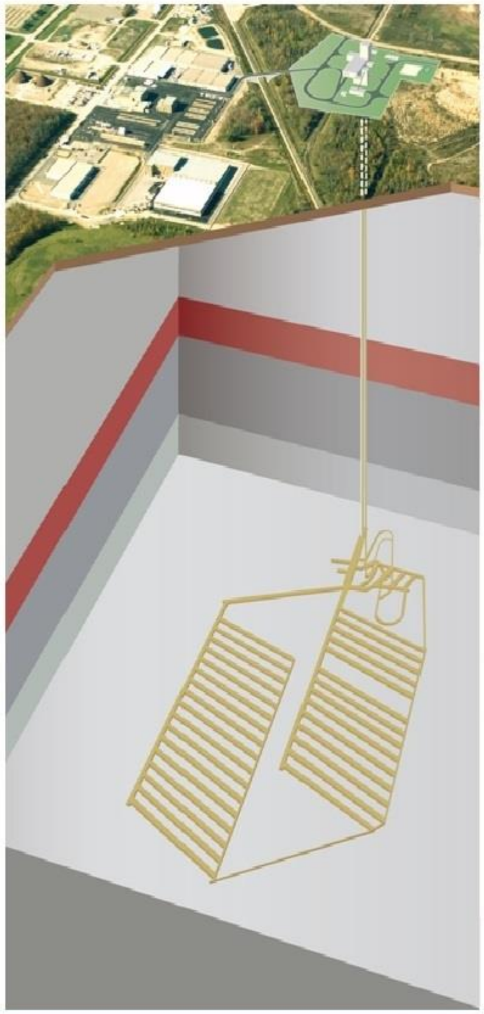
OPG'S DEEP GEOLOGIC REPOSITORY PROJECT

For Low & Intermediate Level Waste

December 2016



Study of Alternate Locations Main Submission

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ABOUT OPG & THE DEEP GEOLOGIC REPOSITORY

Ontario Power Generation Inc. (OPG) is an Ontario-based electricity generation company whose principal business is the generation of electricity in Ontario. OPG was established under the *Business Corporations Act* (Ontario) and is wholly owned by the Province of Ontario.

OPG produces about half of the electricity Ontario homes, schools, hospitals and businesses rely on each day. OPG owns one of the most diversified, low-cost and low-emission electricity generating portfolios in North America. As of September 30, 2016, OPG had an in-service capacity of 17,055 megawatts from two nuclear generating stations; 65 hydroelectric stations on 24 river systems; two biomass stations, one thermal station, and one wind turbine. OPG owns but does not operate two other nuclear generating stations which are leased to Bruce Power L.P., and is co-owner of two gas-fired generating stations. The electricity OPG produces is 99 per cent free of smog and greenhouse gas emissions.

In its 2013 Long Term Energy Plan, the Government of Ontario committed to nuclear as the backbone of Ontario’s electricity system into the future. Ontario’s nuclear fleet (including the Darlington, Pickering and the Bruce Nuclear Generating Stations) currently supplies enough power to meet 60 per cent of Ontario’s daily electricity needs, and is the Province’s largest source of clean, reliable, affordable power. In 2016 the Province announced the decision to proceed with the refurbishment of units at both the Bruce and Darlington Nuclear Generating Stations.

“Proceeding with the refurbishment at Darlington will ensure that nuclear continues to be Ontario’s single largest source of power.”
Minister of Energy, Province of Ontario, January 11, 2016

Since the early 1970’s the Low and Intermediate Level Radioactive Waste (L&ILW) produced as a result of the operation of OPG’s owned nuclear reactors has been stored centrally at OPG’s Western Waste Management Facility (WWMF) located on the Bruce Nuclear site in the Municipality of Kincardine. The existing storage practices are safe and could be continued safely for many decades. However, given that the wastes remain radioactive for thousands of years, long term management is required.

OPG’s plan for the safe, long term management of L&ILW produced at the Darlington, Pickering and Bruce nuclear generating stations, is to develop a facility capable of safely isolating the wastes from people and the environment over the time frame that the wastes remain radioactive. The facility is a Deep Geologic Repository (DGR) located at the Bruce Nuclear Generating Station site in the Municipality of Kincardine where the waste is currently stored.

“OPG’s DGR is a key component of Ontario’s plans to ensure that nuclear remains the backbone of our electricity system for years to come.”
Minister of Energy, Province of Ontario, June 2, 2016

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EXECUTIVE SUMMARY

The federally-appointed Joint Review Panel issued its Environmental Assessment Report in May of 2015, confirming that OPG's DGR at the Bruce Nuclear site is the preferred solution for the management of L&ILW. The Panel concluded that the DGR is not likely to cause significant adverse environmental effects, taking into consideration the commitments made by OPG, the proposed mitigation measures and the recommendations of the Panel. Further the Panel concluded the DGR would not affect Lake Huron and the DGR should be built sooner rather than later to ensure the waste is isolated from the surface environment.

In February 2016 the federal Minister of Environment and Climate Change required OPG to provide additional information prior to making a decision on the DGR EA. In particular, the Minister requested a study that details the environmental effects of technically and economically feasible alternate locations for the DGR Project.

As requested by the Minister OPG has completed an evidence-based study which:

- makes specific reference to alternate locations which meet OPG's criteria and thresholds for technical and economic feasibility,
- determines the environmental effects of the DGR at those alternate locations,
- identifies incremental costs and risks for the off-site transportation of the L&ILW to the alternate locations, and
- identifies additional project related costs and uncertainties associated with alternate locations.

OPG's study shows that the primary objectives of public and worker safety and protection of the environment can be achieved through alternate locations which satisfy OPG's technical and economic feasibility criteria, including the capability to contain and isolate radioactive waste.

OPG's study shows that there would be more environmental effects of a DGR at an alternate location than the environmental effects of the DGR Project at the Bruce Nuclear site. This results from:

- increased effects on air quality, including increased GHG emissions, due to waste transportation from the WWMF to the alternate location;
- increased effects on noise levels due to likelihood of quieter background levels at the alternate locations;
- adverse effects on vegetation communities from increased clearing during site preparation and construction of surface facilities and supporting infrastructure, including access roads;
- adverse effects on wildlife communities due to establishment of a new up to 900 ha site with associated indirect effects from vegetation loss and habitat fragmentation;
- effects on traditional and non-traditional land use due to establishment of a new site and change in land use, traffic from waste transport and workers, and indirect nuisance-related effects relative to background levels;
- increased worker radiation exposure during waste transportation; and
- establishment of new sources of radiation exposure at a location where there is likely to be no existing anthropogenic sources of exposure.

OPG's study shows that relocating the DGR Project to an alternate location would require approximately 22,000 - 24,000 radioactive shipments resulting in over a million kilometres of travel on public roadways throughout the duration of the transportation campaign. The incremental conventional transportation risks are estimated to be between three and 69 road collisions. It would also add a small but incremental risk of exposure to radioactivity to the public and workers. The identified risks are manageable and L&ILW transportation can be conducted safely provided that appropriate processes and programs are in place to ensure safety objectives are met.

OPG's study shows that the incremental costs for implementing a DGR at an alternate location would range from $1.2B and $3.5B (this is in addition to the current cost of $2.4B (2017$) for the DGR Project at the Bruce Nuclear site). These additional costs are attributable to the range of activities that would be required for an alternate location including a multi-year consent based siting process; acquisition of land; development and implementation of services to support facility operation; repackaging and transportation; and re-starting the regulatory approvals and licensing process.

OPG's study also shows that there would be considerable uncertainties associated with a DGR at an alternate location including the time required to develop and implement a consent based site selection process and achieve a willing and supportive host community, as well as the consent of Indigenous communities.

In this respect, OPG's relationship with the Municipality of Kincardine is important, as it was the Municipality of Kincardine that initiated the discussions, recommended the approach and supports as a willing host, the DGR Project at the Bruce Nuclear site.

OPG's relationship with SON is also important as it reflects a commitment for a new type of relationship. OPG and SON have jointly established processes for meaningful and ongoing engagement, to help the community understand the nature of the DGR and its impacts, and to address potential project related impacts identified through those processes. OPG has committed not to move forward with construction until the SON community is supportive of the DGR Project at the Bruce Nuclear site.

OPG's study was reviewed by international experts in waste repository siting. L&ILW repositories have been judged to be safe in locations next to bodies of water (the Baltic Sea, in the case of Sweden and Finland and the Pacific Ocean in the case of South Korea). In the view of the international experts, the proposed DGR Project at the Bruce Nuclear site is a highly robust solution and is consistent with or superior to the approaches utilized in other countries. They believe that deferring costs to future generations, when a safe, cost-effective option already exists, is not necessarily in the best interests of society.

OPG therefore concludes that the DGR Project at the Bruce Nuclear site remains the preferred location based on a relative consideration of environmental effects, transportation risks, transportation and other project-related costs and uncertainties; and the absence of any guarantee of improved safety or environmental quality at an alternate location.

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1. INTRODUCTION

In February 2016 the federal Minister of Environment and Climate Change requested Ontario Power Generation (OPG) to provide additional information prior to making a decision on the Environmental Assessment (EA) regarding OPG's Low and Intermediate Level Waste (L&ILW) Deep Geologic Repository (DGR) Project. In particular the Minister requested:

a) A study that details the environmental effects of technically and economically feasible alternate locations for the Project, with specific reference to actual locations that would meet OPG's criteria for technical and economic feasibility. In conducting this study, OPG is to detail the thresholds for what is considered to be technically and economically feasible. In addition, OPG is to indicate what the incremental costs and risks would be for additional off-site transportation of the nuclear waste.
b) An updated analysis of the cumulative environmental effects of the Project in light of the results of the Phase 1 Preliminary Assessments undertaken by the Nuclear Waste Management Organization, which identified three potential host communities that fall within the traditional territory of the Saugeen Ojibway Nations (SON).
c) An updated list of mitigation commitments for each identified adverse effect under CEAA [Canadian Environmental Assessment Act] 2012. OPG shall identify out-dated or redundant commitments that were previously brought forward to the Panel.

This report and accompanying documents are OPG's response to item a), Study of Alternate Locations.

The response to the information requested is documented in four reports, a main submission and three technical documents. This report is the main submission which provides context, describes the project for study purposes, summarizes the studies, and presents other project related costs and the overall findings. The technical documents present detailed information on different elements of the information requested. The technical documents are:
- Description of Alternate Locations
- Environmental Effects of Alternate Locations
- Cost and Risk Estimate for Packaging and Transporting Waste to Alternate Locations

The technical documents and the main submission rely to some degree, on content in the others. Cross-references are provided where appropriate. These four documents in total constitute the response to the Minister on this particular study request.

This report is structured as follows:

- Criteria and thresholds for economic and technical feasibility are discussed in Section 2;
- The project as described for the purposes of this study is in Section 3;
- The alternate locations are described in Section 4;
- The environmental effects are described in Section 5;
- The transportation program costs and risks and other project costs are discussed in Section 6;
- A discussion of OPG's social licence including Indigenous communities' perspectives is in Section 7;
- Communications and engagement are described in Section 8;

- Section 9 presents the findings from a panel of international experts; and
- Section 10 presents the overall summary and conclusions.

1.1 BACKGROUND ON THE DGR

The proposed DGR will accommodate all of the L&ILW from the operation of the current fleet of nuclear reactors in Ontario, including the wastes generated during the refurbishment of the existing stations. The DGR will protect health, safety and the environment, and if necessary, will do so in the absence of institutional controls (administrative or physical controls that help minimize the potential for exposure).

Radioactive wastes to be accepted by the DGR are classified as solid low-level or solid intermediate-level. The classification is as described below, and is consistent with Canadian Standards Association standards (specifically N292.3). Low level waste (LLW) consists of non-fuel waste in which the concentration or quantity of radionuclides is above the clearance levels and exemption quantities established by the regulations under the *Nuclear Safety and Control Act*, and which contain primarily short-lived radionuclides (i.e., half-lives shorter than or equal to 30 years). LLW normally does not require significant shielding for worker protection during handling and storage. Intermediate level waste (ILW) consists of non-fuel waste containing significant quantities of long-lived radionuclides. ILW often requires shielding for worker protection during handling.

The plan involves placing the waste 680 metres underground in impermeable rock at the Bruce Power Nuclear Generating Station site (the DGR Project at the Bruce Nuclear site). The repository is capable of safely isolating the L&ILW from people and the environment over the hundreds to thousands of years that the L&ILW remain radioactive. The DGR Project at the Bruce Nuclear site:

- provides a greater margin of public and environmental safety than the existing facilities which are interim and not built to contain the L&ILW over the time frames they remain radioactive.
- was developed in partnership with the Municipality of Kincardine (the host municipality) and is supported by the municipality; and
- is science and evidence based, following 13 years of extensive studies that have been subject to exhaustive environmental and technical reviews, including review by international experts.

The current estimated life cycle cost for the DGR Project at the Bruce Nuclear site is estimated at $2.4B (2017 constant dollars)[1]. This is for all phases of the project starting from 2004, through licensing and regulatory approvals, construction, retrieval, operations and ultimately decommissioning.

OPG has made a commitment not to move forward with construction of the DGR at the Bruce Nuclear site until the Saugeen Ojibway Nations (SON) community is supportive. This

[1] All $ references are to constant dollars (sometimes referred to as overnight dollars). The relevant year is specified.

underscores the importance OPG places on building and growing long-term, mutually beneficial working relationships with Indigenous communities near our current and future operations.

OPG is currently seeking a licence to prepare the site and construct the DGR at the Bruce Nuclear site in the Municipality of Kincardine.

1.2 REGULATORY APPROVALS AND PRIOR EA STEPS

Under the federal nuclear regulatory framework, an EA must be carried out to identify whether a project is likely to cause significant adverse environmental effects, before any federal authority can issue a permit or licence. The findings of the EA are presented in an Environmental Impact Statement (EIS).

The EIS Guidelines were finalized in 2009 by the Canadian Environmental Assessment Agency (the Agency) and the Canadian Nuclear Safety Commission (CNSC). In 2011 OPG submitted:

- a 13 volume EIS along with supporting documents, which presents an EA consistent with the EIS guidelines; and
- a 20 volume Preliminary Safety Report (PSR) along with other supporting documents, which presents the safety case for the DGR.

In 2012 a federally appointed Joint Review Panel (the Panel) was established by the federal Minister of the Environment and the President of the CNSC. The Panel undertook extensive technical reviews of OPG's submissions, and conducted public hearings for 33 days over a 2 year period (2013 and 2014). During its review, the Panel requested additional information from OPG about alternatives including alternate locations.

In response, OPG hired independent experts to assess a conceptual DGR in another location. The experts evaluated the relative risks and noted that either a repository at the Bruce Nuclear site or one located in granite would be expected to perform well within the regulatory requirements for long term safety and environmental protection. However, the additional step of moving the wastes off of the Bruce Nuclear site, where the wastes are processed and stored, would require substantially more handling and transportation of waste. Longer distances would increase the risk of more conventional transportation accidents. The potential for radiological exposure was judged to be quite low for both handling and transportation. This additional information was submitted to the Panel in 2014 [OPG's response to Information Request EIS-12-513, (OPG 2014a, OPG 2014b, and OPG 2014c)].

In 2015 the Panel issued its EA report to the federal Minister of Environment and Climate Change. The Panel determined that OPG has met the EIS guidelines. The Panel concluded that, provided certain mitigation measures are implemented:

> "*that the project is not likely to cause significant adverse environmental effects" [JRP 2015]*

As part of its assessment, the Panel carefully considered the safety of the DGR Project and determined that it is not likely to cause significant adverse effects on the health and safety of the public and workers with the implementation of certain mitigation measures.

Among other things, the Panel:

> *"concluded that the project is not likely to cause significant adverse effects on the water quality or aquatic ecosystems of Lake Huron or the other Great Lakes, provided that mitigation measures, including the Panel's recommendations, are implemented. The Panel is confident that there will be no significant adverse effects on Lake Huron or the other Great Lakes because:*
>
> - *radiation releases from the project during preclosure and postclosure phases would be extremely low relative to current radiation levels in Lake Huron and negligible relative to dose limits for the protection of the public;*
> - *malfunctions, accidents, and malevolent acts during the preclosure phase would not have the potential to release sufficient radiation to exceed dose limits for the protection of the public via use of Lake Huron;*
> - *natural processes, barriers and physical laws present and active during the normal evolution of the postclosure phase could not produce the conditions that would result in exceedances of regulatory limits for the protection of the public;*
> - *disruptive, "what if" scenarios would not result in exceedances of dose limits related to human uses of water from Lake Huron;*
> - *the project will not contribute significantly to any of the current primary risks to Lake Huron and the other Great Lakes, such as invasive species;*
> - *the project will not contribute to cumulative effects to Lake Huron, provided all discharges comply with applicable statutes and regulations, notably the Fisheries Act; and*
> - *there would be no significant adverse effect on the use by Aboriginal peoples of drinking water, fish or other species in Lake Huron due to radionuclides or chemicals of concern".* [JRP 2015]

The Panel also concluded that the DGR is the preferred solution for the management of L&ILW and the sooner the waste is isolated from the surface environment the better.

1.3 THE CURRENT EA CONTEXT FOR THE STUDY OF ALTERNATE LOCATIONS

The federal government announced early in 2016 that it will introduce new EA processes and has commenced a review of the existing federal EA processes which will take time[2]. The federal government remains responsible for making decisions related to projects being assessed (such as the DGR Project at the Bruce Nuclear site) while the review is under way. During the interim period, the federal government has confirmed that timely decisions on individual projects will depend upon the provision of sufficient information in accordance with a number of principles, including:

1. No project proponent will be asked to return to the starting line — project reviews will continue within the current legislative framework and in accordance with treaty provisions, under the auspices of relevant responsible authorities and Northern regulatory boards.

[2] NRCAN January 26, 2016 Statement Article "Government of Canada Moves to Restore Trust in Environmental Assessment".

As set out above, in February 2016 the federal Minister of Environment and Climate Change required OPG to provide a study that details the environmental effects of technically and economically feasible alternate locations for the Project, with specific reference to actual locations that would meet OPG's criteria for technical and economic feasibility.

OPG understood this requirement, in accordance with its terms, to be for a study, rather than the design and implementation of a new multi-year, multi-phased site selection process based on voluntarism and consent. That, in effect, would amount to "returning to the starting line," contrary to the first principle guiding the federal government's review of current EAs, described above. Current standards of practice and international experience in the siting of radioactive waste repositories show that multi-year processes, based on voluntarism and consent, are the preferred approach to the identification of a willing host community for a deep geologic repository [USDOE 2016; NFCRC 2016; NWMO 2007]. This approach has emerged following unsuccessful attempts by various agencies to arbitrarily select a site or not seek a willing host.

The over-arching principle in the consent based approach is that a knowledgeable community makes an informed decision on whether to accept the responsibility of hosting a facility. Typical steps in such a process could include the following:

- Develop Siting Process (2 - 3 years) collaboratively with public input
- Initiate Siting Process (3-4 years) seek willing host communities
- Screen Potential Locations (3 – 4 years) technical screening
- Identify Preferred Locations for Detailed Investigation (2 – 4 years)

Generally, once the preferred location is identified and detailed investigation initiated, confirmation of technical suitability occurs through regulatory processes.

OPG has proceeded based on the distinction between a feasible alternate location and a specific potentially suitable site that could be identified through a consent based site selection process. Potentially suitable sites are a subset of feasible alternate locations; among other things, these sites are specific geographic areas within feasible alternate locations that satisfy initial screening and also have the consent or support of willing hosts. Since this is a study – and not a site selection process – OPG has not sought, nor has it obtained, consent of a willing host or Indigenous community for any of the alternate locations discussed below.

Guided by, among other things, the federal government's principle that "No project proponent will be asked to return to the starting line", the existing information that OPG already generated, and the potentially feasible alternate locations, OPG developed an alternate location study approach to address the Minister's requirement.

In a letter to the Agency dated April 15, 2016 [OPG 2016a], OPG described its proposed approach to the alternate location study requirement and sought confirmation from the Agency that OPG had interpreted the requirement correctly. In its response in September 7, 2016, the Agency raised no objection to OPG's approach, but did provide further clarifications regarding the alternate locations study, including a clarification indicating that the study could be based on geologic regions:

> "*[OPG] has indicated that it intends to provide an assessment of the environmental effects of two technically and economically feasible geologic regions in Ontario, specifically in a sedimentary rock formation in southern Ontario and in a granite rock formation located in central to northern Ontario, without providing specific reference to actual locations.*

The Agency also clarified as follows:

> *.... the Agency requests that the analysis of the environmental effects of the alternate locations to be provided by OPG provide a narrative assessment that does not assume that alternate sites in the geologic formation would have the same geographical and hydrological characteristics of the preferred site."*

For clarification OPG is providing in this report and in the "Description of Alternate Locations" [OPG 2016b] technical document, specific references to actual locations. Further, OPG has not assumed that the alternate locations would have the same geographical and hydrological characteristics as the Bruce Nuclear site, as requested by the Agency.

2. TECHNICALLY & ECONOMICALLY FEASIBLE ALTERNATE LOCATIONS

An alternate location for a project is one type of alternative means considered in an EA. Alternative means were considered fully as part of the EIS and the Panel's assessment [OPG 2011a], [JRP 2015]. For the purposes of this alternate locations study OPG has followed the Agency requirements and guidance on alternative means to the extent relevant to alternate locations[3]. The applicable relevant steps in the multi-step process are summarized here:

- Identify technically and economically feasible alternative means:
  - Develop technical and economic feasibility criteria;
  - Identify and describe the alternative means; and
  - Establish which of these alternative means are technically and economically feasible.

- List their potential effects on valued components (VCs):
  - Identify elements that could produce environmental effects;
  - Identify the key VCs potentially affected by each alternative means; and
  - Examine briefly the potential effects on the VCs for each alternative means.

Subsequent steps (which require the selection of the preferred means and a detailed assessment of the environmental effects of the preferred means) are outside the scope of this study but were completed for the original EIS [OPG 2011a].

The remainder of this section describes the criteria and thresholds for technical and economic feasibility as they pertain to alternate locations. A summary description of the economically and technically feasible alternate locations and their environmental features is in Section 4. The discussion of potential effects on VCs at the alternate locations is in Section 5.

2.1 CRITERIA AND THRESHOLDS FOR TECHNICAL AND ECONOMIC FEASIBILITY

In this study of alternate locations – which is distinct from a siting process – technically and economically feasible alternate locations are to be identified based on criteria and thresholds. As this assessment is in support of an alternative means analysis for an alternate location, the criteria and thresholds applied are consistent with those of alternative means analysis. These criteria and thresholds are consistent with those in an early screening phase of a site selection process; these are basic necessary conditions for a DGR. Simply put, if a location does not meet these criteria and thresholds, it is not a feasible location for a DGR for L&ILW.

A further discussion of criteria and thresholds used for this analysis and a detailed description of the alternate locations is included in the technical document "Description of Alternate Locations" [OPG 2016b].

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[3] Operational Policy Statement, Addressing "Need for", "Purpose of", "Alternatives to" and "Alternative Means" under the *Canadian Environmental Assessment Act (update November 2007).*
Operational Policy Statement, Addressing "Purpose of", and "Alternative Means" under the *Canadian Environmental Assessment Act, 2012.*

2.1.1 Technical Feasibility

The ultimate technical objective for a DGR is that any selected location must support the safe construction, operation and postclosure performance of the DGR without harm to the public, workers or the environment. This safety is achieved by a combination of the physical features of the site, the design and the wastes, and by how the facility is constructed, operated and monitored

OPG has therefore identified the following technical feasibility criteria for a DGR:

- Is the host rock geologically stable and resistant to expected geological and climate change processes?

- Is the depth and thickness of competent rock sufficient to host and enclose a DGR?

These criteria reflect the basic requirement of a DGR to provide long-term containment and isolation of the wastes.

OPG has further considered thresholds for these criteria.

With respect to geological stability, the requirement should be that the rock has been stable for times that are long compared to the duration of the main hazard in the L&ILW, and that have been resilient to past glacial and seismic events. While much of the radioactivity in the L&ILW will decay within about 100,000 years, the OPG DGR safety assessment considered time frames of 1 million years. Therefore for demonstrated geologic stability, the bedrock should be much older than this. For context, in Ontario, the crystalline rock of the Canadian Shield at more than 1 billion years old, and the sedimentary rock formations of southern Ontario at 354 to 543 million years old, readily satisfy this criterion.

With respect to depth and volume, the thresholds adopted in the present study are a minimum of 200-m depth and 300-m bedrock thickness. These consider the nature of the hazard of the L&ILW, and in particular that it contains long-lived ILW. Therefore, consistent with international practice, such wastes are planned for disposal in deeper rock formations. The minimum depth of 200-m is consistent with remaining below the extent of shallow groundwater regimes. A minimum rock thickness of 300-m allows for at least a 100-m layer of competent bedrock to lie above and below the repository to ensure that it is fully enclosed.

2.1.2 Economic Feasibility

For the purposes of this alternate locations study, the economic feasibility criterion is

- Does OPG have the ability to finance the DGR at an alternate location?

The threshold for the economic feasibility criterion is whether OPG reasonably expects to be able to finance the cost of the DGR at an alternate location from internal resources, or through debt financing, or a combination of the two. The economic feasibility threshold is satisfied because in OPG's judgment OPG expects to be able to secure financing for the DGR at either of the alternate locations through one or more of the mechanisms, if required.

2.2 TECHNICALLY & ECONOMICALLY FEASIBLE ALTERNATE LOCATIONS

The technical and economic criteria were applied to the province of Ontario. Two alternate locations that satisfy the criteria and thresholds were identified: a crystalline alternate location (shown in brown) and a sedimentary alternate location (shown in green) (Figure 2-1.)

Figure 2-1: The Crystalline and Sedimentary Alternate Locations

The crystalline alternate location is in the Canadian Shield and extends through central and northern Ontario. The sedimentary alternate location extends through the western portion of southern Ontario. Table 2-1 illustrates how the alternate locations satisfy the economic and technical feasibility criteria and thresholds.

Table 2-1: Technical and Economic Feasibility Criteria and Thresholds

Criterion	Criteria	Thresholds	How the Alternate Locations Satisfy the Criteria and Thresholds
Technical	• The host rock is geologically stable and resistant to expected geological and climate change processes	• The rock has been stable for times that are long compared to the main hazard in the L&ILW, and has been resilient to past glacial and seismic events (older than 1 million years).	• The crystalline rock of the Canadian Shield is more than 1 billion years old. • The sedimentary rock formations of southern Ontario are 354 to 543 million years old.
Technical	• The depth and volume of competent rock is sufficient to host and enclose a DGR.	• A minimum depth of 200-m. • A minimum bedrock thickness of 300-m.	• The crystalline rocks of the Canadian Shield in Ontario have sufficient thickness at depth to meet the thresholds. • The sedimentary alternate location is defined by a minimum 300-m thickness of low permeability Ordovician sediments, in which the DGR could be positioned 200 m or deeper below ground surface.
Economic	• OPG's ability to finance the DGR at the alternate location.	• OPG reasonably expects to be able to finance the cost of the DGR at an alternate location from internal resources, or through debt financing, or a combination of the two.	• The economic feasibility threshold is satisfied because in OPG's judgment OPG expects to be able to secure financing for the DGR at either of the alternate locations through one or more of the mechanisms, if required.

3. THE PROJECT

For the purposes of this study, the project to be considered at the alternate location is termed the "DGR at an alternate location" (subsequently referred to as the Alternate Project). The DGR at an alternate location is described strictly for the purposes of conducting this study, and is not intended to trigger a new or different project under the *Canadian Environmental Assessment Act 2012.*[4]

The DGR at an alternate location involves the same Project works and activities as described in the EIS for the DGR project at the Bruce Nuclear site, with some key differences including additional works and activities as required for a location that is not proximate to the Western Waste Management Facility (WWMF) or the Bruce Nuclear site [OPG 2011a]. A brief summary follows.

The DGR at an alternate location would receive L&ILW currently stored in interim facilities at the WWMF, as well as that produced from the continued operation of OPG-owned or operated nuclear generating stations. Low level waste (LLW) consists of industrial items and materials such as incinerator ash, tools, equipment, and occasional large objects such as heat exchangers, which have become contaminated with low levels of radioactivity. Intermediate level waste (ILW) consists primarily of used reactor components, including those from refurbishment, as well as resins and filters used to clean the reactor water circuits. The repository would accommodate approximately 200,000 m^3 of L&ILW with provision for possible future expansion to accommodate L&ILW from decommissioning (the expansion would be subject to future decision and licensing processes).

The DGR at an alternate location assumes the same design as the DGR Project at the Bruce Nuclear site including above-ground/surface infrastructure and below-ground/underground facilities, specifically two shafts, a number of emplacement rooms, and support facilities for the long-term management of L&ILW.

The above ground/surface infrastructure for the DGR at an alternate location would consist of a waste package receiving, staging and transfer area, shaft headframes and ancillary areas. The waste packages would be transferred underground via a main shaft to the repository level, nominally 680 metres below ground surface (mbgs). The main shaft would be the intake for repository ventilation, with the heater house and intake fans located adjacent to the headframe. The ventilation shaft and headframe complex would be used to transport the rock generated from the repository development to the surface, and to pull the exhaust air out of the repository. Waste rock piles, some temporary in nature, for the full excavated volume of rock would be accommodated on the Alternate Project location, within a Waste Rock Management Area (WRMA).

The below-ground/underground facilities would comprise access-ways (shafts and tunnels), emplacement rooms and various underground service areas and installations. The areal extent of the underground facilities would be approximately 40 hectares (ha). Access to the underground repository from ground surface would be via two vertical concrete-lined shafts that

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[4] To avoid any confusion or misunderstanding, OPG is not proposing to carry out the activities at either of the alternate locations; this study has been undertaken to respond to the Minister's information request.

lead to the shaft and services area at the repository level. The underground repository would consist of two panels of emplacement rooms that are nominally 250 m in length and arranged in parallel to the assumed direction of the major principle horizontal in situ stress. The repository would have 31 rooms, accommodating approximately 200,000 m³ of waste (emplaced volume).

There are some key differences between the main features of the DGR Project at the Bruce Nuclear site and those for the Alternate Project. One key difference is provision for repackaging and transportation of the waste containers; this is described in detail in Section 3.2. Other key differences are the need for the following:

- The development and implementation of a consent based, site selection process (as described earlier). In that process site characterization would be needed to assess and select the site including deep boreholes. A greater level of site characterization activity would be needed in crystalline rock than in sedimentary rock in order to characterize the nature of the fractures, define the performance targets for engineered barriers, and assess the properties of the rock in detail for the design and the safety case.

- Property acquisition, site clearing and installation of site infrastructure, including road access, power lines, fencing, and shop/maintenance facilities. There may also be a requirement to establish on-site emergency response capabilities depending on the proximity of the site to established services.

    - For the purposes of this study the surface facility is assumed to require about 40 ha (compared with 30 ha at the Bruce Nuclear site). The area of the underground footprint would also be about 40 ha. It is further assumed that the repository site would be selected with capacity to allow for doubling of the underground repository in the future to accommodate L&ILW from decommissioning (about 80 ha total area).

    - For direct comparison with the Bruce Nuclear site, it can be assumed that the controlled site area extends one kilometre from the project surface facilities and the underground footprint. This gives a total site area of about 700 ha (1700 acres) if the controlled area is just around the 40 ha surface facilities, or about 900 ha (2200 acres) if the controlled area is around the expanded underground footprint. This is for direct comparison; a buffer outside of the underground footprint for surface land use is not required by regulation and may not be required for safety reasons.

- Additional facilities to receive and temporarily store waste before transfer underground to the repository. It is estimated that two storage buildings would be required at the alternate location to receive and store the waste packages (shielded appropriately) before transfer underground to the repository, to enable efficient facility operations.

- Additional storage facilities (4-6 additional Low Level Storage Buildings and 2-3 In-Ground Containers (IC18's)) at the WWMF to accommodate interim storage of up to 20 to 30 additional years of operational waste (until the DGR at an alternate location is available and in-service).

3.1 PROJECT PHASES AND TIMELINES

Overall the DGR at an alternate location would be constructed in sequential stages consistent with those contemplated for the DGR Project at the Bruce Nuclear site. The durations of these phases is estimated to be similar to those as for the DGR Project at the Bruce Nuclear site. The assumed sequential phases are as follows:

- Site preparation and construction phase, which includes completion of all activities associated with site preparation, followed by construction of the surface infrastructure, including the shaft headframes. The two shafts (main and ventilation) would be developed simultaneously, followed by the construction of the underground services area infrastructure and access and exhaust ventilation tunnels. The emplacement rooms would then be developed. All construction activities would be completed prior to commencement of operations. This phase is expected to last five to seven years.
- Operations phase, which includes the period during which waste is emplaced in the DGR, as well as a period of monitoring prior to the initiation of decommissioning activities. This phase is expected to last approximately 40 to 45 years, with waste being placed for the first 35 to 40 years and the subsequent monitoring carried out for a period that would be decided at some future time in consultation with the appropriate authority.
- Decommissioning phase, which includes dismantling surface buildings and sealing the shafts, is expected to begin immediately following operations and to take approximately five to six years to complete.
- The postclosure phase which begins once decommissioning is completed. This phase includes institutional controls which would be put in place indefinitely.

As indicated in Section 1.3, prior to site preparation and construction, a site selection process would need to be designed and implemented. Accordingly a site selection and licensing phase would need to be added to the overall project schedule. It has been estimated that the site selection and licensing phase could take approximately 15 - 20 years or more, from initiation to the time an EA decision would be made and a licence issued.

The current in-service date for the DGR Project at the Bruce Nuclear site is 2026. The addition of a site selection phase, along with the time required for construction would make the Alternate Project in-service dates at least 20-30 years later than the in-service date of the DGR Project at the Bruce Nuclear site. The in-service date would be approximately 2045 for a sedimentary location and 2055 for a crystalline location (assuming more time to accommodate a more complex geology and site characterization). The timeline for the various project phases for the DGR at alternate locations is portrayed in Figure 3-1 (assuming a 2045 In-Service) and Figure 3-2 (assuming a 2055 In-Service), respectively.

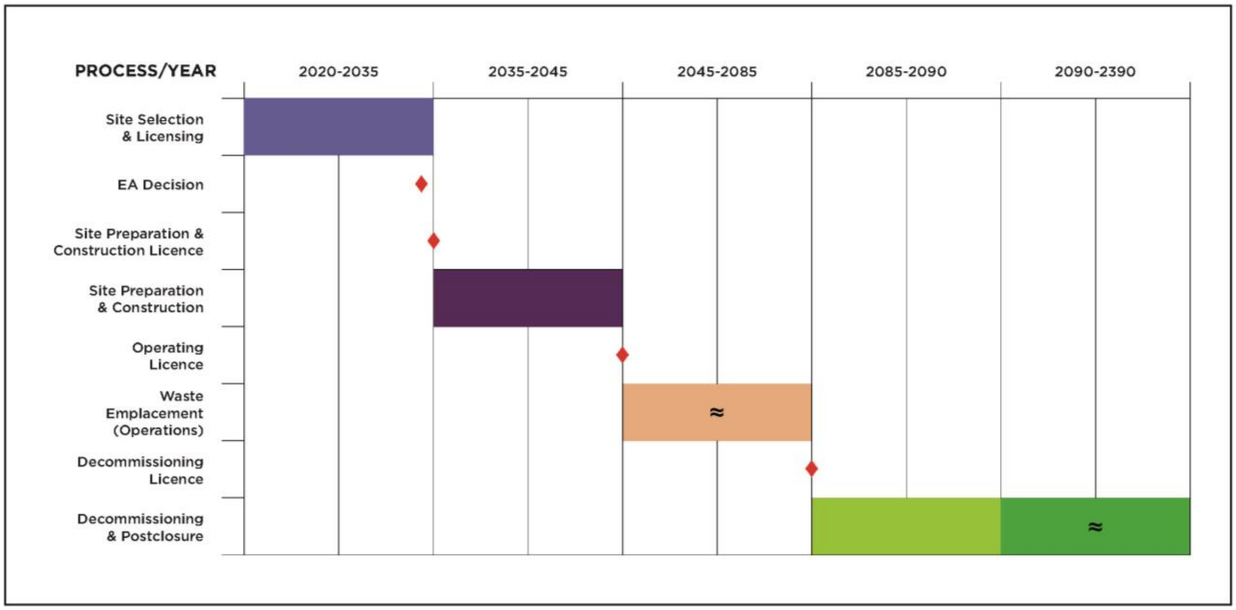

Figure 3-1: Approximate Timelines for Project Implementation at a Sedimentary Location

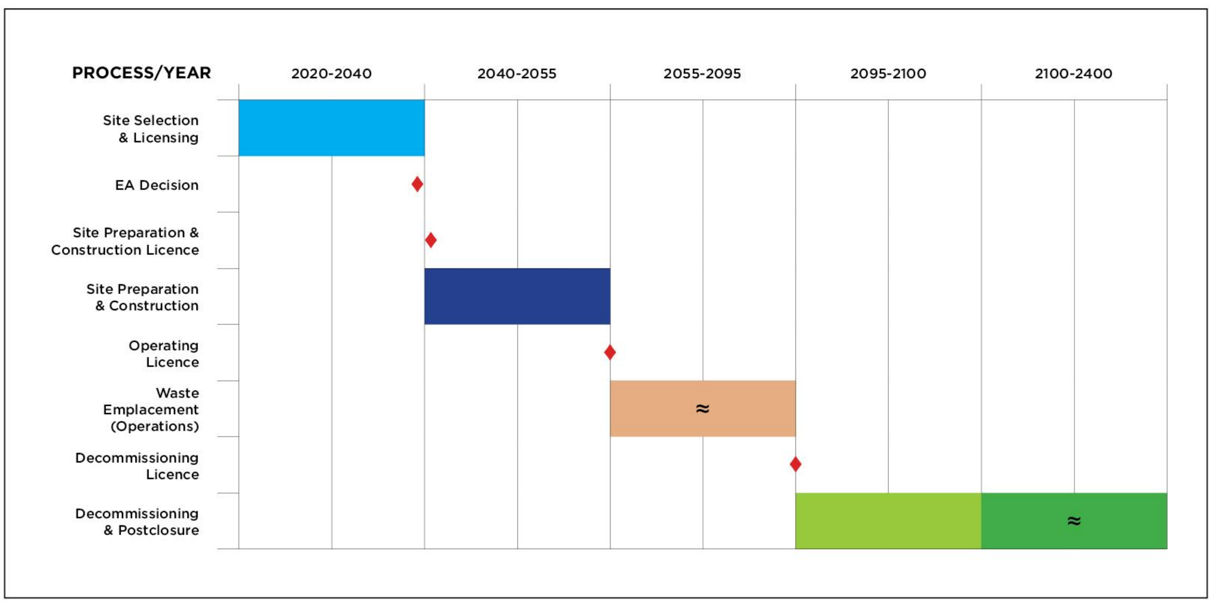

Figure 3-2: Approximate Timelines for Project Implementation at a Crystalline Location

3.2 PACKAGING AND TRANSPORTATION

The DGR at an alternate location includes a transportation component. OPG has a baseline plan for retrieval of the L&ILW in storage at the WWMF to prepare it for emplacement in the DGR at the Bruce Nuclear site. The retrieval plan (and the DGR EIS) did not contemplate packaging the waste for public road transportation and transporting it by public road in accordance with the Packaging and Transport of Nuclear Substances Regulations, 2015 (PTNSR) to an alternate location that is not contiguous with WWMF and Bruce Nuclear sites. The PTNSR comes into effect upon leaving the Bruce Nuclear site fence, and using public roads.

The additional work to transport the waste would begin after the waste has been retrieved from the WWMF. The associated additional (incremental) works and activities are described in detail in the technical document “Cost and Risk Estimate for Packaging and Transporting Waste to Alternate Locations” [ENERGY SOLUTIONS 2016].

The inventory of waste at the WWMF to be transported at the estimated in-service date includes four LLW waste categories with an estimated total volume of approximately 138,000 to 147,000 m^3 and eight ILW waste categories with an estimated total volume of 10,000 to 11,000 m^3. This entire waste inventory of twelve waste categories is stored in approximately 54,000 to 57,000 containers (consistent with the in-service dates for two alternate locations identified in Section 3.1).

The sequence of work would generally be as follows following retrieval from the WWMF (Figure 3-3):

- Determine if the waste containers retrieved can be emplaced in a transportation package and be compliant under PTNSR, or if the container is required to be placed in an alternate configuration;
- Place and secure the waste container in the appropriate transport packages (place transport package on truck conveyance; secure package to truck conveyance if required; prepare shipping manifest; perform pre-shipment surveys, inspections and testing; mark, label and placard, etc.);
- Conduct transport operations (transport the package to the alternate location by truck);
- At the alternate location conduct transport package receipt operations;
- Prepare empty reusable transport packaging for return. CNSC transport regulations require that the empty reusable transport packaging be classified under the “Excepted Package” designation which means that it is still a manifested radioactive shipment (no label is required and the maximum dose rate on the surface package must be equal to or below 0.005 mSv/hr); and
- Conduct return transport operations (truck transport back to the WWMF).

In addition at the alternate location work is required to prepare for container/component repository emplacement, including;

- Stage disposal-ready containers/components for emplacement;
- Overpack non disposal-ready containers/components; and
- Temporarily store containers/components awaiting emplacement as necessary.

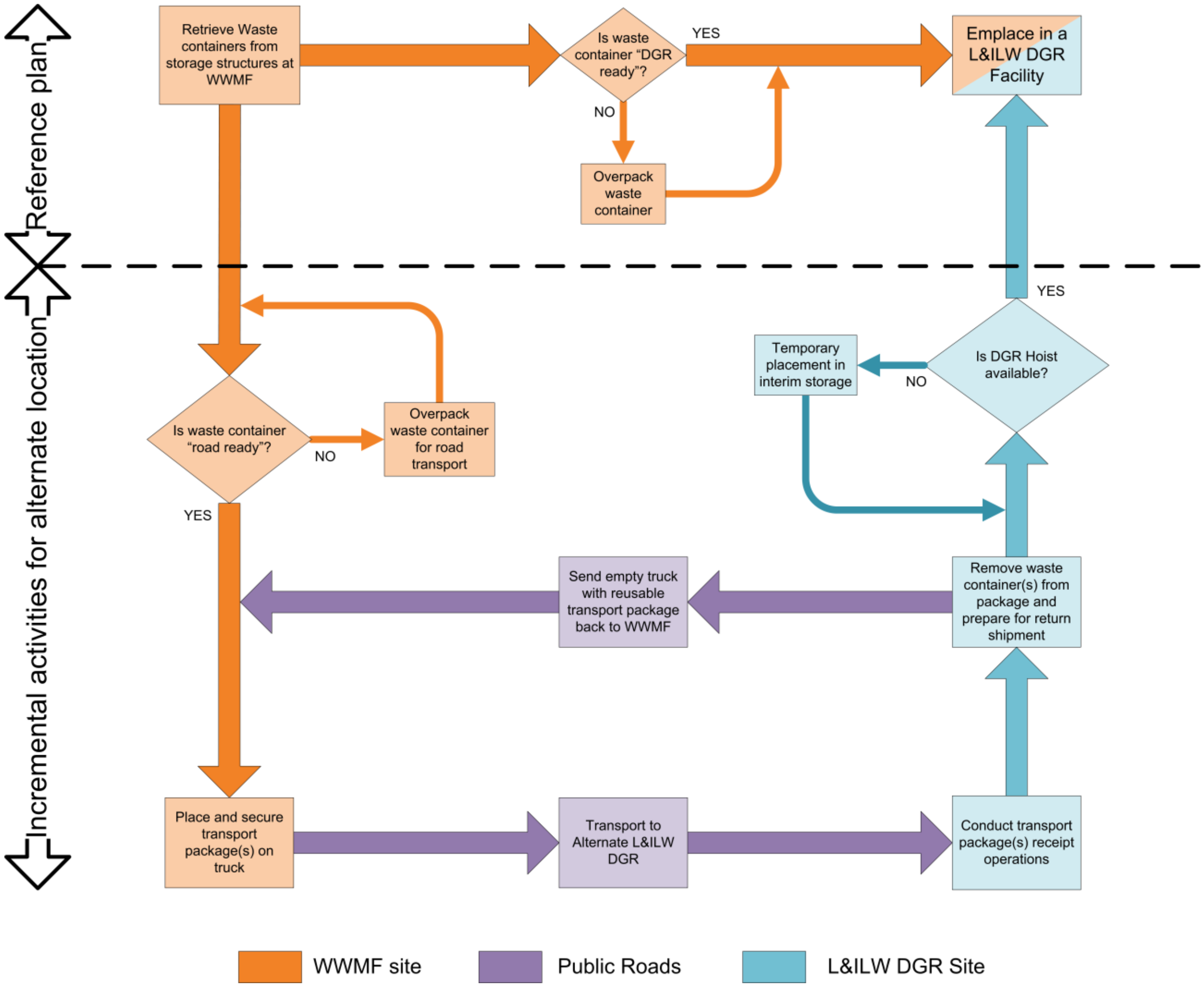

Figure 3-3: Key Steps in L&ILW Transportation from the WWMF to an Alternate Location

Each waste category was reviewed to determine whether additional packaging would be required and the nature and number of transport packages/freight containers required. The review concluded that there would be some radioactive decay due to the longer time waiting for shipment, which would reduce some of the packaging requirements. However, a portion of all waste categories still would require additional packaging and all waste categories could be accommodated in one of the three packaging types:

- Industrial Package Type 2 (Type IP-2): Used for transporting low specific activity (LSA) waste and surface contaminated object (SCO) waste (Figure 3-4).
- Type A Package: Used for transporting medium activity waste (higher activity Low Level Waste (LLW) and the lower activity Intermediate Level Waste (ILW)) (Figure 3-5).
- Type B Package: A shielded packaging type used for transporting larger quantities of higher activity ILW (Figure 3-6).

Figure 3-4: Industrial Package Type 2 (Type IP-2)

Figure 3-5: Type A Package

Figure 3-6: Type B Package

The total number of shipments required to transport each waste category was calculated. Of the total number of shipments, approximately 11% are estimated to be oversized and/or overweight and therefore subject to more restrictions. The schedule of shipments assumes that lower activity LLW would be transported first, followed by higher activity ILW to maximize the radioactive decay period and to minimize radioactive dose uptake to workers.

It was determined that approximately 11,000 to 12,000 outbound shipments would be required over more than a 30 year period to package and transport the entire inventory of L&ILW from the WWMF to an alternate location as well as 11,000 to 12,000 inbound shipments (to return the empty reusable transport packages to the WWMF), see Table 3-1.

Table 3-1: Container Outbound Shipments

	Containers		**Shipments**	
Type of Package	**2045 In-Service**	**2055 In-Service**	**2045 In-Service**	**2055 In-Service**
Type IP-2	44,752	47,616	6,797	7,155
Type A	5,995	6,399	1,436	1,531
Type B	3,104	3,306	3,104	3,306
	53,851	**57,321**	**11,337**	**11,992**

4. DESCRIPTION OF ALTERNATE LOCATIONS

OPG has identified two alternate locations that satisfy the economic and technical feasibility criteria and thresholds: a crystalline alternate location and a sedimentary alternate location. They are described in the technical document “Description of Alternate Locations” [OPG 2016b] and key features are summarized here.

4.1 THE CRYSTALLINE LOCATION

The crystalline location extends through central and northern Ontario as shown in Figure 4-1. The nearest edge of the crystalline location is about 200 km by road from the Bruce Nuclear site, while the farthest edge is at the Manitoba/Ontario border which is about 2000 km from Bruce Nuclear site.

Figure 4-1: The Crystalline Location

GPS co-ordinates of the crystalline alternate location are listed in Table 4-1.

Table 4-1: GPS Co-ordinates of the Crystalline Alternate Location

Latitude, Longitude
44.9, -79.8
46.0, -81.2
46.6, -84.5
48.8, -86.6
48.0, -89.6
49.2, -95.1
52.8, -95.1
55.1, -91.6
53.5, -87.4
50.4, -85.4
50.8, -79.5
47.2, -79.6
45.3, -76.4
44.6, -76.6

4.1.1 Key Environmental Features

Key environmental features of the Crystalline Alternate Location are as follows:

- The location has a low seismic hazard, it is within the North America interior cratonic region.

- The physical topography has low relief as is typical of Canadian Shield, reflecting erosion over millions of years. There are numerous small water bodies as is typical of the Canadian Shield. Defined wetlands cover a small percentage of the surface area. Central to northern Ontario is generally well drained with an abundance of wetlands, lakes and rivers.

- Surface water quality in the area is generally good with limited anthropogenic influence. It is assumed that the repository surface facilities are placed at least 120 m from any provincially significant wetland consistent with provincial guidelines.

- Consistent with typical Canadian Shield settings in central to northern Ontario, land cover is dominated by Boreal forest.

- It lies within the Boreal Shield ecozone.

- The background air quality is typical of central to northern Ontario. Atmospheric background concentrations of relevant air quality parameters are likely to be lower than in southern Ontario.

- The geology is defined by a layer of glacial drift, and lake and river sediments (i.e., clay, silt and sand), overlying the crystalline rock of the Canadian Shield. Crystalline rock is typically fractured, so the repository position within the rock would be dependent on the nature of the fractures.

- Much of the crystalline alternate location is currently Crown land and covers the traditional territory of multiple Indigenous communities. It is assumed that the repository could be located to avoid culturally sensitive areas, and to avoid or minimize impacts on areas currently used for harvesting, trapping or hunting. Siting would require the support of Indigenous communities in whose traditional territory the DGR could be located.

- All the lands and rivers in the crystalline alternate location lie within one of two main watersheds: the Great Lakes basin/watershed which ultimately drains towards the Atlantic Ocean, or the Hudson Bay basin/watershed which ultimately drains to Hudson Bay. With an appropriate geology and design, the proximity of a water body to the DGR is not relevant because the movement of water or gas, even if it was released from the DGR, would not reach the water body until the radioactivity of such water or gas had diminished to the levels generally found naturally occurring throughout Ontario.

4.1.2 Unique Alternate Project Attributes in the Crystalline Location

A repository in the crystalline alternate location may require some unique attributes.

- As the location is in Central to Northern Ontario, it is likely that there would be a need to construct new road and power access to the site. For the purpose of assessing environmental impacts, a range of 0-20 km has been assumed for the establishment of road access, and 0-50 km to establish a high-voltage power corridor to the site.

- Additional engineered barrier(s) would likely be required because of the fractured, more permeable nature typical of crystalline rock. This could include additional grouting to control water inflow from fractures, and backfilling of some emplacement rooms to limit the free water movement in the vicinity of the waste packages.

- Ion exchange resins (a type of ILW) are used to maintain the purity of the moderator heavy water and contain a significant amount of Carbon-14 (C-14). This radionuclide has a long half-life (5700 years), and is relatively mobile in groundwater and as a gas (e.g., methane). In the crystalline location it is likely that groundwater will eventually contact the ion exchange resins leading to the release of C-14 sooner than expected in the sedimentary alternate location. For a more fractured and permeable crystalline location, it is likely that additional engineered barriers would be required including pre-processing of the resins (e.g., solidification) and backfilling the space within or around the waste packages with cement. These additional barriers would minimize contact with groundwater and mitigate C-14 release rates.

- An additional two underground rooms are assumed to accommodate the increased packaged ILW volume from waste processing and cementing. The resin waste processing is assumed to be done at an off-site licensed facility.

- A somewhat larger volume of excavated rock may be needed if (a) waste processing and grouting leads to a larger volume of the as-packaged wastes, (b) additional spacing is needed to avoid major fractures, and/or (c) additional concrete structure is needed as support for the rooms or waste packages due to the stress conditions in the host rock.

4.2 THE SEDIMENTARY LOCATION

The sedimentary alternate location extends through the west part of southern Ontario as shown in Figure 4-2. The furthest edge of the sedimentary alternate location is about 300 km by road from the Bruce Nuclear site. GPS co-ordinates of the sedimentary alternate location are listed in Table 4-2. The white circle represents the location of the Bruce Nuclear site.

Figure 4-2: The Sedimentary Location

Table 4-2: GPS Co-ordinates of the Sedimentary Alternate Location

Latitude, Longitude
44.5, -80.2
43.7, -79.4
43.3, -79.8
43.2, -79.1
42.9, -79.0
42.0, -83.1
44.6, -81.3

4.2.1 Sedimentary Location Key Environmental Features

Key environmental features of the sedimentary alternate location are as follows:

- The alternate location is within an area of low seismic hazard
- The physical topography is low relief, as is typical of southern Ontario.
- There are numerous small rivers or streams in the vicinity. Defined wetlands cover a small percentage of the surface area. Other areas may be transiently wet in the spring.
- The southern Ontario region is generally well drained. Most watercourses are cool to coldwater. It is assumed that the repository surface facilities are at least 120 m from any provincially significant wetland as per provincial guidelines.
- The repository surface facilities are assumed not to be located on a floodplain; therefore, it is expected that the nearby water courses are not large.
- Surface water quality in the area and where streams merge with other watersheds, is assumed to be influenced by agriculture. Most of the sedimentary alternate location is rural, non-urban, with former agricultural land, and no nearby industry as a source of noise or air emissions.
- The sedimentary alternate location lies within the Mixedwood Plains ecozone.
- Land cover is dominated by cropland, pasture and abandoned fields, with woodland cover at about 16%. The vegetation is diverse; the land is not expected to have significant existing tree cover.
- The background air quality is typical of southern Ontario.

- The geology is comprised of a layer of glacial drift, overlying thick sequences of sedimentary rock, which sit upon crystalline basement bedrock. In this sedimentary rock, the Ordovician carbonates and shales are suitable, particularly the mechanically competent and very low permeability Cobourg limestone Formation. Fractures are generally sparse and infrequent at depth.

- Most of the sedimentary alternate location is currently land that is privately owned. The sedimentary alternate location is within the traditional territory of one or more Indigenous communities. It is assumed that the repository could be located to avoid culturally sensitive areas, and to avoid or minimize impacts on areas currently used for harvesting, trapping or hunting. Siting would require the support of Indigenous communities in whose traditional territory the DGR could be located.

- All the lands and rivers in the sedimentary alternate location lie within the Great Lakes basin/watershed which ultimately drains towards the Atlantic Ocean. With an appropriate geology and design, the proximity of a water body to the DGR is not relevant because the movement of water or gas, even if it was released from the DGR, would not reach the water body until the radioactivity of such water or gas had diminished to the levels generally found naturally occurring throughout Ontario.

4.2.2 Unique Alternate Project Attributes in the Sedimentary Location

As this location is in southern Ontario, it is unlikely that there would be a need to construct extensive new road and power access to the site. For the purpose of assessing environmental impacts, a range of 0-5 km has been assumed for the establishment of road access, and 0-5 km to establish a high-voltage power corridor to the site.

5. ENVIRONMENTAL EFFECTS AT ALTERNATE LOCATIONS

This section describes the environmental effects of the DGR at each of the sedimentary and crystalline alternate locations. As noted previously, the alternate locations have different geographical and hydrological features as compared with the Bruce Nuclear site. The detailed analysis is contained in the technical document, “Environmental Effects of Alternate Locations” [GOLDER 2016].

5.1 METHODOLOGY

Valued Components (VCs) refer to environmental features that may be affected by a project. The selection of appropriate VCs allows the assessment to be focused on those aspects of the natural and human environment that are of greatest importance to society.

The list of VCs considered in an alternative means analysis is dependent on the nature of the alternative means under consideration (in this case only alternate locations) and those VCs most likely to be affected. For the purposes of this assessment the VCs include the environmental components as defined in section 5(1) (a) of CEAA 2012 (i.e., fish habitat and aquatic species are considered under the aquatic habitat and aquatic biota VCs, migratory birds are considered under the wildlife and wildlife habitat VC), and were also chosen to encompass the range of changes in environmental conditions that may be encountered. These VC groupings are also consistent with the VCs used in the EIS for the DGR Project at the Bruce Nuclear site, which was based on input from the public in preparing the EIS guidelines for the prior assessment [OPG 2011]. Table 5-1 presents the VCs that are the subject of this assessment.

Table 5-1: Valued Components Identified for Evaluation of Alternate Locations

Environmental Component	Valued Component (VC)
Atmospheric Environment	Air quality Noise levels
Surface Water	Surface water quality Surface water quantity and flow
Aquatic Environment	Aquatic habitat Aquatic biota
Terrestrial Environment	Vegetation communities, including upland and wetland Wildlife habitat and biota
Geology and Hydrogeology	Soil quality Groundwater quality Groundwater flow
Radiation and Radioactivity	Humans Non-human biota
Land and Resource Use (Traditional and Non-traditional)	Use of lands and resources

A screening was undertaken to identify potential interactions between the DGR at alternate locations and the environment (as represented by the VCs). The purpose of the screening was to identify whether there is a feasible pathway, either directly, or indirectly, between likely works and activities with a VC. This allows the identification of effects to be focused on those aspects of the environment most likely to be affected. The screening for potential interactions was conducted using professional judgment; a general understanding of existing environmental conditions in the regions under consideration; and consideration of potential interactions identified for the DGR Project at the Bruce Nuclear site in the EIS [OPG 2011a].
Where potential interactions were identified, the potential environmental effects, mitigation measures and residual adverse effects on the environment were then described for each VC.

5.2 OTHER VALUED COMPONENTS

Changes in environmental conditions as represented by the above VCs have the potential to affect health, socio-economic conditions, cultural heritage and land use. Consideration of human health is implicit in the discussion of these biophysical environmental components and VCs. Non-radiological effects on human health are considered implicitly through the discussion of relevant standards, guidelines and receptor locations, where applicable for each VC (e.g., changes in air quality). Potential effects of radiation and radioactivity are considered explicitly as part of discussion on the human receptor VC.

The DGR at an alternate location may also affect VCs within the socio-economic environment. Many effects would be beneficial, and may serve to enhance community well-being including:

- increased population associated with DGR related employment in nearby municipalities, with the greatest benefit anticipated in the host municipality;
- increased educational opportunities for local students and others with an interest in nuclear technology;
- the creation of new direct, indirect and induced employment opportunities through project spending;
- increased business activity through policies to utilize local business services wherever practical and appropriate;
- increased municipal revenue because of property tax payments and other revenues; and
- increases in the direct, indirect and induced labour income in local and regional area.

Adverse effects on socio-economic, land use and cultural heritage may occur due to changes in the environment (i.e., the biophysical VCs), such as nuisance effects to nearby land users and depletion of resources (e.g., forestry resources) through land clearing. These effects are considered through discussion of potential effects on the land and resource use VC.

A DGR at an alternate location is likely to be located in the traditional territory of one or multiple Indigenous communities. There is the potential to adversely affect Aboriginal Title and/or potential or established Aboriginal or Treaty Rights. The potential for an alternate location to affect the current use of lands and resources for traditional purposes is considered through the use of lands and resources VC in the assessment.

5.3 ENVIRONMENTAL EFFECTS AT A SEDIMENTARY LOCATION

This section summarizes the environmental effects of the DGR at an alternate sedimentary location for each identified VC. For more detailed information, see the technical document, “Environmental Effects of Alternate Locations” [GOLDER 2016].

5.3.1 Atmospheric Environment

Most DGR-related works and activities have the potential to affect air quality.

- During site preparation and construction, the operation of vehicles, equipment and material handling would cause temporary increases in emissions of combustion products, dust, and other compounds such as volatile organic compounds (VOCs) and acrolein, into the atmosphere, which could affect air quality and greenhouse gas emissions (GHGs).

- Increases in ambient concentrations of a number of air quality indicator compounds are likely during the site preparation and construction, operations, decommissioning and closure phases.

- Transportation between the WWMF and the alternate location would have the potential to cause localized emissions of combustion by-products and dust. Transportation would be largely along existing roads, and the frequency of shipments is relatively small (two shipments per day) as compared to existing traffic levels. Therefore, localized effects of transport-related emissions on air quality are not likely measurable.

- The additional handling and transportation of waste from the WWMF to the DGR at the sedimentary alternate location represents a likely effect on air quality and GHGs. A 100 km shipping distance to the DGR at the sedimentary alternate location would be approximately equivalent to an increase of 0.6 kt of CO_2 equivalent over the lifetime of the DGR’s operation, while a 300 km waste transportation shipping distance would be equivalent to an increase in 1.8 kt of CO_2 equivalent over the life of the project.

- Taking into consideration mitigation and the magnitude of effects, potential effects on air quality are not likely to be significant.

Most DGR-related works and activities have the potential to affect noise levels.

- Operation of equipment and vehicles, as well as blasting activities during site preparation and construction, and the operation of equipment at surface, including shaft ventilation fans, would result in DGR-related noise emissions no greater than 40 A-weighted decibels (dBA). When a background noise level of 35 dBA, or less, is combined with emissions from the project that cannot exceed 40 dBA, the predicted change in noise level for the sedimentary location would be equal to or greater than 5 decibels (dB). This is considered noticeable. During operations, DGR contributions to noise levels are likely to be lower than during the site preparation and construction phase; however, an increase in noise levels of 3 dB or greater is predicted.

- Transport vehicles would cause localized emissions of noise levels in the vicinity of the vehicle while en route. Transportation would largely be along existing roads with existing truck traffic, and the frequency of shipments would be small (two shipments per day) as compared to existing traffic levels. Localized noise level changes are therefore not likely to be measurable.

- Effects on noise levels from decommissioning activities would be similar to or lower than those identified for site preparation and construction. Following decommissioning there would be no further plausible pathway for noise effects.

- A number of noise mitigation measures are inherent in the prediction of effects, including assumed emission control measures. To limit the potential for nuisance-related noise effects along the transportation route, a noise management plan may also be developed. Taking into consideration mitigation, adverse effects identified of the DGR at a sedimentary alternate location on noise levels are not likely to be significant.

Overall effects on the atmospheric environment at the sedimentary alternate location are likely to be similar to or greater than those predicted for the DGR Project at the Bruce Nuclear site. The incremental atmospheric effects of site preparation, construction, operation and decommissioning are expected to be similar to that predicted for the DGR Project at the Bruce Nuclear site. However, cumulative ambient air quality concentrations are likely to be lower at the alternate location and less mitigation may be required to maintain compliance with air quality standards. The transportation of wastes would result in the emission of GHGs, between 0.6 and 1.8 kt over the lifetime of the facility operations. Overall effects on noise levels are likely to be greater at the DGR at the sedimentary alternate location, predominantly as a result of lower background noise levels and potential nuisance effects during waste transportation. This may require the implementation of additional mitigation measures to meet applicable regulatory requirements for noise.

5.3.2 Surface Water Environment

This section considers potential effects on the surface water quality and hydrology (i.e., surface water quantity and flow) of a DGR at the sedimentary alternate location.

- All runoff from the DGR and associated lands is assumed to be captured in a stormwater management system, with discharge from the waste rock pile runoff at a single location since some level of treatment would be required (e.g., settling basin for solids removal or treatment plant).

- Site preparation and construction may affect surface water quality and quantity through diversion of surface runoff to a stormwater management pond (SWMP) and discharge to the environment. The SWMP would include water from both surface and underground, including process water and groundwater inflows from the shafts; and alternate location runoff and runoff from the waste rock stored in the waste rock management area (WRMA). It is expected that all the runoff from the waste rock pile and any water from underground would be discharged from the alternate location at a single spot to a local watercourse.

- The potential effects of the DGR on surface water quantity and flow are associated with potential changes to drainage pathways as a result of site preparation and establishment of the WRMA. If the area selected for the waste rock pile covers more than one drainage path, then changes to flows may be expected in more than one local watercourse.

- Since the sedimentary alternate location is predominantly agricultural, it is assumed that the waste rock pile would be in an area that is currently farmland drained by either roadside drainage ditches or small natural streams. Since it is likely that the area will not be in or near an existing floodplain, it expected that the sedimentary alternate location drainage is not to a larger watercourse. Therefore, it is expected that there may be an adverse effect on surface water quantity and flow at the sedimentary alternate location in local drainage features.

- Surface water that has been collected would also have come in contact with the waste rock which could have the potential to leach metals. There are also assumed to be increased concentrations of nitrate and ammonia from residual blasting compounds. To manage surface water quality, the SWMP would collect all water, either from underground or the surface, which has been in contact with waste rock for storage and monitoring. The water would be treated on-site as needed. As all permitting requirements would be required to be met at discharge, no adverse effect on water quality is likely.

- It is assumed that effects identified above would persist into the operations phase.

- During transportation, there is the potential for increased sedimentation to off-site ditches, as well as incremental risk of a conventional spill as a result of an accident or malfunction. As the increase in traffic would be small relative to existing levels (i.e., two vehicles per day), localized adverse effect on water quality is not likely to be measurable.

- No measurable changes to groundwater quality or flow are anticipated outside of the project footprint. Therefore, no indirect effect on surface water is likely.

- The acceptability of the quality of water for discharge would be determined through the Environmental Compliance Approval process with the MOECC and would consider location-specific conditions. In addition to specific discharge concentrations, no water that is acutely toxic to aquatic life would be permitted for discharge. In addition, a spills management plan would be prepared for waste transportation to minimize effects on surface water quality in the case of an accidental release.

Overall project-related effects on surface water at the sedimentary alternate location are likely to be similar to those predicted for the DGR Project at the Bruce Nuclear site, as water volumes and quality to be managed are similar. The magnitude of effects may be slightly higher or lower, depending on the specific characteristics of the receiving waterbody, likely to be anthropogenically modified drainage features (i.e., industrial site drainage; agricultural drainage). However in the case of the sedimentary alternate location, the ditches would likely lead to a smaller watercourse. If the smaller watercourse has a low assimilative capacity, additional restrictions may be required prior to discharge.

5.3.3 Aquatic Environment

This section considers potential effects on the aquatic environment, specifically aquatic habitat and biota VCs of the DGR at the sedimentary alternate location. The aquatic habitat and biota VC includes fish, benthic invertebrates and/or macrophytes and their habitats, as well as species at risk.

- The ecozone (mixed wood plains) of the sedimentary alternate location is generally well drained. Most watercourses in the area are cool to coldwater and are considered to be more sensitive to disturbances than warmwater systems. The characteristic fish species include white sucker, smallmouth bass, walleye, northern pike, yellow perch, rainbow darter, emerald shiner and pearl dace.

- Effects on the aquatic environment are most likely during the site preparation and construction phase. Considering the terrain and topography in the region, it is assumed that the DGR at the sedimentary alternate location could be sited without encroaching on wetlands or streams. However, some supporting habitat for aquatic species such as burrowing crayfish may be removed. These effects are likely to be low in magnitude (i.e., non-critical habitat only is removed or rendered unusable).

- Localized changes in surface water quantity and flow are predicted. The potential indirect effect on aquatic VCs is very specific to the specific receiving body. However, as discharge to a small, local receiving waterbody is assumed, the effects may be slightly higher in magnitude as they may affect a greater proportion of a smaller watershed. No adverse effect from changes in surface water quality is likely as discharges would meet criteria established considering aquatic toxicity thresholds.

- Blasting activities have the potential to cause an indirect on aquatic VC habitat through changes in vibrations levels. Blasting management strategies would be employed to minimize predicted levels at aquatic spawning habitats in the region. Therefore, no adverse effect is anticipated.

- No changes in groundwater flow or quality at aquatic feature locations are likely as a result of the DGR at the sedimentary alternate location. Therefore, no adverse effect through this pathway is anticipated.

- During operations, the potential to affect aquatic VCs is only through indirect effects from changes in surface water quantity and quality. Effects on surface water quantity are expected to persist through the operations phase, however, at a reduced level from those observed during construction. No adverse effect on surface water quality is likely. Therefore, no effect on aquatic VCs is likely in the operations phase.

- Following decommissioning, the potential to affect aquatic VCs is further reduced, and focused on the potential for indirect effects from changes in surface water quantity and quality, and changes in groundwater quality. Effects on surface water quantity are not likely following the closure of the DGR. In addition, no adverse effect on groundwater or surface water quality is likely. Therefore, no effect on aquatic VCs is likely in the long-term performance phase.

- Mitigation and monitoring strategies identified for surface water are also protective of aquatic habitat. In addition, a blasting management plan would be established to ensure vibrations levels during blasting are protective of applicable Fisheries and Oceans Canada (DFO) thresholds. Therefore, taking into consideration mitigation, no significant effect on the aquatic environment is likely.

Overall project-related effects on the aquatic environment are likely to be similar to those of the DGR at the Bruce Nuclear site. The magnitude of effects may be slightly higher. Depending on the sensitivity and size of nearby aquatic habitat, additional mitigation may be required at the sedimentary alternate location.

5.3.4 Terrestrial Environment

This section considers potential effects of the DGR at the sedimentary alternate location on the terrestrial environment, specifically vegetation and wildlife VCs. Where wildlife VCs are referred to, these may be mammals, birds, herpetiles and/or terrestrial invertebrates and their habitat as well as species at risk. Wildlife habitat and wildlife species VCs also have the potential to be indirectly affected through changes in soil quality; surface water flow, quality and quantity; air quality; noise levels; vibrations levels; and light levels.

- The climate of the mixed wood plains ecozone is cool to mild, with cool winters and relatively warm summers. This ecozone is the most densely populated area in Canada and many of its natural ecosystems have been converted to human uses, for agriculture and infrastructure. Land cover in the ecozone is dominated by cropland, pasture and abandoned fields, with woodland cover at only 16%. The vegetation is relatively diverse and includes hardwood forest species, lowlands including floodplain forests and peatlands. Characteristic wildlife in this ecozone includes white-tailed deer, northern raccoon, striped skunk, great blue heron, field sparrow, American bullfrog, and snapping turtle.

- It is assumed that surface facilities would not be located within a provincially significant wetland, as defined by the Ministry of Natural Resources and Forestry (MNRF). In addition, surface facilities are assumed to maintain a 120 m setback surrounding provincially significant wetland. Where possible, the surface footprint would avoid habitat of threatened or endangered species listed under the Ontario *Endangered Species Act*, and the federal *Species at Risk Act* (on federal land). If habitat cannot be avoided, mitigation would be proposed in accordance with permitting, as required.

- For the site preparation and construction of the DGR, additional lands would have to be cleared and developed for necessary infrastructure. Overall, it is assumed that a minimum of 9 ha (equivalent to area of woodland to be cleared at the Bruce Nuclear site), and up to 40 ha (equivalent to the total project surface facilities footprint) of natural vegetation would be removed as part of site preparation and construction. In addition, the full site would be fenced (up to 900 ha). This may cause fragmentation of habitats and a potential effect on wildlife VCs. However, for the sedimentary alternate location, considering the regional setting, there is a high probability that the land has already been anthropogenically altered (i.e., agricultural, commercial or industrial).

- In general, the spatial extent of wetlands at the sedimentary alternate location would likely be limited because of extensive anthropogenic influences (i.e., alteration due to land development pressure such as drainage for agriculture, and filling in for urban development). The smaller amount of wetland cover on the landscape increases the importance of each wetland community as it must perform the same biological, hydrological, social and cultural functions to ensure ecosystem integrity as regions with more extensive wetland cover. These wetlands have the potential to be more sensitive to the incremental effects of further development such as a DGR.

- No measurable changes to soil quality, groundwater quality or groundwater flow is likely outside of the immediate footprint of the DGR. Similarly, changes in surface water quality, quantity and flow, are also not likely to be measurable as a result of the project outside the immediate vicinity of the footprint. Therefore, no indirect effect on vegetation or wildlife VCs is likely through these pathways.

- Direct effects on wildlife VCs may occur as a result of additional worker traffic, construction vehicle operation at the sedimentary alternate location. In addition, increased noise levels are likely as a result of site preparation, construction and operations, relative to ambient background levels. As background noise levels are assumed to be low at the sedimentary alternate location, wildlife may not be habituated to the increased noise and activity levels from construction. It is also assumed that there are fewer existing light sources in this region and increased light levels may also contribute to effects on habitat quality. Changes in air quality during site preparation, construction and operations are predicted.

- Overall the above changes in the quantity and quality of vegetation communities and wildlife and wildlife habitat may have an adverse effect on biodiversity at the sedimentary alternate location. However, as the land cover in this ecoregion is fairly disturbed, it is likely that this effect would be of low magnitude.

- Transport would result in an increased potential for wildlife strikes. This is a small number relative to existing traffic (an additional two trips per day), but represents up to an additional approximately 6,600,000 km travelled and associated incremental risk of wildlife-vehicle strikes.

- Indirect effects on the terrestrial environment VCs during decommissioning and closure activities would be similar to or lower than those identified for site preparation and construction. Following decommissioning there would be no measurable indirect effects likely on vegetation or wildlife VCs. No measurable changes to surface water or groundwater are likely, and therefore there is no potential effect on the terrestrial environment.

- Location-specific mitigation would be required depending on the amount and nature of habitat removed and the specific VCs affected. Should avoidance of sensitive environmental features not be possible, further mitigation measures would be required to reduce or eliminate effects. This may include avoiding construction/site clearing activities during sensitive timing windows (e.g., migratory bird nesting season) and habitat compensation measures (e.g., installation of bat boxes). Taking into consideration mitigation measures, no significant adverse effect on terrestrial environment VCs is likely at the sedimentary alternate location.

Overall project-related effects on the terrestrial environment are likely to be greater at a sedimentary location than those predicted for the DGR Project at the Bruce Nuclear site. Vegetation removal would be greater and the need for a separate and independent licensed nuclear site would require the establishment of a new large secured (i.e., fenced) area which may result in effects on habitat connectivity. As the sedimentary alternate location is not likely to be within an already industrialized area; increases in traffic, noise and light levels may have a proportionally larger effect on wildlife VCs, as they may not be habituated to anthropogenic disturbances.

5.3.5 Geology and Hydrogeology

This section considers potential effects on geology, hydrogeology and soil quality of a DGR at the sedimentary alternate location. Potential interactions occur on two broad time scales, the near-term (i.e., when activities are occurring on-site during the site preparation and construction, operations, and decommissioning phases) and in the long-term (i.e., following closure of the DGR).

- Geology, hydrogeology and soil quality have the potential to be affected by site preparation and construction activities. Specifically, the potential effects of the proposed DGR in the sedimentary alternate location on the geology VCs include the following: direct effects on soil quality and on overburden groundwater transport and shallow bedrock groundwater and solute transport; and indirect effects on overburden groundwater quality, on shallow bedrock groundwater quality, and shallow bedrock groundwater and solute transport.

- For the purpose of identifying potential effects, it is assumed that the geology over this area would have low permeability layered rock around the repository, with permeable features near surface.

- The main potential effects on geology during site preparation and construction relate to construction dewatering and the resulting zone of influence due to pumping and management of pumped groundwater, which would have direct and indirect effects on overburden and shallow bedrock groundwater quality and solute transport. This effect occurs primarily during shaft sinking in the upper more permeable portions of the geology, until the shaft liner is installed. The zone of influence during dewatering would be limited to approximately 50 m from the shaft. Dewatering effects would also be temporary, and are therefore unlikely to result in residual adverse effects. During operations, the DGR would have the potential to continue to affect groundwater flow from dewatering of underground facilities; however, volumes of water to be managed are likely to be much smaller during operations, and therefore, the potential for effects are even further reduced.

- Potential effects are also identified during the postclosure phase of the DGR at the sedimentary alternate location. Given the engineered and natural barriers inherent in the design, including shaft seals, no residual adverse effect is likely on the geology and hydrogeology VCs due to a DGR at the sedimentary alternate location during post-closure.

Overall project-related effects on the soil quality, geology and groundwater are likely to be similar to those predicted for the DGR Project at the Bruce Nuclear site and are unlikely to result in residual adverse effects.

5.3.6 Radiation and Radioactivity

This section considers potential effects of radiation and radioactivity of a DGR at the sedimentary alternate location. The dose to human and non-human biota is used to measure potential direct DGR-related effects.

- There is no potential interaction with radioactivity during the construction phase activities with the exception of potential exposure to naturally occurring radiation (i.e., radon) during excavation of the underground facilities.

- Radioactivity may be released as a result of waste package handling and storage during operation (including above-ground and underground transfer of waste), decommissioning and closure activities at the DGR at the sedimentary alternate location. However, any releases are expected to be small and much less than relevant criteria. Therefore radioactivity releases from the DGR are not likely to result in an adverse effect on human or non-human biota VCs.

- Waste package transportation has the potential to affect radiological dose to members of the public and non-human biota off-site. In addition, there is incremental worker dose related to the handling, packaging and transportation of waste. Transportation would be carried out in accordance with the *Nuclear Safety and Control Act* and its regulations and other applicable regulations (e.g., as made under the *Transportation of Dangerous Goods Act, 1992*). Therefore no adverse effect is predicted.

- After closure, the radionuclides would be retained within the DGR as they decay. Any releases of radionuclides would have to occur by transport through the surrounding rock or shaft seals as dissolved or gaseous species. This sedimentary alternate location borders on the Great Lakes. Depending on the geological characteristics of the site, the proximity of a water body is not relevant because the movement of water or gas from the DGR would not reach the water body until the radioactivity of such water or gas had diminished to the levels generally found naturally occurring throughout Ontario. These processes are very slow in low permeability rock. No residual adverse effect during postclosure is expected, and predicted dose rates would be much less than the public dose criterion under normal operations.

Overall effects on radiation and radioactivity of a DGR at the sedimentary alternate location are likely to be similar as that of the DGR Project at the Bruce Nuclear site, given the geological similarity between the locations. The DGR would introduce new radiological exposure pathways at a sedimentary alternate location which was previously not a nuclear site.

5.3.7 Land and Resource Use (Traditional and Non-traditional)

This section considers potential effects land and resource use of a DGR at the sedimentary alternate location.

- Site selection and licensing activities would involve the acquisition of at least 40 ha, and up to approximately 900 ha of land. During site preparation, security fencing and land clearing would commence, which would further restrict access and remove at least part of the land from its previous use.

- Changes to the existing use of the land (from agricultural, or other non-industrial land uses), to industrial use for the site would likely require zoning bylaw and Official Plan amendments to accommodate the licensed facility.

- Up to 40 ha of clearing is assumed to be required, and would likely include some areas that have not been previously disturbed, and would therefore, have archaeological potential. Prior to any site preparation, archaeological assessment(s) would be completed, to remove or mitigate the potential for effect.

- Measurable change in transportation infrastructure functioning throughout the DGR is likely as a result of movement of employee vehicles and project-related truck traffic. If traffic associated with the site cannot be accommodated within the current transportation infrastructure, mitigation would be recommended to upgrade intersections accordingly and mitigate the potential effect.

- Potential changes in the biophysical environment are likely to be confined to the immediate vicinity of the DGR. Background noise and light levels are likely to be low because of limited other industrial influences. Therefore, mitigation would likely be required to meet regulatory limits, and it may take longer for adjacent land users to habituate to changes in noise levels.

- A DGR at the sedimentary alternate location is likely to be located in the trditional territory of one or multiple Indigenous communities. It is assumed that appropriate mitigation and accommodation measures would be applied to address potential effects on current use of lands and resources for traditional purposes, or other issues that could be raised during the consultation process on Aboriginal or Treaty Rights.

Overall project-related effects of the DGR at a sedimentary alternate location on land use are likely to be much higher than those at the Bruce Nuclear site. Up to 40 ha of clearing is assumed to be required, and would likely include some areas that have not been previously disturbed, and would therefore, have archaeological potential. Up to 900 ha will need to be repurposed from its existing land use (likely agricultural) potentially affecting current users of the land and surrounding lands. In addition, background levels of nuisance-related environmental pathways (e.g., noise) are likely to be lower; therefore, changes as a result of the project may be more pronounced, potentially necessitating additional mitigation.

5.4 ENVIRONMENTAL EFFECTS AT A CRYSTALLINE LOCATION

This section summarizes the environmental effects of the DGR at an alternate crystalline location for each identified VC. For more detailed information, see the technical document "Environmental Effects of Alternate Locations" [GOLDER 2016].

5.4.1 Atmospheric Environment

Most DGR-related works and activities have the potential to affect air quality.

- During site preparation and construction, the operation of vehicles, equipment and material handling would cause temporary increases in emissions of combustion products, dust, and other compounds such as VOCs and acrolein, into the atmosphere, which could affect air quality and greenhouse gas emissions.

- Increases in ambient concentrations of a number of air quality indicator compounds are likely during the site preparation and construction, operations, decommissioning and closure phases.

- Transportation of waste between the WWMF and the alternate location would have the potential to cause localized emissions of combustion by-products and dust. Transportation would be largely along existing roads, and the frequency of shipments is relatively small (two shipments per day) as compared to existing traffic levels. Therefore, localized effects of transport-related emissions on air quality are not likely measurable.

- The additional handling and transportation of waste from the WWMF to the DGR at the crystalline alternate location of up to 2,000 km one-way represents a likely effect on air quality and greenhouse gases. A 200 km transportation distance to the DGR at the crystalline alternate location would be approximately equivalent to an increase of 1.2 kt of CO_2 equivalent over the life of the project, while a 2,000 km waste transportation shipping distance would be equivalent to an increase in 11.7 kt of CO_2 equivalent over the life of the project.

- Taking into consideration mitigation and the magnitude of effects, potential effects on air quality are not likely to be significant.

Most DGR-related works and activities have the potential to affect noise levels.

- Operation of equipment and vehicles, as well as blasting activities during site preparation and construction, and the operation of equipment at surface, including shaft ventilation fans, would result in DGR-related noise emissions no greater than 40 dBA. When combined with a background noise level of 30 dBA, or less, the predicted change in noise level for the crystalline location may be greater than 10 dB. This is considered disturbing. During operations, DGR contributions to noise levels are likely to be lower than during the site preparation and construction phase; however, an increase in noise levels of 3 dB or greater is predicted.

- Transport vehicles would cause localized emissions of noise levels in the vicinity of the vehicle while en route. Transportation would largely be along existing roads with existing truck traffic, and the frequency of shipments would be small (two shipments per day) as compared to existing traffic levels. Localized noise level changes are therefore not likely to be measurable.

- Effects on noise levels from decommissioning activities would be similar to or lower than those identified for site preparation and construction. Following decommissioning there would be no further plausible pathway for noise effects.

- A number of noise mitigation measures are inherent in the prediction of effects, including assumed emission control measures. To avoid increases in noise levels that may be considered disturbing at receptor locations, additional mitigation (e.g., shielding, silencers) may be required. Siting of facilities to maximize distance to receptors, or take advantage of shielding through terrain, may also be considered. To limit the potential for nuisance-related noise effects along the transportation route, a noise management plan may also be developed. Taking into consideration mitigation, adverse effects identified of the DGR at a crystalline alternate location on noise levels are not likely to be significant.

With the exception of waste transport, project-specific emissions to air quality for a DGR at the crystalline alternate location are likely to be similar to those predicted for the DGR Project at the Bruce Nuclear site. Background air quality concentrations at the crystalline alternate location are likely to be lower, therefore the cumulative ambient air quality concentrations are likely to be lower as compared to those at the Bruce Nuclear site; therefore, less mitigation may be required to maintain compliance with air quality standards. Overall effects on noise levels are likely to be greater at the crystalline alternate location, predominantly as a result of lower background noise levels and potential nuisance effects during waste transportation. The lower background levels may require the implementation of additional mitigation measures to meet applicable regulatory requirements. Additional effects on air quality and noise levels at the crystalline alternate location are possible as result of waste transportation. The transportation of wastes will also result in the emission of between 1.2 - 11.7 kt of GHGs over the operational life of the facility.

5.4.2 Surface Water Environment

This section considers potential effects on the surface water quality and hydrology (i.e., surface water quantity and flow) of a DGR at the crystalline alternate location.

- The DGR at the crystalline alternate location may affect surface water directly through the requirement to redirect drainage patterns during site preparation and construction, including construction of required additional linear infrastructure (i.e., transmission line, access road). This alternate location is generally well drained with an abundance of lakes, wetlands and rivers. Therefore, it is expected that the DGR would affect some drainage patterns in the area and would likely change flows at one or more locations.

- All runoff from the DGR and associated lands is assumed to be captured in a stormwater management system, with discharge from the waste rock pile runoff at a single location since some level of treatment would be required (e.g., settling basin for solids removal or treatment plant).

- Site preparation and construction may affect surface water quality and quantity through diversion of surface runoff to a stormwater management pond (SWMP) and discharge to the environment. This SWMP includes water from both surface and underground, including process water and groundwater inflows from the shafts; and alternate location runoff and runoff from the waste rock stored in the waste rock management area (WRMA). It is assumed that the crystalline alternate location would have higher water ingress in both the shafts and underground excavations. This would require the potential for increased pumping capacity, or alternative methods for water handling of mitigation (i.e., grouting, full hydrostatic shaft liners).

- The runoff from the waste rock pile and any water from underground would be discharged from the alternate location at a single spot to a local watercourse. There would likely be a measurable adverse effect on surface water quantity and flow from the discharge (i.e., increase in flow); however, the magnitude of effects would depend greatly on the specific characteristics of the receiving water body. Given the characteristics of the region, this is likely to be a local creek, lake or river.

- Surface water that has been collected would also have come in contact with the waste rock which could have the potential to leach metals, and would have residual blasting compounds. To manage surface water quality, the SWMP would collect all water, either from underground or the surface, which has been in contact with waste rock for storage and monitoring. The water would be treated on-site as needed. It is assumed that effects identified above would persist into the operations phase. As all permitting requirements would be required to be met at discharge, no adverse effect on water quality is likely.

- During transportation, there is the potential for increased sedimentation to off-site ditches, as well as incremental risk of a conventional spill as a result of an accident or malfunction. As the increase in traffic would be small relative to existing levels (i.e., two vehicles per day), localized adverse effect on water quality is not likely to be measurable.

- No measurable changes to groundwater quality or flow are anticipated outside of the DGR footprint. Therefore, no indirect effect on surface water is likely.

- The acceptability of the quality of water for discharge would be determined through the Environmental Compliance Approval process with the MOECC and would consider location-specific conditions. In addition to specific discharge concentrations, no water that is acutely toxic to aquatic life would be permitted for discharge. A spills management plan would be prepared for waste transportation to minimize effects on surface water quality in the case of an accidental release.

Overall effects on surface water quantity and flow are likely to be higher in magnitude for the DGR at the crystalline alternate location than for the Bruce Nuclear site, as it may be difficult to construct the waste rock pile and supporting infrastructure without affecting and/or encroaching to some degree on a creek or stream and changing drainage patterns (i.e., through redirection of streams or wetlands). In addition, initially there would be higher volumes of water to be managed from underground which would affect some drainage patterns in the area and would change flows at one or more locations.

5.4.3 Aquatic Environment

This section considers potential effects on the aquatic environment, specifically aquatic habitat and biota VCs of the DGR at the crystalline alternate location. The aquatic habitat and biota VC includes fish, benthic invertebrates and/or macrophytes and their habitats, as well as species at risk.

- The ecozone of the crystalline alternate location is generally well drained with an abundance of wetlands, lakes and rivers. Characteristic fish include species such as lake trout, northern pike, and burbot. Water quality in this region is generally good with limited anthropogenic influences.

- Effects on the aquatic environment are most likely during the site preparation and construction phase. While the project design would avoid watercourses, however it may not be feasible to avoid encroaching on waterbodies with the DGR footprint. These activities have the potential to cause direct effects to the aquatic environment through the direct removal of aquatic habitat and vegetation.

- Changes in surface water conditions may indirectly affect aquatic VCs. Localized changes in surface water quantity and flow are predicted. The potential indirect effect on aquatic VCs is very specific to the specific receiving body. However, as discharge to a small, local receiving waterbody is assumed, the effects may be slightly higher in magnitude as it may affect a greater proportion of a smaller watershed. No adverse effects on surface water quality are likely as discharges will meet criteria established considering aquatic toxicity thresholds.

- Blasting activities have the potential to cause an indirect effect on aquatic VC habitat through changes in vibrations levels. Blasting management strategies would be employed to minimize predicted levels at aquatic spawning habitats in the region. Therefore, no adverse effect is anticipated.

- No changes in groundwater flow or quality at aquatic feature locations are likely as a result of the DGR at the crystalline alternate location. Therefore, no adverse effect through this pathway is anticipated.

- During operations, the potential to affect aquatic VCs is only through indirect effects from changes in surface water quantity and quality. Effects on surface water quantity are expected to persist through the operations phase, however, at a reduced level from those observed during construction. No adverse effect on surface water quality is likely. Therefore, no effect on aquatic VCs is likely in the operations phase.

- Following decommissioning, the potential to affect aquatic VCs is further reduced, and focused on the potential for indirect effects from changes in surface water quantity and quality, and changes in groundwater quality. Effects on surface water quantity are not likely following the closure of the DGR. In addition, no adverse effect on groundwater or surface water quality is likely. Therefore, no effect on aquatic VCs is likely in the long-term performance phase.

- To minimize effects on aquatic species and habitat in any watercourses that would be crossed, as part of the DGR, appropriate design features (e.g., embedded culvert for fish passage), specific mitigation measures (e.g., management of surface water runoff) and best management practices (e.g., erosion and sediment control) during and after construction would be implemented. Mitigation and monitoring strategies identified for surface water are also protective of aquatic habitat. In addition, a blasting management plan would be established to ensure vibrations levels during blasting are protective of applicable Fisheries and Oceans Canada (DFO) thresholds. Therefore, taking into consideration mitigation, no significant effect on the aquatic environment is likely.

It is likely that the potential effects on the aquatic environment of the DGR at the crystalline alternate location would be higher than those of the DGR Project at the Bruce Nuclear site. This is due to the increased likelihood that there would be direct habitat removal, as well as potential effects during the installation of watercourse crossings assumed to be required for supporting infrastructure.

5.4.4 Terrestrial Environment

This section considers potential effects of the DGR at the crystalline alternate location on the terrestrial environment, specifically vegetation and wildlife VCs. Where wildlife VCs are referred to, these may be mammals, birds, herpetiles and/or terrestrial invertebrates and their habitat as well as species at risk. Wildlife habitat and wildlife species VCs also have the potential to be indirectly affected through changes in soil quality; surface water flow, quality and quantity; air quality; noise levels; vibrations levels; and light levels.

- The climate in the Boreal shield ecozone is relatively cold and moist, with long, cold winters and short, warm summers, and a wide range of weather patterns. Vegetation in the Boreal shield ecozone is diverse. Land cover in this area tends to be dominated by woodlands, including mixed, coniferous and deciduous forests. Anthropogenic influences such as cutovers and burns are also noted. Characteristic wildlife species vary within the ecozone, but can include species such as American black bear, moose, snowshoe hare, bald eagle, yellow-rumped warbler, and western painted turtle. In certain areas of the ecozone woodland caribou and gray wolf are also characteristic species. In general, characteristic wildlife in the crystalline rock location ecozone is likely to have a large home range and movement corridors.

- It is assumed that surface facilities would not be located within a provincially significant wetland, as defined by the MNRF. In addition, surface facilities are assumed to maintain a 120 m setback surrounding provincially significant wetland. Where possible, the surface footprint would avoid habitat of threatened or endangered species listed under the Ontario *Endangered Species Act*, and the federal *Species at Risk Act* (on federal land). If habitat cannot be avoided, mitigation would be proposed in accordance with permitting, as required.

- For the site preparation and construction of the DGR, lands would have to be cleared and developed for necessary infrastructure. Overall, it is assumed that development of the DGR at the crystalline alternate location is likely to result in the loss of vegetation of up to 40 ha for the DGR's surface facilities and up to 20 km and 50 km for the required site access road and electrical transmission line, respectively. The removal of vegetation and associated habitat may result in an increased measurable effect on factors such as habitat fragmentation.

- In general, the spatial extent of wetlands communities at the crystalline alternate location is extensive. Because of the large extent of wetland cover on the landscape, the removal of small pieces would not be considered as significant or detrimental to the function of wetlands at the regional scale.

- No measurable changes to soil quality, groundwater quality or groundwater flow are likely outside of the immediate footprint of the DGR. Similarly, changes in surface water quality, quantity and flow, are also not likely to be measurable as a result of the project outside the immediate vicinity of the DGR. Therefore, no indirect effect on vegetation or wildlife VCs is likely through these pathways.

- Direct effects on wildlife VCs may occur as a result of additional worker traffic and construction vehicle operation. In addition, increased noise levels are likely as a result of site preparation, construction and operations, relative to ambient background levels. As background noise levels are assumed to be lower, with few anthropogenic sources at the crystalline alternate location, wildlife may not be habituated to the increased noise and activity levels from construction. It is also assumed that there are fewer existing light sources in this region and increased light levels may also contribute to effects on habitat quality. Changes in air quality during site preparation, construction and operations are predicted.

- Overall the above changes in the quantity and quality, and increase in fragmentation of vegetation and wildlife habitat may have an adverse effect on biodiversity at the crystalline alternate location, particularly as the site is assumed to be comprised of undeveloped natural lands.

- Transport would result in an increased potential for wildlife strikes. This is a small number relative to existing traffic (an additional two trips per day), but represents up to an additional approximately 48,000,000 km travelled and associated incremental risk of wildlife-vehicle strikes.

- Indirect effects on the terrestrial environment VCs during decommissioning and closure activities would be similar to or lower than those identified for site preparation and construction. Following decommissioning there would be no measurable indirect effects likely on vegetation or wildlife VCs. No measurable changes to surface water or groundwater are likely, and therefore there is no potential effect on the terrestrial environment.

- Location-specific mitigation would be required depending on the amount and nature of habitat removed and the specific VCs affected. Should avoidance of sensitive environmental features not be possible, further mitigation measures would be required to reduce or eliminate effects. This may include avoiding construction/site clearing activities during sensitive timing windows (e.g., migratory bird nesting season) and habitat compensation measures (e.g., installation of bat boxes). Taking into consideration mitigation measures, no significant adverse effect on terrestrial environment VCs is likely at the crystalline alternate location.

Overall effects on the terrestrial environment are likely to be greater as a result of the DGR at a crystalline alternate location. Vegetation removal for surface facilities and additional linear infrastructure (e.g., roads, hydro corridor) would result in losses to plant communities and wildlife habitat and would be greater than those assessed for the Bruce Nuclear site. Increases in traffic, noise and light levels may have a proportionally larger effect on wildlife VCs, as they may not be habituated to anthropogenic disturbances.

5.4.5 Geology and Hydrogeology

This section considers potential effects on geology, hydrogeology and soil quality of a DGR at the crystalline alternate location. Potential interactions occur on two broad time scales, the near-term (i.e., when activities are occurring on-site during the site preparation and construction, operations, and decommissioning phases) and in the long-term (i.e., following closure of the DGR).

- Geology, hydrogeology and soil quality have the potential to be affected by site preparation and construction activities. Specifically, the potential effects of the proposed DGR in the crystalline alternate location on the geology VCs include the following: direct effects on soil quality and on overburden groundwater transport and shallow bedrock groundwater and solute transport; and indirect effects on overburden groundwater quality, on shallow bedrock groundwater quality, and shallow bedrock groundwater and solute transport.

- Experience in the crystalline alternate location of the Canadian Shield has shown that active groundwater flow in bedrock is generally confined to shallow localized fractured systems, and at depths is dependent on the secondary permeability associated with the fracture networks.

- The main potential effects of a DGR at the crystalline alternate location relates to construction dewatering and the resulting zone of influence due to pumping and management of pumped groundwater, which would have direct and indirect effects on overburden and shallow bedrock groundwater quality and solute transport. Water inflow into the repository will be minimized by the repository layout, and also by grouting or sealing of intersected fracture zones. During operations, the DGR has the potential to continue to affect groundwater flow from dewatering of underground excavations; however, volumes of water to be managed are likely to be much smaller during operations, and therefore, the potential for effects even further reduced.

- Construction of additional site infrastructure to access the site may also have an interaction with shallow groundwater flows. It is assumed that up to 20 km of additional road may need to be constructed, and taking into consideration the variable bedrock terrain in the region, excavation or blasting for road cuts may be required. Localized dewatering may be required in the vicinity of excavations.

- Potential effects are also identified during the postclosure phase of the DGR at the crystalline alternate location. Given the expected groundwater flow regimes in a suitable crystalline alternate location in central to northern Ontario, the potential effects on geology VCs would therefore be unlikely to result in residual adverse effects during post-closure.

Overall effects on soil quality, geology and groundwater at the crystalline alternate location are likely to be similar to effects of the DGR Project at the Bruce Nuclear site. Given the expected groundwater flow regimes in the crystalline alternate location, residual adverse effects are unlikely.

5.4.6 Radiation and Radioactivity

This section considers potential effects of radiation and radioactivity of a DGR at the crystalline alternate location. The dose to human and non-human biota is used to measure potential direct DGR-related effects.

- There is no potential interaction with radioactivity during the construction phase activities with the exception of potential exposure to naturally occurring radiation (i.e., radon) during excavation of the underground facilities.

- The above-ground transfer of waste, transportation of waste packages to the DGR at the crystalline alternate location, and underground transfer of wastes activities would all involve the movement and/or handling of waste packages. Therefore, there is the potential for these activities to interact directly and contribute to the dose to humans and non-human biota. Any releases are expected to be small and much less than relevant criteria. Therefore radioactivity releases from the DGR to the environment from waste package handling are not likely to result in an adverse effect on human or non-human biota VCs.

- Waste package transportation has the potential to affect dose to members of the public and non-human biota off-site. In addition, there is incremental worker dose related to the handling, packaging and transportation of waste. Transportation would be carried out in accordance with the *Nuclear Safety and Control Act* and its regulations and other applicable regulations (e.g., as made under the *Transportation of Dangerous Goods Act, 1992*). Therefore no adverse effect is predicted.

- After closure, the radionuclides would be retained within the DGR as they decay. Any releases of radionuclides would have to occur by transport through the surrounding rock and/or shaft seals as dissolved or gaseous species. Part of this crystalline alternate location borders on the Great Lakes. Depending on the geological characteristics of the site, the proximity of a water body is not relevant because the movement of any fluid or gas from the DGR would not reach the water body until the radioactivity of such fluid or gas had diminished to the levels generally found naturally occurring throughout Ontario. Since the specific site would be selected to ensure safety, no adverse effects on radiation and radioactivity during postclosure are expected, and predicted dose rates would be much less than the public dose criterion under normal operations.

Overall effects on radiation and radioactivity of a DGR at the crystalline alternate location are likely to be similar as that of the DGR Project at the Bruce Nuclear site. Potential differences in the postclosure performance of a DGR at a crystalline location relative to the DGR Project at the Bruce Nuclear site could occur due to differences in rock permeability and fractures, rock porosity, porewater salinity, sorption, mineralogy and rock strength. In particular, crystalline rock is likely to be more permeable and there would be greater use of other engineered barriers, such as extensive cement backfill, and upfront processing of the wastes. It is likely that the margin of safety would be lower than that of the DGR Project at the Bruce Nuclear site if the crystalline rock was more permeable. The DGR at a crystalline alternate location would also introduce new radiological exposure pathways as the alternate location was not previously a nuclear site; this would be expected to persist through post-closure. The total effect on radiation and radioactivity at the crystalline alternate location would likely be lower than at the Bruce Nuclear site, as there would be no other, existing sources of radiation other than naturally occurring background.

5.4.7 Land and Resource Use (Traditional and Non-traditional)

This section considers potential effects land and resource use of a DGR at the crystalline alternate location.

- Site selection and licensing activities would involve the acquisition of at least 40 ha, and up to approximately 900 ha of land. During site preparation, security fencing and land clearing would commence, which would further restrict access and remove at least part of the land from its previous use.

- Changes to the existing use of the land (assumed to be likely Boreal forest on Crown land), to industrial use would require disposition of land by the Ontario Crown, which would be subject to the relevant regulatory processes.

- Up to 40 ha of clearing is assumed to be required, and would likely include some areas that have not been previously disturbed, and would therefore, have archaeological potential. Prior to any site preparation, archaeological assessment(s) would be completed, to remove or mitigate the potential for effect.

- Measurable change in transportation infrastructure functioning throughout the DGR is likely as a result of movement of employee vehicles and project-related truck traffic. If traffic associated with the site cannot be accommodated within the current transportation infrastructure, mitigation would be recommended to upgrade intersections accordingly and mitigate the potential effect.

- Potential changes in the biophysical environment are likely to be confined to the immediate vicinity of the DGR. Background noise and light levels are likely to be low because of limited other industrial influences. Therefore, mitigation would likely be required to meet regulatory limits, and it may take longer for adjacent land users to habituate to changes in noise levels.

- A DGR at the crystalline alternate location is likely to be located in the traditional territory of one or multiple Indigenous communities. It is assumed that appropriate mitigation and accommodation measures would be applied to address potential effects on current use of lands and resources for traditional purposes, or other issues raised during the consultation process on Aboriginal or Treaty Rights.

Overall effects of the DGR at a crystalline alternate location on land and resource use are likely to be much higher than those at the Bruce Nuclear site. Up to 40 ha of clearing is assumed to be required, and would likely include some areas that have not been previously disturbed, and would therefore, have archaeological potential. Up to 900 ha will need to be repurposed from its existing land use (likely Boreal forest) potentially affecting current users of the land and surrounding lands. Background levels of nuisance-related environmental pathways (e.g., noise) are likely to be lower; therefore, changes as a result of the project may be more pronounced, potentially necessitating additional mitigation.

5.5 ENVIRONMENTAL EFFECTS SUMMARY

A DGR could be constructed at either of the alternate locations without any likely significant adverse environmental effects. However, environmental effects are likely to be greater at both the sedimentary and crystalline alternate locations as compared to those at the DGR Project at the Bruce Nuclear site (see Table 5-2). Increased environmental effects include:

- increased effects on air quality, including increased GHG emissions, due to waste transportation from the WWMF to the alternate location;
- increased effects on noise levels due to likelihood of quieter background levels at the alternate locations;
- adverse effects on vegetation communities from increased clearing during site preparation and construction of surface facilities and supporting infrastructure, including access roads;
- adverse effects on wildlife communities due to establishment of a new up to 900 ha site with associated indirect effects from vegetation loss and habitat fragmentation;
- effects on traditional and non-traditional land use due to establishment of a new site and change in land use, traffic from waste transport and workers, and indirect nuisance-related effects relative to background levels;
- increased worker exposure during waste transportation; and
- establishment of new sources of radiation exposure at a location where there are likely to be no existing anthropogenic sources of exposure.

There would be more environmental effects related to a DGR at either alternate location than the DGR Project at the Bruce Nuclear site.

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Table 5-2: Summary of Likely Environmental Effects of Alternate Locations as Compared to the DGR Project at the Bruce Nuclear site

Environmental Component	Valued Component	Sedimentary Location		Crystalline Location		Notes
		Environmental Effects	Mitigation Requirements	Environmental Effects	Mitigation Requirements	
Atmospheric Environment	Air Quality	▲	▼	▲	▼	Increased effects on air quality are anticipated at both alternate locations as a result of shipments of waste packages from WWMF to the alternate location Potential nuisance related effects to adjacent residences along the transport route DGR-related increases in concentrations of air quality indicator compounds at the DGR's fence line are likely to be similar at all locations Lower background air quality may necessitate less mitigation to meet relevant air quality criteria
	Noise Levels	▲	▲	▲	▲	Although DGR noise emissions are likely to be similar, effects on noise levels are likely to be of higher magnitude at alternate locations due to lower background noise levels Effects at the crystalline alternate location may be higher than the sedimentary alternate location, although it would be dependent on distance to closest receptor Additional mitigation may be required at alternate locations to meet relevant noise criteria
Surface Water Environment	Surface Water Quality	↔	▲	↔	▲	Effects on surface water quality are likely to be similar at all three locations as releases would be required to meet discharge limits protective of the environment Site-specific discharge limits may be more restrictive for both alternate locations if the receiving water body has a low assimilative capacity
	Surface Water Quantity and Flow	↔	▲	▲	▲	Effects on surface water quantity and flow are likely to be similar at the sedimentary alternate location to the Bruce Nuclear site as there would be similar water volumes to be managed; however, additional mitigation may be required at the alternate locations depending on the specific capacity of the receiving water body Effects may be higher in magnitude at the crystalline alternate location as there may be more water to manage and greater likelihood of drainage area changes
Aquatic Environment	Aquatic Habitat	↔	▲	▲	▲	Effects on aquatic habitat are likely to be similar at the sedimentary alternate location to those at the Bruce Nuclear site Direct habitat loss likely at the crystalline alternate location for construction of supporting infrastructure Additional mitigation may be required, at an alternate location if discharged to a smaller watershed, but is highly dependent on the discharge location identified
	Aquatic Biota	↔	↔	↔	↔	Effects on the aquatic biota are likely to be similar at all three locations
Terrestrial Environment	Vegetation Communities, including upland and wetland	▲	↔	▲	↔	Increased area of vegetation removal for additional surface facilities for both alternate locations At the sedimentary alternate location, wetland features are likely to experience a greater degree of impact from developmental activities; impacts at wetland communities at the crystalline alternate location may be less affected Increased effects on habitat connectivity due to additional fenced areas and additional site infrastructure at both alternate locations
	Wildlife Habitat and Biota	▲	↔	▲	↔	Increased area of habitat loss at both alternate locations due to vegetation clearing Increased effects on habitat connectivity at both alternate locations due to additional fenced areas and onsite roads Greater potential for adverse effects from changes in air quality, noise, light, vibrations, as both alternate locations are less influenced by anthropogenic disturbances Greater potential for wildlife-vehicle interactions for both alternate locations due to additional waste transport
Geology and	Soil Quality	↔	↔	↔	↔	Effects on soil quality are expected to be similar between all three locations

Environmental Component	Valued Component	Sedimentary Location		Crystalline Location		Notes
		Environmental Effects	Mitigation Requirements	Environmental Effects	Mitigation Requirements	
Hydrogeology	Groundwater Quality	↔	↔	↔	↔	Residual effects on groundwater quality are expected to be similar between all three locations
	Groundwater Flow	↔	↔	↔	▲	Given the similar geologic setting, effects on groundwater flow are expected to be similar at the sedimentary alternate location Residual effects on groundwater flow are expected to be similar at all three locations; however, additional mitigation may be required at the crystalline alternate location
Radiation and Radioactivity	Humans	↔ (members of the public) ▲ (workers)	▲	↔ (members of the public) ▲ (workers)	▲	All alternate locations would be designed to protect workers and members of the public Incremental worker dose related to the handling, packaging and transportation of waste Mitigations for the crystalline alternate location are likely to be more extensive than for the sedimentary alternate location based on the different geologic settings
	Non-human Biota	↔	↔	↔	▲	No residual effects are likely as site-specific mitigation would be implemented to protect the environment Mitigations for the crystalline alternate location are likely to be more extensive than for the sedimentary alternate location based on the different geologic settings
Land and Resource Use	Use of lands and resources (traditional and non-traditional)	▲	▲	▲	▲	Increased effects for both alternate locations New site required Additional traffic from waste transport and workers Disruption to current use of land and resources for traditional and non-traditional purposes Increased indirect nuisance-related effects relative background levels

Notes:
▲= Increased magnitude, frequency or extent of effects relative to the DGR Project at the Bruce Nuclear site
↔ = Similar magnitude, frequency or extent of effects relative to the DGR Project at the Bruce Nuclear site
▼= Decreased magnitude, frequency or extent effects relative to the DGR Project at the Bruce Nuclear site

6. INCREMENTAL PROJECT COSTS AND RISKS

6.1 TRANSPORTATION COSTS

An estimate was prepared of the incremental cost to package the entire inventory of L&ILW containers residing at the WWMF so that they are suitable for transportation in compliance with PTNSR and to transport them by road to an alternate location. The estimate was at a level suitable for a project that is in the early conceptual stage to provide a high-level indication of the approximate cost for a project (Class 5). The classification system and guidelines followed were those published by the American Association of Cost Engineering (AACE) International.

The estimate includes the costs of the following major work activities:

- The cost to supply and install (when required) the following equipment:
    - Truck, tractor and trailer equipment and devices to secure packages;
    - Road-permitted transport packaging;
    - Equipment needed to facilitate waste handling operations on the WWMF site and at the alternate location (e.g., forklifts, etc.); and
    - New containers as required (i.e., Modular Shielded Containers).

- Labour costs associated with all activities related to transportation including:
    - Transporting waste from WWMF to the alternate location;
    - Onsite labour at WWMF and at the alternate location for retrieval, loading and unloading, and transport preparation operations; and
    - Return of the empty truck with reusable transport package back to the WWMF.

- Maintenance costs.

Indicative costs estimates were developed for each waste category for each of four assumed transport distances. Representative distances from the WWMF to the alternate locations are 100 and 300 kilometres for the sedimentary alternate location; and, 200 and 2000 kilometres for the crystalline alternate location.

Wherever possible, the transport packages chosen for each waste category were based on existing standard designs that can be procured from commercial sources. For unique waste categories where standard transport packages were not suitable or compatible, the design and procurement of custom waste category-specific packages was assumed.

The transportation cost estimate assumed that both reusable and one-time transport packages are used depending on waste category-specific requirements. The quantity of packages needed to support shipment rates that keep pace with the baseline plan for waste retrieval operations was determined. The associated equipment and labour resources needed on the WWMF site to conduct transport packaging and road transport readiness operations, and transport package unloading operations at the alternate location were also included.

All road transport operations were assumed to be performed in compliance with Ontario Ministry of Transportation (MTO) requirements, Transportation of Dangerous Goods Regulations (TDGR) and PTNSR.

Other assumptions for cost estimating purposes included the following:

- All shipments were assumed to be made by truck transport.
- Most shipments were essentially assumed to be unencumbered other than normal traffic patterns and movement is assumed 24 hours per day.
- Shipments that exceeded the MTO size restrictions for the combined truck conveyance and transport package were assumed to be permitted (authorized by MTO). The resulting combined restrictions (by provincial and local permitting along the transportation routes) would limit movement to an average of 8 hours per day for such shipments.
- The transportation schedule was assumed to align with the waste retrieval schedule already developed for the DGR Project at the Bruce Nuclear site because it is the most logical way to retrieve the waste.
- For the purposes of this study, two in-service dates have been assumed: one in 2045 for the sedimentary alternate location and one in 2055 for the crystalline alternate location. Waste inventory was based on waste volumes that would reside at WWMF at the time the DGR at an alternate location would be available to initiate waste emplacements (under the 2045 or 2055 scenarios). This means that more waste would accumulate, and more shipments would be required in the 2055 scenario[5].

Costs were defined in seven cost areas (or cost categories) (Figure 6-1):

- Repackaging waste containers: this includes the cost for procurement, fabrication and delivery of new waste containers (that are transportable and DGR-ready) for repackaging bulk waste such as tile hole liner wastes.
- Transport packaging: this includes the cost for procurement, fabrication and delivery of suitable transportation packages for waste containers and large components that are not transportable in their current form (unshielded LLW containers, unshielded ILW resin liners, etc.).
- Packaging specific equipment: this includes the cost for procurement, fabrication and delivery of support equipment needed for loading, transferring, lifting, handling supporting, securing and unloading the various transportation packages (hoisting/lifting fixtures, rigging, cribbings, etc.).

[5] There is a small (i.e. <10% at 2045 and <4% at 2055) volume that would be created after those dates (up until the last reactor is taken out of service) thus this cost estimate is conservative.

- Truck transport: this includes the cost for the fleet of tractor/trailers and drivers to conduct road transport operations, as well as consumables (fuel, maintenance, permitting, etc.).

- Site common equipment: this includes the cost of equipment that is common to all waste categories needed to support transport packaging and loading operations at the WWMF, and unloading operations at the alternate location.

- Site Labour: this includes the cost for site labour resources needed to support incremental operations at the WWMF and operations at the alternate location.

- Management Reserve: this is to offset the cost of unknown, unanticipated and unplanned but necessary additional work. A contingency of 12% has been applied, which is reasonable given that radioactive waste transportation is a well established business.

The data shows that the costs associated with road transport are between 7 and 50% of the total transportation costs. A large component of the cost is attributed to getting the waste compliant with PTNSR, including but not limited to on-site labour and fabrication of the transportation packages.

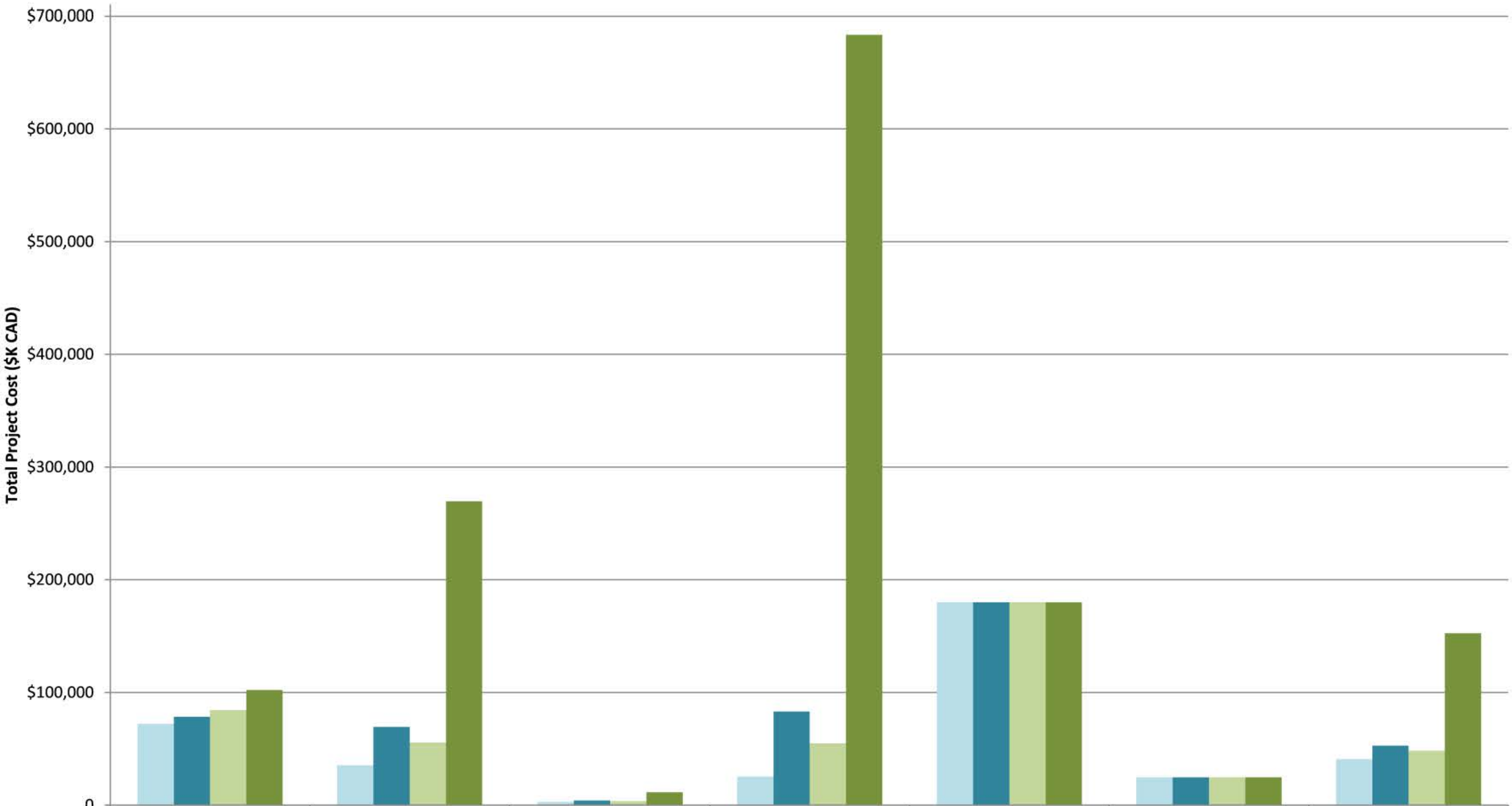
The resulting total cost for packaging and transporting the inventory of L&ILW from the WWMF to an alternate location, based on the volume stored at the estimated in-service dates (i.e. 2045 and 2055) would be in a range between $0.4B to $1.4B (in 2016 Canadian dollars) depending on distance:

- Between $0.4B and $0.5B for the sedimentary alternate location.

- Between $0.5B and $1.4B for the crystalline alternate location.

The specific values for each transportation distance are shown in

Figure 6-2 and 6-3.



	Repackaging Bulk Waste Containers	Transport Packaging	Packaging-Specific Equipment	Truck Transport	Site Labor	Site Equipment	Management Reserve
100km	$72,167	$35,445	$2,804	$25,572	$180,099	$24,807	$40,907
300km	$78,524	$69,446	$4,186	$83,189	$180,099	$24,807	$52,830
200km	$84,207	$55,689	$3,665	$54,853	$180,099	$24,807	$48,398
2,000km	$102,197	$269,680	$11,450	$683,526	$180,099	$24,807	$152,611

Cost Category

Figure 6-1: Total Cost for L&ILW Packaging and Transporting by Cost Category

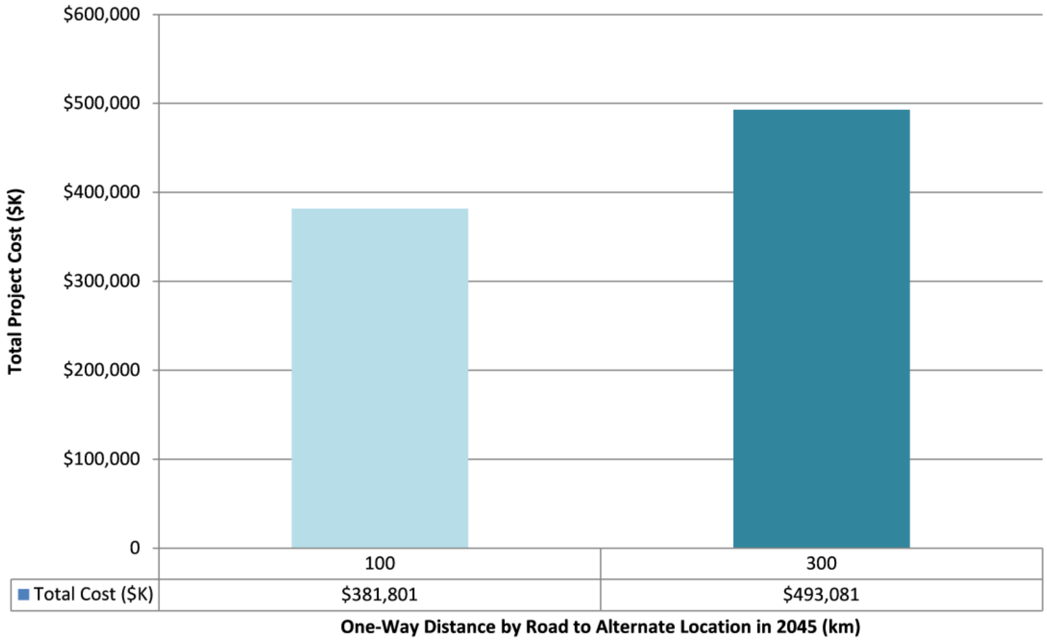


Figure 6-2: Cost for Packaging and Transport to the Sedimentary Location

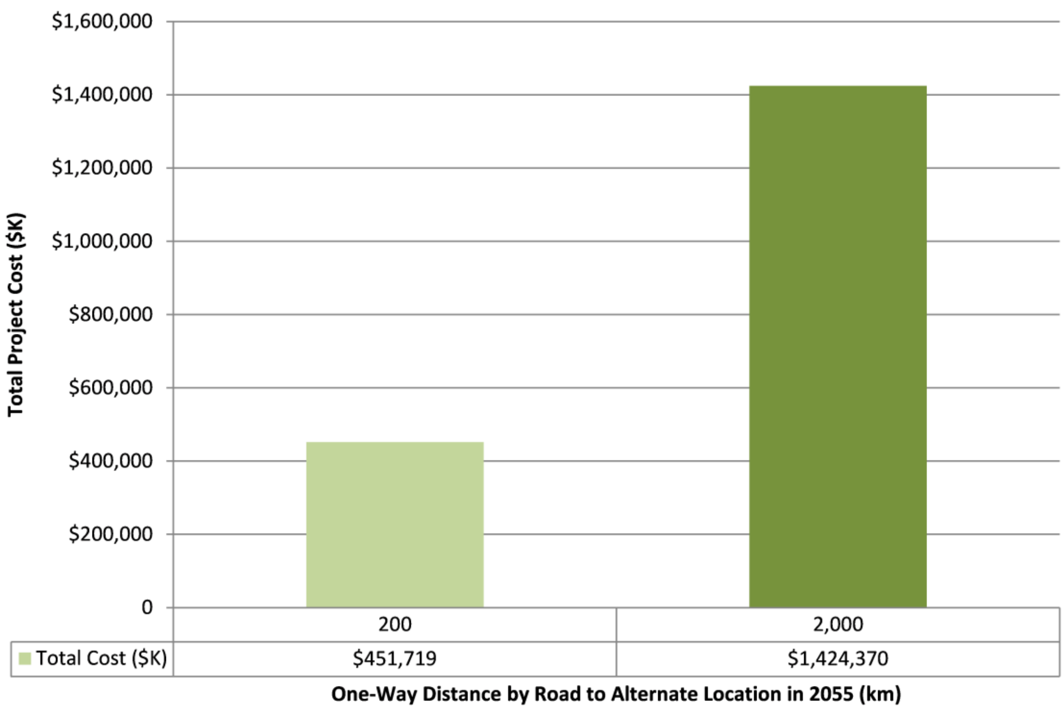


Figure 6-3: Cost for Packaging and Transport to the Crystalline Location

6.2 INCREMENTAL NON-TRANSPORTATION PROJECT RELATED COSTS

OPG has also developed an estimate of the non-transportation related additional costs associated with establishing a DGR at an alternate location. These costs are incremental to the base costs of implementing the DGR Project at the Bruce Nuclear site and are estimated to range between $0.8B and $2.1B (in 2016$). The incremental costs are associated with the following major work activities:

- Site Selection and Acquisition: Site selection design and implementation (described earlier) was assumed to range between approximately $30M and $60M. Site acquisition costs were based on the minimum required 40 hectares (to be conservative) and a range of published market prices (an average of $300/ha in northern Ontario to $7,600/ha in southern Ontario).

- Site Characterization: This includes the costs associated with geoscientific investigations and analysis, environmental investigations and assessment, engineering/design, safety assessment (pre- and post- closure), licence application preparation and submissions. Site characterization costs were based on the NWMO's APM site selection process.

- Regulatory Approvals: This includes the cost to obtain all regulatory approvals. CNSC fees are assumed to be $1M/year for the pre site selection period. For the site selection phase the incurred costs for the DGR Project were used. The review phase assumes a similar process to that of the DGR at the Bruce Nuclear site and the costs incurred to-date for the DGR Project at the Bruce Nuclear site have been used.

- Site Preparation and Infrastructure: This includes a range of costs, including the establishment of site facilities such as fencing, security facilities, emergency facilities and equipment, an on-site maintenance/garage facility and fueling station, emergency services and redundant fire water supply. It includes the cost of constructing road and power corridor access to the site, and the cost to provide incremental storage facilities at the alternate location.

- DGR Operational Requirements: This includes only the cost for incremental staffing required for site security and emergency response services (it is assumed that the same number of resources are required to operate and maintain the DGR at the alternate location as at the Bruce Nuclear site).

- Additional Repository Work: This includes the costs associated with additional engineered barriers likely required at the crystalline alternate location due to its more permeable and fractured nature. The costs are based on pre-processing the resin waste as described in 4.1.2, excavating the volume of additional emplacement rooms, repackaging the waste, grouting the waste in the packages, and backfilling the emplacement rooms with cement grout to ensure sufficient C-14 retention.

- WWMF Infrastructure Requirements: This includes the costs to construct, maintain and decommission additional low level and intermediate level waste storage facilities at the WWMF to accommodate the additional waste associated with deferred DGR in-service dates. These result in a total incremental cost of $201M and $290M for the 2045 and 2055 in-service dates respectively.

The costs for decommissioning and closure, and post closure are assumed to be the same and are included in the cost for the DGR Project at the Bruce Nuclear site.

The costs are listed in Table 6-1 for the sedimentary and crystalline alternate locations.

Table 6-1: Incremental Project Cost Estimate

Element	Sedimentary Alternate Location $M	Crystalline Alternate Location $M
Site Selection and Acquisition	30	41
Site Characterization	349	509
Regulatory Approvals	45	51
Site Preparation and Infrastructure	54	139
DGR Operational Requirements	136	153
Additional Repository Work	0	832
WWMF Infrastructure Requirements	201	290
Total (2015$)	816	2,015
Total (2016$)	832	2,056

(Numbers may not add up due to rounding)

6.3 TOTAL INCREMENTAL PROJECT COSTS

In total, the additional cost associated with the incremental cost to repackage and transport the waste to an alternate location and the other incremental costs associated with establishing a DGR at an alternate location is/was estimated to be between $1.2B and $3.5B as shown in Table 6-2 and Table 6-3.

Table 6-2: Total Incremental Project Cost Estimate for the Alternate Sedimentary Location (2016 $'s)

Grand Total Sedimentary Location	Low Estimate $M	High Estimate $M
Incremental Project Costs Subtotal	832	832
Repacking and Transportation		
Sedimentary Alternate Location[6]	381	493
Grand Total Sedimentary Alternate Location	1,213	1,325

6 The low estimate is for a 100 km representative distance and the high estimate is for a 300 km representative distance.

Table 6-3: Total Incremental Project Cost Estimate for the Alternate Crystalline Location (2016 $'s)

Grand Total Crystalline Location	Low Estimate $M	High Estimate $M
Incremental Project Costs Subtotal	2,056	2,056
Repacking and Transportation		
Crystalline Alternate Location[7]	452	1,424
Grand Total Crystalline Alternate Location	2,508	3,480

6.4 TRANSPORTATION RISKS

OPG has been safely transporting radioactive materials from its nuclear stations and other licensed nuclear facilities for over 40 years, and has never had an accident resulting in a radioactive release or a serious personal injury. In an average year, OPG transports approximately 800 shipments of radioactive material and travels approximately 500,000 total kilometres.

This record of safe performance is attributable to the Canadian regulatory system which requires robust waste packages, consistent with international best practices. It is also attributable to OPG's Nuclear Management System which provides a framework of processes and programs to ensure OPG achieves its safety objectives, continuously monitors its performance against these objectives, and fosters a healthy safety culture.

The objective of OPG's Radioactive Material Transportation Program is to ensure that shipments of radioactive material are performed safely and in accordance with the TDGR and PTNSR. The program establishes controls and procedures for handling, packaging, shipment, and receipt of radioactive material, and verification that emergency response for transportation incidents is appropriately established. The program is both self and independently assessed on a routine basis to ensure regulatory and program compliance. Federal regulators, such as Transport Canada and the CNSC, also complete periodic inspections of the program and its performance.

OPG has a Transportation Emergency Response Plan (TERP) designed to respond to an incident involving transportation of any radioactive material. OPG's plan is registered with and has been accepted by Transport Canada. OPG provides a comprehensive training program to its drivers that is more rigorous than required by the TDGR and includes, among other elements, radiation protection training, skid avoidance training, and defensive driver training. This training is reviewed annually to ensure that it remains accurate and effective. These managed systems minimize transportation related risks as demonstrated by OPG's excellent operating performance.

[7] The low estimate is for a 200 km representative distance and the high estimate is for 2000 km representative distance.

It should be noted that OPG's current TERP does not cover areas of the province where OPG does not transport waste. Therefore, for a DGR at an alternate crystalline location, a new or amended TERP would be required.

For the purposes of this study, two areas of transportation risk were identified – radiological risk and conventional risk. These are described in the technical document "Costs and Risk Estimate for Packaging and Transporting Waste to Alternate Locations" [ENERGY SOLUTIONS 2016] and are summarized here.

Incremental conventional and radiological risks are inherent to a large long-duration truck transportation campaign, such as that to transport the entire inventory of L&ILW from the WWMF on public roads to the DGR at an alternate location. The transportation of radioactive materials may pose radiological risks because of the characteristics and potential hazards of the material being transported. Conventional risks include those resulting from the nature of transportation itself, independent of the characteristics of the cargo (e.g., traffic accidents).

The re-packaging of waste which is currently stored at the WWMF and its transportation to an alternate location by way of public roadways, will result in incremental risks to workers and the public, as well as result in increased GHG emissions to the environment. The duration of such a transportation campaign, necessary to transport stored waste over significant distances, means that the incremental risks will exist for 30 – 35 years.

In describing the risks, quantitative references are provided where the necessary information is available for a quantitative assessment.

6.4.1 Radiological Risks

6.4.1.1 Re-packaging of Waste for Transportation

In order to transport waste from the WWMF, OPG needs to be assured that all of the stored waste is placed into appropriate packaging in containers which satisfy regulatory requirements for shipment of radioactive waste on public roadways. Accomplishing this task requires that workers retrieve the stored waste, examine the containers, and as necessary re-package waste in preparation for transportation to the alternate location.

Activities associated with the retrieval and re-packaging of the waste would result in incremental occupational radiation doses to workers, since these exposures would be greater than they would be for transfer of WWMF waste to the DGR Project at the Bruce Nuclear site. Handling of the waste upon its arrival at the alternate location, would further contribute to occupational exposures to workers.

The incremental doses resulting from the activities described in this section would be quantified because radiation doses to Nuclear Energy Workers (NEWs) are continuously monitored.

6.4.1.2 Exposure to Transport Vehicle Operators

Operators of transportation vehicles (drivers) constitute a second group of workers who would be subject to incremental exposures in the transfer of L&ILW to the alternate location.

While it is recognized that the waste characteristics and the approved radioactive waste packaging are designed to limit the exposure dose to persons in contact or close proximity to waste packages, transportation regulations do allow for dose rates above background in proximity to the packages. Consequently the packages themselves would represent a source of continuous low level exposure to vehicle operators transporting the waste from the WWMF to the alternate location. As in the case of the workers re-repackaging the waste for shipment, as well as those off-loading at the alternate location, these exposures are also incremental since exposure times would exceed those required for transfer of waste from the WWMF to the DGR Project at the Bruce Nuclear site.

6.4.1.3 Exposure to Members of the Public

Similar to the manner in which operators of transportation vehicles are exposed to ionizing radiation emanating from external surfaces of the transportation packages, members of the public who are in proximity to the transportation vehicles are also subject to exposure.

For the distances currently used in OPG's transportation program, rest stops and refueling are not required. For the longer distances assumed for the crystalline alternate location, trucks would need to stop for driver rest periods and for refueling. Persons who reside along the transportation routes, or work along the transportation roadways would be exposed to radiation from vehicles in transit. Similarly, persons at re-fuelling stops or rest stops used by the transport vehicles, as well as those sharing the roadways would also be subject to exposures as a result of the in-vehicle radioactive waste.

As a point of reference, studies conducted by the NWMO have derived estimates of radiation doses to members of the public as a result of transportation of radioactive materials. Those studies show that:

- Radiological doses to members of the public were estimated to be 0.000 013 mSv/year for residents living along the transportation route [NWMO 2013, NWMO 2014].

It should be noted that the NWMO data is based on transportation of used fuel in specially designed transport packages, not L&ILW. Therefore, while the data demonstrates the point, the conditions while analogous, are not equivalent.

- Another point of reference is included in the "Cost and Risk Estimate for Packaging and Transporting Waste to Alternate Locations" technical document [ENERGY SOLUTIONS 2016]. A radiological dose to the population was derived based on industry data (published bythe U.S. Department of Energy) and was estimated to range between seven person-rems per year (for a distance of 100 km) to 144 person-rems per year (for a distance of 2000 km). This represents the potential annual collective dose to a group of people (in this instance the workers and members of the public) along the transportation route in any one year. The portion that any one individual would receive would be much less. This is a very small dose to an individual. For unit comparison, seven person-rems is equivalent to 70 person mSv.

A further risk to members of the public resulting from the transportation of radioactive material on public roadways is derived from the potential occurrence of a vehicular accident involving a waste transportation vehicle in which the transport packaging fails as a consequence of the accident, resulting in the release of radioactive material to the environment.

In such a scenario, persons in the vicinity of the accident can be exposed to radiation through a number of pathways, depending on the nature of the radioactive material and its movement through various media.

The probability of such an accident is very low. Managed systems such as the TERP provide guidance in the management of such an occurrence to minimize the potential impact on people or the environment. However, with an extended transportation campaign requiring the movement of radioactive material over thousands of kilometres, an incremental risk to the public exists.

6.4.2 Conventional Risks

The travel by transportation vehicles during the waste transportation campaign increases the risk of conventional highway accidents involving those vehicles. Specifically, the risks consist of traffic accidents with consequences ranging from property damage, to personnel injury or fatality.

In order to estimate the incremental conventional risk associated with the L&ILW transportation campaign, OPG reviewed data provided by MTO for year 2013. The data indicates that a total of 15,692 collisions involving large trucks occurred, of which 13,022 resulted in property damage, 2,577 in personal injury and 93 resulted in fatalities.

Extrapolating the MTO baseline statistics, OPG estimates that for the transportation campaign of approximately 22,000 – 24,000 shipments over 35 years, statistically between three and 69 collisions may be predicted with less than one fatality resulting from those collisions (

Table 6-4).

Table 6-4: Risk Estimates Conventional Accidents

Distance from WWMF (km)	Number of shipments	Total distance travelled over the life of the campaign (km)	Estimated Number of Collisions	Estimated Number of Fatalities
2045 In-service date				
100	22,000	2,200,000	3.15	0.01
300	22,000	6,800,000	9.72	0.02
2055 In-service date				
200	24,000	4,800,000	6.86	0.02
2,000	24,000	48,000,000	68.64	0.17

Note: shipment #'s have been rounded from the technical document.

6.4.3 Risk Summary

The identified risks are manageable and transportation can be conducted safely provided that the appropriate Nuclear Managed System is in place. However, transferring the waste from the WWMF to an alternate location would add a small but incremental risk exposure to the public and workers from a conventional and radiological perspective.

7. SOCIAL LICENCE

OPG owns and/or operates 70 generating stations and other facilities, in 70 communities across Ontario. Some of these stations have been generating power for more than 100 years. Instrumental to OPG's ability to continue its operations and to build new projects is its development of social licence, which includes:

- having supportive and welcoming host communities;
- building public trust;
- fostering positive and mutually beneficial relationships with Indigenous communities; and
- being well regarded by the public at large.

7.1 SUPPORTING AND WELCOMING HOST COMMUNITIES

The DGR Project at the Bruce Nuclear site has the support of the host municipality (Municipality of Kincardine) and was chosen by the municipality as the preferred method for long term management of L&ILW. The host municipality has been engaged with nuclear technology for over a half a century, beginning with the development of the Douglas Point facility in the 1960s. Over time the community has participated in and supported the further development of the site, including major site development such as the construction and operation of the Bruce A Nuclear Generating Station in the 1970s, Bruce B Nuclear Generating Station in the 1970s, Bruce Used Fuel Dry Storage Facility in the 1990s, the refurbishment of Bruce Units 1 and 2 in the 2000's as well as various incremental site changes (decommissioning and infrastructure installations).

The host community is an informed community, with a significant portion of the resident population employed at the site, or associated with someone employed at the site. In addition to direct knowledge the community is informed through regular newsletters, open houses, mobile display units, and presentations to local and regional councils. The local elected government is active and participatory, as demonstrated by the pro-active discussions initiated by the municipality on long term waste management options. That support has been reiterated through numerous municipal resolutions, the most recent as of June 2015.

For OPG, an informed, willing host community that seeks to participate in decisions regarding facility management is the best demonstration, and a key element of social licence.

For a DGR at an alternate location, OPG estimates that it would take almost two decades to identify a suitable alternate site through detailed site investigations and to garner a willing host community in a participatory process. While OPG is confident that it would ultimately be successful, the time and resources required to obtain that support would introduce uncertainty.

7.2 BUILDING PUBLIC TRUST

OPG's plan for the safe, long term management of L&ILW is supported by a majority of Ontarians, and at the same time, is not an area of concern among the general population.

7.2.1 Support for OPG's DGR Project at the Bruce Nuclear site

A survey of 805 Ontarians, performed by the Gandalf Group on behalf of OPG in 2016, with the goal of understanding the public's opinion of the DGR Project at the Bruce Nuclear site, showed that more than half (53%) of Ontarians have heard about OPG's proposal to bury L&ILW for long term management in a DGR [Gandalf 2016]. This is considered representative where the margin of error is +/- 3.45%, 19 times out of 20. The data was weighted to represent the gender, age, and regional distribution of the province.

Based on their initial understanding of the DGR Project at the Bruce Nuclear site, 60 percent of those who had heard of the project were supportive. Respondents were then presented with a series of critiques of the proposed DGR Project at the Bruce Nuclear site. These included the following:

- The DGR will be built 1.2 kilometers away from Lake Huron. It will pose a threat to our drinking water and the health of the lake.
- Other DGRs have failed in other countries so the science cannot be trusted.
- We cannot be confident that Kincardine is a good location for the DGR because OPG did not look at other locations.
- Nuclear waste should continue to be stored above ground until a better solution is found.

Each of the critiques was paired with rebuttals including:

- International experts say that the limestone rock that the Deep Geologic Repository would be buried in is virtually impenetrable, which prevents any leaking.
- DGR's have safely stored waste around the world, including the US, Sweden, Germany, Finland and Korea.
- If the DGR was built elsewhere, the risks of transporting all the radioactive material by truck would greatly increase the risk of the project
- International experts find that it is much safer to bury waste deep underground than to let it sit aboveground where it is vulnerable to weather and other hazards.

After all of the information was given, respondents were then asked to gauge their level of support for the project. The results showed that 70 percent of respondents supported the project.

7.2.2 DGR Not a Concern

Research shows that there is little interest among the general public regarding the DGR Project at the Bruce Nuclear site. OPG had a social media analysis prepared in the fall of 2016. The analysis began with a detailed query in Sysomos MAP – a media analysis platform that provides news, blogs, forums, tweets and many other media results. A year's worth of data was passed through IBM Watson's Alchemy – a language analysis platform to identify key themes identified from OPG DGR related media activity and conversations in the past year. In addition to media analysis, the Google Keyword Planning Tool as well as Google Trends was used to understand how Ontarians are seeking information about nuclear waste disposal. In particular, the analysis focused on the keywords being used, and the frequency with which Ontarians are looking for this information.

The analysis showed that Ontarians are not looking for information on nuclear waste disposal in large volumes. This topic is not a popular one, nor is it generating large volumes of curiosity.

- Compared to other energy related keywords (wind turbines, solar power) there is very little curiosity about nuclear waste disposal, or deep geologic repositories.
- DGR related searches are at a frequency of virtually zero, and nuclear waste as a topic shows less interest amongst Canadians than other energy topics.
- Looking at how Ontarians search, there is an even greater discrepancy. Energy and power are more important (or generate more curiosity) than disposal and waste related searches.
- Currently, interest in DGR in Ontario has flat-lined; outside of a spike in May 2015 attributed to the release of the Joint Review Panel report, there has been very little search frequency for 'deep geologic repository'.

Figure 7-1 and Figure 7-2 show the results of the Google Trends query nationally and provincially for various energy or large scale projects. The horizontal axis of the main graph represents time (starting from 2004 to August 2016), and the vertical is how often a term is searched for relative to the total number of searches (0 to 100). The search terms and legend are as follows:

- "Deep geological repository" is represented by the green line
- "Nuclear waste" is represented by the blue line
- "Wind turbines" is represented by the red line;
- "Solar power" is represented by the yellow line.

In both cases OPG's DGR (the green line) is almost imperceptible.

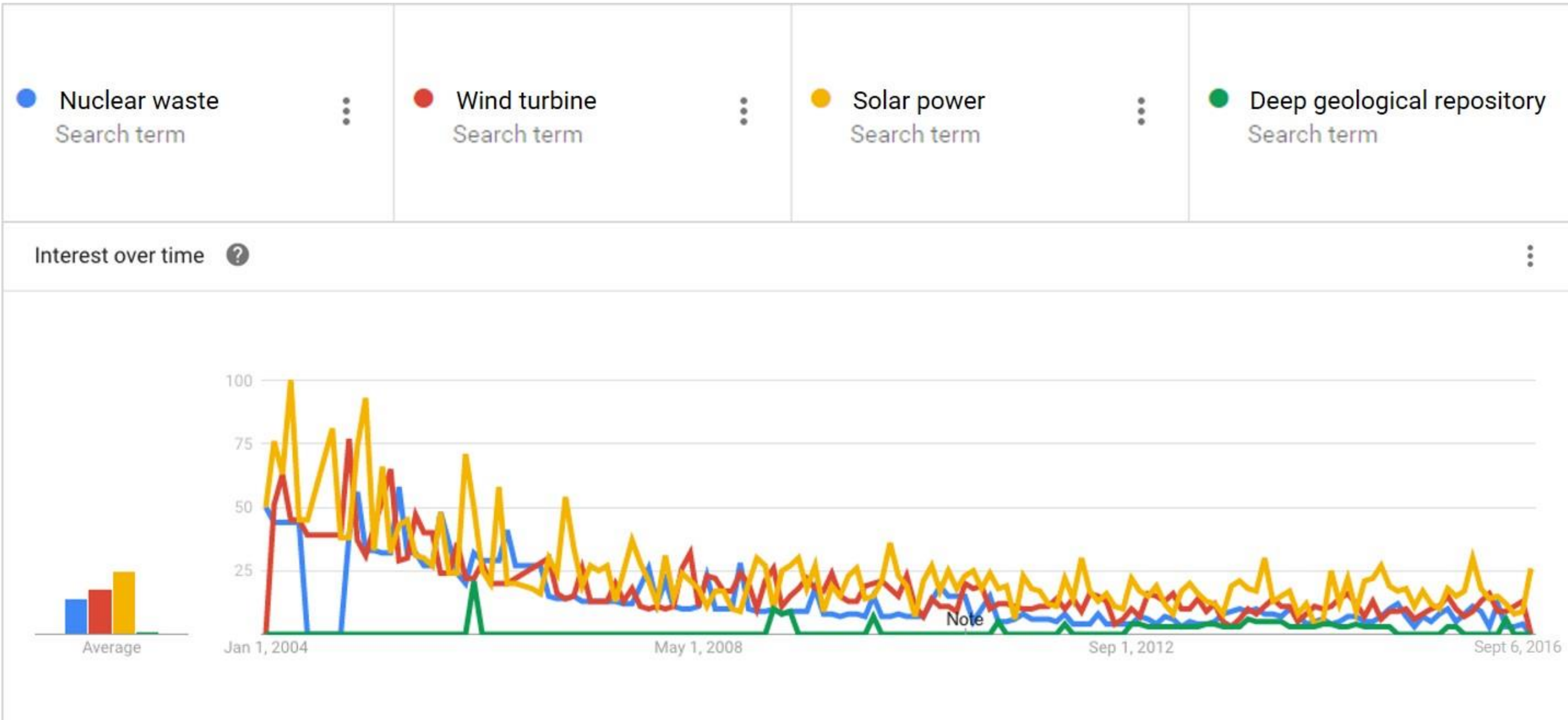


Figure 7-1: Canadian Frequency

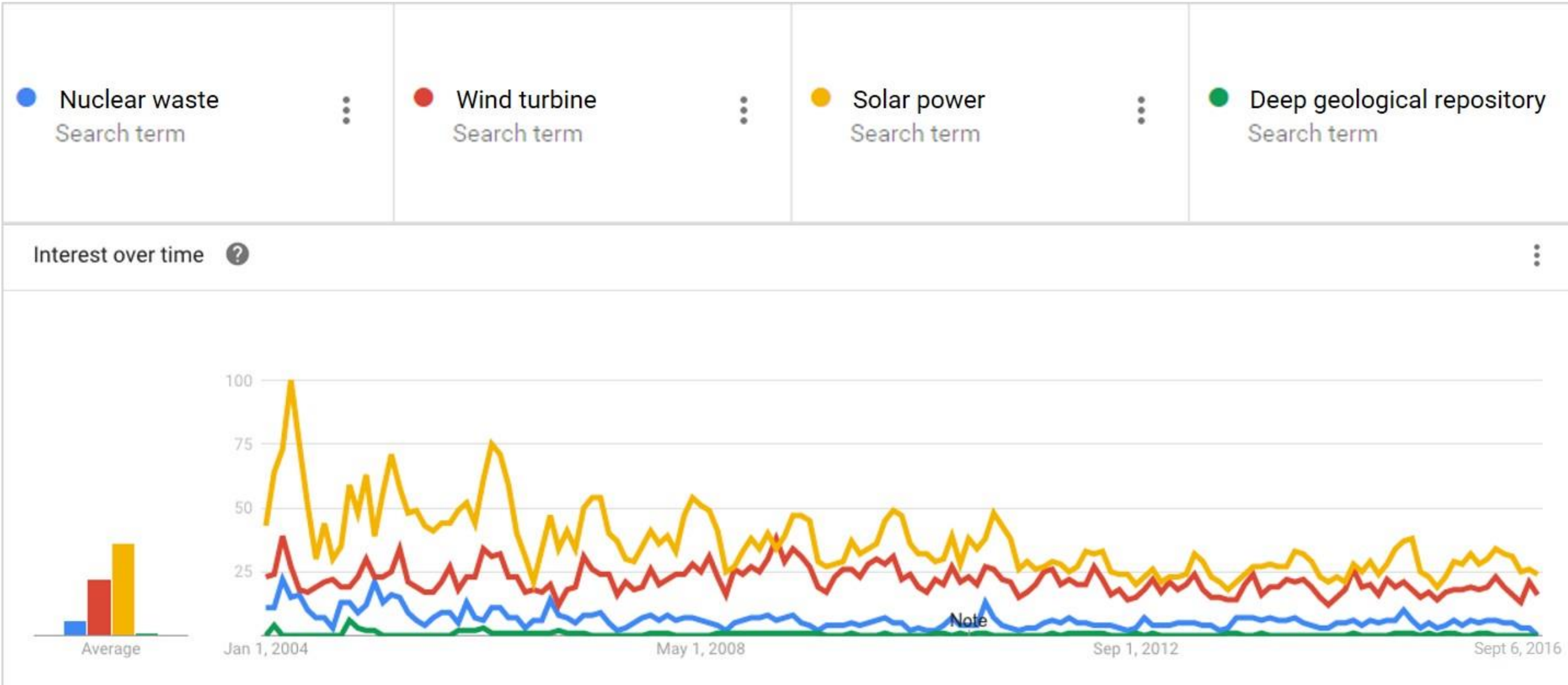


Figure 7-2: Ontarian Frequency

7.3 RELATIONSHIPS WITH INDIGENOUS COMMUNITIES

OPG's Indigenous Relations Policy (OPG-POL-0027 updated 2016), commits OPG to building long-term mutually beneficial relationships with Indigenous communities proximate to its present and future operations. OPG is committed to developing these relationships on a foundation of respect for the languages, customs, and political, social and cultural institutions of Indigenous communities. OPG is engaged with Indigenous communities who are proximate to and/or have an interest in the lands associated with OPG's nuclear facilities.

OPG has been engaged with the Saugeen Ojibway Nations (SON) for almost two decades regarding its operations at the Bruce nuclear site. OPG's 2013 commitment not to move forward with construction until the SON community is supportive of the DGR Project at the Bruce Nuclear site is important. It reflects OPG's desire to approach the relationship with SON through a model of partnership. OPG and SON have established processes for meaningful and ongoing engagement, to help the community under the nature of the DGR and its impacts, and to address potential project related impacts identified through those processes. To that end, OPG provided SON with a draft of the reports and preliminary findings, and received SON's initial feedback, prior to submission.

OPG has also established meaningful relationships with Métis communities who have a historical presence in the vicinity of OPG operations and the proposed DGR Project at the Bruce Nuclear site.

The Historic Saugeen Métis (HSM) describe themselves as descendants of the historic Métis who have resided along the Lake Huron proper shoreline from the islands at the tip of the Bruce Peninsula to the Ausable River system (south of Goderich) in the vicinity of Port Franks, beginning in 1818. An agreement between OPG and HSM was established in 2010 providing capacity to facilitate their engagement on the DGR Project. OPG and HSM continue to engage in matters of mutual interest and concern.

The Métis Nation of Ontario – Region 7 includes the Métis Councils of Georgian Bay, Moon River and Great Lakes; and is represented by Regional Consultation Committee Region 7 (MNO Georgian Bay TTCC). An agreement between OPG and the Métis Nation of Ontario was established in 2014 providing capacity to facilitate their engagement on the DGR Project at the Bruce Nuclear site. OPG and MNO continue to engage in matters of mutual interest and concern.

OPG and representatives of the Williams Treaties First Nations (who have a historical interest in the lands associated with OPG's Darlington and Pickering Nuclear sites) meet regularly to share information and provide updates on various topics of mutual interest. These First Nations, signatories to the Williams Treaties, have regularly provided feedback and identified areas of interest and concern with respect to OPG's nuclear operations and projects.

OPG has provided regular updates to the above mentioned Indigenous communities regarding the status of the regulatory approvals for OPG's DGR Project at the Bruce Nuclear site and in 2016, specifically regarding the Minister's requests for additional information (see Table 7-1).

Table 7-1: 2016 Meetings with Indigenous Communities

Indigenous Community	Date	Location
Métis Nation of Ontario/Georgian Bay Traditional Territory Consultation Committee	May 10	Owen Sound
Historic Saugeen Métis	May 11	Southampton
Métis Nation of Ontario/Georgian Bay Traditional Territory Consultation Committee	June 7	Owen Sound
Williams Treaty First Nations	July 5	Courtice
Curve Lake First Nation	August 8	Curve Lake First Nation
Hiawatha First Nation	August 11	Hiawatha First Nation
Métis Nation of Ontario/Georgian Bay Traditional Territory Consultation Committee	November 5	Courtice
Saugeen Ojibway Nations	November 9	Toronto
Historic Saugeen Métis	November 18	Southampton
Saugeen Ojibway Nations	December 8	Toronto

Key comments, questions and feedback received included (and OPG's responses) are below:

- Whether the federal duty to consult would be triggered:
  - OPG indicated that, it was not OPG's accountability rather it was up to the federal government as the Crown.

- How many nuclear waste repositories would be built in Ontario:
  - OPG is involved in two programs for deep geologic repositories, one for its L&ILW and one for used fuel through NWMO's APM process. Other waste generators also have plans for nuclear waste repositories.

- Who decides where repositories will be located, what criteria are used:
  - Current standards of practice and international experience in the siting of radioactive waste repositories show that multi-year processes, based on voluntarism and consent, are the preferred approach to the identification of a willing host community for a deep geologic repository. The over-arching principle is that a knowledgeable community makes an informed decision on whether to accept the responsibility of hosting such a facility.

- What is the role of First Nations and Métis Communities in decision making about alternate locations:
  - OPG's practice is that the support of the host Indigenous community/ies is required for the construction of a deep geologic repository.

- Are there current employment and business opportunities.

- OPG's operational business plans are developed with a view to provide employment and business opportunities for Indigenous communities.

OPG estimates that a siting process to identify sites for a DGR could involve discussions with representatives of all 133 First Nations as well as most Métis Communities in Ontario, particularly in the early stages of siting process development. OPG is confident that a new site for a waste repository could be successfully identified with the support and consent of the Indigenous communities. However, the nature of the discussions, determination of which parties would need to be involved, and how that may affect the timing and/or schedule all result in additional uncertainty.

8. COMMUNICATIONS AND ENGAGEMENT

OPG's open, transparent, and timely communications ensure that information regarding its operations and plans, as well as anticipated effects on the environment and the health and safety and persons that may result from licensed activities, are shared widely, and particularly with those living in the vicinity of the site. OPG is compliant with Regulatory Document RD-99.3, *Public Information and Disclosure*, and the OPG Nuclear Public Information Disclosure and Transparency Protocol is posted on OPG's web site (www.opg.com).

8.1 PUBLIC COMMUNICATIONS AND COMMUNITY ENGAGEMENT

Throughout 2016 OPG shared its proposed work plans and preliminary findings with the public, elected officials, communities of interest, and key stakeholders. OPG undertook a number of notifications and briefings regarding the information request (Table 8-1).

Table 8-1: 2016 Public and Stakeholder Engagement

Who	Date	Location
Information Request Posted on OPG web site	February	Web site
Email notifications to Key Stakeholders	March	Various
Pickering Community Advisory Council	May 24	Pickering
Brockton Council	June 6	Cargill
Darlington Community Advisory Council	June 7	Clarington
Bruce County Council	June 9	Walkerton
Arran-Elderslie Council	June 13	Chesley
Kincardine Council	June 15	Kincardine
Durham Nuclear Health Committee (DNHC)	June 17	Whitby
Huron Kinloss Council	June 20	Ripley
Bruce County Municipal Staff	June 21	Kincardine
Saugeen Shores Council	June 27	Port Elgin
Key Michigan Stakeholders including Department of Environmental Quality, Agency for Energy, Governor's Office	August	Various offices
Kincardine Council	November 2	Kincardine
Bruce County Council and Municipal Staff	November 3	Walkerton
Huron Kinloss Council	November 7	Ripley
Stakeholder Information Session	November 11	Toronto
Brockton Council	November 14	Cargill
Arran-Elderslie Council	November 14	Chesley

Pickering Community Advisory Council	November 15	Pickering
Saugeen Shores Council	November 28	Saugeen Shores
Federal Authorities Information Session	December 2	Ottawa

Throughout, OPG sought feedback on the proposed work and preliminary findings.

At council and committee meetings often local media were in attendance and a local radio or news article would appear shortly after the presentation. No significant concerns were raised with OPG's approach to the work, or to the preliminary findings. However, the discussion raised a number of questions regarding the management of L&ILW (OPG's response is also indicated) including these:

- Whether this was an exercise to combine the OPG DGR with the NWMO DGR for used fuel:
    - OPG indicated that this was not an exercise to combine the OPG DGR with the NWMO DGR. A DGR intended for OPG L&ILW would be designed differently than one intended for used nuclear fuel due to the differences in the wastes. Important differences in the wastes include their physical composition, the preferred chemical environment for waste stability, the higher radioactivity in used fuel, the generation of heat by used fuel, and the need to comply with international safeguards with used fuel. This means even if the facilities were sited together, they would in effect be two DGRs co-located beside each other with sufficient underground distance to avoid interaction. There is limited opportunity to minimize the surface footprint of the combined facility as the two activities would be separated for security and efficiency reasons. Although two DGRs could share some site infrastructure elements (i.e. power, water, waste management, emergency response, security), there would be no significant cost savings for a combined facility.

- How many nuclear waste repositories were planned for/in Ontario:
    - OPG is involved in two programs for DGR's, one for its L&ILW and one for used fuel through NWMO's APM process. Other waste generators also have plans for nuclear waste repositories.

- Whether all the communities currently involved in the NWMO process should be considered as alternate locations for OPG's DGR:
    - NWMO discussions with communities about the possibility of hosting a used fuel DGR have identified Canadian used fuel as the waste material that would be emplaced. The communities have not been asked to consider OPG L&ILW, and it cannot be assumed that they would agree to this change in inventory.

- Why didn't OPG use existing sites or communities currently involved in nuclear waste siting?
    - Alternative approaches were considered and the reasons why they were not utilized include:
        - Communities currently engaged in the NWMO siting process are contemplating a DGR for used fuel, not all radioactive wastes. Seeking to

involve them might introduce risk to the substantive investment that the NWMO and the communities have made in a collaborative site selection process. Further, no specific sites have yet been identified in the NWMO's siting process; the siting of a DGR for L&ILW would require the consent of the communities involved. It was deemed that the risk of disrupting the NWMO program was greater than the benefit that would be derived.
    - While there are other nuclear sites in Ontario (e.g., AECL/CNL sites) OPG has no control over these sites.

- How many radioactive shipments a week does WWMF currently receive?
    - Approximately ten to fifteen shipments a week plus transfers from Bruce Power.

- Why are return shipments radioactive?
    - If a shipment contains radioactive waste, it is conservatively assumed to have radioactivity even with the waste removed. Regulations require that the empty reusable transport packaging be manifested as a radioactive shipment. No label is required and the maximum dose rate on the surface package must be equal to or below 0.005 mSv/hr.

- What are the next steps after OPG submits its reports?
    - The Canadian Environmental Assessment Agency manages the review process. It has indicated that there will be a period of public comment on OPG's submission to the federal government. Following that public comment a report will be prepared for the federal Minister of the Environment and Climate Change.

- What is the contingency plan if OPG does not secure the necessary approvals for the DGR Project at the Bruce Nuclear site?
    - OPG is confident of the plan; however, if approval is not obtained, OPG would seek to understand whether additional work could address the issues. OPG would need to continue with interim storage until a new long term management plan was in place. This would eventually require expansion of the current WWMF site footprint.

On November 11, 2016 OPG held a full day Stakeholder Information Session with invited representatives of various organizations and individuals who have previously commented on the DGR Project at the Bruce Nuclear site. OPG delivered presentations on the preliminary findings and following each presentation, a question and answer session was held. The participants provided many comments on different ways to approach the identification of alternate locations (such as, the process used, how the locations should be defined, etc.); and on whether the DGR Project at the Bruce Nuclear site should be redefined (e.g., to include decommissioning wastes) and questions of clarification on the transportation work (such as, what percentage of packages need to be over packed, what additional barriers may be required, types of transportation packages required, whether alternative modes of transportation should have been considered, etc.). Some participants expressed a concern that OPG should be re-thinking the overall project and its approach to stakeholder engagement. A report from this meeting and the associated PowerPoint presentation are posted on OPG's web site.

On December 2, 2016 OPG held a half day Stakeholder Information Session with representatives of federal authorities involved in the review of the DGR Project at the Bruce Nuclear site. OPG delivered presentations on the preliminary findings and following each presentation, a question and answer session was held. The meeting agenda and the Power Point presentations given are posted on the CEAA registry.

9. INTERNATIONAL EXPERT PANEL

OPG engaged a panel of international experts in the siting of nuclear waste repositories to determine if the alternate locations study approach and findings were consistent with international best practices. The International Expert Panel (IEP) included:

- Timo Äikäs – Executive Vice President Posiva (retired), responsible for the development and siting of Finland's deep repository for low and intermediate level waste. Mr. Äikäs was also chief geologist for developing and siting Finland's deep repository for used fuel.
- Larry Camper – US Nuclear Regulatory Commission (NRC) Retired Director of the NRC Division of Decommissioning, Uranium Recovery and Waste Programs. Mr. Camper served for 10 years as the Director of the NRC Division of Waste Management and Environmental Protection. Outside the NRC he served for 10 years as the US Representative to the Waste Safety Standards Advisory Committee at the International Atomic Energy Agency (IAEA).
- Lawrence Johnson formerly a senior scientist and research and development coordinator at NAGRA (Swiss National Cooperative for the Disposal of Radioactive Waste). Mr. Johnson has also advised on and reviewed nuclear waste management programs in Finland, Sweden, Japan and the U.S.

Following a detailed review of OPG's submission the IEP determined that [IEP 2016]. :

- The conclusion that a safe DGR at an alternate location could be constructed without any significant environmental effects is relevant to geological repositories in general and can be supported by the experience from other countries. The environmental effects of a DGR project have been found to be small in many countries in studies of technically feasible sites for the purpose of radioactive waste disposal.
- The conclusion that the environmental effects of the DGR at an alternate location (at an "independent" disposal site) are likely to be greater as compared to those for the DGR Project at the Bruce Nuclear site, is supported by international experience. Environmental impact assessments conducted for L&ILW repositories and repositories for deep geologic disposal of spent nuclear fuel in Finland and Sweden, for example, indicate similar results.
- The use of safety as starting point for technical feasibility is appropriate. Safe disposal is only possible at a site with suitable rock properties and application of appropriate design measures.
- The IEP considers that a suitable economic threshold would be any project cost increase for which there is no benefit from an environmental or public health and safety perspective.
- In the case of a site in crystalline rock of the Canadian Shield, the IEP noted that treatment of some of the waste would be required to reduce the release into repository

pore-water and additional engineered barriers would be required to enhance carbon-14 retention. If these measures were taken, the long-term safety requirements could be met. Nonetheless, even with some waste treatment and additional engineered barriers, the margin of safety for a DGR in crystalline rock in the Canadian Shield is likely to be smaller than for a repository in the Cobourg formation.

The IEP also summarized the situation regarding the disposal of LLW, ILW and L&ILW in Finland, France, Germany, South Korea, Sweden and the United States, and highlighted several important points relevant to the proposed OPG repository for L&ILW including:

- repositories for L&ILW vary considerably in their depths, depending on the rock properties, disposal site characteristics and regulatory safety requirements specified by the various countries;

- repositories in crystalline fractured rock environments are typically regarded as requiring engineered barrier systems to limit groundwater movement and enhance containment of radionuclides in the repository;

- several L&ILW repositories are designed as connected facilities (e.g., Sweden, Finland, South Korea), that is they are directly located at and connected to nuclear power plant sites where wastes are produced and are presently in interim storage. This has distinct advantages with respect to operational safety, security and cost, although these advantages can only be realized where the rock and engineered barrier system meet long-term safety requirements; and

- L&ILW repositories have been judged in the licensing process to be safe in locations next to bodies of water (the Baltic Sea, in the case of Sweden and Finland and the Pacific Ocean in the case of South Korea) or for shallow land disposal as is the case in the United States.

The IEP concluded that OPG had adequately addressed the questions and concerns posed by the Minister and the Agency and adequately documented the conclusions.

In the view of the IEP, the OPG submission illustrates that the solution with the least environmental and economic consequence is the DGR Project at the Bruce Nuclear site. Further, the proposed DGR Project at the Bruce Nuclear site is a highly robust solution for the disposal of the L&ILW in question and is consistent with or superior to the approaches utilized in other countries.

10. SUMMARY AND CONCLUSIONS

The federally-appointed Joint Review Panel issued its Environmental Assessment Report in May of 2015, confirming that OPG's DGR at the Bruce Nuclear site is the preferred solution for the management of OPG's L&ILW. The Panel concluded that the DGR is not likely to cause significant adverse environmental effects, taking into consideration the commitments made by OPG, the proposed mitigation measures and the recommendations of the Panel. Further the Panel concluded the DGR would not affect Lake Huron and the DGR should be built sooner rather than later to ensure the waste is isolated from the surface environment.

In February 2016 the federal Minister of Environment and Climate Change required OPG to provide additional information prior to making a decision on the DGR EA. In particular, the Minister requested a study that details the environmental effects of technically and economically feasible alternate locations for the DGR Project.

As requested by the Minister OPG has completed an evidence-based study which:

- makes specific reference to alternate locations which meet OPG's criteria and thresholds for technical and economic feasibility,
- determines the environmental effects of the DGR at those alternate locations,
- identifies incremental costs and risks for the off-site transportation of the L&ILW to the alternate locations, and
- identifies additional project related costs and uncertainties associated with alternate locations.

OPG's study shows that the primary objectives of public and worker safety and protection of the environment can be achieved through alternate locations which satisfy OPG's technical and economic feasibility criteria, including the capability to contain and isolate radioactive waste.

OPG's study shows that there would be more environmental effects of a DGR at an alternate location than the environmental effects of the DGR Project at the Bruce Nuclear site. This results from:

- increased effects on air quality, including increased GHG emissions, due to waste transportation from the WWMF to the alternate location;
- increased effects on noise levels due to likelihood of quieter background levels at the alternate locations;
- adverse effects on vegetation communities from increased clearing during site preparation and construction of surface facilities and supporting infrastructure, including access roads;
- adverse effects on wildlife communities due to establishment of a new site with associated indirect effects from vegetation loss and habitat fragmentation;
- effects on traditional and non-traditional land use due to establishment of a new site and change in land use, traffic from waste transport and workers, and indirect nuisance-related effects relative to background levels;
- increased worker radiation exposure during waste transportation; and
- establishment of new sources of radiation exposure at a location where there is likely to be no existing anthropogenic sources of exposure.

OPG's study shows that relocating the DGR Project to an alternate location would require approximately 22,000 - 24,000 radioactive shipments resulting in over a million kilometres of travel on public roadways throughout the duration of the transportation campaign. The incremental conventional transportation risks are estimated to be between three and 69 road collisions. It would also add a small but incremental risk of exposure to radioactivity to the public and workers. The identified risks are manageable and L&ILW transportation can be conducted safely provided that appropriate processes and programs are in place to ensure safety objectives are met.

OPG's study shows that the incremental costs for implementing a DGR at an alternate location would range from $1.2B and $3.5B (this is in addition to the current cost of $2.4B (2017$) for the DGR Project at the Bruce Nuclear site). These additional costs are attributable to the range of activities that would be required for an alternate location including a multi-year consent based siting process; acquisition of land; development and implementation of services to support facility operation; repackaging and transportation; and re-starting the regulatory approvals and licensing process.

OPG's study also shows that there would be considerable uncertainties associated with a DGR at an alternate location including the time required to develop and implement a consent based site selection process and achieve a willing and supportive host community, as well as the consent of Indigenous communities.

In this respect, OPG's relationship with the Municipality of Kincardine is important, as it was the Municipality of Kincardine that initiated the discussions, recommended the approach and supports as a willing host, the DGR Project at the Bruce Nuclear site.

OPG's relationship with SON is also important as it reflects a commitment for a new type of relationship. OPG and SON have jointly established processes for meaningful and ongoing engagement, to help the community understand the nature of the DGR and its impacts, and to address potential project related impacts identified through those processes. OPG has committed not to move forward with construction until the SON community is supportive of the DGR Project at the Bruce Nuclear site.

OPG's study was reviewed by international experts in waste repository siting. L&ILW repositories have been judged to be safe in locations next to bodies of water (the Baltic Sea, in the case of Sweden and Finland and the Pacific Ocean in the case of South Korea). In the view of the international experts, the proposed DGR Project at the Bruce Nuclear site is a highly robust solution and is consistent with or superior to the approaches utilized in other countries. They believe that deferring costs to future generations, when a safe, cost-effective option already exists, is not necessarily in the best interests of society.

OPG therefore concludes that the DGR Project at the Bruce Nuclear site remains the preferred location based on a relative consideration of environmental effects, transportation risks, transportation and other project-related costs and uncertainties; and the absence of any guarantee of improved safety or environmental quality at an alternate location.

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12. ABBREVIATIONS AND ACRONYMS

Agency	Canadian Environmental Assessment Agency
AACE	American Association of Cost Engineering
AECL	Atomic Energy of Canada Ltd.
CEA	Cost Effectiveness Analysis
CEAA	Canadian Environmental Assessment Act
CNL	Canadian Nuclear Laboratories
CNSC	Canadian Nuclear Safety Commission
DGR	Deep Geologic Repository
EA	Environmental Assessment
EIS	Environmental Impact Statement
GHG	Greenhouse Gas
HSM	Historic Saugeen Métis
IAEA	International Atomic Energy Agency
IEP	International Expert Panel
ILW	Intermediate Level Waste
IP	Industrial Package
JRP	Joint Review Panel
L&ILW	Low and Intermediate Level Waste
LLW	Low Level Waste
LSA	Low Specific Activity
MTO	Ministry of Transportation Ontario

NRC	US Nuclear Regulatory Commission
NRCAN	Natural Resources Canada
NWMO	Nuclear Waste Management Organization
OEB	Ontario Energy Board
OHSA	Ontario Health and Safety Act
ONFA	Ontario Nuclear Funds Agreement
OPG	Ontario Power Generation
PSR	Preliminary Safety Report
PTNSR	Packaging and Transport of Nuclear Substances Regulations
SCO	Surface Contaminated Object
SON	Saugeen Ojibway Nations
VC	Valued Component
WRMA	Waste Rock Management Area
WWMF	Western Waste Management Facility
$	Constant dollars of a particular year