlain by the Paleozoic sedimentary rocks of the Western St. Lawrence Platform (Johnson *et al.* 1992). Within the central part of this area, a SW-NE trending feature known as the *Algonquin Arch* occurs in the crystalline basement (Figure 3-3).

The Algonquin Arch separates two major basins. To the southeast, there is the Appalachian Basin or Allegheny Trough and to the northwest of the Arch, the Michigan Basin where the proposed DGR site is located (Figure 3-3). The Michigan Basin is a circular-shaped intracratonic basin with a diameter of 500 - 600 km, centred on Michigan, with a maximum depth of over 4 km.

#### **3.3.2 Topography**

Surface relief at the Bruce site is relatively flat with variously open or forested areas including dry upland hardwood areas and low, poorly-drained cedar-dominated areas. The elevation of the

site ranges between 180 and 195 metres above sea level (masl); compared to the Lake Huron level of 176 masl. The highest elevations, between 190 and 195 masl, occur in the vicinity of the WWMF and the central eastern areas of the Bruce site.



**FIGURE 3-3: LARGE-SCALE TECTONIC ELEMENTS IN SOUTHERN ONTARIO (ADAPTED FROM JOHNSON ET AL. 1992).**

### 3.3.3 Quaternary Geology

Beneath Bruce site the glacial drift overlying the bedrock surface thickens eastward from the Lake Huron shoreline ( $\approx 0$  m) to the eastern site perimeter ( $\approx 27$  m). Within the vicinity of the proposed DGR footprint drift thickness vary between  $\sim 12$  and 15 m. Overburden thicknesses in the vicinity of the WWMF, located to the south of the proposed DGR location, vary 14 to 19 m.

The overburden in this area consists of a complex sequence of surface sand and gravel overlying a dense glacial till, which is locally interbedded with sand lenses and layers. The top 2 m to 4 m of the glacial till unit is weathered. Underlying this brown weathered till horizon is an unweathered grey till comprised of dense silty sand to very hard clayey silt with sand and

boulders. The unweathered till unit is locally intervened by a horizontal middle sand layer of variable thickness. In specific areas of the Bruce site this middle sand layer is found in direct contact with the underlying carbonate bedrock surface. A detailed description of the overburden geology is provided in Appendix D.

### 3.3.4 Bedrock Geology

The highest bedrock surface elevation (180 to 185 masl) occurs beneath the western portion of the Bruce site in the vicinity of the Bruce B generating station. The lowest confirmed bedrock elevations occur locally beneath the northwestern portion of the site (168 to 170 masl).

The Paleozoic rock underlying the Bruce site is comprised of a near horizontally layered sedimentary sequence of carbonates, shales, evaporites and minor sandstones. This sedimentary sequence is approximately 800 m thick resting upon the crystalline Precambrian basement. The stratigraphy, age, thickness and nomenclature of the sedimentary formations as extrapolated beneath the Bruce site are depicted in Figure 3-4. Descriptions of the various sedimentary rock formations and their geomechanical characteristics are in Appendix D.

### 3.3.5 Hydrogeology

A descriptive conceptual hydrogeologic model has been developed for Bruce site based on the information described in Appendix D. A schematic of this conceptual model as described by Golder (2003a) that depicts the geometry and depths of the groundwater flow systems occurring beneath the Bruce site is provided in Figure 3-5. These groundwater regimes are described in more detail below.

In the **Surficial Zone**, fresh water enters the groundwater system from precipitation through the recharge zone and percolates vertically downward into the underlying **Shallow Bedrock Zone**. Average linear groundwater velocities within the dense glacial till are estimated to be on the order of a few centimetres per year. Within the locally more permeable middle sand unit, velocities are on the order of ten metres per year.

The **Shallow Bedrock Zone** comprises principally the Devonian age dolomitic bedrock. Groundwater quality within this zone varies with depth, from fresh to brackish, and in some instances has a high sulphur content. In this zone, the influence of weathered, solution enhanced open bedding planes, interconnected vertical joints and weathered intraformational breccia horizons on formation permeabilities could be significant. The permeability in this zone is

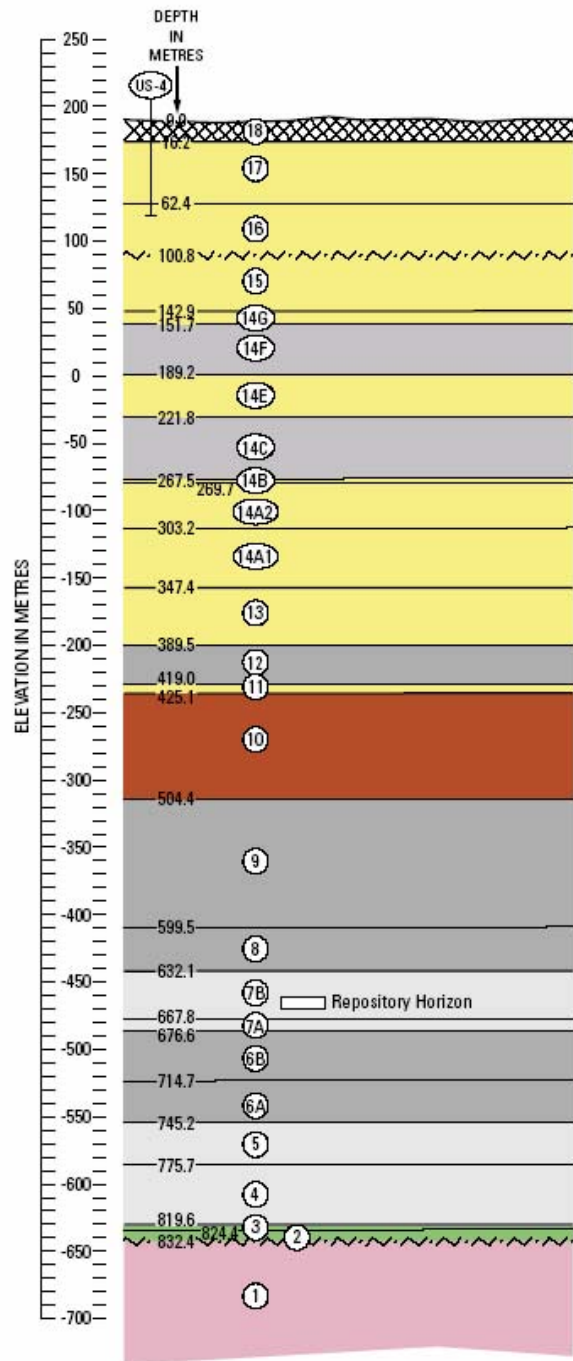
anticipated to be moderate to high with groundwater flow velocity in the order of ten to hundreds of metres per year. The groundwater flows horizontally westward to a point of near-shore discharge in Lake Huron.

According to Golder (2003a), the groundwater in the upper portion of Salina Formation of the **Intermediate Bedrock Zone** varies from fresh to brackish and then saline (brine) in the lower section. Vertical circulation of groundwater between the overlying freshwater zone and the underlying saline zone is restricted by horizontally layered and laterally continuous shale aquitards. The vertical movement of groundwater is further restricted because of the presence of low permeability, horizontally layered, anhydrite beds.

The Guelph and Lockport Formations are associated with reef structures that have inter-granular porosity. Deep groundwater samples from these formations elsewhere in southern Ontario indicate the presence of sulphur and saline water. Low to moderate permeability is anticipated in this zone. The movement of groundwater within this zone is limited to the horizontal direction. In part, this occurs because the horizontal bedded shale and anhydrite units within the Salina Formation do not allow vertical movement of water from the Shallow Bedrock Groundwater Zone downwards. The horizontal groundwater velocities in these formations are estimated in the order of one to ten meters per year.

The **Deep Bedrock Zone** is located within the Ordovician shale and limestone sequences. These formations have not been affected by geological events such as the dissolution of evaporite beds within the overlying Salina formations. These rocks possess extremely low permeabilities. Within this deep flow domain, the porewater is characterized as a brine, and evidence suggests that mass transport is expected to be diffusion dominated (Golder, 2003a). Porewater movement is very slow at a velocity in the order of millimetres per year, or less.





**STRATIGRAPHIC LEGEND**

<b>PLEISTOCENE</b>	
18	Surficial Deposits
<b>MIDDLE DEVONIAN</b>	
17	Amherstburg Formation - Limestone and Dolostone
<b>LOWER DEVONIAN</b>	
16	Bois Blanc Formation - Cherty Dolostone
~~~~~	Silurian/Devonian Discontinuity
<b>UPPER SILURIAN</b>	
15	Bass Island Formation - Dolostone
14	Salina Formation
14G	G Member - Dolostone and Shale
14F	F Member - Dolomitic Shale and Shale
14E	E Member - Dolostone
14D	D Member - Salt (absent in site area)
14C	C Member - Dolomitic Shale and Shale
14B	B Member - Dolostone and Anhydrite (2m)
14A2	A2 Member - Dolostone, Shaly Dolostone
14A1	A1 Member - Dolomitic Shale and Shale
<b>MIDDLE SILURIAN</b>	
13	Guelph, Lockport and Reynales Formations - Dolostone
<b>LOWER SILURIAN</b>	
12	Cabot Head Formation - Grey Shale
11	Manitoulin Formation - Argillaceous Dolostone
<b>UPPER ORDOVICIAN</b>	
10	Queenston Formation - Red Shale and Siltstone
9	Georgian Bay Formation - Grey Shale and Siltstone
8	Collingwood Formation - Grey Shale
<b>MIDDLE ORDOVICIAN</b>	
7	Lindsay Formation
7B	Upper Member - Limestone and Agrillaceous Limestone
7A	Sherman Falls Member - Limestone
6	Verulam Formation
6B	Upper Member Shaly Limestone
6A	Lower Member Argillaceous Limestone
5	Bobcaygeon Formation - Shaly Limestone to Crystalline Limestone
4	Gull River Formation - Lithographic Limestone
3	Shadow Lake Formation - Siltstone, Sandstone
<b>CAMBRIAN</b>	
2	Cambrian Sandstone
~~~~~	Cambrian Precambrian Unconformity
<b>PRECAMBRIAN</b>	
1	Precambrian Basement - Granitic Gneiss

**NOTE:**

1. STRATIGRAPHIC SEQUENCE WAS DEVELOPED FROM A COMPOSITE OF THE SHALLOW BOREHOLE US-4 ONSITE AND THE DEEP OFFSITE GAS EXPLORATION WELL TEXACO #6 IN BRUCE TWP LOT E CONCESSION IV BASED UPON A MATCH POINT AT THE AMHERSTBURG / BOIS BLANC CONTACT.

**FIGURE 3-4: PALEOZOIC BEDROCK GEOLOGY BENEATH BRUCE SITE (GOLDER, 2003a).**

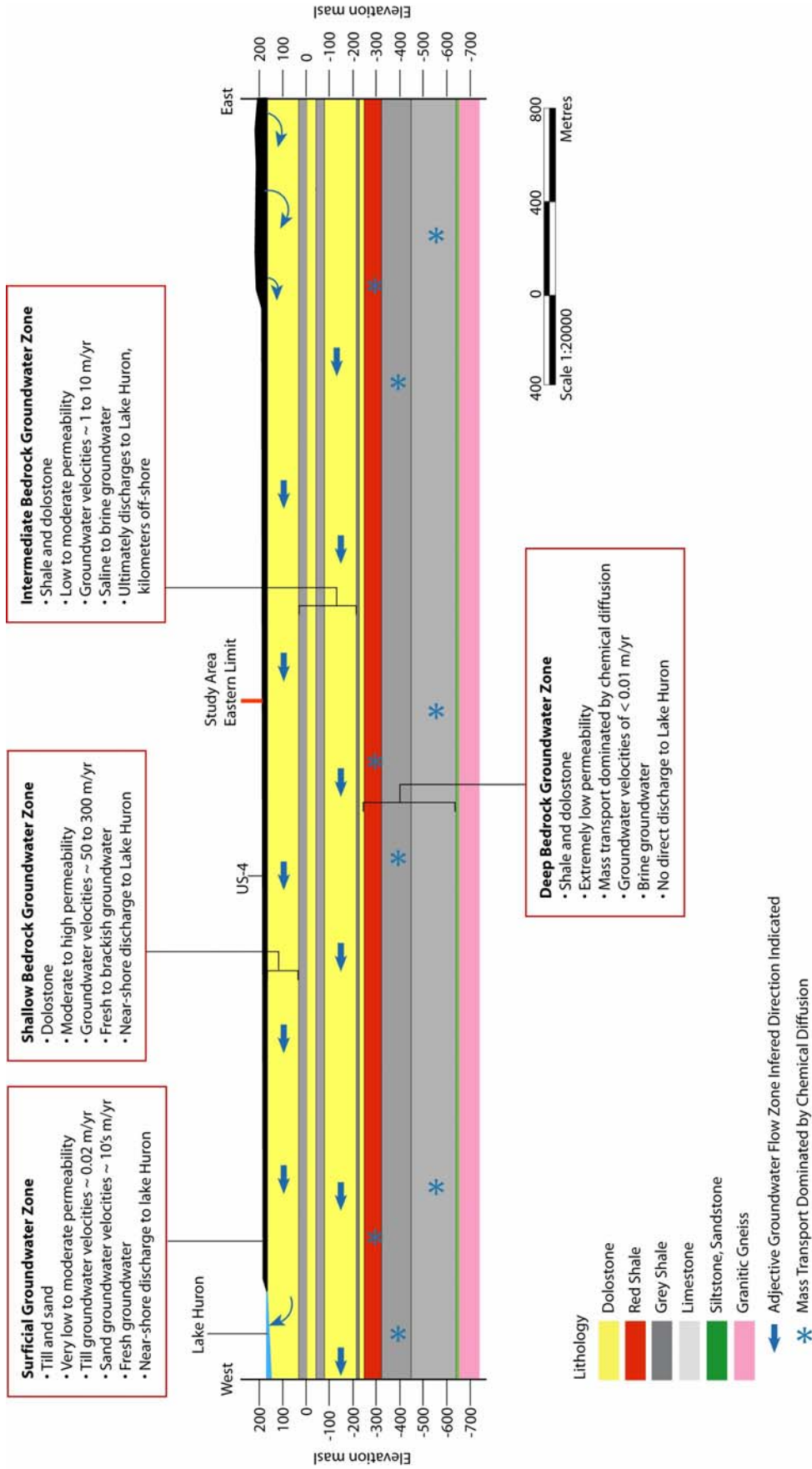


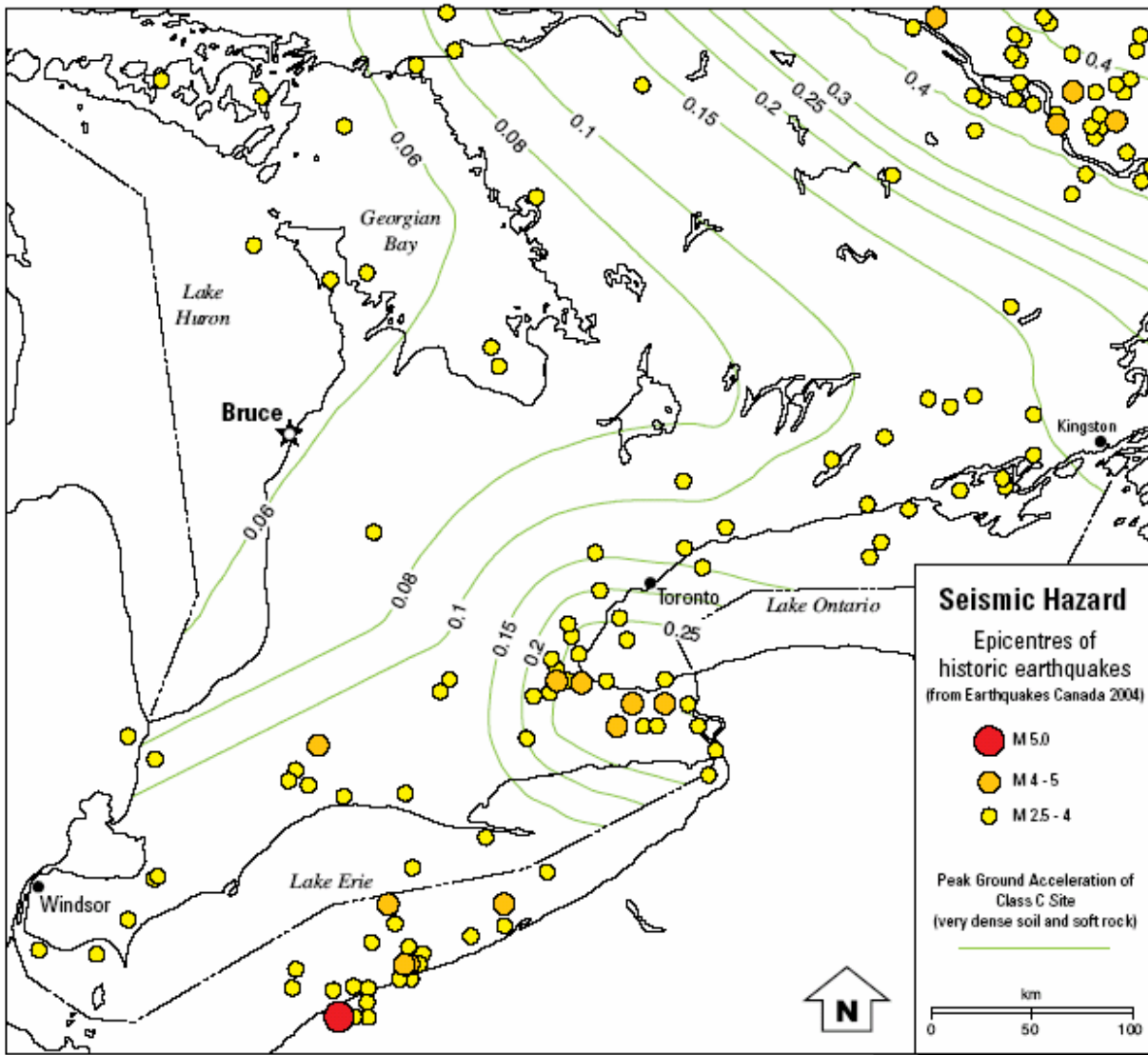
FIGURE 3-5 CONCEPTUAL HYDROGEOLOGIC MODEL OF BRUCE SITE (GOLDER 2003a)

### 3.3.6 Seismicity

Southern Ontario is located in the southeastern part of the North American Craton and is also known to be one of the tectonically stable regions in the world. The stable cratonic core region has limited active faulting and seismicity.

In Ontario, the largest recorded earthquake is along the Ottawa-Bonnechere Graben system with a magnitude of 6.2. The focal depths in this Graben are typically 5 to 20 km (Mazurek 2004). However, in southern Ontario, seismicity is low and largely limited to the Niagara Peninsula. The Bruce site and its surrounding regions is virtually aseismic historically.

Figure 3-6 shows a compilation of historic earthquake events prior to 2004 and the peak ground acceleration contours in southern Ontario with a return period of 1/2500 years (2%over 50 years).



**FIGURE 3-6: EARTHQUAKE EPICENTRES AND CONTOURS OF SEISMIC SURFACE ACCELERATION IN SOUTHERN ONTARIO. (ADAM, 2005; MAZUREK 2004)**

### 3.4 TERRESTRIAL ENVIRONMENT

The Bruce site is located within the Huron-Ontario section of the Great Lakes – St. Lawrence Forest Region. This region is characterized by sugar maple, beech, red and white ash, yellow birch, and red, white and bur oaks.

Although Bruce County contains a number of large forested areas and wetlands providing core habitat for a variety of wildlife species, much of the surrounding area consists of agricultural land. Consequently, few natural terrestrial features or wildlife corridors exist. There are remnant forested areas that are primarily associated with the Lake Huron shoreline, watercourse valleys, areas with steep topography and poorly drained sites (OPG, 2005b).

Core natural areas surrounding the Bruce site include Inverhuron Provincial Park, and the Scott Point Provincially Significant Wetland and Provincially Significant Life Science Area of Natural and Scientific Interest (ANSI). The Huron Fringe Deer Yard runs along the Lake Huron shoreline from Inverhuron Provincial Park to MacGregor Point Provincial Park and provides winter habitat for white-tailed deer.

Inverhuron Provincial Park, located immediately south of the Bruce site, contains primarily early succession and second growth vegetation communities resulting from past disturbances. The most mature forest within the park is found along the Little Sauble River near the river mouth. A sand dune succession system is also present.

The Scott Point Provincially Significant Life Science ANSI is a complex of small coastal wetlands consisting of swamp, marsh, fen, shoreline bluffs and beach ridges.

The Bruce site was purchased by Ontario Hydro (predecessor to OPG) for a nuclear power development. Construction of the generating stations and nuclear support facilities began in the early 1970s. The Bruce A and Bruce B generating stations were brought into service in 1977 through 1979 and 1984 through 1987, respectively. The site is zoned for industrial use. As a result of this use and activities over the years, much of the site has been disturbed (vegetation has been removed for construction laydown areas, areas paved, landscaped, etc). The treed and vegetated areas on the site are generally early succession and second growth generation.

Several distinct vegetations ecosites have been identified on the Bruce site, the most common being fresh-moist white cedar coniferous forest, dry-fresh sugar maple deciduous forest, and mineral cultural meadow. No rare or unique vegetation species have been identified within these ecosites.

Approximately 4 ha of the 19.0 ha WWMF are currently wooded, in two separate areas. In July 2004, surveys of flora and fauna on the two wooded areas, as well as a 100 m section of the Railway Ditch adjacent to one of the woodlots, were undertaken. The two woodlots provide

limited habitat as a result of their small size and disturbed nature. In addition, the discontinuous nature of both areas and on-going construction and operation activities likely preclude them from acting as critical wildlife corridors.

Approximately 25 ha of the area across the railway ditch to the north of the WWMF are also wooded, primarily immature forest.

### **3.4.1 Vegetation Communities**

The fresh-moist white cedar coniferous forest overstorey mainly comprises mature to semi-mature eastern white cedar in pure stands, or in association with balsam fir and tamarack. This occurs on poorly drained soils and groundcovers include sensitive fern, field horsetail and mosses. On the Bruce site, heavy deer browsing is widespread in cedar stands.

Dry-fresh sugar maple deciduous forest is dominated by mature sugar maple and beech in varying proportions. It is underlain by well-drained sandy or silt loams, often with boulders. Understorey regeneration is poor due to canopy closure and deer browsing.

Mineral cultural meadow occurs within areas of open exposed gravel soils overlying poorly drained clay soils. The mineral cultural meadow contains primarily grasses and regenerating shrub growth of white cedar and balsam poplar.

### **3.4.2 Wildlife**

The Bruce site provides habitat for a variety of wildlife, including reptiles, amphibians, birds, and mammals. An important natural heritage feature is the Baie du Doré Provincially Significant Wetland. It is located within and immediately north of the Bruce site. The wetland consists of shrub and open fen, shallow marsh, and swamp habitats for a number of provincially significant animal species.

#### Birds

The bird species recorded in the vicinity of the Bruce site are common edge species that would be expected in areas of fragmented habitat. Common species such as mourning dove, American crow, American robin, blue jay and rose-breasted grosbeak have been observed within the area. There is also a flock of wild turkeys on the Bruce site. Shoreline habitats in the area are used by many species including pied-billed grebe, green heron and belted kingfisher. None of these species is considered rare or endangered. The Baie du Doré provides habitat for

an overwintering population of bald eagles (LGL, 2002) which are rare to uncommon in Ontario. Other rare species reported in the Baie du Doré include the horned grebe, great egret, canvasback, redhead and Caspian tern. The presence of mudflat habitat in the late summer attracts a variety of shorebird species.

### Mammals

Mammals observed to inhabit the Bruce site include white-tailed deer, porcupine, raccoon, groundhog, gray squirrel, muskrat, and beaver. All of these species are common, many being abundant in disturbed habitats (OH, 1997). The Bioinventory Study (LGL, 2002) also identified skunk, snowshoe hare, eastern cottontail, red squirrel, eastern chipmunk, meadow vole, woodland jumping mouse and little brown bat on the Bruce site.

### Amphibians and Reptiles

Amphibian and reptile species observed in the area include the northern spring peeper, American toad, northern leopard frog, green frog, gray treefrog, wood frog yellow-spotted salamander and redback salamander (OPG, 2002; OPG, 2003). Spotted turtle, which is rare to uncommon in Ontario and listed as vulnerable by the MNR, has been reported in Baie du Doré. The Bioinventory Study (LGL, 2002) also listed midland chorus frog, mudpuppy, and midland painted turtle, as well as eight species of reptiles. The most widespread reptile, based on observation, was the eastern garter snake.

## **3.5 RADIOLOGICAL ENVIRONMENT**

Radiation and radioactivity in the environment are present as a result of natural and anthropogenic sources. People, regardless of their place of residence, are exposed to natural sources of radiation attributable to ionizing radiation from cosmic rays, naturally occurring radionuclides in air, water, and food, and gamma radiation from radioactive material in soil, rocks and building materials used in homes. The total annual radiation dose from natural background sources in Ontario is estimated at 2,000  $\mu\text{Sv/a}$ .

Bruce Power and OPG operate facilities at the Bruce site. The facilities include the Bruce A and Bruce B nuclear generating stations, the Central Maintenance and Laundry Facility (CMLF), operated by Bruce Power and the WWMF, operated by OPG. These activities at the Bruce site result in the release of some radionuclides, some of which are also present naturally in the environment. These include tritium, carbon-14, radioactive particulate in air and gross beta in water. Anthropogenic sources of radioactive noble gases and iodine (most commonly iodine-131) are larger than natural sources.

Environmental monitoring programs are conducted at the Bruce site, routinely measuring radiological emissions and the concentrations of selected radionuclides in the atmospheric, aquatic, terrestrial, and geophysical environments. Results of radiological emission monitoring for 2004 are provided in Table 3-1 (Bruce Power, 2005b). Blank areas denote that that radionuclide is not released from the indicated facility.

Pathway- Radionuclide	Emissions (Bq)				
	Bruce A	Bruce B	CMLF	WWMF	Total
AIR					
Tritium Oxide	6.71E+14	1.93E+14	1.24E+10	3.29E+13	8.97E+14
Noble Gas <sup>1</sup>	4.98E+13	5.63E+13			1.06E+14
<sup>131</sup> I	3.76E+07	3.90E+07	2.77E+05	1.26E+05	7.70E+07
Particulates	3.46E+06	1.14E+08	1.62E+05	1.70E+05	1.18E+08
<sup>14</sup> C	1.17E+12	2.64E+12		3.97E+08	3.80E+12
WATER					
Tritium Oxide	9.92E+13	4.85E+14		2.05E+10	5.84E+14
Gross Beta/Gamma	8.13E+08	2.48E+09		6.19E+06	3.30E+09
<sup>14</sup> C	5.70E+09	8.47E+09			1.42E+10

1 Noble gas emissions are reported in units of  $\gamma$ Bq-MeV

**TABLE 3-1 BRUCE SITE RADIOLOGICAL EMISSIONS – 2004 (BRUCE POWER, 2005b)**

The data in the table indicates that the WWMF makes a very small contribution to the total emissions at the Bruce site.

The results from these monitoring programs, together with data on water use and food sources, are used to calculate the radiation dose to members of the public living in the vicinity of the Bruce site. The highest calculated dose in 2004 was 1.6  $\mu$ Sv from all activities on the Bruce site (Bruce Power, 2005b). This is less than one per cent of the legal limit (of 1,000  $\mu$ Sv/a).

### 3.6 ABORIGINAL INTERESTS

The Chippewas of Saugeen First Nation Reserve No. 29 is located on the shoreline of Lake Huron, adjacent to the Town of Southampton about 30 km north of the WWMF. The Band population on-reserve in 2002 (INAC, 2003) was estimated to be 639, with an additional 836 living off-reserve.



The Chippewas of Nawash Unceded First Nation is located at the Cape Croker Reserve No. 27 on the east shore of the Bruce Peninsula north of the town of Wiarton. The on-reserve population in 2002 was estimated to be 737, with an additional 1338 members living off-reserve (INAC, 2003).

The traditional territories of the Chippewas of Saugeen First Nation and the Chippewas of Nawash Unceded First Nation "Sauking Territory" is identified by Treaty 451/2, dated August 9, 1836, and includes most of Bruce and Grey Counties, and subsequently, the Robinson-Huron Treaty surrender of the Saugeen Peninsula, dated October 13, 1854, which includes most of the Bruce Peninsula.

After that date, the Aboriginal communities on the Bruce shoreline settled permanently on the reserves. Each of the First Nations have filed a statement of claim against Ontario and Canada for a breach of their fiduciary obligations to the First Nations in the negotiations and signing of the Treaty of 1854 (OPG, 2005b).

The First Nation communities have a known interest in traditional land use for harvesting, protection of the traditional Aboriginal burial ground on the Bruce site, and the potential for additional burial sites along the former glacial lake shorelines within the Bruce site.

Two registered archaeological sites, Upper Mackenzie and Dickie Lake are on record as having been located within the confines of the Bruce site. A third heritage area, the "Indian Burial Ground", was identified by Ontario Hydro in the mid-1970s and demarcated by sign posts in the early 1980s. The evidence for its declaration, however was obscure (DIAND, 2005).

In the early 1970s, Ontario Hydro identified a third heritage area, the "Indian Burial Ground" within the Bruce site, approximately 1,100 m south-south-west of the WWMF. Although no documentation was available to prove the location was actually a burial ground, Ontario Hydro marked it with signs and since then has preserved it as such (OPG, 2005b).

A stage 2 archaeological study conducted in association with the development of the Western Used Fuel Dry Storage Facility clarified that the "Indian Burial Ground" is the archaeological site which was previously identified in the archaeological database as the "Dickie Lake" site. This connection confirmed the significance of the site. OPG reached agreement with the First Nations on the ongoing care of the burial ground within the Bruce site and access to the site for ceremonies. The site is now referred to as Jibegmegoon (Spirit Place).

The "Upper Mackenzie" site is located at the most southerly corner of the Bruce site. The two identified sites are not in close proximity to the location of the proposed DGR.

### **3.7 SOCIAL AND ECONOMIC CONDITIONS**

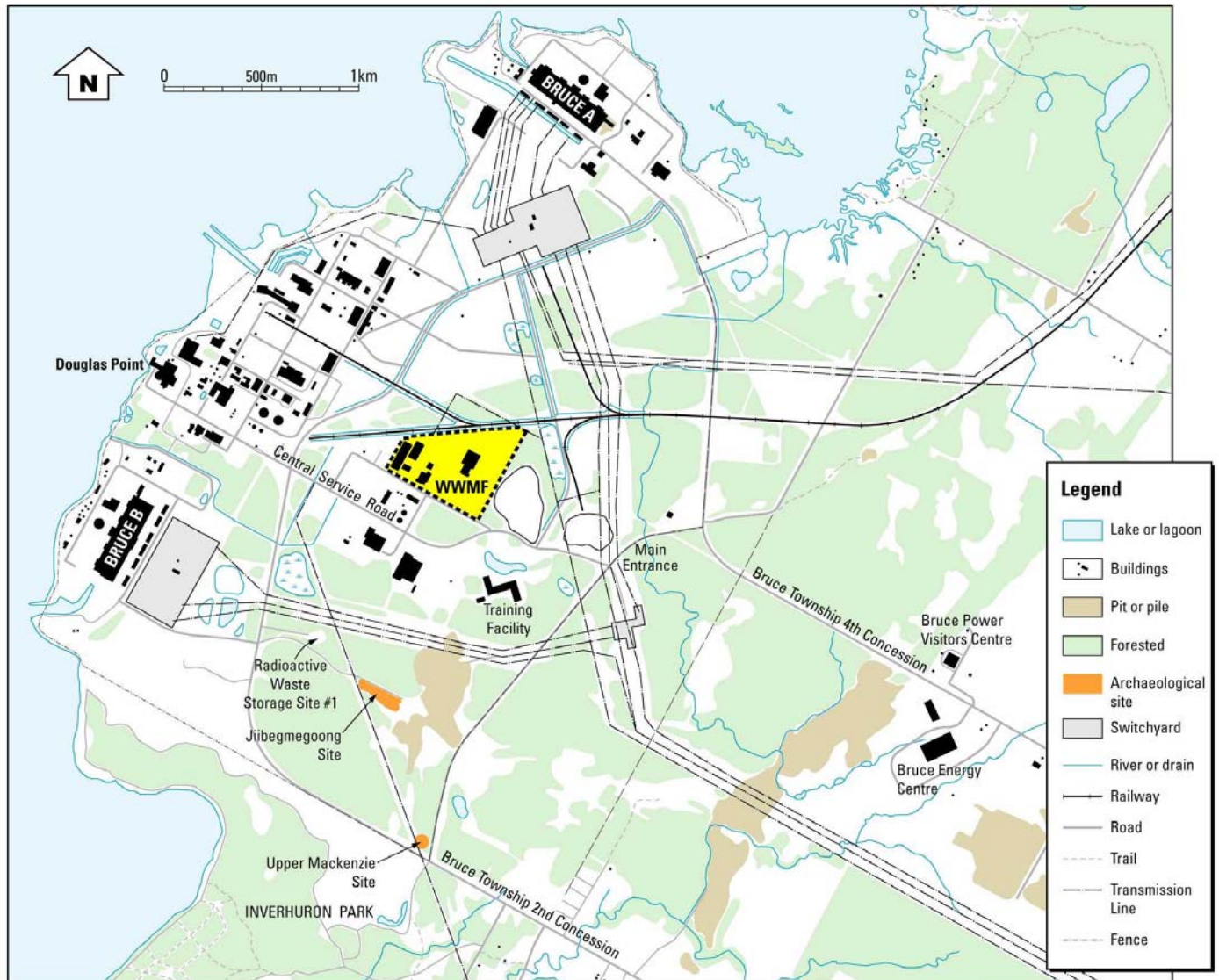
#### **3.7.1 Land Use**

The Bruce site is located in the Municipality of Kincardine in Bruce County. The majority of the Municipality of Kincardine and Bruce County consists of rural land uses which are designated in the County's Official Plan as rural, agricultural, major open space, natural environment areas, shoreline development areas, special policy area, and Inverhuron Provincial Park. The nearest primary urban areas to the Bruce site are the towns of Kincardine and Port Elgin, located approximately 10 km southwest and 15 km northeast, respectively. A village community (Tiverton) and two hamlet communities (Underwood and Inverhuron) are closer to the Bruce site.

The municipal land use policies of Kincardine zone the majority of the lands in the vicinity of the Bruce site as Environmental Protection (EP) or Open Space (OS), which permit uses associated with agriculture and recreation. Within this area, the majority of the lands are maintained in agricultural uses, with some lands designated for industrial development. Agriculture-related industrial development is located 2 km east of the site at the Bruce Energy Centre (BEC). The BEC is a privately-owned 240 ha industrial park (OPG 2000a).

The Bruce site, which is approximately 932 ha in size, is fenced, with restricted and controlled access. There is a 914 m exclusion zone around both the Bruce A and the Bruce B nuclear generating stations. These exclusion zones restrict the types of uses that can occur within the area. Within the Bruce site boundary, existing land uses consist of buildings, structures and transportation access required to operate and support the nuclear generating stations. Figure 3-7 provides an overview of land use on the Bruce site.

In addition to the designation of the Bruce site as a Controlled Development Area, two "Hazard Land Areas", which correspond to the natural features located on site (an active and closed landfill site, and a Provincially Significant Wetland), are identified in the County's Official Plan in close proximity to the Bruce site.



**FIGURE 3-7 LAND USE ON BRUCE SITE**

The Municipality of Kincardine zoning by-law identifies the Bruce site as “Institutional” and permits a variety of land uses related to electrical and heat energy production, transmission and distribution. In keeping with its purpose, there are no other land uses within the Bruce site boundary. The area enclosed within the Bruce site perimeter fence consists of a number of industrial facilities and sites which are interspersed by woodlots and open fields (LGL 2002).

### **3.7.2 Socio-economic Conditions**

The economic base of Bruce County is diverse, with the Bruce site being the single largest employer in Bruce County. The WWMF provides a small portion of the employment within the overall Bruce site. Agriculture and tourism are the next two largest industries in Bruce County (OPG, 2004c). There are more than 3,750 farm operators, and more than one in seven members of the working population in Bruce County are employed in the tourism industry. There are also many well-established small manufacturing businesses, retail trade and service industries throughout Bruce County.

Lake Huron is used locally for fishing for personal consumption, sport and commercial harvesting, as well as recreational swimming and boating. The cooling water discharges from Bruce A and Bruce B provide year-round sport fishing opportunities. Cottages, resorts, beaches and marinas are located along the shoreline, focused around the communities of Kincardine and Port Elgin.

The lake provides water supply to the larger adjacent communities such as Port Elgin, Kincardine, Southampton, Tiverton and Inverhuron by means of water supply plants. However, most of the rural population within 20 km of the Bruce site obtain water for drinking, bathing, laundry, sanitation and farm animals from wells drilled to depths of about 100 m, and to a far lesser extent from shallow dug wells. A few community wells exist, serving inhabitants of Underwood and Scott Point (OPG 2004b).

Hunting for white-tailed deer, waterfowl (ducks, geese), ruffed grouse, and woodcock for consumption purposes occurs within 5 km of the Bruce site. Hunting does not occur on the Bruce site or on OPG-owned property.

Inverhuron Provincial Park is located immediately south of the Bruce site and is operated as an overnight and day-use facility. MacGregor Point Provincial Park is located approximately 15 km north of the Bruce site and is operated as an overnight camping and day-use facility. The 1,200 ha McGregor Park, located 5 km south of Port Elgin, includes a Provincially Significant Wetland complex and offers year-round recreational and sightseeing activities.

## **3.8 PHYSICAL AND CULTURAL HERITAGE**

Two archaeological assessments (Stage 1 and Stage 2) were conducted for the WUFDSF near to the likely location of the surface facilities for the proposed DGR. A moderately low archaeological potential was assessed with no evidence of habitation or burial sites

encountered. The archaeological potential of the proposed DGR site is expected to be consistent with that of the WUFDSF.

OPG recognizes the sensitivity of any archaeological finds on the site. An archaeological assessment of the proposed DGR areas will be undertaken as part of the environmental assessment.

There are no natural or built heritage features near or adjacent to the WWMF.

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#### 4.0 POTENTIALLY AFFECTED COMPONENTS OF THE ENVIRONMENT

One objective of this project description document is to assist the Responsible Authority (the CNSC) and Federal Agencies in the early identification of potential environmental issues that should be considered in the preparation of the EA Guidelines for the DGR project. This section identifies the potential interactions between the DGR and the environment, based on preliminary analysis and recent studies.

In sections 4.1 through 4.3, the project-environment interactions are identified for each of the three project phases, construction, operation, and decommissioning and long-term performance, based on a consideration of the anticipated favourable properties of the Bruce site identified through feasibility studies (Golder, 2003a; Golder 2004, Quintessa, 2003), recent experience with construction projects and WWMF operations, and the knowledge of the existing environment described in section 3. A simple qualitative ranking is used to identify the degree of interaction (strong, moderate or weak) between the DGR project and the environment as follows:

- Long term or intense interactions that cannot be mitigated are considered to be **strong**.
- Long-term or intense interactions that can be mitigated are considered to be **moderate**.
- The interactions that are short-term (for example, limited to the construction phase), or are not intense, are considered to be **weak**.

The geographic extent of the potential effects of the DGR is expected to be limited to the Bruce site for most components of the environment throughout the three phases of the project life. Social and economic effects are expected to extend into Bruce County, but not beyond, and are expected to be beneficial. Potential impacts on Lake Huron would only be associated with the construction and operations phases and would be localized to the near-shore area and near-shore fishery. International impacts are not expected to result from the DGR at any time during its life cycle.

The Independent Assessment Study (Golder, 2004) included an environmental protection feasibility review. The goals of the review were to examine potential effects on the environment and identify adverse effects during construction and operation, and determine if feasible management and mitigation measures exist to allow potential adverse effects to be avoided. The IAS concluded that although there is potential to cause effects on the environment, all the identified potential effects can be managed using appropriate mitigation and management

methods. The geologic feasibility study (Golder 2003a) and preliminary safety assessment (Quintessa, 2003) assessed the suitability of the geology and the potential effects in the long term, respectively. The activities associated with each phase of the DGR and the likely potential effects are described in further detail below.

#### **4.1 SITE PREPARATION AND CONSTRUCTION**

Site preparation and construction of the DGR would begin upon receipt of site preparation and construction licence(s) from the CNSC, and would end approximately six years later when commissioning of the DGR is complete.

##### **4.1.1 Site Preparation and Construction Activities**

Site preparation activities include the clearing of the site and development of the road network needed to provide access to the areas where construction activities will take place. The major activity during construction is the development of the underground accesses, including the main shaft or access ramp, and the ventilation shaft. Underground access tunnels would also be excavated, along with an initial set of emplacement rooms. The underground excavation will result in extraction of rock, which will be stored in a temporary storage pile on the Bruce site.

During this phase it is also necessary to construct the surface buildings and complete the site works including clearing, grading, servicing, curbs, sidewalks and roadways and any landscaping. Procurement and installation of fixtures, furnishings and equipment for the operation of the facilities is followed up with the commissioning, start-up, and occupancy of the facilities.

##### **4.1.2 Likely Site Preparation and Construction Effects on the Environment**

Table 4-1 provides information on the project-environment interactions and ranks the degree of interaction for site preparation and construction phases of the DGR. This section documents the extent of the potential effects on the environment which are expected to be associated with these interactions.

The proposed DGR site is a previously disturbed industrial site. During the site preparation and construction phase of the proposed DGR, environmental effects are expected to be similar to those typically associated with a construction site, such as dust, surface runoff, vehicle traffic and exhaust, and noise. OPG has experience in managing these types of effects based on its



recent construction projects, such as the LLSBs and UFDSF at the WWMF. The local community will experience social and economic effects associated with the increased labour force for the construction.

The implementation of an environmental management plan for the site preparation and construction activities is expected to minimize environmental effects associated with above-ground construction activities. The environmental management plan will be similar to that used in other recent construction projects at the WWMF and may include measures such as water spraying to control dust, vehicle maintenance standards to reduce noise and emissions, and scheduling of certain activities during daylight hours.

The shaft(s) and ramp, if used, would be constructed through rock layers which may be water bearing. Grouting would be used to seal the shaft or ramp, eliminating any interface between the repository and groundwater and preventing water inflow into the accessways, thereby minimizing the amount of discharge water to be managed at ground surface. OPG may draw on experience from the mining industry in sealing the shaft or ramp.

Underground extraction of rock will result in a temporary rock stockpile, consisting largely of limestone rock. The runoff from the stockpile is expected to be saline and will be collected, along with any effluent resulting from the underground drilling and extraction activities and, if necessary, treated before discharge. The discharge of treated water could ultimately make its way to Lake Huron, but would not have an impact because, if contaminated, it would be treated prior to discharge.

Site preparation and construction activities would not involve radioactive materials. The occupational health and safety considerations associated with this phase are typical of underground excavation and construction projects, such as falls, impact injuries, and strains, and would be managed through application of safety procedures and systems similar to those already in place at the WWMF and described in Appendix D. Experience in the mining industry would be drawn on to assist in developing additional safety procedures.

The construction work force is not expected to be large enough to have a significant effect on municipal services.

## **4.2 OPERATION**

The operation phase is the time period during which waste is emplaced in the DGR. Operation would continue throughout the period of operation of OPG's generating stations, with a buffer period for activities associated with laying up the reactors and for repository monitoring.

### **4.2.1 Operational Activities**

This phase includes retrieving LLW and ILW from storage at the WWMF and transferring it to the emplacement rooms of the DGR, as well as receipt of newly produced waste for direct emplacement in the DGR. Retrieval activities would include inspection of waste containers, placing wastes in overpacks as necessary, shielding of ILW containers, if necessary, and documentation for transfer and emplacement. Transfer and emplacement of L&ILW would take place throughout the operational phase, except during the campaigns to construct additional emplacement rooms. As each emplacement room is filled to capacity, it would be sealed. The interim seal may consist of a concrete block wall. The seal is expected to remain in place, even after the repository is decommissioned, however if necessary the seal could be removed and the waste retrieved.

The Operational phase would also include several staged construction campaigns to prepare additional emplacement rooms. Maintenance of the equipment and facilities, including safety checks and inspections, would be carried out routinely throughout this phase.

Monitoring would be conducted throughout the operation of the facility, and could include emissions monitoring, environmental monitoring, monitoring waste container performance, and maintenance of the repository. Operation would include a period of monitoring after emplacement of the waste to confirm that the DGR was performing as expected. Most monitoring activities would end when approval to decommission the repository was received.

### **4.2.2 Likely Operational Effects on the Environment**

Table 4-2 provides information on the project-environment interactions and ranks the degree of interaction for the operation of the DGR. This section documents the extent of the potential effects on the environment which are expected to be associated with these interactions.

The activities and effects associated with the emplacement of L&ILW in the DGR during the operational phase are similar to those of the current operation of the WWMF, including potential air quality impacts from transfer vehicle emissions, surface water quality impacts from storm

runoff, spills, snow melt, and discharge water from underground, effects on worker occupational health and safety such as falls, impact injuries, and strains, the effects of radiation exposure to humans or non-human biota, and social and economic benefits to the local community. In addition, the effects described in section 4.1.2, such as dust emissions, noise, surface runoff, and worker health and safety effects, would be associated with the periodic construction campaigns to complete repository emplacement room excavations.

The construction methods used, including grouting of the shaft(s) or ramps, and the very low permeability of the Ordovician rock in which the DGR would be located, are expected to minimize the amount of water inflow into the repository during the operational phase. Water in the DGR, resulting from inflow, would be collected in a sump, pumped to surface and, if necessary, treated prior to discharge.

The HVAC system will be designed and operated to ensure that concentrations of potential contaminants in air are below acceptable limits throughout the accessible areas of the DGR as well as in the exhaust air from the DGR. Air contaminants and contaminant concentrations are expected to be similar to those experienced in the LLSBs, for example tritium and carbon-14 resulting from the decay of the waste. Emissions from vehicle exhaust, such as carbon dioxide, nitrogen oxides, and sulphur dioxide would be removed from the DGR through the ventilation system. Gases generated from the decomposition of the waste, such as methane and hydrogen, are not expected to be generated in sufficient quantity to have any impact on the surrounding rock and will be removed by the ventilation system during operation.

OPG has operated the WWMF since 1974. The safety performance of the facility has been excellent over the entire period. Operating experience achieved at the WWMF provides a high level of confidence that the DGR can be operated safely and without undue risk to workers, the public or the environment. During the period of the WWMF operation there have been no significant environmental spills or damages and no incidents related to public safety. To date the WWMF emissions have not exceeded any action levels. The dose to workers has consistently remained below CNSC limits and OPG targets. OPG has had no lost time accidents for the past 10 years at the WWMF. OPG plans to apply its current management systems, which have proved effective at the WWMF, to the proposed DGR to assist in managing and minimizing potential effects. These systems, which are described in more detail in Appendix C, include:

- Waste packaging and handling procedures designed to limit the maximum individual dose and collective dose to workers
- The Occupational Radiological Protection Program which provides guidelines and procedures to monitor and minimize occupation dose and reduce the potential for contamination
- Use of the "Zone" areas that define procedures and practices that are mandatory in order to move from one area to another
- the Loss Control System, which manages health and safety performance through identification of all tasks associated with each activity, and changing process and equipment or implementing barriers to minimize or eliminate potential losses
- the Environmental Management System, registered to ISO 1400, which identifies environmental aspects, potential environmental effects and programs to manage and minimize effects

Monitoring programs would continue to operate to identify any emissions from the repository operation, including:

- Occupational Dose Control which would include the wearing of external dosimetry badges for personnel involved in the operation of the DGR
- Routine surveys conducted at specified frequencies and locations to detect loose or removable contamination
- The Bruce Radiological Environmental Monitoring Program (REMP), designed to measure environmental radioactivity in the vicinity of the Bruce site. Data from the REMP is used to assess off-site public dose consequences resulting from the operation of the nuclear facilities at the Bruce site, including the WWMF. It will also monitor any emissions from the DGR.

OPG has demonstrated experience in safely managing radioactive waste at its WWMF. These safe work practices will be applied to the emplacement of waste in the DGR. Although OPG does not have experience in working in underground facilities, the hazards of working underground are known based on experience in the mining industry. Further, OPG will review international experience with respect to the operation of an underground radioactive waste management facility. This experience will be used in managing underground work in the DGR. Experience in the mining industry will also be reviewed to assist in developing evacuation procedures for the DGR.

As concluded by Golder (2004) no incremental impacts on air and surface water quality, or worker health and safety are expected to result from the operation of the DGR on the Bruce site. Over the course of the DGR operation, as the L&ILW currently stored at the surface facilities at the WWMF is transferred to the DGR, the environmental effects of OPG's waste management operation at the Bruce site is expected to decrease because the contaminant releases will be isolated and contained underground.

### **4.3 DECOMMISSIONING AND LONG-TERM PERFORMANCE**

The long-term conceptual plan is to decommission the facility and ultimately close the DGR. Under the CEEA additional environmental assessment work may be required for decommissioning. OPG would complete any necessary environmental assessment work and obtain a licence to decommission for this phase at a later date. The decommissioning concept includes the following activities.

#### **4.3.1 Decommissioning Activities**

The decommissioning phase activities include dismantling the equipment, sealing the repository and accessways and, decontaminating and demolishing the surface facilities. The decommissioning activities would be followed by a period of monitoring to demonstrate that the DGR is performing as expected.

In the longer term, the plan is to dismantle and permanently seal the borehole monitoring systems. Regulatory approval processes at that time may require implementation of continuing institutional controls to prevent the public from accessing the site for some period of time. Further monitoring could be required but at a reduced level. Any remaining facilities would ultimately be dismantled. All documents would be properly archived.

#### **4.3.2 Likely Decommissioning and Long-term Effects on the Environment**

Table 4-3 provides information on the project-environment interactions and ranks the degree of interaction for decommissioning and long-term performance of the DGR. This section documents the extent of the potential effects on the environment which are expected to be associated with these interactions.

The potential environmental effects associated with the decommissioning of the proposed DGR include economic effects associated with the loss of jobs, dust and noise resulting from the dismantling of the buildings. The potential environmental effects of the long-term performance

include the possible release of small quantities of radioactivity from the waste in the DGR. Additional environmental assessment work may be required to identify any potential effects associated with the decommissioning of the proposed DGR.

Information on the potential for long-term effects, based on regional information, is discussed below. This information provides the rationale for OPG's prediction that the long-term environmental effects will not be significant.

OPG contracted with several internationally recognised consultants in recent years to complete a number of studies about the technical feasibility of siting a long-term management facility at the Bruce site. Studies conducted included a geotechnical feasibility study (Golder, 2003a) and a preliminary safety assessment (Quintessa, 2003). The understanding of the potential environmental effects of the proposed DGR in the long-term, and the prediction that there will be no significant adverse effects on the environment resulting from the DGR during or following decommissioning, are based on the results of these studies..

As concluded in Golder (2003a), the Bruce site has a number of favourable properties that would serve to limit any adverse effects of the DGR project on the surrounding environment in the long term (Golder, 2003a). These include the following factors:

**Predictability of Rock Strata:** The sedimentary rock layers beneath the Bruce site occur in predictable near-horizontal, laterally continuous layers that extend for many 100s of kilometres. It is expected that large domains of rock mass unaffected by regional fracturing with near homogeneous rock properties exist beneath the Bruce site. This geologic setting and predictability will allow a more straight-forward understanding of the site and explanation of DGR performance.

**Geologic Stability:** The bedrock that will host the DGR is 450 million years old. These bedrock formations have endured mountain building events at their margins, deep sedimentary burial, uplift and erosion, earthquakes and multiple glaciations, and yet have maintained a simple and relatively undeformed stratigraphy that would be expected to remain in the future. Further, the site is located in an area of the stable cratonic core that is known to be seismically quiet.

**Permeability of Host Rock:** The Ordovician shales and underlying limestone that will enclose the repository possess extremely low permeabilities. These low permeabilities are expected to

create a diffusion dominated transport regime in which contaminant migration via groundwater is extremely slow. Most of the radionuclides in the L&ILW will decay to insignificant levels long before they would move any distance from the repository.

**Protection of Near-surface Freshwater Aquifer:** Near-surface fresh groundwater resources are drawn from overburden or shallow bedrock wells that extend to depths of approximately 100 m. These groundwater resources are isolated from the DGR by approximately 550 m of sedimentary bedrock. Within this horizontally layered sedimentary sequence, a 200 m thick low permeability “blanketing” shale horizon immediately above the proposed repository prevents vertical groundwater migration. These same sedimentary bedrock formations isolate the DGR from Lake Huron.

**Stagnant Deep Groundwater Flow System:** Within the Ordovician bedrock, high pore water concentrations (i.e., >100 g/L total dissolved solids), formation-distinct hydrogeochemical signatures suggesting an absence of cross formational groundwater flow, a laterally continuous and horizontally layered regional scale bedrock hydrostratigraphy, and extremely low rock mass permeabilities all provide evidence of a sluggish or stagnant groundwater flow system in which groundwater ages are expected to be older than 1 million years.

**Good Constructability and Flexibility of Host Rock:** Rock strength is expected to be similar to the same rock layers at Niagara (Queenston Shale) and at Darlington (Lindsay limestone) that have been shown to be suitable for standard mining technologies requiring only ground and roof support. The lateral extent of the limestone and shale is sufficient without the need to build or grout around major fractures. In addition, water inflow through the shafts can be managed using standard mining techniques, as has been demonstrated in other excavations within this sedimentary layer.

**Low Resources for Oil, Gas, Minerals, and Drinkable Water:** There are no indications of commercially viable oil, gas or rock salt resources in the vicinity of the Bruce site. The rock under the Bruce site does not contain useful metal ores or other mineral resources. The groundwaters in the vicinity of the DGR are too salty to be drinkable and the impermeable rock makes them unrecoverable.

Based on these favourable site characteristics, the effects of the DGR in the long-term, as predicted by the preliminary safety assessment (Quintessa, 2003,) are expected to be very small.

The approach used in the safety assessment followed best international practice in post-closure safety assessment. Two scenarios were considered:

**Reference Scenario** considers the gradual release of radionuclides from the repository due to natural processes such as dissolution. The subsequent migration and dispersion of radionuclides in the environment and the resulting potential exposure of humans to the radionuclides is considered.

**Human Intrusion Scenario** considers the possible inadvertent disruption of the wastes in the future. The scenario is representative of the type of disturbance that might be caused by future exploration activity resulting in the potential direct exposure of individuals to essentially undiluted waste materials.

The results of the analysis of the Reference Scenario indicate that for LLW the dose rates are extremely low, many orders of magnitude below natural background and International Commission on Radiological Protection (ICRP) dose constraint, and the peak dose would occur at approximately 65,000 years. This low dose rate is due to the effective confinement of the host rock.

The Human Intrusion Scenario considered a possible extraction of borehole samples that contain waste. The limited amount of waste that would be retrieved in this scenario means that the calculated dose rates for LLW is very low, well below the ICRP human intrusion threshold and the background dose rate.

The ability of the repository design to accept OPG's ILW was assessed qualitatively (Quintessa, 2003). Due to the very low permeability of the host rocks, the DGR concept is likely to meet the radiological protection criteria adopted for this study for a wide range of ILW. This is supported by the simple diffusion calculation for ILW which indicated very low I-129 concentration at the top of the deep shale layer. I-129 was identified as the key radionuclide because it has a very long half-life, and is mobile.

A more detailed description of the preliminary safety assessment is included in Appendix E.



<b>TABLE 4-1: POTENTIAL INTERACTIONS WITH THE ENVIRONMENT DURING SITE PREPARATION AND CONSTRUCTION</b>			
<b>ENVIRONMENTAL COMPONENT/SUB-COMPONENT</b>	<b>POTENTIAL INTERACTION</b>	<b>COMMENTS</b>	<b>DEGREE OF EFFECT</b>
<u>Atmospheric Environment</u> <ul style="list-style-type: none"> <li>• Emissions</li> <li>• Dust</li> <li>• Noise</li> </ul>	<ul style="list-style-type: none"> <li>• Vehicle exhaust</li> <li>• Emissions from fuel storage and filling</li> <li>• Dust from site preparation, construction laydown area, vehicle traffic and temporary rock stockpile</li> <li>• Noise from blasting and heavy equipment</li> </ul>	<ul style="list-style-type: none"> <li>• Vehicles will be properly maintained to minimize emissions</li> <li>• Volumes of fuel stored will be maintained at reasonable levels and staff will be properly trained in vehicle filling to minimize emissions</li> <li>• Dust will be localized on site</li> <li>• Noise will be intermittent and will be managed using construction best practices</li> </ul>	<ul style="list-style-type: none"> <li>• Weak</li> </ul>
<u>Aquatic Environment</u> <ul style="list-style-type: none"> <li>• Aquatic habitat</li> <li>• Aquatic biota</li> <li>• Sediment quality</li> <li>• Surface Water Quality</li> </ul>	<ul style="list-style-type: none"> <li>• Construction of railway ditch crossing</li> <li>• Surface runoff from roads, construction laydown area, waste rock and temporary rock stockpiles</li> <li>• Discharge from drilling and underground excavation operations</li> <li>• Spills, for example of fuels and lubricants</li> </ul>	<ul style="list-style-type: none"> <li>• The railway ditch is considered to be aquatic habitat; design of the crossing and timing of construction will minimize impacts on the railway ditch</li> <li>• Roads will be paved to reduce contribution of sediment in runoff</li> <li>• Runoff from waste and temporary rock stock piles, drilling and underground excavation, and laydown area will be managed to minimize contaminant discharge</li> <li>• Staff will be trained in fuels management and vehicle filling to minimize spills</li> </ul>	<ul style="list-style-type: none"> <li>• Moderate</li> </ul>
<u>Terrestrial Environment</u> <ul style="list-style-type: none"> <li>• Vegetation Communities</li> <li>• Wildlife Habitat</li> <li>• Wildlife Communities</li> <li>• Significant Species</li> <li>• Natural Heritage System</li> </ul>	<ul style="list-style-type: none"> <li>• Loss of vegetation, which may result in some loss of wildlife habitat</li> </ul>	<ul style="list-style-type: none"> <li>• Loss of up to approximately 15 hectares of vegetation, would have minimal effect on wildlife habitat; trees could be offset by planting elsewhere</li> <li>• Proposed site is on an existing industrial site and has been previously disturbed</li> </ul>	<ul style="list-style-type: none"> <li>• Weak</li> </ul>
<u>Subsurface Environment</u> <ul style="list-style-type: none"> <li>• Geology</li> <li>• Hydrogeology</li> <li>• Groundwater Quality</li> <li>• Seismic</li> </ul>	<ul style="list-style-type: none"> <li>• Construction of DGR access (shafts or ramp) may affect groundwater flow patterns</li> <li>• Spills, for example of fuel , may impact groundwater quality</li> <li>• Extraction of large quantities of borrow material and aggregate</li> </ul>	<ul style="list-style-type: none"> <li>• DGR access host rock will be grouted to minimize groundwater inflow into the DGR openings</li> <li>• Staff will be trained in fuels management and vehicle filling to minimize spills</li> <li>• Stockpiles of aggregate and borrow material will be maintained separately; aggregate-quality material may be sold for future use</li> </ul>	<ul style="list-style-type: none"> <li>• Moderate</li> </ul>

<b>TABLE 4-1: POTENTIAL INTERACTIONS WITH THE ENVIRONMENT DURING SITE PREPARATION AND CONSTRUCTION</b>			
<b>ENVIRONMENTAL COMPONENT/SUB-COMPONENT</b>	<b>POTENTIAL INTERACTION</b>	<b>COMMENTS</b>	<b>DEGREE OF EFFECT</b>
<u>Radiation and Radioactivity</u> <ul style="list-style-type: none"> <li>• Radiation dose to the public</li> <li>• Radiation dose to workers</li> <li>• Radiation dose to aquatic and terrestrial biota</li> </ul>	<ul style="list-style-type: none"> <li>• None</li> </ul>	<ul style="list-style-type: none"> <li>• The Construction Phase would not result in any radioactive emissions as it will involve only non-radioactive materials.</li> </ul>	<ul style="list-style-type: none"> <li>• Weak</li> </ul>
<u>Aboriginal Interests</u> <ul style="list-style-type: none"> <li>• Treaty Rights/Land Claims</li> <li>• Current/Traditional Land Use</li> <li>• Employment</li> <li>• Economic/Business Opportunities</li> <li>• Cultural sites/Activities</li> </ul>	<ul style="list-style-type: none"> <li>• Employment and business opportunities</li> <li>• Effects on future traditional land uses or cultural activities</li> <li>• Effects on fishing</li> </ul>	<ul style="list-style-type: none"> <li>• Employment and business opportunities may result but magnitude would be relatively small and effect is positive</li> <li>• Previous studies indicate that there are no additional burial grounds on site</li> <li>• Effects are not expected to extend off the Bruce site and would have little effect on traditional land uses or cultural activities</li> </ul>	<ul style="list-style-type: none"> <li>• Weak</li> </ul>
<u>Land Use and Visual Setting</u> <ul style="list-style-type: none"> <li>• Land Use</li> <li>• Transportation on and off the WWMF</li> <li>• Landscape and visual setting</li> </ul>	<ul style="list-style-type: none"> <li>• Increased vehicle traffic on- and off-site</li> <li>• Negative impact on visual setting and vistas</li> <li>• Conflict with adjacent land uses</li> </ul>	<ul style="list-style-type: none"> <li>• Vehicle movement on-site will be largely on areas of site which are discrete from ongoing generating station and waste site activities</li> <li>• Construction force is not large so increase in off-site vehicle traffic volumes will be minimal</li> <li>• If necessary trees would be planted to screen views of the rock pile</li> <li>• The proposed DGR is on an existing industrial site and surrounding land is zoned either agricultural or industrial</li> </ul>	<ul style="list-style-type: none"> <li>• Weak</li> </ul>
<u>Social and Economic Conditions</u> <ul style="list-style-type: none"> <li>• Population</li> <li>• Housing and property values</li> <li>• Employment</li> <li>• Business activity, agriculture and tourism</li> <li>• Municipal infrastructure and services</li> <li>• Municipal finance</li> <li>• Community character</li> <li>• Community satisfaction</li> </ul>	<ul style="list-style-type: none"> <li>• Employment opportunities</li> <li>• Changes in local economy</li> </ul>	<ul style="list-style-type: none"> <li>• Impacts on social and economic conditions are expected to be positive, with increased employment opportunities</li> <li>• Work forces are not large and would not strain housing resources or municipal services</li> </ul>	<ul style="list-style-type: none"> <li>• Weak</li> </ul>
<u>Physical and Cultural Heritage</u> <ul style="list-style-type: none"> <li>• Prehistoric Heritage Resources</li> <li>• Historic Heritage Resources</li> <li>• Cultural Landscape Heritage Resources</li> </ul>	<ul style="list-style-type: none"> <li>• Site may contain physical and/or heritage resources</li> </ul>	<ul style="list-style-type: none"> <li>• Site is already disturbed from previous construction activity</li> <li>• Archaeological assessment will be conducted prior to site preparation</li> </ul>	<ul style="list-style-type: none"> <li>• Weak</li> </ul>

TABLE 4-2: POTENTIAL INTERACTIONS WITH THE ENVIRONMENT DURING OPERATION			
ENVIRONMENTAL COMPONENT/SUB-COMPONENT	POTENTIAL INTERACTION	COMMENTS	DEGREE OF EFFECT
<u>Atmospheric Environment</u> <ul style="list-style-type: none"> <li>Emissions</li> <li>Dust</li> <li>Noise</li> </ul>	<ul style="list-style-type: none"> <li>Vehicle exhaust</li> <li>Dust from vehicle traffic and rock stockpile</li> <li>Noise from waste processing</li> <li>Exhaust from repository</li> </ul>	<ul style="list-style-type: none"> <li>Vehicles used on surface will be maintained to minimized emissions</li> <li>Vehicles used in waste transfer could be electric powered to eliminate emissions</li> <li>Roads will be paved to minimize dust</li> <li>No increase in noise levels associated with waste processing</li> <li>Repository exhaust will be managed at the vent shaft (air) and monitored to confirm contaminant levels are negligible</li> </ul>	Weak
<u>Aquatic Environment</u> <ul style="list-style-type: none"> <li>Aquatic Habitat</li> <li>Aquatic Biota</li> <li>Sediment Quality</li> <li>Storm Water Quality</li> </ul>	<ul style="list-style-type: none"> <li>Use of railway ditch crossing</li> <li>Surface runoff from roads, rock stockpile</li> <li>Discharge of water collected in repository sumps</li> <li>Spills of fuel and lubricants</li> </ul>	<ul style="list-style-type: none"> <li>The railway ditch is considered to be aquatic habitat; the crossing would be maintained to minimize interference with habitat</li> <li>Roads will be paved to reduce contribution of sediment in runoff</li> <li>Runoff from stock pile will be managed to minimize contaminant discharge</li> <li>Repository discharge will be monitored and, if necessary treated, before discharge. Volume is expected to be small</li> <li>Vehicles used in waste transport at surface will be maintained to prevent fuel and oil leaks and staff will be trained to minimize fuel spills</li> </ul>	Weak
<u>Terrestrial Environment</u> <ul style="list-style-type: none"> <li>Vegetation Communities</li> <li>Wildlife Habitat</li> <li>Wildlife Communities</li> <li>Significant Species</li> <li>Natural Heritage System</li> </ul>	<ul style="list-style-type: none"> <li>No interaction expected</li> </ul>	<ul style="list-style-type: none"> <li>The footprint of the surface buildings and waste rock pile will be small relative to the Bruce site area</li> <li>The forest on the proposed site is largely immature mixed forest</li> <li>The majority of the operating facility is underground</li> </ul>	Weak

TABLE 4-2: POTENTIAL INTERACTIONS WITH THE ENVIRONMENT DURING OPERATION			
ENVIRONMENTAL COMPONENT/SUB-COMPONENT	POTENTIAL INTERACTION	COMMENTS	DEGREE OF EFFECT
<u>Subsurface Environment</u> <ul style="list-style-type: none"> <li>• Geology</li> <li>• Hydrogeology</li> <li>• Groundwater Quality</li> <li>• Seismicity</li> </ul>	<ul style="list-style-type: none"> <li>• DGR access (shafts or ramp) may affect groundwater flow patterns</li> <li>• Release of contaminants into potable groundwater and/or to Lake Huron</li> <li>• Seismic activity results in instability of underground openings</li> </ul>	<ul style="list-style-type: none"> <li>• DGR shaft and ramp will be lined and sealed, where necessary to minimize groundwater seepage and hydraulic influence on groundwater flow patterns</li> <li>• The wastes will remain in a dry state without leachate generation</li> <li>• The repository will act as a groundwater "sink" preventing outward contaminant migration</li> <li>• Within the thick bedrock formations enclosing the repository contaminant migration is diffusion dominated</li> <li>• The horizontally layered hydrostratigraphy of deep groundwater flow system provides natural barrier to vertical contaminant migration isolating ground- and surface-water resources</li> <li>• Natural groundwater quality at the repository horizon is not potable</li> <li>• Repository is situated in a seismically quiescent geologic setting</li> </ul>	Weak
<u>Radiological Environment</u> <ul style="list-style-type: none"> <li>• Radiation dose to the public</li> <li>• Radiation dose to workers</li> <li>• Radiation dose to aquatic and terrestrial biota</li> </ul>	<ul style="list-style-type: none"> <li>• External radiation field</li> <li>• Airborne and liquid emissions</li> <li>• Radioactive contamination of potable groundwater or Lake Huron</li> </ul>	<ul style="list-style-type: none"> <li>• Emissions will be small and will be monitored and, if necessary, controlled</li> <li>• Waste will be transported in containers with appropriate shielding where necessary</li> <li>• Environmental monitoring programs will be in place</li> <li>• OPG has an excellent record in worker and environmental health and safety management</li> <li>• As waste is moved to the DGR there would be less potential for dose to the public</li> </ul>	Weak
<u>Aboriginal Interests</u> <ul style="list-style-type: none"> <li>• Treaty rights/land claims</li> <li>• Current/traditional land use</li> <li>• Employment</li> <li>• Economic/Business Opportunities</li> <li>• Cultural sites/Activities</li> </ul>	<ul style="list-style-type: none"> <li>• Employment and business opportunities</li> <li>• Effects on future traditional land uses or cultural activities</li> <li>• Effects on fishing</li> </ul>	<ul style="list-style-type: none"> <li>• Employment and business opportunities may result but magnitude would be relatively small and effect is positive</li> <li>• Effects are not expected to extend off the Bruce site and would have little effect on traditional land uses or cultural activities</li> </ul>	Weak

TABLE 4-2: POTENTIAL INTERACTIONS WITH THE ENVIRONMENT DURING OPERATION			
ENVIRONMENTAL COMPONENT/SUB-COMPONENT	POTENTIAL INTERACTION	COMMENTS	DEGREE OF EFFECT
<u>Land Use and Visual Issues</u> <ul style="list-style-type: none"> <li>Land Use</li> <li>Transportation on and off the WWMF</li> <li>Landscape and visual setting</li> </ul>	<ul style="list-style-type: none"> <li>Increased vehicle traffic on-site</li> <li>Negative impact on visual setting and vistas</li> <li>Conflict with adjacent land uses</li> </ul>	<ul style="list-style-type: none"> <li>Vehicle movement on-site will be largely on areas of site which are discrete from ongoing generating station and waste site activities</li> <li>Traffic volumes associated with operation will be limited to a small increase in the work force</li> <li>Trees would be planted to screen the rock pile, if necessary</li> <li>The buildings associated with the DGR are not expected to be visible from off-site</li> <li>The proposed DGR is on an existing industrial site and surrounding land is zoned either agricultural or industrial</li> </ul>	Weak
<u>Social and Economic Conditions</u> <ul style="list-style-type: none"> <li>Population</li> <li>Housing and property values</li> <li>employment</li> <li>Business activity, agriculture and tourism</li> <li>Municipal infrastructure and services</li> <li>Municipal finance</li> <li>Community character</li> <li>Community satisfaction</li> </ul>	<ul style="list-style-type: none"> <li>Employment opportunities</li> <li>Changes in local economy</li> <li>Potential aggregate availability for local market</li> <li>Changes in property value</li> <li>Decline in tourism</li> </ul>	<ul style="list-style-type: none"> <li>Impacts on social and economic conditions are expected to be positive, with increased employment opportunities, and increased municipal tax revenue from new facilities</li> <li>Business tourism related to the proposed DGR may increase; recreational tourism is not expected to change as much of the waste is at the WWMF now</li> <li>Increase in work force will not be large and will not strain housing resources or municipal services</li> <li>Community is satisfied with existing waste management operations</li> <li>Property values are not expected to decline and the Hosting Agreement includes a property value protection clause</li> </ul>	Moderate
<u>Physical and Cultural Heritage</u> <ul style="list-style-type: none"> <li>Prehistoric heritage resources</li> <li>Historic heritage resources</li> <li>Cultural Landscape Heritage Resources</li> </ul>	<ul style="list-style-type: none"> <li>No interaction expected</li> </ul>	<ul style="list-style-type: none"> <li>Site is already disturbed from previous construction activity</li> </ul>	Weak

<b>TABLE 4-3: POTENTIAL INTERACTIONS WITH THE ENVIRONMENT DURING DECOMMISSIONING AND IN THE LONG TERM</b>			
<b>ENVIRONMENTAL COMPONENT/SUB-COMPONENT</b>	<b>POTENTIAL INTERACTION</b>	<b>COMMENTS</b>	<b>DEGREE OF EFFECT</b>
<u>Atmospheric Environment</u> <ul style="list-style-type: none"> <li>Emissions</li> <li>Dust</li> <li>Noise</li> </ul>	<ul style="list-style-type: none"> <li>Dust and noise from demolition of surface facilities and installation of access seal</li> <li>Vehicle emissions</li> </ul>	<ul style="list-style-type: none"> <li>Vehicles used on surface will be maintained to minimize emissions</li> <li>Roads will be paved to minimize dust</li> </ul>	<ul style="list-style-type: none"> <li>Weak</li> </ul>
<u>Surface Water Environment</u> <ul style="list-style-type: none"> <li>Aquatic Habitat</li> <li>Aquatic Biota</li> <li>Sediment Quality</li> <li>Storm Water Quality</li> </ul>	<ul style="list-style-type: none"> <li>Surface runoff from site</li> </ul>	<ul style="list-style-type: none"> <li>The site will be landscaped to minimize runoff</li> </ul>	<ul style="list-style-type: none"> <li>Weak</li> </ul>
<u>Terrestrial Environment</u> <ul style="list-style-type: none"> <li>Vegetation Communities</li> <li>Wildlife Habitat</li> <li>Wildlife Communities</li> <li>Significant Species</li> <li>Natural Heritage System</li> </ul>	<ul style="list-style-type: none"> <li>Landscaping</li> </ul>	<ul style="list-style-type: none"> <li>Surface facilities will be dismantled and area landscaped</li> <li>Landscaping may result in increased land areas suitable for habitat and vegetation communities</li> </ul>	<ul style="list-style-type: none"> <li>Weak</li> </ul>
<u>Subsurface Environment</u> <ul style="list-style-type: none"> <li>Geology</li> <li>Hydrogeology</li> <li>Groundwater Quality</li> <li>Seismicity</li> </ul>	<ul style="list-style-type: none"> <li>DGR access (shafts or ramp) may affect groundwater flow patterns</li> <li>Release of contaminants into groundwater and/or to Lake Huron due to: <ul style="list-style-type: none"> <li>Faults in the rock</li> <li>Normal evolution of the repository</li> <li>Seismic activity</li> <li>Gas generation from wastes causes fracturing of the rock</li> <li>Change in local groundwater chemistry leads to dissolution of sedimentary rock</li> <li>Failure of engineered seals</li> <li>Collapse of engineered openings</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>DGR access shafts/ramps will be sealed, where necessary ,to mitigate contaminant migration</li> <li>The bedrock formations enclosing the DGR have remained stable and unperturbed by geologic events of 100s of millions of years</li> <li>The predictable horizontal layering of the bedrock formations coupled with the deep groundwater flow system hydrostratigraphy isolates near-surface ground- and surface-water resources</li> <li>Geoscientific evidence indicates that the groundwater flow system enclosing the DGR is diffusion dominated</li> <li>Natural groundwater quality at the repository horizon is not potable</li> <li>Repository is situated in a seismically quiescent geologic setting</li> <li>Stagnant groundwater limits extent of dissolution</li> <li>Experience in natural gas resources shows that gases can be safely stored in similar rock formations</li> </ul>	<ul style="list-style-type: none"> <li>Moderate</li> </ul>

<b>TABLE 4-3: POTENTIAL INTERACTIONS WITH THE ENVIRONMENT DURING DECOMMISSIONING AND IN THE LONG TERM</b>			
<b>ENVIRONMENTAL COMPONENT/SUB-COMPONENT</b>	<b>POTENTIAL INTERACTION</b>	<b>COMMENTS</b>	<b>DEGREE OF EFFECT</b>
<u>Radiological Environment</u> <ul style="list-style-type: none"> <li>• Radiation dose to the public</li> <li>• Radiation dose to aquatic and terrestrial biota</li> </ul>	<ul style="list-style-type: none"> <li>• External radiation field</li> <li>• Airborne and liquid emissions</li> <li>• Radioactive contamination of potable groundwater or Lake Huron</li> </ul>	<ul style="list-style-type: none"> <li>• Emissions will be negligible</li> <li>• Migration is diffusion dominated and groundwater movement is on the order of 1 mm per year</li> <li>• Radionuclides will decay before release</li> <li>• Preliminary safety studies indicate there will be no measurable impacts</li> </ul>	<ul style="list-style-type: none"> <li>• Weak</li> </ul>
<u>Aboriginal Interests</u> <ul style="list-style-type: none"> <li>• Treaty rights/land claims</li> <li>• Current/traditional land use</li> <li>• Employment</li> <li>• Economic/Business Opportunities</li> <li>• Cultural sites/Activities</li> </ul>	<ul style="list-style-type: none"> <li>• Employment and business opportunities</li> <li>• Perception of risk to future generations and effects on future traditional land uses or cultural activities</li> <li>• Effects on fishing</li> </ul>	<ul style="list-style-type: none"> <li>• Loss of employment and business opportunities would be very small</li> <li>• Effects are not expected to extend off the Bruce site and would have minimal effect on traditional land uses or cultural activities</li> </ul>	<ul style="list-style-type: none"> <li>• Weak</li> </ul>
<u>Land Use and Visual Issues</u> <ul style="list-style-type: none"> <li>• Land Use</li> <li>• Transportation on and off the WWMF</li> <li>• Landscape and visual setting</li> </ul>	<ul style="list-style-type: none"> <li>• No interaction expected</li> </ul>	<ul style="list-style-type: none"> <li>• Site will be returned to brown field status</li> </ul>	<ul style="list-style-type: none"> <li>• Weak</li> </ul>
<u>Social and Economic Conditions</u> <ul style="list-style-type: none"> <li>• Population</li> <li>• Housing and property values</li> <li>• employment</li> <li>• Business activity, agriculture and tourism</li> <li>• Municipal infrastructure and services</li> <li>• Municipal finance</li> <li>• Community character</li> <li>• Community satisfaction</li> </ul>	<ul style="list-style-type: none"> <li>• Employment opportunities</li> <li>• Changes in local economy</li> <li>• Decline in recreational tourism</li> </ul>	<ul style="list-style-type: none"> <li>• Closure of the facility will result in loss of employment associated with the DGR; decline is expected to be gradual following the completion of the operations phase. Number of employees is relatively small</li> <li>• Much of the waste is safely managed at the WWMF and the DGR will provide a greater margin of safety</li> </ul>	<ul style="list-style-type: none"> <li>• Weak</li> </ul>
<u>Physical and Cultural Heritage</u> <ul style="list-style-type: none"> <li>• Prehistoric heritage resources</li> <li>• Historic heritage resources</li> <li>• Cultural Landscape Heritage Resources</li> </ul>	<ul style="list-style-type: none"> <li>• No interaction expected</li> </ul>	<ul style="list-style-type: none"> <li>• Site will be landscaped with cultural and heritage aspects maintained</li> </ul>	<ul style="list-style-type: none"> <li>• Weak</li> </ul>

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## 5.0 Community and Stakeholder Consultation and Communications

Throughout the development of the DGR project, OPG and the Municipality of Kincardine conducted extensive communication and consultation with both government and community stakeholders. The benefits of a volunteer host municipality and a supportive community are self-evident. A major goal of the communication and consultation was to ensure that the community was fully informed about the DGR and to formally gauge the level of community support before proceeding with the project. Communications and consultation activities began in May 2003 and are on-going. The nature and results of the communications and consultation activities to date are provided in this section of the report.

The outreach area for the communications activities, as shown on Figure 5-1, includes the host Municipality of Kincardine, as well as the neighbouring four municipalities of Saugeen Shores, Arran-Elderslie, Brockton and Huron-Kinloss. Discussions were also held with the local First Nations and are continuing.

The key results of the communications activities in terms of assessing the level of community concern about the proposed DGR facility include:

- turnout at Open Houses and the Community Consultation Centre, in the Municipality of Kincardine and in the surrounding communities, was not significantly higher than turnout for any other project in the Municipality such as Bruce Power's Bruce A Units 3 and 4 Return to Service and OPG's proposed Refurbishment Waste Storage project
- The results of Public Attitude Research indicate that there is a very high level of satisfaction in the community with the current waste management operation at the Bruce site and that a large number of local residents feel a long-term waste management facility would have no effect on their level of satisfaction with the community
- The telephone poll resulted in a relatively high response rate for a community poll and the results of the poll indicate that the majority of those who responded support the establishment of a long-term waste management facility at the WWMF. Of those who did not indicate support, approximately a third was neutral.

- OPG has received a small number of queries/comments through its electronic comment form and fewer telephone contacts. Many of these contacts were requests for additional information.

The nature and extent of the communications and consultation carried out prior to the environmental assessment are indicative of the scope of OPG's proposed activities throughout the conduct of the EA studies. OPG's proposed Communications and Consultation Plan for the environmental assessment is provided as Appendix F.

## **5.1 INDEPENDENT ASSESSMENT STUDY COMMUNICATIONS**

Golder Associates was engaged in 2003, on behalf of the Municipality of Kincardine and OPG, to conduct the Independent Assessment Study (IAS), and to develop and implement a community consultation and communications program as a part of the IAS. The communications included stakeholder briefings, open houses, newsletters, public attitude research, web site, advertising in local newspapers, and presentations at meetings.

### **5.1.1 Stakeholder Briefings**

Key stakeholders included government agencies, local political representatives, community leaders and labour unions. The two local First Nations were also engaged in discussions. The briefings were conducted at three key milestones as outlined below.

- **Initiation of the Independent Assessment Study**

The first stakeholder briefings were conducted jointly by OPG and Municipal officials early in 2003 to introduce the IAS goals and schedule. In general, the feedback from these meetings was appreciation for the overview and a request to be kept informed as the study proceeded

- **Completion of the Independent Assessment Study**

The second set of stakeholder meetings were held in February/March 2004, following completion of the IAS and release of the IAS Report. The responses ranged from appreciation for the information to support for continuing efforts to confirm the acceptability of a facility for the long-term management of L&ILW at the WWMF.

- **Completion of the Community Consultation in Kincardine**

The third set of stakeholder briefings was in February, 2005, immediately before the Municipality of Kincardine announced the results of the poll of residents (see Section

5.2.1). The purpose of this round of briefings was to advise stakeholders of the pending announcement of the outcome of the poll.

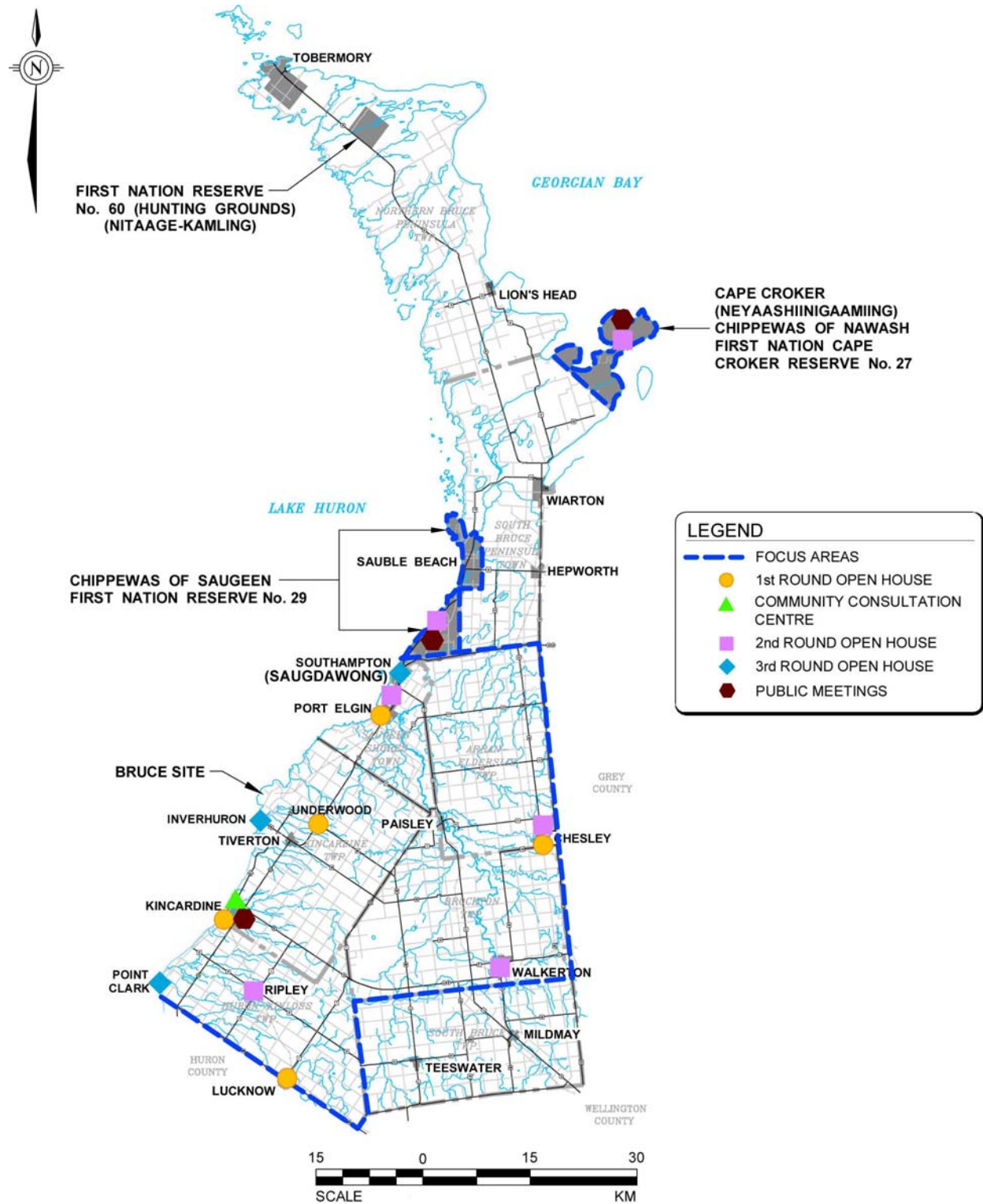
### **5.1.2 Open Houses**

Initially, five open houses were held in Kincardine and in the municipalities in the surrounding area in June, 2003 (see Figure 5-1 for locations). Each Open House was advertised in local newspapers, and post card invitations were mailed to homes in Kincardine and available in Municipal Offices. Letters introducing the IAS and inviting recipients to attend the Open Houses were also sent to a list of identified stakeholders.

Approximately 77 individuals attended the first round of Open Houses and 37 completed comment sheets were returned. The vast majority of visitors wanted to obtain information about the IAS, ask questions about the long-term management options for L&ILW, and learn how they or their community might be affected. Comments and feedback included concerns about health, safety and environmental issues, risks to ground water, flooding, location of aquifers relative to the depth of a deep geologic repository, and questions about the amount of radioactivity associated with low and intermediate level waste. Questions were raised about the cost of a facility and employment opportunities that may result from the construction and operation of a facility.

A second round of open houses, held in April/May 2005 in each of the four surrounding municipalities, including Port Elgin, Walkerton, Chesley and Ripley, was attended by 81 visitors. The majority of visitors left with more information and a greater level of comfort about the DGR. Following each open house, a copy of the display panels, in booklet format, was delivered by Canada Post to each residence, year-round and seasonal, in each municipality.

A number of property owners in the Municipality of Kincardine and adjacent municipalities are seasonal residents who use their properties primarily during the summer months. Open houses were held in three cottage communities, Point Clark, Southampton and Inverhuron, in July 2005 (see Figure 5-1). The open house at Inverhuron was attended by 36 visitors. Eight people attended at Point Clark and there were 18 visitors at Southampton. Visitors to the Open Houses expressed an interest in potential effects of the DGR on water quality in Lake Huron.



**FIGURE 5-1: OUTREACH AREA FOR COMMUNITY AND STAKEHOLDER COMMUNICATIONS AND CONSULTATION**

### **5.1.3 Public Attitude Research**

As a part of the Independent Assessment Study, public attitude research was undertaken to examine the potential for effects of OPG's plans for long-term management of L&ILW at the WWMF on public attitudes and behaviours and various attributes of the local community. The research was undertaken using a telephone survey among adult residents. Seven hundred and fifty one interviews were completed in June 2003. Additional interviews were conducted with tourists in July 2003.

The results of the survey (Intellipulse, 2003) indicated that the current level of satisfaction with the existing WWMF is about 91 per cent; only 4 per cent of respondents were negative. Approximately 75 per cent of respondents believe that a long-term waste management facility would not have any effect on their satisfaction with their community. The 17 per cent of respondents who believed that a facility may have an effect, felt that the DGR would have the greatest overall effect. However, over half the respondents felt the effect would be positive.

The tourist survey showed that the WWMF is not a "thing or image" that first comes to mind when thinking about the area. Interviews also indicated that the existing WWMF is not seen as a negative influence on tourism because it is isolated and not visible from the major population centres or from most beaches frequented by tourists. Moreover, about 80 per cent of tourists interviewed indicated that implementing long-term waste management would have no effect on their tourism experience.

### **5.1.4 Independent Assessment Study Web Site**

As part of the IAS, Golder developed and maintained a web site. This included information on the existing waste management operations at the WWMF and internationally, the objectives of the IAS, the long-term management options being considered, responses to frequently asked questions, and the panels and information from the open houses. Copies of printed materials were also posted on the web site as they became available, including copies of newsletters, the independent social and economic analysis study, the results of the public attitude research study and the IAS report.

### **5.1.5 Newsletters**

Two newsletters were produced in association with the IAS and distributed by Canada Post to approximately 22,000 businesses and residents in the outreach area. Copies were also available at municipal offices and libraries in the focus area.

The first newsletter was distributed in May 2003. It included an overview of the Memorandum of Understanding between the Municipality and OPG, a summary of the long-term management options, a description of the process leading to the selection of the preferred option, and the times and locations of the upcoming open houses.

A second newsletter was distributed in March 2004 at the completion of the IAS. It included information on the results of the public attitude research completed as a part of the IAS, and on the economic benefits associated with the long-term management options, the next steps in the process, and how the public could provide feedback on the IAS report.

## **5.2 PRE-POLLING COMMUNICATION AND CONSULTATION**

Kincardine Municipal Council endorsed the siting of the DGR located adjacent to the existing WWMF at the Bruce site as the preferred approach for long-term management of L&ILW and sought residents' opinion on the DGR through a telephone poll.

Leading up to the poll, a community education/information plan was put in place to provide all residents an opportunity to obtain information about the DGR. Public consultation and communications efforts focused primarily on the residents of the Municipality of Kincardine. A brief summary of the specific communications activities is provided below.

### **5.2.1 Community Consultation Centre**

The Municipality of Kincardine and OPG jointly opened a Community Consultation Centre located on the main street of Kincardine. In total, 312 individuals took the opportunity to attend the Consultation Centre and discuss the proposal with representatives of OPG and the Municipality. The Community Consultation Centre served as a readily accessible location where residents could obtain information on the DGR, the benefits to Kincardine, and the process for expressing their views.

### **5.2.2 Community Presentations**

Presentations were made to community groups on the DGR. These included presentations to the Kincardine Rotary Club, Brucedale Institute, Chamber of Commerce, Ontario Hydro Retirees' Association, and Kincardine Area Seniors Action and Advisory Committee.

An "Experts Day" was held in December 2004 involving a geoscience expert, an environmental assessment expert, a safety assessment expert and local residents for open discussion about any issues related to the DGR.

### **5.2.3 Fact Sheets in the Media**

During the community consultation, OPG and Kincardine placed a number of fact sheets in the local newspapers, providing experts' views of their particular speciality as well as Invitations to attend the Community Consultation Centre to obtain information about the DGR, as follows:

- We're Working Together for the Future of the Community
- Long-Term Solution: John Davis, Golder Associates
- Getting Your Views: Dr. Duncan Moffett, Golder Associates
- A Geoscientist's Perspective on the DGR Proposal: Mark Jensen, OPG
- Letter from Kincardine Mayor Glenn Sutton on the DGR Proposal
- On the Preliminary Safety Assessment for the DGR Proposal: Richard Little, Quintessa
- Myths and Facts about the DGR
- A Public Health Perspective on the DGR Proposal: Dr. Hazel Lynn, Medical Officer of Health for Grey-Bruce

Each of the Fact Sheets appeared in the Kincardine newspapers. Some of the Fact Sheets were also published in the neighbouring Saugeen Shores Beacon-Times which is largely distributed outside the boundaries of the Municipality of Kincardine.

### **5.2.4 Distribution of Printed Material**

Shortly after the opening of the Community Consultation Centre, OPG and Kincardine jointly issued a newsletter specifically on the DGR proposal. The newsletter was distributed by Canada Post to all residences in the Municipality of Kincardine.

In December 2004, a pamphlet on the DGR was delivered by Canada Post to each residence in the Municipality of Kincardine. This pamphlet included background information on radioactive waste, the existing WWMF, the Memorandum of Understanding, the IAS, the proposed DGR, the Hosting Agreement, the regulatory approvals process and the community consultation process.

### **5.2.5 OPG Web Page**

During the community consultation, OPG launched a web page ( [www.opg.com/dgr](http://www.opg.com/dgr) ) relating to the DGR on the existing corporate OPG web site. This web page included information

associated with the IAS (which was on the Golder Web Page, see Section 5.1.4), as well as more detailed background information used in the IAS. The detailed information included the safety assessment study, the geotechnical feasibility study, newsletters, panels displayed at the Community Consultation Centre, and the IAS report. It also included an electronic comment form which could be used to request specific information about the DGR.

Approximately 75 questions about the proposal were received electronically, mostly from the local community. A handful of the electronic communications were “form letters” which were the result of a local resident sending a note to young people who were away at university and asking them to forward an email to OPG to express their opposition to the DGR. There were also questions and requests for information from international visitors to the web page, including inquiries from Korea, United States, Finland and Sweden. The U.S. visitors to the web site included Michigan residents and representatives of Michigan government agencies. OPG responded individually to each party who asked a question or submitted a comment.

### **5.3 COMMUNITY DECISION**

The Hosting Agreement includes a requirement that the Municipality of Kincardine conduct community consultation on the DGR. A formal polling of the community was a prerequisite to the final decision to host a long-term management facility for L&ILW in the Municipality. Council decided upon a telephone poll of all residents eighteen years of age or older.

The question residents were asked was:

***Do you support the establishment of a facility for the long-term management of low and intermediate level waste at the Western Waste Management Facility?***

In addition to providing an affirmative or negative response, residents were allowed to identify their response as being neutral.

The telephone poll was conducted in January 2005 by an independent polling firm and the results audited by a second firm. Each household was contacted up to ten times. After five or six unanswered calls a message was left, if possible, providing a 1-866 number which residents could call to participate in the poll. Households where at least one person had participated in poll by the end of the telephone consultation period were considered complete. Those households which could not be contacted by telephone after 10 attempts were mailed a package and invited to participate by mail. For those with unlisted telephone numbers or who



did not have access to a telephone, an advertisement was placed in the newspaper providing the 1-866 number they could call to participate. Seasonal residents were mailed a copy of the question and also asked to respond by mail.

### **5.3.1 Poll Results**

Of the 5,257 eligible households indicated in the 2001 Statistics Canada Census, 3763 households participated in the poll, representing 6778 individual votes or 72 per cent of eligible participants.

The results of the vote were:

Yes	60%
No	22%
Neutral	13%
Don't Know/Refused	5%

The Kincardine Municipal Council accepted the poll results as an indication of sufficient support to move forward with the Hosting Agreement.

An independent, limited process audit of the telephone poll was conducted by a third party auditor, BDO Dunwoody, for the Municipality of Kincardine. The audit was conducted in accordance with Canadian generally accepted auditing standards. The purpose of the audit was to audit the list of residents used by the Consultant conducting the telephone poll, to verify that residents had been called or contacted by mail, and to verify that they complied with the requirements of the Bylaws of the Municipality for the process. The results of the audit were that the Consultant conducting the telephone poll followed the requirements of the Bylaws of the Municipality and contacted the residents using the processes described in the Bylaws. In the opinion of the auditor, the telephone poll provided a larger response than would have been obtained using mail or news ads asking for input.

### **5.3.2 Volunteer Host Community**

OPG accepted the results of the poll and the subsequent resolution by Council affirming its support of the DGR as sufficient to proceed with the project. The Municipality of Kincardine is acknowledged as the volunteer host community for the DGR.

## **5.4 FIRST NATIONS COMMUNICATIONS**

The IAS included communications with the two local First Nations communities, namely the Chippewas of Saugeen First Nation located just north of Southampton approximately 30 km from

the site, and the Chippewas of Nawash Unceded First Nation located at Cape Croker, 60 km from the site.

#### **5.4.1 Memorandum of Understanding Between First Nations and OPG**

The Municipality of Kincardine and OPG initially made contact with the First Nations in August 2003. In February, 2004, Golder Associates, on behalf of the Municipality of Kincardine and OPG made a presentation to the Joint Council of both First Nations.

Following a second presentation to Joint Council in May 2004, OPG and First Nations selected an Administrative Co-ordinator and a technical advisor for the DGR proposal. Further discussions led to a Memorandum of Understanding between the First Nations and OPG in October 2004. The MOU outlined terms and a process for OPG and First Nations to communicate on the DGR in the short-term. Discussions are currently underway towards reaching agreement on a longer term MOU.

#### **5.4.2 WWMF Site Tours**

OPG provided opportunities for members of the First Nations to visit the WWMF. In total, fourteen Council members and staff toured the site. The tours provided a good opportunity for visitors to see the existing L&ILW management and to have their questions about the waste and the facility answered.

#### **5.4.3 Implementing the MOU with First Nations**

In implementing the MOU, OPG and the First Nation Bands agreed to begin a series of "round table" discussions to explore how to build a better working relationship that would be to their mutual benefit. Five round table meetings have been held to date. At the first meeting First Nations tabled a list of eight issues which are important to the Bands and which they wanted to discuss furthering as a part of studies associated with the proposed Deep Geologic Repository. Through the round table meetings the Bands identified several initiatives which are of highest priority to them and on which they would like to work with OPG to develop proposals.

OPG has provided technical support and advice to First Nations to assist them in developing applications for federal government funding for feasibility studies for wind energy on their lands, and has also provided a preliminary assessment of potential sites suitable for wind energy at both Reserves.

#### **5.4.4 First Nations Peer Review Public Meetings**

In April 2005, First Nations held "Peer Review Public Meetings" at both Reserves. A number of independent presenters spoke at the meetings, including Paul McKee, the technical advisor who reviewed the IAS report, Anna Stanley, a Ph.D. candidate from the University of Guelph, Dr. Richard Kuhn from the University of Guelph, Dr. Brenda Murphy from Wilfred Laurier University and Assembly of First Nations representative Melissa Gus, a Nuclear Waste Dialogue Regional Coordinator.

An invited presenter from the University of Guelph reviewed the experience the Serpent River First Nations people have had with the uranium mining industry. An Assembly of First Nations representative reviewed the work of the NWMO and what First Nations people across Canada have been saying about the issue of high level radioactive waste management.

#### **5.4.5 First Nations Open Houses**

Open houses were held in May 2005 at both Reserves which allowed OPG to present information on the DGR, respond to questions and obtain feedback on the DGR.

Approximately 12 Band members attended the presentation at Nawash. The general response to the DGR was skepticism. Since the DGR would be constructed in First Nations traditional lands, they are concerned about the long-term effects on their land. Other attendees indicated that they did not believe the scientific information showing that the environmental effects would likely be insignificant.

The open house at Saugeen was attended by approximately 15 Band members. Several of the attendees asked technical questions about the DGR and expressed concern about potential environmental effects on their traditional lands. They expressed interest in continuing a dialogue and invited OPG to return to provide future updates on the DGR.

### **5.5 FUTURE COMMUNITY COMMUNICATION AND CONSULTATION**

OPG plans to continue stakeholder consultation and communication throughout the regulatory approvals phase of the proposed DGR project. Activities are expected to include maintaining OPG's DGR web page, open houses, newsletters, advertising, a mobile DGR exhibit, and speaking engagements. A preliminary Community Communication and Consultation Plan is provided in Appendix D.

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## 7.0 GLOSSARY OF TERMS AND ACRONYMS

<b>A</b>	Annum or year
<b>Activity</b>	A measure of the number of becquerels of a radioactive species in a sample
<b>ALARA</b>	As Low As Reasonably Achievable
<b>ANSI</b>	Area of Natural and Scientific Interest
<b>BEC</b>	Bruce Energy Centre
<b>Bq</b>	Becquerel: A standard international unit of radioactivity, equal to one radioactive disintegration per second. The obsolete unit curie, or Ci, based upon the amount of radioactivity in a gram of radium equals $3.7 \times 10^{10}$ Bq
<b>Brackish water</b>	Water with a salinity between 1000 and 10,000 mg/L (or between 1 and 10 g/L) TDS.
<b>Brine</b>	Water with a salinity higher than that of average seawater (more than 35 000 mg/L or 35 g/L TDS)
<b>CEAA</b>	Canadian Environmental Assessment Act
<b>CNSC</b>	Canadian Nuclear Safety Commission
<b>DGR</b>	Deep Geologic Repository
<b>DRL</b>	Derived Release Limit
<b>EMS</b>	Environmental Management System
<b>EP</b>	Environmental Protection
<b>ES&amp;H</b>	Environment, Safety and Health
<b>FA</b>	Federal Authority
<b>g</b>	gram
<b>Global Meteoric Water Line</b>	The values of $\delta^{18}\text{O}$ and $\delta^2\text{H}$ in precipitation and in fresh waters worldwide generally plot close to a straight line, which is referred to as the Global Meteoric Water Line (GMWL): $\delta^2\text{H} = 8 \delta^{18}\text{O} + 10\%$ VSMOW
<b>GS</b>	Generating Station
<b>h</b>	Hour
<b>HVAC</b>	Heating, Ventilation and Air Conditioning

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<b>IAEA</b>	International Atomic Energy Agency
<b>IAS</b>	Independent Assessment Study
<b>ICRP</b>	International Commission on Radiological Protection
<b>IC-HX</b>	In-ground Heat Exchangers
<b>IERS</b>	International Environmental Rating System
<b>ILW</b>	Intermediate Level Waste
<b>ISO</b>	International Organization for Standardization
<b>ISO 14001</b>	An international standard for environmental management systems
<b>ISRS</b>	International Safety Rating System
<b>IX-resins</b>	Ion-exchange resins
<b>L&amp;ILW</b>	Low and Intermediate Level Waste
<b>LLSB</b>	Low Level Storage Building
<b>LLW</b>	Low level waste
<b>m</b>	metre
<b>masl</b>	Metres above sea level
<b>NSCA</b>	Nuclear Safety and Control Act
<b>NWMD</b>	Nuclear Waste Management Division
<b>NWMO</b>	Nuclear Waste Management Organization
<b>OPG</b>	Ontario Power Generation
<b>OS</b>	Open Space
<b>PVC</b>	Polyvinyl Chloride
<b>RA</b>	Responsible Authority
<b>Radiation</b>	The emission and propagation of energy through space or matter in the form of electromagnetic waves (e.g., gamma rays) or fast-moving particles such as alpha or beta particles
<b>REMP</b>	Radiological Environmental Monitoring Program
<b>RPR</b>	Radiation Protection Requirements

<b>S</b>	Second
<b>Salinity of Natural Waters</b>	<p>The <b>salinity or total dissolved solids (TDS)</b> of waters is generally reported in mg/L, and is measured either i) directly, by summing the measured dissolved constituents or by weighing solid residues after evaporation; or ii) indirectly from electrical conductance measurements</p> <p><i>Fresh water:</i> Water with a salinity of less than 1000 mg/L (or 1 g/L) TDS.</p> <p><i>Brackish water:</i> Water with a salinity between 1000 and 10,000 mg/L (or between 1 and 10 g/L) TDS.</p> <p><i>Saline water:</i> Water with a salinity between 10 000 mg/L and 35 000 mg/L TDS (or between 10 and 35 g/L TDS).</p> <p><i>Brine:</i> Water with a salinity higher than that of average seawater (more than 35 000 mg/L or 35 g/L TDS).</p>
<b>Stable Isotopes of Oxygen and Hydrogen</b>	<p>Stable isotopes are measured as the ratio of the two most abundant isotopes of a given element. For oxygen, the important stable isotopes are <math>^{18}\text{O}</math> (<math>\approx 0.2\%</math> of terrestrial oxygen) and the more abundant <math>^{16}\text{O}</math> (<math>\approx 99.8\%</math>).</p> <p>Isotopic concentrations are expressed in delta (<math>\delta</math>) notation, which is the difference between the measured ratio of the sample and of the reference, divided by the measured ratio of the reference. Because variations in isotope concentrations in nature tend to be small, <math>\delta</math>-values are expressed as parts per thousand or <b>permil (‰)</b> difference from the reference:</p> $\delta^{18}\text{O} = \left[ \frac{(^{18}\text{O}/^{16}\text{O})_{\text{sample}}}{(^{18}\text{O}/^{16}\text{O})_{\text{reference}}} - 1 \right] \times 1000\text{‰ VSMOW}$ <p>(Vienna Standard Mean Oceanic Water)</p> <p>where "VSMOW" refers to Vienna Standard Mean Oceanic Water, the reference to which the isotopic signature of the sample is being compared.</p> <p>Hydrogen has two stable isotopes, <math>^1\text{H}</math> (most abundant) and <math>^2\text{H}</math>. The stable isotope ratio of hydrogen is expressed as:</p> $\delta^2\text{H} = \left[ \frac{(^2\text{H}/^1\text{H})_{\text{sample}}}{(^2\text{H}/^1\text{H})_{\text{reference}}} - 1 \right] \times 1000\text{‰ VSMOW}$ <p>The isotopic composition of seawater is, by definition of the Standard Mean Oceanic Water (or SMOW) scale, zero permil (0‰) for both <math>\delta^{18}\text{O}</math> and <math>\delta^2\text{H}</math>. A <math>\delta</math>-value that is positive, for example <math>\delta^{18}\text{O} = +10\text{‰}</math>, indicates that the sample has 10 permil or 1% more <math>^{18}\text{O}</math> than the reference (or is enriched by 10‰). A sample that is depleted relative to the reference by this amount would be expressed as <math>\delta^{18}\text{O} = -10\text{‰}</math>.</p>
<b>Sv</b>	Sievert: A unit of equivalent or effective dose. In theory, the unit Sv should only be applied at low doses and low dose rates. Equivalent and effective doses are frequently expressed as millisieverts (mSv), equal to one-thousandth of a sievert, or as microsieverts ( $\mu\text{Sv}$ ) equal to one-millionth of a sievert
<b>Stakeholders</b>	Broad term used to describe individuals, organizations, governments that have

	an interest in the proposed project
<b>TDS</b>	Total Dissolved Solids
<b>VEC</b>	Valued Ecosystem Component
<b>VSC</b>	Valued Social Component
<b>VSMOW</b>	Vienna Standard Mean Oceanic Water
<b>WUFDSF</b>	Western Used Fuel Dry Storage Facility
<b>WWMF</b>	Western Waste Management Facility
<b>μSv</b>	microsievert (one-millionth of a sievert)
<b>y</b>	Year

- Appendix A International Experience with Low and Intermediate Level Radioactive Waste Management
- Appendix B Description of Current WWMF L&ILW Operation
- Appendix C Geology, Hydrogeology, Hydrochemistry and Geomechanics at Bruce Site
- Appendix D Operational Controls at the WWMF
- Appendix E Preliminary Safety Assessment
- Appendix F Communications Plan

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## **APPENDIX A: INTERNATIONAL EXPERIENCE WITH LOW AND INTERMEDIATE LEVEL RADIOACTIVE WASTE MANAGEMENT**

### **A-1 INTERNATIONAL EXPERIENCE WITH LOW & INTERMEDIATE LEVEL WASTE MANAGEMENT**

In a number of countries it has been accepted that adequate protection of public health and safety against the hazards associated with short-lived low and intermediate level wastes can be achieved with engineered facilities on the surface. Other countries have chosen to place such wastes in a well-engineered and well-chosen underground repository which is believed to provide additional protection from surface hazards, both man-made (e.g., security against aircraft accidents and sabotage), and natural (e.g., the avoidance of extreme weather conditions). Underground structures are also inherently less vulnerable to seismic events. Underground repositories are designed so as to provide the necessary long-term safety and to do so without institutional control. Consequently, a well engineered underground repository can provide a greater degree of public protection and safety than a comparable surface facility.

Underground repositories have been in operation for many years in other countries, including in Sweden, Finland and United States.

The **Forsmark** facility in Sweden, SFR, has been operating since 1988. SFR, located at the Forsmark nuclear power plant, was the first of its kind in the world when it was built. The underground repository was excavated to a depth of 60 metres in crystalline metamorphic rock below the bottom of the Baltic Sea.

Only operational waste is currently stored in SFR. Operational waste has a low or intermediate level of radioactivity and a short half-life. The repository access is by ramp. Two parallel tunnels run from the surface down to the repository. One tunnel is used to carry the waste transport containers to the repository vaults. The other is used for personnel transport and could also be used in connection with any future expansion of the SFR. Low level waste is disposed in 160-m long rock vaults. The current capacity of the repository is 63,000 m<sup>3</sup>, of which approximately 25,000 cubic metres is filled with waste. Another 30,000 m<sup>3</sup> capacity will be created in a second phase. Decommissioning wastes are to be stored in a final phase with a capacity of 100,000 m<sup>3</sup>.

The intermediate level waste is stored in a concrete silo of 25-m diameter and 50-m depth cast in a cylindrical rock chamber.

The SFR has been proven to work extremely well – there have been zero emissions from the waste and the radiation dose experienced by the personnel is low (SKB, 2005).



**FIGURE A-1: SKB'S FORSMARK REPOSITORY FOR MANAGEMENT OF LOW AND INTERMEDIATE LEVEL WASTE**

**Table A-1 : SFR – principal facts and figures**

<b>Construction work started:</b>	1983
<b>Operations started:</b>	1988
<b>Storage capacity:</b>	63,000 m <sup>3</sup>
<b>Incoming deliveries:</b>	1,000–2,000 m <sup>3</sup> /a
<b>Operating and maintenance:</b>	Approx. 12 people
<b>Above-ground section:</b>	Office & workshop building, terminal building, ventilation building
<b>Underground section:</b>	4 underground caverns, 1 silo, operations centre
<b>Owners:</b>	SKB
<b>Operations and maintenance:</b>	Forsmarks Kraftgrupp AB
<b>Construction cost:</b>	SEK 740 million (~\$116 million Canadian)
<b>Operating cost:</b>	Approx. SEK 25 million/a (~\$4 million Canadian)
<b>Total cost:</b>	Approx. SEK 1,500 million (inc. sealing) (~\$232 million Canadian)



In Finland, at the **Olkiluoto nuclear plant**, an underground repository for low and intermediate level waste has been operating since 1992. Low and intermediate level wastes are separated and placed in concrete lined silos excavated in crystalline bedrock at depths of 70 to 100 m below ground surface. The facility is designed to take 40,000 200-litre drums. After the conclusion of the operating phase, the tunnel and the shaft will be sealed. It will not be necessary to maintain control of the repository after sealing.

Also in Finland, near the **Loviisa** nuclear plant, a comparable facility has been constructed. The repository was opened in 1998. The repository has been built in an intact granite rock mass between two fracture zones in a stagnant saline groundwater regime. The facility was designed, taking account of the quantity of waste to be disposed, and the geological and hydrogeological conditions of the site. Provisions have been made for future enlargement of the repository for the disposal of power plant decommissioning wastes. The facility is located at a level of 110 m, optimal with respect to both the local geological structure and groundwater flow conditions. The construction of the underground facility has been divided into three stages. In the first stage, only one maintenance waste tunnel and the systems serving the whole repository were completed. In the second stage, another maintenance waste tunnel and a cavern for solidified waste will be constructed. In the third stage, after 2020, coinciding with the closure of the power plant, excavation of the caverns for decommissioning waste will take place.

In the United States, the **Waste Isolation Pilot Plant (WIPP)** was the United States' first operating underground repository for defense-generated transuranic radioactive waste<sup>2</sup>. It began operation in March 1999 (U.S. Department of Energy, 2003).

The U.S. Department of Energy's Carlsbad Field Office administers the WIPP project. The mission of the Field Office is to protect human health and the environment by opening and operating WIPP for safe disposal of transuranic waste and by establishing an effective system for managing transuranic waste.

Located in southeastern New Mexico, the WIPP is designed to demonstrate the safe, permanent disposal of transuranic radioactive waste left from the production of nuclear weapons. The

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<sup>2</sup> Transuranic waste consists of clothing, tools, rags, residues, debris and other such items contaminated with small amounts of radioactive elements – mostly plutonium. These elements are radioactive, man-made, and have an atomic number greater than uranium.

project facilities include excavated rooms 2,150 feet (approximately 655 m) underground in an ancient, stable salt formation. Figure A-2 provides a photo of waste in an underground storage room at WIPP.



**FIGURE A-2: WASTE STORED UNDERGROUND AT WIPP**

**APPENDIX B: DESCRIPTION OF CURRENT WWMF L&ILW OPERATION**

OPG has gradually increased the processing and storage capacity within the WWMF on an "as needed" basis (subject to applicable regulatory approvals), to accommodate wastes arising from normal operation and maintenance activities. The development history of the WWMF is summarized in Table B-1. Table B-2 provides a summary of the status of L&ILW waste structures at the WWMF. Descriptions of the various structure/building types are provided in Section B-3. A photo showing the locations of the existing facilities on the WWMF site is provided in Figure B-1.



**FIGURE B-1: WWMF SITE LAYOUT**

- 1:** LLSBs (1-8); **2:** LLSB 9; **3:** Tileholes; **4:** Waste Volume Reduction Building; **5:** In-ground Containers; **6:** Quadcells; **7:** Dry Storage Container Processing Building; **8:** Dry Storage Container Storage Building; **9:** Amenities Building; **10:** Trenches; **11:** IC-HXs; **12:** Proposed Refurbishment Waste Storage Area; **13:** Transport Package Maintenance Building; **14:** Reserved for Dry Fuel Container Storage Buildings; **15 & 16:** Proposed Refurbishment Waste Storage Area

<b>TABLE B-1: CHRONOLOGY OF WWMF DEVELOPMENT</b>			
<b>Structure / Building</b>	<b>Units</b>	<b>Capacity</b>	<b>In-Service Dates</b>
<b>Above-Ground Storage Structures or Buildings</b>			
Low Level Storage Buildings (LLSBs)	1	7,660 m <sup>3</sup>	October 1982
	2	7,660 m <sup>3</sup>	December 1985
	3	7,660 m <sup>3</sup>	March 1988
	4	7,660 m <sup>3</sup>	June 1989
	5	7,660 m <sup>3</sup>	June 1989
	6	7,660 m <sup>3</sup>	November 1992
	7	8,000 m <sup>3</sup>	December 1999
	8	8,000 m <sup>3</sup>	May 2002
	9	8,000 m <sup>3</sup>	October 2004
<b>Above-Ground Storage Structures or Buildings</b>			
Used-Fuel Dry Storage (UFDS) Buildings	4 (staged)	500 Dry Storage Containers (each)	October 2002 (Storage Building 1)
Quadricells	15	360 m <sup>3</sup>	October 1978
Contaminated Tool Storage Area (CTSA) <sup>(a)</sup>		4,700 m <sup>2</sup>	September 1990
<b>In-Ground Storage Structures</b>			
Trenches: Stage 1 Stage 3 Stage 3E		2,080 m <sup>3</sup>	December 1974
		1,440 m <sup>3</sup>	March 1976
		2,350 m <sup>3</sup>	May 1979
Tile Holes: Stage 1 Stage 3		80 m <sup>3</sup>	March 1974
		144 m <sup>3</sup>	June 1977
In-Ground Containers IC-2 IC-12 IC-18 IC-18 IC-18 IC-18 IC-18	20	40 m <sup>3</sup>	December 1985
	20	240 m <sup>3</sup>	March 1987
	8	144 m <sup>3</sup>	June 1989
	32	576 m <sup>3</sup>	December 1990
	54	972 m <sup>3</sup>	October 1993
	50	900 m <sup>3</sup>	May 1997
	54	972 m <sup>3</sup>	February 2002
In-Ground Heat Exchanger Containers (IC-HXs) Phase 1 Phase 2 Phase 3	41 HXs		
	23		1991
	4		1993
	10		1997

<b>TABLE B-1: CHRONOLOGY OF WWMF DEVELOPMENT</b>			
<b>Structure / Building</b>	<b>Units</b>	<b>Capacity</b>	<b>In-Service Dates</b>
<b>Above-Ground Storage Structures or Buildings</b>			
Phase 4	4		2002
<b>Processing</b>			
Waste Volume Reduction Building (WVRB) Original <sup>(b)</sup> Upgrades			1977 2002 <sup>(f)</sup>
<b>Processing</b>			
Used-Fuel Dry Storage Container Processing Building			October 2002
Radioactive Waste Incinerator Original Replacement			1977 - 2001 2002-3 <sup>(g)</sup>
Non-Radioactive Incinerator <sup>(c)</sup>			1977 - 1992
Compactor <sup>(d)</sup>			1977 - 1981
Drum Crusher			1983 - 1992
Baler <sup>(e)</sup>			1981 - 1992
Box Compactor			1993
<b>Amenities</b>			
Wing on WVRB			1977
Temporary Expansions: Phase 1			1992
Phase 2			1999
New Amenities Building			December 2001
Transportation Package Maintenance Building			November, 2004

**Notes:**

- (a) The CTSA is currently not in use.
- (b) The WVRB underwent major renovations in 2001 and 2002.
- (c) Non-radioactive incinerator was removed from service in 1992 and dismantled in 2002.
- (d) Compactor was converted to a drum crusher in 1983 and removed in 1992.
- (e) The box compactor replaced the baler in 1993.
- (f) The WVRB was placed back in normal operations in the second part of 2003.
- (g) The replacement incinerator began processing waste in 2003, and is likely to be officially declared In-Service in late 2005.

**B-1 WASTE TYPES AND VOLUMES MANAGED AT THE WWMF**

Annual waste receipts at the WWMF have varied from year to year, depending on the routine operation and maintenance programs at Ontario Nuclear Generating Stations. OPG anticipates that between 4,000 and 6,000 cubic metres of L&ILW will be received each year for processing at the WWMF. The low level operational waste stored at the WWMF will continue to increase at approximately 3000 m<sup>3</sup> per year. Figure B-2 below depicts the generalized flow chart of the LLW management system leading to storage on-site. The waste transfer/transport is

from all Ontario nuclear generators using licensed transport packages and related equipment. Processing via incineration and/or compaction is key to reducing the volume of waste that is stored. The vast majority of these wastes get stored in the LLSBs at the WWMF.

TABLE B-2 LOW AND INTERMEDIATE LEVEL WASTE STRUCTURES AT THE WWMF			
Structure	Number In-Service	Additional Number with EA Approval	Additional Number Planned but not yet EA Approved
Low Level Storage Buildings	9	2	0
Quadricells	360 m <sup>3</sup>	0	0
Trenches	5,870 m <sup>3</sup>	0	0
Tile Holes	224 m <sup>3</sup>	0	0
IC-2	20	0	0
IC-12	20	0	0
IC-HX	41	17	~30
IC-18	198	54	~270
Steam Generator Storage Building	0	0	~6
Retube Waste Storage Building	0	0	~6

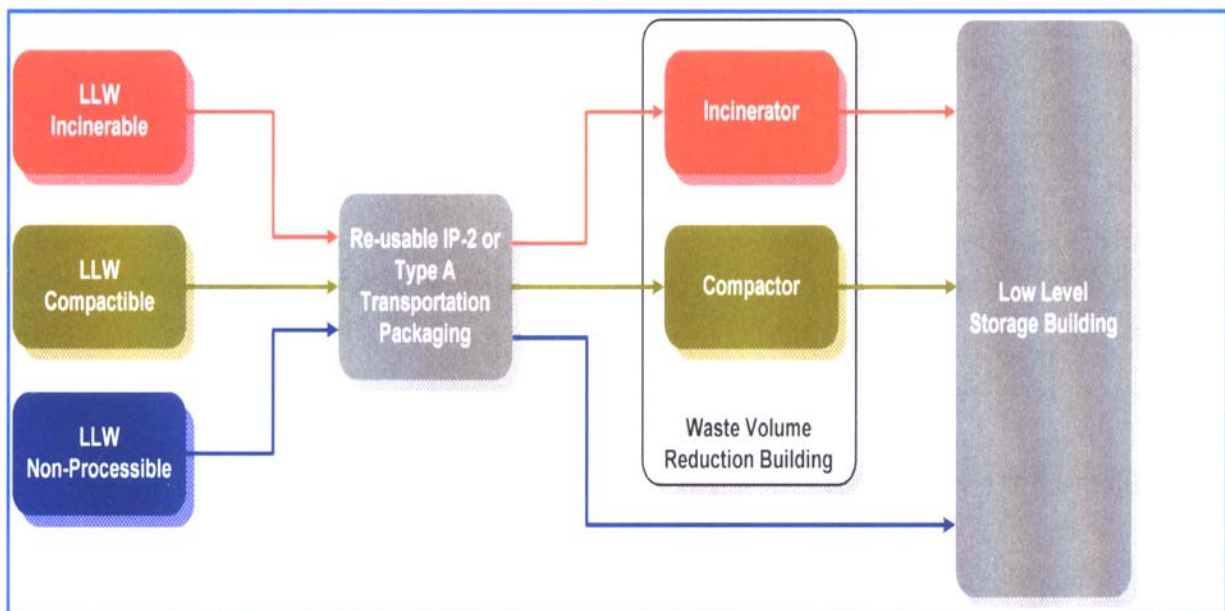
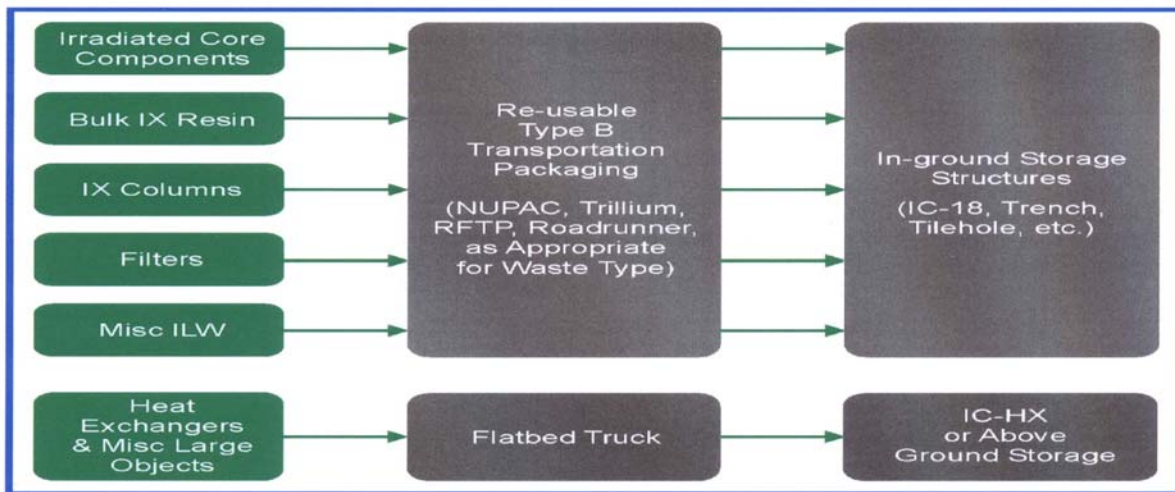


FIGURE B-2: REFERENCE LLW TRANSFER, PROCESSING AND STORAGE SYSTEM AT THE WWMF

Intermediate level operational radioactive waste arising and stored at the WWMF will also continue to increase at approximately 290 m<sup>3</sup> per year. Figure B-3 depicts the generalized flow chart of the ILW management system leading to storage on-site. The waste transfer/transport is from all Ontario nuclear generators using licensed transport packages and related equipment.



**FIGURE B-3: REFERENCE ILW SYSTEM AT THE WWMF**

ILW includes some waste packages that require shielding overpacks for transfer/transport and other large object wastes and low dose rate packages that do not require overpacks, most notably the heat exchangers.

OPG operates a number of facilities at the WWMF for handling, processing, and storing low and intermediate level waste. While the handling and processing facilities will continue to operate with the Deep Geologic Repository, the low and intermediate level waste storage facilities would be replaced, in due course, by the proposed deep geologic repository.

## **B-2 LOW LEVEL STORAGE BUILDINGS**

Solid wastes, of Type 1 and Type 2, which have radiation fields less than 10 mSv/h at 30 cm, and liquid waste awaiting incineration (limited to contaminated oil), with beta-gamma activity less than  $3.7 \times 10^{12}$  Bq/m<sup>3</sup>, are currently stored in Low Level Storage Buildings (LLSBs) at the Western Waste Management Facility. The LLSBs, of which there are nine at present, are warehouse-like



structures approximately 50-m long by 30-m wide by 8-m high, each with a waste storage capacity of approximately 7600 to 8000 m<sup>3</sup>. The structural design of the building utilizes prefabricated pre-stressed concrete. The superstructure consists of concrete roof support columns with prefabricated concrete walls and a concrete roof. The concrete panels are joined in an overlapping configuration to prevent radiation streaming between the panels. The buildings are provided with services such as fire protection, ventilation, lighting and drainage. Wastes are stacked in various types of boxes and racks using conventional forklift type equipment. Wastes can be retrieved from the buildings using similar equipment. There are currently 9 LLSBs. OPG has approval, under the Canadian Environmental Assessment Act to construct an additional two LLSBs at the WWMF. The additional two buildings will be constructed based on the rate of waste production and the effectiveness of volume reduction. In total, the approved LLSBs provide low level waste storage capacity of about 86,000 m<sup>3</sup>.

Solid wastes with dose rates greater than 2 mSv/h are now stored in **in-ground structures**. The In-ground Containers (ICs) provide storage capacity for Type 2 and Type 3 radioactive wastes. The diameter and depth of the containers can be altered to suit any special waste storage needs. In-ground structures in use at the WWMF include trenches, tile holes, and a range of in-ground containers of various volumes up to 18 cubic metres (IC-18s).

The IC design utilizes the natural shielding provided by the surrounding fill. The structure possesses an inner and outer liner, both constructed from welded carbon steel pipe. There is an interspace between the inner retrievable liner and the outer fixed liner. This interspace is provided for routine water detection and dose rate monitoring as required. Liners are placed in a cylindrical hole made by vertical auguring of the soil. The annular space between the augured hole and outer liner is backfilled with a concrete material that encases the liner. The inner liners are retrieved using a conventional mobile crane.

There are 20 IC-2s, each with a nominal capacity of 2 m<sup>3</sup>. The inner retrievable liner is approximately 0.6-m diameter by 7.6-m long. Similar to the tile holes, the IC-2s contain filters, ion-exchange columns and similar small sized wastes. There are no plans to construct any more IC-2s. New wastes of this type are now stored in Tile Hole Equivalent (T.H.E.) IC-18s.

There are 20 IC-12s, each with a nominal capacity of 12 m<sup>3</sup>, consisting of four 3 m<sup>3</sup> bulk resin liners stacked up inside. Unlike the IC-2, there is no outer liner that encompasses the entire storage structure. The 3 m<sup>3</sup> resin liners are individually retrievable. There are no plans to construct any more IC-12s. New wastes of this type are now stored in "bulk resin" IC-18s.

The current design of choice for Type 2 and Type 3 waste storage is the IC-18. There are currently 198 IC-18s: 33 are fitted as T.H.E. and 165 are fitted for bulk resin storage. Additional IC-18s of both types will be constructed in the future as required. Similar to the IC-12, the bulk resin IC-18s contain individually retrievable 3 m<sup>3</sup> resin liners but they are stacked 6 liners high instead of 4 for the IC-12. The T.H.E. IC-18s each contain 7 steel pipe storage tubes, 0.55-m diameter by 10.7 m deep. The tubes are designed to be individually retrievable.

In its basic configuration, the IC-18 consists of an augured hole, with a 1.7-m inside diameter steel liner, approximately 12 m deep. The space between the liner and the augured hole is backfilled with concrete. Shielding is provided by the surrounding till. A concrete and steel shield plug rests on top. The IC-18 design concept is very flexible.

Environmental assessment approval is in-place for an additional 54 IC-18s to be constructed.

Some large heat exchangers are stored in in-ground containers heat exchangers (IC-HXs) at the WWMF. The IC-HX is a sealed vessel placed in an augured hole in the WWMF till. The IC-HXs provide storage for scrap radioactive heat exchanger tube bundles from moderator, PHT and auxiliary systems from Ontario Power Generation stations. These tube bundles will be Type 1 or Type 2 radioactive waste, with contact fields up to 150  $\mu$ Sv/h. In preparation for storage by the Waste Generator, the heat exchanger is drained, dried and all openings sealed and leak tested. The entire vessel is covered in a protective coating, such as coal tar epoxy.

The space around the heat exchanger is backfilled with limestone gravel. Shielding from any low-level radiation associated with these heat exchangers is provided by the surrounding till. Temporary laydown areas for these large waste packages may be established as "staging areas" in proximity to the existing structures to prepare for loading of in-ground structures.

There are currently 41 IC-HXs in-place, and environmental assessment approval is in place for an additional sixteen.

**Tile holes** are an early (1970's) design for the storage of Type 3 waste. They can be used for any wastes with dimensions compatible with tile holes, such as small filters and disposable ion-exchange columns. They are in-ground structures consisting of a pre-cast concrete pipe set on

a concrete base. There are several variations in the details of construction of the concrete pipe and base. Shielding is provided by the surrounding backfill. There are a total of 224 tile holes in two groups - "Stage 1" with 80 tile holes and "Stage 3" with 144 tile holes, each with a nominal capacity of 1 m<sup>3</sup>. There are no plans to construct any more tile holes. These types of waste are now stored in "in-ground containers" as described above.

The Stage 3 tile holes all incorporate a retrievable steel liner. Steel liners were also retrofitted into 37 of the Stage 1 tile holes. The remaining 43 Stage 1 tile holes are "grouted in place". With some variation, the tile holes are approximately 0.6-m inner diameter by 3.5 m deep. Wastes are emplaced using a conventional mobile crane to unload the shielded transportation package used to bring the waste to the WWMF site. Wastes would be retrieved from all but the 37 "grouted in place" tile holes by removing the inner steel liner. The "grouted in place" tile holes would be retrieved by extracting the entire concreted monolith.

The concrete **trenches** are classified into two types, a wide-type and a narrow-type. They are designed to provide storage capacity for Types 1 and 2 LLW. There are a total of two wide trenches and 13 narrow trenches with a combined storage capacity of 5790 m<sup>3</sup>.

The wide trenches are approx 38 m long by 6.8 m wide and divided into 6 sections; the narrow trenches are approx 40 m long by 3.8 m wide and divided into 3 sections. Each trench has an internal depth of approximately 3 m. Each trench section has a removable concrete cover. Wastes are emplaced or retrieved by removing the appropriate trench section cover and hoisting the individual waste item with a conventional mobile crane. There are no plans to construct more trenches. Although many of the trenches contain historic wastes similar to those now stored in LLSBs, they are now mainly used for large, heavy or otherwise difficult to handle objects such as scrap shielding casks or non-processible wastes requiring more shielding than can be provided by the LLSBs.

The above-ground **quadricells** provide storage capacity for Type 3 radioactive wastes. Each quadricell is four independent, cylindrical, reinforced concrete shells with integral bottoms, contained within a cubic, reinforced concrete structure that is subdivided into four cells. This outer shell possesses its own integral bottom. The quadricells are placed above ground, in line, back-to-back, covering an area 6.2 m wide by 83.2 m long. Waste, such as steel vessels containing ion-exchange resins and filters, is removed from its shielded transfer package and placed inside the inner concrete shell using a conventional mobile crane. When two vessels

have been placed, the shell is capped with a concrete plug. Retrieval of the complete inner concrete cylindrical shells is the design basis provision for waste retrieval. There are a total of 60 such concrete shells to be retrieved. There are no plans to construct any more Quadricells. Wastes of this type are now stored in in-ground containers.

The total capacity of the existing in-ground storage structures is about 11,000 m<sup>3</sup>.

### **B-3 STEAM GENERATOR STORAGE BUILDINGS<sup>3</sup>**

OPG's environmental assessment in support of the licensing process for construction and operation of up to six steam generator storage buildings at the WWMF is under review. The steam generator storage buildings are expected to be similar in dimension and construction to the low level storage buildings. They would be approximately 30 m by 50 m, adjusted to fit the space available within the WWMF. The buildings, if approved, will be used to store steam generators, pre-heaters, heat exchangers and similar large waste packages, arising from the operation, maintenance and anticipated major refurbishment activities of Ontario Power Generation and Bruce Power. The buildings would be constructed on an as-needed basis.

### **B-4 RETUBE COMPONENT STORAGE BUILDINGS<sup>3</sup>**

OPG's environmental assessment in support of the licensing process for the construction and operation of up to six retube component storage buildings at the WWMF is under review. The proposed retube component storage buildings would be similar in dimension and construction to the low level storage buildings, adjusted to fit the space available within the WWMF. The buildings would house intermediate level retube component wastes such as pressure tubes, calandria tubes, end fittings and shield plugs, spacers and other related or similar wastes. The buildings would be constructed on an as-needed basis.

### **B-5 WASTE VOLUME REDUCTION BUILDING**

The Waste Volume Reduction Building (WVRB; formerly the Waste Volume Reduction Facility or WVRF) provides for the management of LLW through activities such as waste receiving and handling, compaction, and incineration prior to storage. An incinerator and a box compactor

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<sup>3</sup> EA has been submitted for approval.

are housed in the WVRB. It also contains worker amenities and support facilities, such as offices, change rooms, lunch room, maintenance shops, etc.

#### **B-6 TRANSPORT PACKAGE MAINTENANCE BUILDING (TPMB)**

The TPMB, which was constructed in 2004, is used for inspection, decontamination (if necessary), maintenance and refurbishment of the transportation packagings. It includes mechanical maintenance and control maintenance equipment and services for all of the WWMF.

#### **B-7 PROPOSED WASTE REFURBISHMENT STORAGE BUILDINGS**

OPG is seeking environmental assessment approval for Steam Generator Storage Buildings and Retube Component Storage Buildings. The buildings will be single storey, commercial-type, and pre-engineered or pre-cast concrete structures with a concrete slab floor. They will be open concept and adaptable to changing storage requirements. Large waste packages, such as steam generators (and potentially pre-heaters and heat exchangers), will be stored in Steam Generator Storage Buildings. Retube component wastes, including pressure tubes, calandria tubes, end fittings and shield plugs, spacers and other similar wastes, will be stored in individually shielded packages in Retube Components Storage Buildings.

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## **APPENDIX C: OPERATIONAL CONTROLS AT THE WWMF**

OPG has a system for managing worker and public health and safety based on a set principles governed through documents that guide management action and controls facility operations. These systems and documents, with revisions as necessary, would apply to the construction and operation of the DGR.

This set of policy documents provides the objectives, principles, responsibility statements and policies that will govern radiation protection at the DGR, and include the Radiation Protection Requirements for general use and for radiography, referred to as the "RPRs". The RPRs comply with the federal Nuclear Safety and Control Act and regulations, as well as other applicable federal and provincial regulations. The RPRs also apply the intent of internationally-accepted principles and recommendations established by the International Commission on Radiological Protection (ICRP) and the International Atomic Energy Agency (IAEA). They also take into account the knowledge gained through OPG's long experience in designing, constructing and operating nuclear generating stations and the WWMF.

### **C-1 Occupational Radiological Protection Program**

A Radiation Protection Program (RPP) is currently in place for the WWMF. The preferred method of limiting dose is to remove the source; when this is not possible, control of exposure is accomplished through controlling the circumstances of the work (including controlling duration, distance and use of shielding).

The RPP identifies operations and materials that have the potential to contribute to the radiation dose to workers. The RPP provides guidelines and procedures to monitor and minimize occupational dose and reduce the potential for contamination in the WWMF. These proven programs and procedures would be used in the DGR, as outlined below.

### **C-2 Occupational Dose Control**

The doses to workers from routine waste management operations are monitored and assessed against dose targets. Thermoluminescent Dosimeter (TLD) badges will be worn as a minimum external dosimetry requirement for personnel involved in the operation of the DGR. Further, access to all DGR buildings and structures will be limited to designated personnel and those escorted by qualified personnel. The DGR will be designated as a Radiological Controlled Area.

### **C-3 Contamination Control**

A key practice in maintaining control of radiation exposure and contamination is through the use of "Zone" areas that define procedures and practices that are mandatory in order to move from one area to another. Areas are designated as Zone 1 (a clean area which may be considered as the equivalent of a normal public access area), and Zones 2 and 3 (radiological areas). Procedures are in place for controls over personnel and materials movement through the zones. Zones are clearly marked and any changes to zones, zone barriers, or zone boundary monitoring equipment, require the approval of the Responsible Health Physicist. Inter-zonal monitoring is in place to prevent the spread of radioactive contamination to the public domain.

Routine surveys are conducted at specified frequencies and locations. The purpose of this monitoring is to identify loose or removable contamination. Any occurrence of loose contamination is removed by manually wiping with a cloth, or by wet methods if necessary, taking appropriate measures for containment of contamination at the source and for personnel protection.

During operation of the DGR, the proposed buildings/structures and emplacement rooms will be subject to similar procedures and processes.

### **C-4 Radiological Hazard Monitoring**

RPP requirements include area gamma radiation monitoring and routine radiological surveys, as well as contamination monitoring. The main objective of monitoring is the timely detection of changes in radiological hazard levels so that appropriate remedial actions can be taken and radiation exposures to workers are avoided. Routine gamma radiation surveys would be performed to cover the entire sequence of DGR operations including monitoring for overall changes in radiation levels and initiating corrective action, if needed, as described in RPP procedures to maintain occupational safety standards.

### **C-5 Establishment of Radiation Zones**

Identification of zones within the DGR will include the following considerations taking into account the movement of people and materials:

- All DGR facilities will be classified in accordance with criteria for potential contamination, ranging from Zone 1 to Zone 3.



- Appropriate personnel and materials/equipment monitoring devices would be required at each inter-zonal boundary.
- Movement from the storage structures to the receipt/access building would take place through the WWMF.
- The emplacement rooms would be Zone 3 since they would contain possible sources of contamination.
- During the construction of additional emplacement rooms, the shaft and access tunnels are assumed to be dedicated to construction activities only, and the filled emplacement rooms would constitute a “repository island” within the construction island. De-zoning to facilitate construction would include monitoring, as needed, to confirm status of the areas to be de-zoned.

### **C-6 Management of Radiation Dose During L&ILW Handling**

Radiation dose to workers would be limited according to established targets for the DGR. Current waste packaging and handling procedures in place for the WWMF are designed to limit the maximum individual dose to 10 mSv/a and the collective dose to all workers to 50 mSv/a. This dose is a fraction of the current CNSC dose limit for Nuclear Energy Workers of 50 mSv/a and 100 mSv in any five-year period.

Radiation dose to workers would be controlled by ensuring that appropriate shielding is provided and that the dose rate from wastes, waste packages and in areas where wastes are managed is strictly limited. Table C-1, below, shows typical criteria currently in place.

Applying dose rate criteria, and assuming conservative occupancy time for workers carrying out their respective tasks, would ensure that the targets for DGR operations are met. Ventilation will be provided to ensure that the airborne concentration of radionuclides is sufficiently low to maintain a safe working environment within the access tunnels and emplacement rooms as they are being filled. Air humidity inside an emplacement room being filled with waste is controlled to minimize the condensation of tritiated water vapour inside the vault.

Location	Dose rate limit	Reference
Shielded flask	2 mSv/h in contact	Transportation regulations, non-exclusive use
Positions in emplacement rooms where personnel entry required	3 mSv/h	OPG Radiation Protection Requirements
Positions outside emplacement rooms	25 $\mu$ Sv/h	OPG Radiation Protection Requirements
Areas with a high occupancy rate	10 $\mu$ Sv/h	OPG Radiation Protection Requirements

**TABLE C-1: DOSE RATE CRITERIA FOR DGR OPERATIONS**

## C-7 ENVIRONMENTAL PROTECTION

OPG has established an Environment, Safety and Health (ES&H) Program (OPG, 2005a) that utilizes the principles and tools of "Loss Control" as an effective method of managing risks. This ES&H Program establishes the necessary controls to ensure that all activities related to the DGR will be performed in such a way as to ensure worker and public safety, and protection of the environment. Program activities and performance measures have been developed based on the requirements of the International Safety Rating System (ISRS), and International Environmental Rating System (IERS).

The environmental components of the DGR project will be carried out consistent with ISO 14001 Environmental Management System (EMS). This includes continuous improvements in environmental performance, complying with all relevant legislation, committing to the prevention of pollution, and ensuring that any adverse environmental impacts of OPG activities, products and services are as low as reasonably achievable.

The performance of the EMS is maintained through annual reviews by an independent registrar and evaluations by the Environmental Management Review Team. The aspects list (those activities that can interact with the environment) of the EMS will be reviewed throughout the DGR project to incorporate any new activities, products and services.

## **C-8 Environmental Monitoring Programs**

OPG and Bruce Power, the operator of the Bruce site, have established comprehensive environmental monitoring programs that apply to both the WWMF and the Bruce site. These programs, which are briefly described below, will be revised and supplemented to address specific monitoring requirements for the DGR.

## **C-9 Bruce Site Radiological Environmental Monitoring Program**

The current WWMF radiological monitoring program is a component of the Bruce site Radiological Environmental Monitoring Program (REMP) administered by Bruce Power. The REMP is designed to measure environmental radioactivity in the vicinity of the Bruce site from all site sources, including the WWMF. Data from the REMP are used to assess off-site public dose consequences resulting from the operation of all of the nuclear facilities at the Bruce site.

The REMP is conducted at fixed locations surrounding the Bruce facilities and at control areas 10 to 20 km from the Bruce site. Monitoring is carried out for radioactivity in the atmosphere, water, aquatic biota, sediments and terrestrial foodstuffs. In all environmental monitoring programs, the media sampled, locations, frequency of sampling and the analyses performed are in accordance with four primary objectives:

- To confirm that discharges of radioactive materials are under control,
- To verify that assumptions on site-specific release limits (Derived Release Limits or DRLs) remain valid,
- To permit an estimate of the doses to members of the public resulting from emissions, and
- To provide data to aid development and/or evaluation of models which describe the movement of radionuclides through the environment.

## **C-10 WWMF Radiological Monitoring**

There are a number of specific monitoring programs in place at the WWMF that are used to characterize potential contributions of the existing WWMF to the overall radiation environment. These programs will be modified, or similar new programs will be established as appropriate, to monitor all releases from the DGR, including:

- Sampling and analyzing runoff leaving the site
- Groundwater monitoring
- Monitoring airborne emissions
- Measuring average ambient radiation dose rates at the perimeter of the site
- Radiation and Contamination Control

### **C-11 Non-Radiological Environmental Monitoring**

Non-radioactive releases to the environment are regulated by the Ontario Ministry of the Environment. Certificates of Approval, as appropriate, would be obtained for any non-radiological releases from the DGR project. In addition, OPG would continue to comply with all federal and provincial regulatory requirements, including reporting requirements under the National Pollutants Release Regulation and O. Reg. 127/01 Contaminant Discharge Monitoring and Reporting.

### **C-12 Safety**

The NWMD Environment, Health and Safety Program utilizes the Loss Control Managed System as an effective method of managing risks associated with loss due to:

- Personal injury and illness;
- Property/equipment and damage;
- Process loss;
- Work environment damage;
- Natural environment damage; and
- Regulatory non-compliance.

The Loss Control Program has been developed based upon the requirements of the International Safety Rating System (ISRS) and the International Environment Rating System (IERS) audit protocol (OPG 2004c).

### **C-13 Fire Protection and Emergency Response**

All facilities on the Bruce site, including the WWMF, are served by the site Emergency Response Team, medical aid and fire protection and response capabilities. In addition, a comprehensive on- and off-site emergency response plan is in place. Response teams have been trained and

are equipped to respond to potential emergencies such as fire, personnel injury, chemical releases (spills) or non-routine releases of radioactivity. The municipal fire department, the Regional Medical Officer of Health and Kincardine's health and safety service providers work co-operatively with Bruce Power, who provide Emergency Response Services to OPG at the WWMF, to ensure that additional support and response capability is in place.

## **C-14 QUALITY ASSURANCE**

The existing OPG NWMD Management Program will govern the work performed during the DGR Project. This program provides a disciplined approach to determining, communicating and attaining the required level of safety, reliability, maintainability, environmental protection and performance. The program defines requirements for work to be done and provides for the integration and co-ordination of pertinent activities.

The NWMD Management Program encompasses all aspects of NWMD activities including engineering and design, procurement, manufacturing, construction and installation, commissioning, operation, decommissioning and record keeping. The expectations also provide overall direction regarding the administration of NWMD, and establish requirements to which all employees and contractors must comply. It applies to all organizational units in NWMD that are involved with engineering and design, procurement, manufacturing, construction and installation, commissioning, operation or decommissioning. Quality assurance is accomplished by control of activities in keeping with the principles expressed in the Canadian National Standard CAN/CSA-N286.0 and subsidiary standards, where applicable. The following processes implement the program:

- A managed system of governing documents that communicate the elements of program activities;
- Individuals that are accountable for implementing and adhering to the managed system elements; and
- Program elements that are evaluated and enhanced through continuous improvement processes.

The NWMD Management Program includes provisions for a system of planned audits and assessments designed to provide a comprehensive, critical and independent evaluation of all NWMD activities. The audits and assessments monitor compliance with governing codes, standards and technical requirements, and verify that Management Program requirements are being effectively implemented. Audit and assessment results are documented, reported to and

assessed by a level of management having sufficient breadth of responsibility to assure that action is taken to address findings.

Additional oversight of NWMD activities is provided through self-assessments and the corrective action program. In particular, the corrective action program assures that adverse conditions are identified, documented, reported, evaluated and corrected in a timely manner.

## **APPENDIX D: GEOLOGY, HYDROGEOLOGY, HYDROCHEMISTRY AND GEOMECHANICS AT THE BRUCE SITE**

### **D-1 QUATERNARY GEOLOGY**

Beneath Bruce site the glacial drift overlying the bedrock surface thickens eastward from the Lake Huron shoreline ( $\approx 0$  m) to the eastern site perimeter ( $\approx 27$  m). Within the vicinity of the proposed DGR footprint drift thicknesses vary between  $\sim 12$  and 15 m. Overburden thicknesses in the vicinity of the WWMF, located to the south of the proposed DGR location vary 14 to 19 m.

The overburden in this area consists of a complex sequence of surface sand and gravel overlying a dense glacial till, locally interbedded with sand lenses or layers. The top 2 to 4 m of the glacial till unit is weathered. Underlying this brown weathered till horizon, there is an unweathered grey till comprised of dense silty sand to very hard clayey silt fill with sand and boulders. The unweathered till unit is locally intervened by a horizontal middle sand layer of variable thickness. In specific areas of the site this middle sand layer is found in direct contact with the underlying carbonate bedrock surface. Jensen and Heystee (1987) provide a detailed description of the overburden stratigraphy within the area of the proposed repository.

### **D-2 BEDROCK GEOLOGY**

The Paleozoic rocks underlying Bruce site are comprised of a near horizontally layered sequence of carbonates, shales, evaporites and minor sandstones. This sedimentary sequence is approximately 800 m thick resting upon the crystalline Precambrian basement. The stratigraphy, age, thickness and nomenclature of the sedimentary formations beneath Bruce site are depicted in Figure D-1. Detailed lithologic descriptions of the individual formations are provided in the following sections.

### Devonian Dolostones

The Devonian dolostone sequence beneath the site consists of the Amherstburg and Bois Blanc Formations. The Amherstburg Formation consists of fine grained to very fine grained lithographic dolostone. Vuggy horizons and breccia zones with varying degrees of weathering can be occasionally found within the unit. The thickness of the formation, as intersected by previous on-site borehole drilling, varies up to 65 m.

The 38 m thick Bois Blanc Formation consists of fine grained, massive bedded limestone and dolostone. This formation and the overlying Amherstburg dolostone are separated by a 4 to 10 m thick coarse grained, massive bedded fossiliferous coral limestone bed.

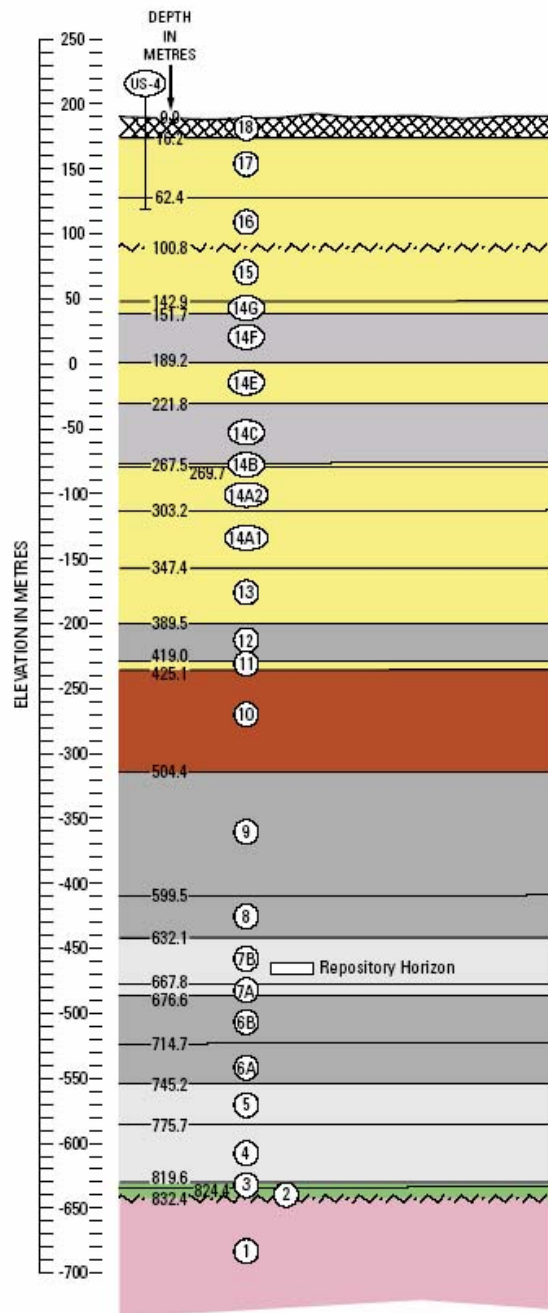
### Upper Silurian Dolostones

The Upper Silurian sequence has been subdivided into the upper Bass Island Formation and the lower Salina Formation. As drilling information extending below the Bois Blanc Formation does not exist at the Bruce site, all lithological information on this and the underlying formations is based on stratigraphy as encountered in Texaco well #6, situated 2.5 km to the southeast.

The Bass Island Formation consists of faintly porous, fine crystalline, faintly petroliferous medium bedded dolostone with occasional stylolite beds and thin shale partings. The thickness of this formation is 42 m. It is underlain by the 205 m thick Salina Formation, a complex interbedded sequence of dolostones and shales with minor evaporites. The Salina Formation can be subdivided into seven members, A to G, as shown in Figure D-1.

At the top, the G Member is approximately 9-m thick and consists of shale overlying dolostone. The underlying F Member is predominately shale approximately 38 m in thickness. Previous drilling at Texaco #6 encountered a 1 m thick anhydrite bed approximately 5 m above the basal contact of the F Member. There is a potential that collapse breccia exists within this shale as a result of solutioning in the geologic past. This can lead to the development of locally very porous, vuggy and permeable conditions within the formation.





**STRATIGRAPHIC LEGEND**

- PLEISTOCENE
  - 18 Surficial Deposits
- MIDDLE DEVONIAN
  - 17 Amherstburg Formation - Limestone and Dolostone
- LOWER DEVONIAN
  - 16 Bois Blanc Formation - Cherty Dolostone
  - ~~~~~ Silurian/Devonian Discontinuity
- UPPER SILURIAN
  - 15 Bass Island Formation - Dolostone
  - 14 Salina Formation
  - 14G G Member - Dolostone and Shale
  - 14F F Member - Dolomitic Shale and Shale
  - 14E E Member - Dolostone
  - 14D D Member - Salt (absent in site area)
  - 14C C Member - Dolomitic Shale and Shale
  - 14B B Member - Dolostone and Anhydrite (2m)
  - 14A2 A2 Member - Dolostone, Shaly Dolostone
  - 14A1 A1 Member - Dolomitic Shale and Shale
- MIDDLE SILURIAN
  - 13 Guelph, Lockport and Reynales Formations - Dolostone
- LOWER SILURIAN
  - 12 Cabot Head Formation - Grey Shale
  - 11 Manitoulin Formation - Argillaceous Dolostone
- UPPER ORDOVICIAN
  - 10 Queenston Formation - Red Shale and Siltstone
  - 9 Georgian Bay Formation - Grey Shale and Siltstone
  - 8 Collingwood Formation - Grey Shale
- MIDDLE ORDOVICIAN
  - 7 Lindsay Formation
  - 7B Upper Member - Limestone and Agrillaceous Limestone
  - 7A Sherman Falls Member - Limestone
  - 6 Verulam Formation
  - 6B Upper Member Shaly Limestone
  - 6A Lower Member Argillaceous Limestone
  - 5 Bobcaygeon Formation - Shaly Limestone to Crystalline Limestone
  - 4 Gull River Formation - Lithographic Limestone
  - 3 Shadow Lake Formation - Siltstone, Sandstone
- CAMBRIAN
  - 2 Cambrian Sandstone
  - ~~~~~ Cambrian Precambrian Unconformity
- PRECAMBRIAN
  - 1 Precambrian Basement - Granitic Gneiss

**NOTE:**

1. STRATIGRAPHIC SEQUENCE WAS DEVELOPED FROM A COMPOSITE OF THE SHALLOW BOREHOLE US-4 ONSITE AND THE DEEP OFFSITE GAS EXPLORATION WELL TEXACO #6 IN BRUCE TWP LOT E CONCESSION IV BASED UPON A MATCH POINT AT THE AMHERSTBURG / BOIS BLANC CONTACT.

**FIGURE D-1: PALEOZOIC BEDROCK GEOLOGY BENEATH BRUCE SITE (GOLDER, 2003a).**

The E Member is approximately 33 m thick and consists of a fine grained, faintly porous and petroliferous dolostone with some thin shale and anhydrite beds. The salt horizon, Member D that can be found elsewhere in the basin, was not encountered.

The C Member is a 46 m thick shale sequence with some thin anhydrite beds occurring within the middle. The C Member apparently did not contain salt and accordingly would not have been subject to the effects of salt solution.

The B Member beneath Bruce is an anhydrite bed approximately 2 m thick.

The lowermost A2 and A1 Members have a combined thickness of approximately 78 m. These members are largely comprised of dolostone and shaly dolostone similar in lithology to the E Member. An anhydrite bed 2 m thick separates the A1 and A2 Member beds and there may be some similar beds of 0.5 to 1-m thickness interbedded near the base of the A1 Member.

#### Middle Silurian Dolostone

The Middle Silurian sequence is approximately 42 m in thickness and is subdivided into the Guelph, Lockport and Reynales Formations.

The Guelph Formation is a potential permeable gas and/or water-bearing horizon approximately 10 m thick. Off-site well records indicate that gas was not encountered but that the water quality was sulphurous (Golder 2003a).

The Lockport Formation includes the 20 m thick Goat Island and the 8-m thick Gasport dolostone beds of variable porosity. This formation overlies the Reynales Formation which consists of a fine grained thin to medium bedded argillaceous to shaly dolostone. The Reynales Formation is approximately 5.5 m thick.

#### Lower Silurian Shale and Dolostone

The Cabot Head Formation is a 30 m thick sequence of soft, fissile shale becoming a shaly dolostone in the lower 10 m of the unit. The Manitoulin Formation is approximately 6 m in thickness and consists of a fine to coarsely crystalline, thinly bedded dolostone with shaly partings.

### Ordovician Shale Sequence

The 207 m thick Ordovician shale sequence identified beneath the Bruce site includes in descending order, the Queenston Formation, the Georgian Bay Formation and the Collingwood Formation.

The Queenston Formation is approximately 80 m thick beneath the Bruce Site. The Formation consists of mudstone with occasional thin interbeds of siliceous to calcareous siltstone. The Georgian Bay Formation is approximately 95 m in thickness with the upper section of the formation consisting of interbedded shale, shaly limestone and siltstone. The lower half of the formation is predominately shale. The Collingwood Formation consists of approximately 32 m of shale.

### Middle Ordovician Limestone Sequence

The Middle Ordovician limestones are sub-divided into four formations, in descending order the Lindsay Formation, the Verulam Formation, the Bobcaygeon Formation and the Gull River Formation.

The Lindsay Formation is approximately 45 m thick. The upper member in this formation consists of very fine grained, thin to medium bedded, nodular textured argillaceous limestone. The lower Member, also known as the Sherman Falls Member, is approximately 9 m thick and consists of similar limestone with medium to thick beds of less argillaceous nature.

The thin to medium bedded shaly limestone of Verulam Formation limestone has a total thickness of approximately 70 m. The unit has a more shaly nature compared to the remaining Ordovician sequence. The formation has been sub-divided into an Upper Member and a Lower Member based upon its geophysical signature and the relative percentage of slake susceptible shaly beds and litho clastic beds.

The Bobcaygeon Formation marks a sharp transition into noticeably less argillaceous and more crystalline calcarenitic limestone compared to the overlying strata. The 30 m thick rock consists of fine to medium grained, thinly to medium bedded, crystalline limestone.

The Gull River Formation is a very fine grained to lithographic limestone. The total thickness of the formation is estimated to be approximately 43 m to 45 m. The rock is similar to the

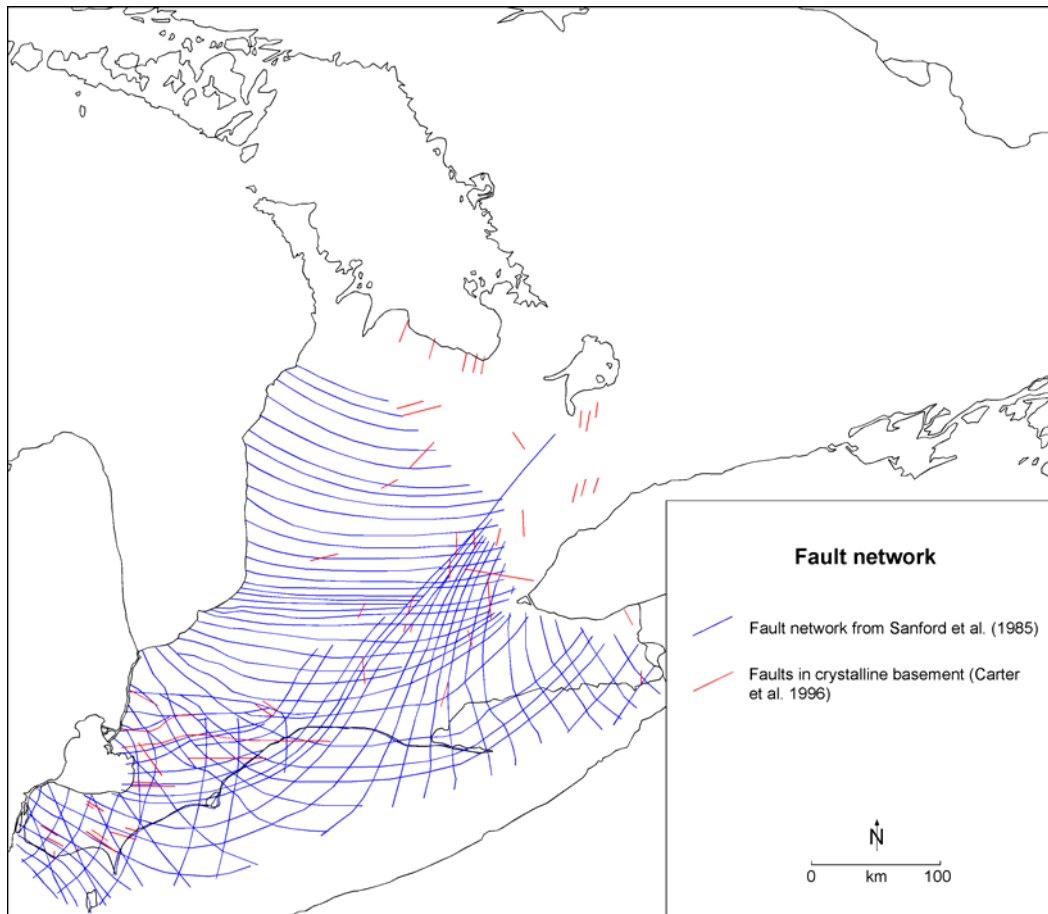
Bobcaygeon Formation with respect to the comparatively low shale content.

#### Shadow Lake Formation and Cambrian Sandstone

The basal sedimentary sequence underlying the Middle Ordovician limestones is the Cambrian basal sandstone and Ordovician Shadow Lake Formation which lie unconformably on Precambrian granitic gneiss. The Cambrian sandstone is known to be locally porous and is approximately 2 to 3 m thick. The Shadow Lake Formation is about 5 m thick and consists of silty and calcareous shales and siltstone alternating with argillaceous, dolomite and limestone (Winder and Sanford 1972).

#### Regional Fracture Network

Based on geologic data obtained from oil and gas well records and observations in LANDSAT imagery, Sanford et al (1985) have postulated that Paleozoic fault movements in southwestern Ontario occurred from late Cambrian to late Devonian times. They used isopach maps of selected marker formations to derive a conceptual framework of fracture systems for southwestern Ontario (Figure D-2). The synsedimentary faulting of this region has a simple geometry as shown in Figure D-2. This faulting is mainly attributed to relative movements along basement faults between the Algonquin Arch and the basin. In reviewing Sanford's conceptual fracture framework, Mazurek (2004) described that these faults could have lengths ranging from tens to hundreds of kilometres and spacings of 10 to 30 km. He also showed that the theory was partially corroborated by Carter et al (1996) using a compilation of regionally mapped basement faulting. This conceptual theory suggests a large block of unfractured rock could exist between regional faults.



**FIGURE D-2: REGIONAL FRACTURE NETWORK MODEL OF SOUTHERN ONTARIO (Mazurek, 2004, compiled from Sanford *et al.* 1985 and Carter *et al.* 1996).**

### D-3 HYDROGEOLOGICAL CHARACTERIZATION

The hydrogeological characterization of the site is based upon previous on-site investigations and correlation with investigation of other areas within Southern Ontario where the same bedrock strata sub-crop (Golder, 2003a). The conceptual hydrogeologic model for Bruce site relevant to the DGR concept is described in section 3.3.5. The information in this section provides background on estimates of hydraulic conductivity within the glacial drift and bedrock strata.

#### *Hydraulic Conductivities*

A summary of geometric mean hydraulic conductivities for the various glacial sediments and bedrock formations beneath Bruce site are plotted in Figure D-3. Based, in part, on these hydraulic conductivity distributions, four horizontally stratified hydrostratigraphic zones were identified. These are described below in descending order from ground surface.

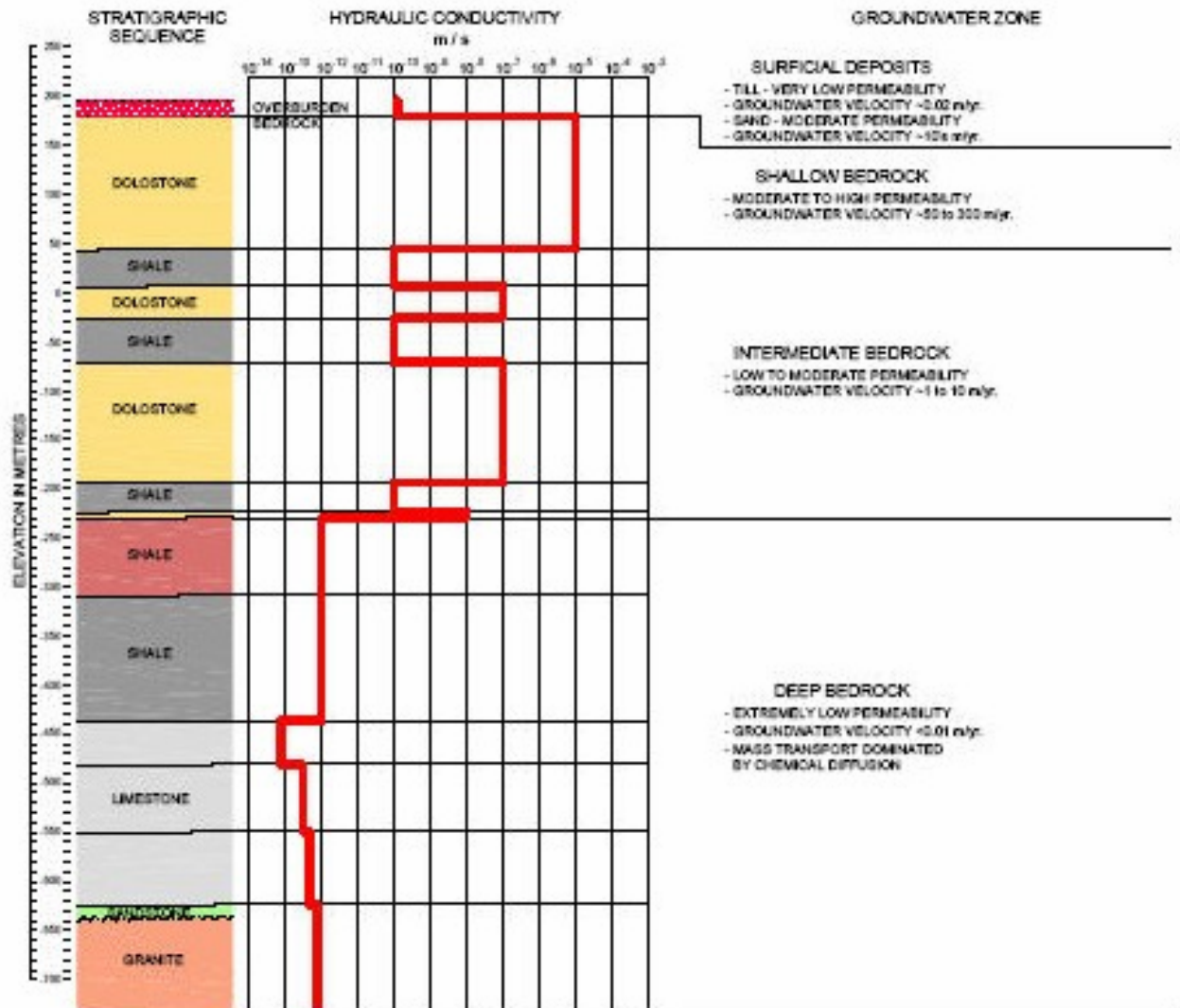


FIGURE D-3 SUMMARY OF HYDRAULIC CONDUCTIVITY (GOLDER 2003a)

The uppermost **Surficial Zone** consists of glacial sediments with thicknesses ranging from 1 to 27 m. The principal unit is a dense glacial till with estimated hydraulic conductivities on the order of  $10^{-10}$  m/s. Locally occurring sand lenses or layers within the glacial till unit possess measured hydraulic conductivities on the order of  $10^{-5}$  m/s.

The second horizon is the **Shallow Bedrock Zone**, which consists of the upper 150 m of the limestone and dolomite of the middle and lower Devonian Formations, the Bass Island Formation of the Upper Silurian and the contact zone with the underlying Salina Formation.

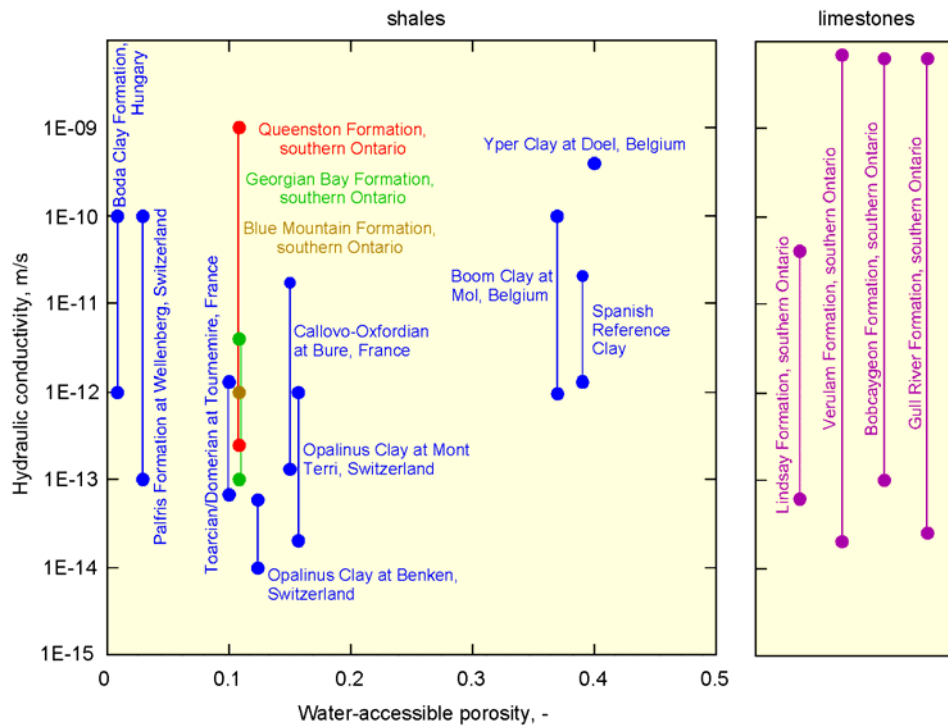
The upper Amherstburg and Bois Blanc Formations were hydraulically tested during on-site investigations and are characterized by moderate to high hydraulic conductivities with a mean value of approximately  $10^{-5}$  m/s. This permeability was verified by observations during generating station foundation and tunnel construction activities at Bruce. It is anticipated that the Bass Island and the upper Salina Formation have the same magnitude of permeability as the upper two units given their similar lithology and geologic history (Golder, 2003a).

The **Intermediate Bedrock Zone** extends down through the remaining sequence Silurian age sedimentary formations. It consists of shale and dolostone of the Salina Formation, the underlying dolostone sequence of the Guelph, Lockport and Reynales Formations, the Cabot Head Formation (shale) and Manitoulin Formation (dolostone). It is anticipated that the hydraulic conductivities within this horizon vary considerably, with the shale units having low values in the order of  $10^{-10}$  m/s and the dolostone have higher values in the order of  $10^{-7}$  m/s (Golder 2003a).

The **Deep Bedrock Zone** is associated with the thick Ordovician shales and limestones. It is anticipated, based on packer injection testing in these formations elsewhere in southern Ontario, that hydraulic conductivities within these formations would range between  $10^{-13}$  to  $10^{-12}$  m/s. Under such conditions it is expected that the migration of solutes would be dominated by diffusion (Golder 2003a).

It is expected that the permeabilities described above are vertically anisotropic as they were estimated from tests conducted largely in vertical or sub-vertical boreholes. The presence of horizontally layered shale and anhydrite beds and the more permeable horizontal bedding planes would infer that vertical permeabilities are potentially lower. As a consequence of this distribution, it is postulated that regional groundwater flow is preferentially horizontal within the horizontally layered aquifer-aquitard hydrostratigraphic system.

Hydraulic conductivities of sedimentary formations considered for radioactive waste management purposes in Europe are compared against those in the Ordovician sediments at the Bruce site in Figure D-4.



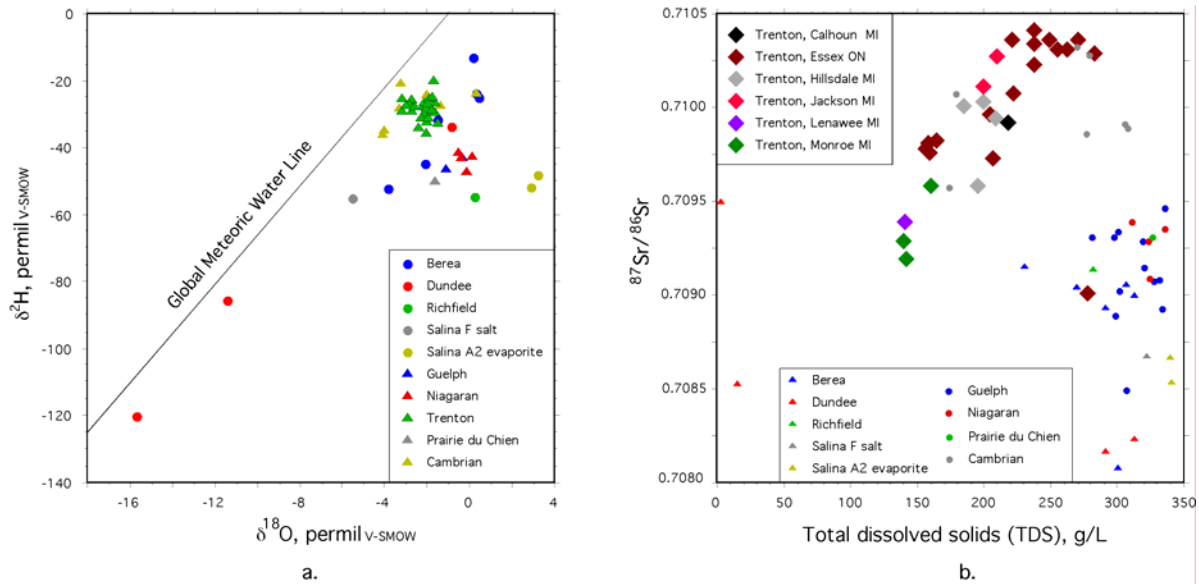
**FIGURE D-4 WATER ACCESSIBLE POROSITY VS. HYDRAULIC CONDUCTIVITY OF VARIOUS ARGILLACEOUS FORMATIONS COMPARED WITH SHALES AND LIMESTONES FROM SOUTHERN ONTARIO (MAZUREK 2004).**

#### D-4 HYDROGEOCHEMICAL CHARACTERIZATION

The groundwater within the uppermost two groundwater flow zones is typical of that in carbonate terrain. It is fresh, hard, neutral to slightly alkaline pH, calcium, magnesium, bicarbonate and sulphate mineralized with total dissolved solids (TDS) in Shallow Bedrock Zones ranging from 1000 to 2500 mg/L. TDS values appear to increase with depth. This is principally associated with increases in sulphate concentrations.

Within the deep groundwater flow domains, groundwater compositions have been summarized in Table D-1. Groundwater samples from deep exploration wells reveal very high TDS concentrations of up to 300,000 mg/L, that are either sodium chloride or calcium chloride dominant. These TDS conditions coupled with formation-distinct stable water isotope ( $\delta^{18}\text{O}$  vs  $\delta^2\text{H}$ ) and  $^{87}\text{Sr}/^{86}\text{Sr}$  ratios (Figure D-5a and b) are indicative of long-term in-situ rock water reaction and very long groundwater residence times.





**FIGURE C-5: CHEMICAL CHARACTERISTICS OF FORMATION WATERS FROM SOUTHWESTERN ONTARIO AND MICHIGAN (DATA FROM McNUTT ET AL. 1987).**  
**A. STABLE WATER ISOTOPES.**  
**B. TOTAL DISSOLVED SOLIDS VS. <sup>87</sup>Sr/<sup>86</sup>Sr. SAMPLING AREAS ARE INDICATED FOR THE TRENTON GROUP.**

	Precambrian	Cambrian	Trenton Gp	Guelph Fm	Salina Fm	Dundee Fm
Ca	65.0	48.0	32.5	31.3	8.2	31.5
Na	16.9	43.8	49.7	65.5	100.0	70.6
Mg	0.01	6.09	5.96	7.77	2.85	5.41
K	0.12	1.39	2.07	1.88	2.60	3.03
Sr	1.39	1.21	0.62	0.435	0.215	0.75
Cl	156.0	179.8	150.3	189.0	207.0	179.0
Br	1.09	1.53	1.19	1.39	0.59	1.05
SO <sub>4</sub>	1.14	0.26	0.335	0.25	0.75	0.165
TDS	241.0	282.0	242.7	297.6	322.2	291.6

Data are in g/L. Source: McNutt *et al.* (1987).

**TABLE D-1: REPRESENTATIVE COMPOSITIONS OF FORMATION WATERS FROM SOUTHWESTERN ONTARIO AND FROM SOUTHEASTERN MICHIGAN**

## D-5 GEOMECHANICAL CHARACTERIZATION

The following description of geotechnical/geomechanical properties for overburden and selected rock formations are compiled based on data from Golder report (2003a).

### Overburden

The sand deposit is described as dense to very dense, fine to medium sand layer with coarse sand to medium gravel. Standard penetration test results of this material reveal values ranging from mid teens to over 100 blows per 0.3 m and the average is in the order of 40 blows per 0.3 m. The underlying dense to hard till has standard penetration values varying from 20s to over a hundred blows per 0.3 m, and from 30s to over 100 blows per 0.3 m for weathered and unweathered till, respectively.

### Amherstburg Formation

The dolostone of the Amherstburg Formation is hard, fossiliferous, finely laminated, horizontally bedded, lightly fractured dolostone. The bedding is medium to massive with some soft bituminous seams on bedding partings with spacing of 0.3 to 3 m (average 1 to 1.2 m). Vertical joint spacings increase with depth with an average ranging from 0.6 to 1 m. The maximum joint spacing is about 1 m along the Amherstburg-Bois Blanc contact. These joints are tight with minor surface weathering. Localized highly fractured zones, leached zones and vuggy to very vuggy zones are present within the formation.

In order to provide an index of the relative behaviour of rock mass surrounding the proposed underground excavation, the Norwegian Geotechnical Institute (NGI) Rock Tunnel Quality Index (Q), as well as, the Rock Mass Rating System (RMR) for the Amherstburg Formation were estimated and are approximately 4.75 and 58, respectively. The rock mass condition is classified as "fair" based on these indexes. Table D-2 presents other mechanical properties for all the rock formations.

### Salina Formation

Because of lack of site-specific information on bedrock formation below 100 m, the description and properties of the shale, dolostones, and evaporites of the Salina Formation are based on gypsum and salt mining observations in Southern Ontario (Golder 2003a). The carbonate rocks have thin to medium bedded, medium grained dolostones to gypsiferous dolostones with vugs or infilling of gypsum, to strong, massive or medium bedded dolomitic limestones. The bedding partings can vary from 0.5 to 4 mm in thickness and can exhibit

gypsum coatings. Solution action could exist in some units. The gypsumiferous dolostones have a brecciated matrix infilled with gypsum stringers or nodules. The Q and RMR index ratings indicate the condition of this rock formation is "fair" (Table D-2).

#### Queenston and Georgian Bay Formations

The Queenston Formation comprises reddish-brown shale with occasional interbeds and nodules of green siltstone. The formation is massive to blocky with some fissile sections. The upper beds show an upwards fining sequence of reddish brown shales and siltstones with less than 30 percent of green muddy siltstone interbeds. The lower beds comprise reddish brown muddy siltstone and siltstone with frequent green siltstone bands. A good demonstration of the massiveness of this rock formation is the construction of a 13.5-m diameter enlargement section of the exploratory audit for the Niagara River Hydroelectric Development scheme in 1991-93.

Within the formation, sub-horizontal bedding planes associated with thin siltstone beds form discontinuities occurring at spacings of 5 to over 10 m. Many of these bedding planes are clay-rich creating weak discontinuity surfaces. The Q and RMR ratings for this rock are 10.75 and 65, respectively (Table D-2). These ratings classify the rock mass as "Good".

The Georgian Bay Formation consists of soft, thin to thick bedded grey shale with interbedded grey limestone beds throughout. A steeply dipping joint set is anticipated in this formation as these joints were encountered during the deep borehole drilling at Lakeview GS (OHD-1). The rock mass is rated as "Good" with ratings similar to those of Queenston Formation.

Both shales exhibit anisotropic deformational behaviour and are susceptible to swelling when unconfined. They also weather very rapidly upon exposure.

#### Lindsay Formation

The upper member of the Lindsay Formation comprises fresh, fine grained, thin to medium bedded, nodular textured argillaceous limestone. The unit is occasionally separated by interbeds of shaly limestone and thin black shale partings. An exception is the Sherman Falls member of the Lindsay Formation, which is much less argillaceous in nature and is a fresh, fine grained, medium to thickly bedded, smaller nodular textured micritic limestone. The unit occasionally contains laminar to thin interbeds of fine to medium grained, partly

crystalline calcarenitic limestone. Q and RMR indexes of 31.7 and 75, respectively, reveal that the overall quality of the rock mass could be classified as "good" (Table D-2).

Previous OPG experience in underground excavation in this rock formation was the tunnel construction at Darlington and Wesleyville GSs. The approximately 8 m wide Darlington intake tunnel was a horseshoe cross-section and was constructed in 1981-82. The tunnel was excavated horizontally to about 800 m under Lake Ontario at a maximum depth of about 35 m. Drill-and-blast technique was used for the excavation and no significant construction problems were encountered during the process. The excavation was dry with no visible seepage reported (Figure 2-8).

The Wesleyville access tunnel was excavated in 1978-79 and is 6-m wide by 5-m high rectangular in shape. The tunnel is about 470 m long and extends to a maximum depth of about 60 m. Drill-and-blast technique was also used. There are no significant problems during construction. The tunnel was completely dry except some seepage was observed along the overburden/rock contact and from a shale seam at about 23 m depth below ground surface.

#### In-situ Stresses

The regional stress field in southern Ontario is characterised by excess horizontal stresses. The in-situ stress measured in Queenston, Georgian Bay and Lindsay Formations are tabulated in Table D-2. These maximum horizontal stresses shown are known to be larger than the vertical stresses. Despite the deepest measurement of in-situ stresses being less than 200 m, it is anticipated that the magnitude of stresses would increase significant with depth. According to Mazurek (2004), limited stress measurements from southern Ontario, mainly from the Niagara Megablock, indicate the directions of the maximum stress trajectories generally fall within the NE quadrant. It was suggested that a thrust or a strike-slip regime (or a combination of both) appear to be mostly likely existing in Bruce site region. High in-situ compressive stresses in the rock mass are one of the beneficial features identified from the point of view of fault sealing.

Formation	Rock Type		$\gamma$ (MN/m <sup>3</sup> )	$\sigma_c$ (Mpa)	E (Gpa)	$\nu$	Q (RMR)	$\sigma_t$ (Mpa)	$\sigma_H$ (Mpa)
Amherstburg	Dolostone	Median	2.45	60	45		4.75 (58)		
		Range	2.35 - 2.6	12 - 136	9 - 117				
Salina	Dolostone	Median	2.6	100	35	0.25	3.5 (56)	5	
		Range		85 - 120	30 - 40	0.25 - 0.3		4 - 7.5	
	Shale	Median	2.6	35	8	0.35	0.8 (42)	1.5	
		Range			8 - 10			1 - 2.6	
	Gypsum	Median	2.4	30	8	0.35	3.0 (54)	1.5	
		Range		25 - 35				1.1 - 2.7	
Queenston	Shale	Median	2.68	40	12	0.3	10.75 (65)	3	
		Range		33 - 46	6 - 23	0.10 - 0.44		2 - 4.6	5 - 9
Georgian Bay	Shale	Median	2.6	36	20	0.2	7.5 (62)		
		Range		11 - 97	11 - 41	0.10 - 0.20			1 - 9
Lindsay	Limestone	Median	2.65	60	40	0.3	31.7 (75)		
		Range	2.6 - 2.65	25 - 140	16 - 66				9 - 13

$\sigma_c$  – Uniaxial Compressive strength of intact rock

E – Intact elastic modulus

Q – NGI Tunnel Quality Index

RMR – CSIR Rock Mass Rating

$\nu$  – Poisson's ratio

$\sigma_t$  – Tensile Strength of Intact Rock

$\sigma_H$  – Horizontal in-situ stress (insitu stresses are dependent on depth. Values shown on this table were measured at <200 m depth)

$\gamma$  – Unit weight of rock

**TABLE D-2: GEOMECHANICAL PROPERTIES OF SEDIMENTARY ROCKS (GOLDER 2003a)**

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## APPENDIX E: PRELIMINARY SAFETY ASSESSMENT

Based on the favourable site characteristics, as discussed in section 4.3.2, and waste characteristics, post-closure dose impacts are expected to be very small. This is supported by the preliminary safety assessment of the DGR in limestone concept at the Bruce site by Quintessa Limited (UK) (Quintessa, 2003). Similar results were estimated for the DGR in Ordovician shale concept. Quintessa has adopted the best international practice in safety assessment of a radioactive waste repository for the study (International Atomic Energy Agency's ISAM (Improving Long Term Safety Assessment Methodologies for Near Surface Radioactive Disposal Facilities)). The approach is applicable to the DGR and is designed to provide a reasoned and comprehensive analysis of post-closure radiological impacts of the repository concept. It consists of the following steps:

1. specification of the assessment context (what is being assessed and why it is being assessed);
2. description of the repository system (the *near field*, *geosphere* and *biosphere*);
3. development and justification of the *scenarios* to be assessed;
4. formulation and implementation of models and associated data; and
5. presentation and analysis of the results.

Based largely on expert judgement and use of the ISAM list of features, events and processes associated with a radioactive waste repository, two scenarios have been considered in the preliminary assessment.

1. **Reference Scenario** considers the gradual release of radionuclides from the repository due to natural processes such as dissolution. The subsequent migration and dispersion of radionuclides in the environment and the resulting potential exposure of humans to the radionuclides is considered.
2. **Human Intrusion Scenario** considers the possible inadvertent disruption of the wastes in the future. The scenario is representative of the type of disturbance that might be caused by future exploration activity resulting in the potential direct exposure of individuals to essentially undiluted waste materials.

Three calculation cases were identified associated with these two scenarios (Table E-1). Each had a specific conceptual model that provided a description of the release, migration and fate of radionuclides from the repository and the associated features, events and processes considered in the model. The features, events and processes associated with each conceptual model have been represented using algebraic expressions within a mathematical model.

Site-specific data from the Bruce site and its vicinity were obtained and supplemented with other information, e.g., from compilations of data from other sources. The mathematical models and associated data were implemented in a software tool (AMBER) to simulate the migration of radionuclides from the near field into the environment, and to calculate the resulting dose and environmental consequences for each calculation case. AMBER was developed under Quintessa's quality management system, which is compliant with the international standard ISO 9001:2000.

Scenario	Calculation Case Name	Potential Exposure Group(s)	Features
Reference Scenario	Lake Release	Fisherman	Contaminated groundwater release by diffusion to Intermediate Bedrock Groundwater System, then transport to off-shore lake sediments.
	Shaft Pathway	Fisherman	Contaminated groundwater released via shaft and transported via more diffusive pathway to Intermediate Bedrock Groundwater System, then transport to off-shore lake sediments.
Human Intrusion Scenario	Exploration Borehole	Intruder	Waste retrieved to the surface via deep borehole.

**TABLE E-1: CALCULATION CASES ASSESSED FOR THE DGR IN LIMESTONE CONCEPT**

The safety criteria for this study were taken from the recommendations of the International Commission on Radiological Protection (ICRP) 81, with the exception that the criteria for human intrusion are more restrictive. For all events other than human intrusion, the calculated dose rate constraint is 0.3 mSv y<sup>-1</sup>. For inadvertent human intrusion, the following criteria were used:



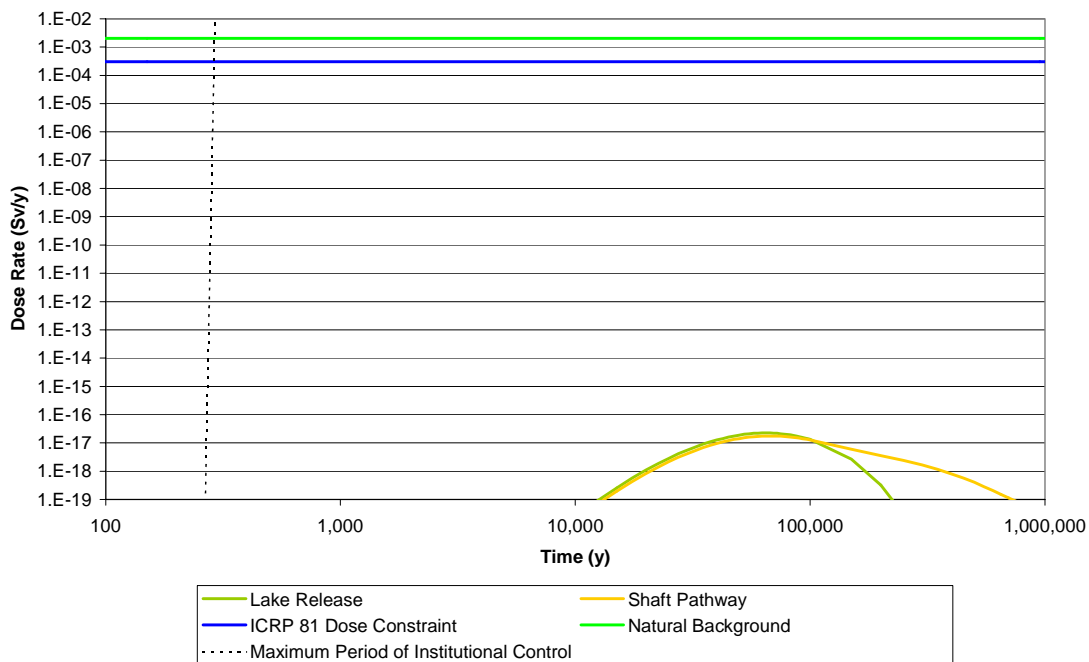
- a) If the calculated dose rate is below 1 mSv y<sup>-1</sup>, optimization of the repository system is not required;
- b) If the calculated dose rate is above a level of 1 mSv y<sup>-1</sup>, reasonable efforts should be made to reduce the likelihood of human intrusion or to limit its consequences;
- c) If the calculated dose rate is above a level of 100 mSv y<sup>-1</sup> efforts must be made to reduce the consequences of human intrusion below this level.

The ICRP 81 criteria were selected for this study prior to issuance of the CNSC draft G-320 document, which suggests a radiological risk criterion of 10<sup>-5</sup> per year (CNSC, 2005). This risk criterion corresponds to a radiological dose criterion of 0.14 mSv y<sup>-1</sup> for the reference scenario. The calculation results were also compared to the average annual individual radiation dose rate from natural background radiation in Ontario, about 2 mSv y<sup>-1</sup> (LaMarre, 2003). The background radiation excludes the contribution from man-made background and medical exposures. In addition to annual dose rate, radionuclide concentrations in lake water were used as indicators of safety.

### **Reference Scenario**

Radionuclides released from the DGR would diffuse through the limestone and overlying shale before being released into the dolostone aquifer in the Intermediate Bedrock Groundwater System. The aquifer would then discharge into Lake Huron at a distance of 10 to 20 km, where it sub-crops in the lake. The total calculated dose rates for the two groundwater release cases in the Reference Scenario from LLW are shown in Figure E-1. This figure shows that the calculated dose rates for LLW are extremely low, many orders of magnitude below natural background and ICRP dose constraint. The calculated peak dose rate for LLW is 2.3 x 10<sup>-17</sup> Sv y<sup>-1</sup> at 65,000 year for the Lake Release Case and 1.8 x 10<sup>-17</sup> Sv y<sup>-1</sup> at 67,500 year for the Shaft Pathway Case. (The time at which the peak dose rate occurs is likely in the order of hundred thousands or million of years for the smaller effective diffusivity actually expected for Ordovician limestone and shale, compared with that conservatively assumed in the Quintessa calculations). This low dose rate is due to the extremely effective confinement of the radionuclides by the host rock. In the limestone and shale, there is no advective circulation of groundwater, and so radionuclide migration can only occur via diffusion. Radionuclides are further dispersed and diluted in the

Intermediate Bedrock Groundwater System and in the lake. The main exposure pathways are fish ingestion (91%) and water ingestion (9%).



**FIGURE E-1: CALCULATED DOSE RATES FOR REFERENCE SCENARIO FROM LLW (QUINTESSA, 2003)**

The very effective containment of radionuclides in the DGR means that only highly mobile and long-lived radionuclides are released within the timeframe of the calculations. The calculated dose rate is dominated by I-129. The next most significant radionuclides are Cl-36 and Tc-99. Although these radionuclides are highly mobile in groundwater, the slow rate of transport by diffusion through the limestone and shale means that the peak dose rate is not reached until about 65,000 years after DGR closure. Other radionuclides that are more highly sorbed are transported more slowly, and consequently they are not released in the period of calculations. This gives the opportunity for most of these radionuclides to decay before reaching the lake.

Table 5-2 compares the calculated peak radionuclide concentrations in lake water from LLW with the Maximum Acceptable Concentrations (MACs) in drinking water and background concentrations in surface water. The radionuclide concentration in lake water from LLW is very low, both because of the long period over which radionuclides are released and the large volumes into which groundwater is dispersed and diluted. No values are available on the MAC for Cl-36, but calculated concentrations are well below the lowest MAC value for any radionuclide (100 Bq m<sup>-3</sup> for Pb-210 and Th-232 (Health Canada, 2002)). Data are available for I-

I-129 and Tc-99. Calculated concentrations are well below the MAC (see Table E-2), and are much lower than background concentrations resulting from fallout from atmospheric nuclear weapons testing.

Radionuclide	MAC (Water, Bq m <sup>-3</sup> )	Background Concentration (Bq m <sup>-3</sup> , Surface Water)	Calculated Peak Concentration (Bq m <sup>-3</sup> , Lake Water)
I-129	1 000	3.0x10 <sup>-5</sup>	1 x 10 <sup>-11</sup>
Cl-36	-	4.8x10 <sup>-3</sup>	5 x 10 <sup>-10</sup>
Tc-99	200,000	1.5x10 <sup>-5</sup>	3 x 10 <sup>-12</sup>

**Notes:** Maximum Acceptable Concentrations are defined in Health Canada (2002). Data on background concentrations for I-129 and Tc-99 in surface water have been obtained from Amiro (1992). Cl-36 background concentration in Lake Huron water is from Bird and Schwartz (1997).

**TABLE E-2 COMPARISON OF CALCULATED PEAK CONCENTRATIONS FROM LLW WITH MAXIMUM ACCEPTABLE CONCENTRATIONS AND BACKGROUND CONCENTRATIONS, SHAFT PATHWAY CALCULATION CASE**

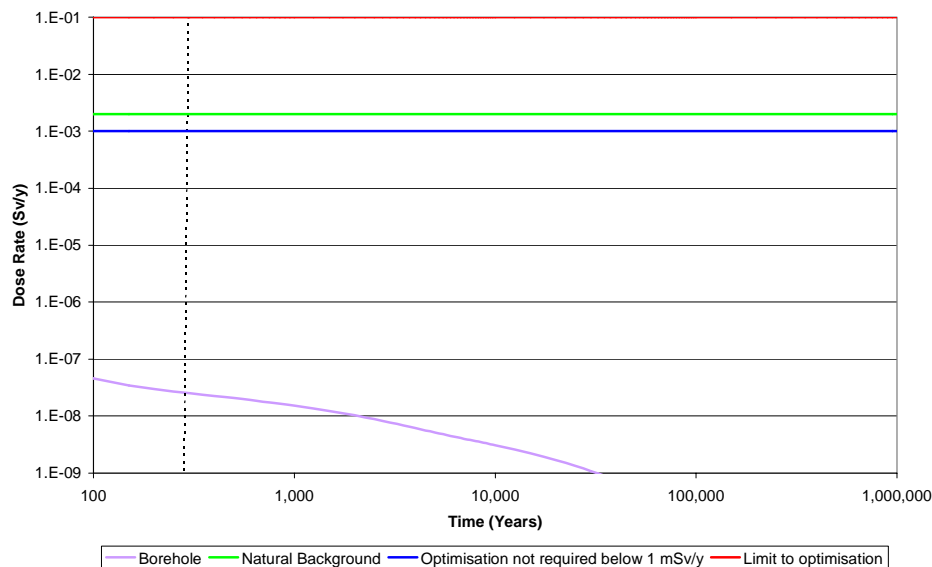
In addition to Quintessa's calculations for LLW, a simple one-dimensional diffusion calculation for ILW has shown that there would be no I-129 (the key radionuclide) released through the deep shale layer (400 m below the surface) for one hundred thousand years, and that the peak concentration of I-129 at the top of the deep shale layer would be less than 100 Bq m<sup>-3</sup>. The concentration in the surface water would be even much lower. The dose rate that would result from drinking water with the radionuclide levels in the groundwater from this shale layer, would be less than 0.01 mSv y<sup>-1</sup>. This is much less than the ICRP 81 dose constraint of 0.3 mSv y<sup>-1</sup> and the natural background dose rate of about 2 mSv y<sup>-1</sup>. Furthermore, the calculated peak I-129 concentration at the top of the deep shale layer is much less than the MAC in drinking water. In fact, no one would actually drink the groundwater from the top of the deep shale layer, because the deep groundwaters are undrinkable (too saline) and unrecoverable (rock is too impermeable).

### **Human Intrusion Scenario**

Isolation of the waste from the surface reduces the range of intrusion events that could affect the wastes for the DGR concept. For the DGR, located several hundred metres below the surface, it is only possible to envisage the incidental extraction of borehole samples that contain waste. Larger excavations are not credible, given the low mineral value of the formations under consideration.

Human intrusion results for the DGR concept therefore only consider the Borehole Calculation Case (Quintessa, 2003). In this case, even though the radionuclides are effectively retained in the DGR over very long periods of time, the limited amounts of waste retrieved means that calculated dose rates for LLW is very low ( $3 \times 10^{-8} \text{ Sv y}^{-1}$  at 300 years), as shown in Figure E-2. The dose rates are well below the ICRP human intrusion threshold of  $1 \text{ mSv y}^{-1}$  and the natural background dose rate of  $2 \text{ mSv y}^{-1}$ . In addition, the likelihood of human intrusion is very small due to the depth of the repository (few hundreds of meters below ground) and the low resources for oil, gas, minerals and drinkable water. Therefore, the risk from human intrusion is expected to be very small.

Potential doses from the human intrusion scenario are dominated by the inhalation of dust. Consequently, the radionuclides that dominate doses are those with high inhalation dose coefficients – long-lived alpha emitters such as Pu-239, Pu-240 and Am-241.



**FIGURE E-2: CALCULATED DOSE RATES FOR HUMAN INTRUSION SCENARIO FROM LLW (QUINTESSA, 2003)**

In summary, Quintessa's preliminary post closure safety analyses indicated that the DGR concept for LLW would meet the ICRP 81 safety criterion of  $3 \times 10^{-4} \text{ Sv y}^{-1}$  by a very large margin.

The ability of the repository designs to accept OPG's ILW was assessed qualitatively (Quintessa, 2003). Due to the very low permeability of the host rocks, the DGR concept is likely to meet the radiological protection criteria adopted for this study for a wide range of ILW. This is supported by the simple diffusion calculation for ILW, which indicated very low I-129 concentration at the top of the deep shale layer.

Based on the site characterization data and DGR design updates, the safety assessment of the DGR will be updated for L&ILW. In addition to the existing good baseline environmental data about the site surface conditions, the site will be monitored for decades during the licensing, construction and operation periods, so that there will be a substantial database of information on the deep groundwater system and repository performance to confirm the site characteristics, before a decision on repository closure is made.

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## **APPENDIX F: COMMUNITY COMMUNICATION AND CONSULTATION PLAN FOR THE DGR PROJECT**

### **F-1 INTRODUCTION**

The Bruce area has been the focus of a number of projects over the last few years and several organizations, including Bruce Power, the NWMO and OPG have been carrying out community consultation in the area. There is a real risk of "consultation fatigue" and it is important that future plans address this issue. The Communications and Consultation Plan for the DGR project will use a multi-tactic approach to provide a broad range of opportunities and methods to make it easy for the community to obtain information, ask questions, identify issues and provide comments regarding the DGR Project.

This section summarizes the detailed stakeholder consultation and communication plan developed by OPG for the DGR project.

### **F-2 FOCUS AREA**

The primary focus area for the communications and consultation plan will consist of the host municipality of Kincardine and the four adjacent municipalities of Saugeen Shores, Brockton, Huron-Kinloss and Arran-Elderslie. In addition, some members of the public, including stakeholders and interested parties that do not live in close proximity to the Bruce site will be included in all aspects of the plan. These include the Nawash and Saugeen First Nations and interested stakeholders in the Owen Sound area.

OPG recognizes the requirements of the *International Convention on Environmental Impact Assessment in a Transboundary Context* (Espoo, Finland, 25 February 1991) to:

- take all appropriate and effective measures to prevent, reduce, and control significant adverse transboundary environmental impacts of proposed activities; and
- to "ensure that affected Parties are notified" of the proposed installation

Based on the information presented in this Project Description, particularly Section 4, OPG does not believe that environmental effects of the DGR will be experienced outside of the primary focus area. OPG is therefore not planning to actively inform or seek to engage stakeholders in the United States in consultation on the proposed DGR. Several stakeholders in the United States

have asked and have been included on the stakeholder list to receive communications about the proposed DGR.

The DGR web page ([www.opg.com/dgr](http://www.opg.com/dgr)) will continue to be updated as new information about the DGR project becomes available. The web page and accompanying comment form will be the primary vehicle for those outside the primary focus area to obtain information about the DGR project and to provide feedback to OPG. All questions from any interested stakeholder will continue to be responded to.

### **F-3 PROCESS**

To maximize the effectiveness of the communication and consultation plan, the following process will be followed:

- a. Transparency and openness in all aspects of the communication and consultation program.
- b. Maintain flexibility to respond to unanticipated issues and stakeholder input throughout the EA study period.
- c. Identify interested stakeholders and members of the public along with the appropriate level of their communications needs and interests.
- d. Inform all stakeholders about the progress of the project, i.e., key milestones and key activities
- e. Provide multiple and various types of opportunities for stakeholders to identify and discuss any concerns they may have with the project
- f. Document and maintain a record of all communication and consultation processes and outcomes
- g. Identify and document issues, comments and concerns as they are raised by stakeholders related to the Project
- h. Develop and maintain an up-to-date stakeholder comment and response database
- i. Maintain a public website where comments and responses to issues can be accessed by stakeholders

### **F-4 STAKEHOLDERS**

An unprecedented level of pre-project communication and consultation regarding the DGR proposal has taken place in the Bruce area over the last three and a half years. This has



enabled OPG to identify a number of individuals, groups and key stakeholders included in the following categories:

- a. General Public in the vicinity of the Bruce site
- b. Landowners in the vicinity of the proposed DGR
- c. Community Committees including the Bruce Liaison Committee, the Impact Advisory Committee and local economic development/tourism committees etc.
- d. Regulatory Agencies including the CNSC, local MOE and the Medical Officer of Health
- e. Federal government including the local MPs and departmental and agency staff, i.e., Natural Resources Canada, Environment Canada, AECL, etc.
- f. Local First Nations, i.e., Chippewas of Saugeen and Nawash
- g. Provincial Government including the local MPPs and departmental and agency staff, i.e., Ministry of Energy, Ministry of Finance, Ministry of the Environment
- h. Regional and local councils, agencies and staff
- i. Established Non-Governmental Organizations (NGOs)
- j. Bruce Power and OPG Employees and Retirees
- k. Print and Broadcast Media

OPG will continue throughout the EA study period to actively identify additional stakeholders.

## **F-5 COMMUNICATION AND CONSULTATION ACTIVITIES IN SUPPORT OF THE ENVIRONMENTAL ASSESSMENT**

### a) Key Stakeholder Briefings

During the pre-DGR project period, OPG identified and provided briefings to several key stakeholders, including the Local MP, MPP, First Nations, Local Councils, Medical Officer of Health, Local MOE Supervisor and District Engineer, the Bruce Liaison and Impact Advisory Committees. OPG will continue throughout the EA study period to provide briefings at key stages of the Project and will actively seek the concerns, views and opinions of key stakeholders in the Bruce area.

### b) Open Houses

OPG will conduct several rounds of open houses in the DGR project focus area to communicate key milestone activities such as information on sub-surface characteristics, conceptual design of the DGR and the safety assessment.

c) Mobile DGR Exhibit

OPG is looking at additional ways to engage the public in the Bruce area. A mobile exhibit will be developed to be deployed at community events to take information on the DGR project to the public rather than having them attend one of our open houses. The exhibit can be deployed at Fall Fairs, Home Shows etc. throughout the DGR project focus area.

d) Advertising

During the pre-project consultation period, OPG used newspaper advertorials to get key points regarding the DGR proposal to the public. This tactic proved very helpful in getting information to the public and creating discussion and exchanges of information. OPG will continue to use this vehicle to engage the public in the project focus area.

e) Web Site

A project web page on the main OPG web site will be developed. The web site will serve as a vehicle to provide information to interested parties, as well as a mechanism to receive input from interested parties as an enhancement of the communication and consultation program. Information such as scope, schedule, descriptions, events and contacts pertaining to the Project and the EA study will be maintained current.

f) Media Interviews

The media are an important vehicle to disseminate information to a wider audience. Media interviews with key project staff will be arranged as required to allow access to experts at various stages of the EA study.

g) Newsletters

Newsletters/brochures relating to the DGR project, including key dates and events will be prepared and distributed to stakeholders, residents and businesses in the primary focus area for the project.

h) Employee Communications

Employee communications will be provided through presentations, the NWMD Quarterly Business Review and the internal NWMD intranet site.

## i) First Nations

OPG will continue to work with First Nations to develop and implement a Memorandum of Understanding on joint communications between the two, including communications on the proposed DGR, existing operations and aboriginal traditional knowledge.

## j) Speaking Engagements

OPG will continue to provide speakers for groups and organizations to learn more about the DGR project and provide opportunities for comment and exchanges of information.

## k) Use of Libraries

Libraries throughout the project focus area will be used as repositories for DGR project information to provide public access to the information.

## l) Stakeholder Comment Database

A comment database will be created to track, record and monitor all comments, correspondence and communications with stakeholders throughout the Project communication and consultation process.

## m) Consultation with Non-Government Organizations (NGOs)

OPG will provide an opportunity for NGOs to obtain information and provide comments on the proposed DGR Project.