OPG's DEEP GEOLOGIC

REPOSITORY

FOR LOW & INTERMEDIATE LEVEL WASTE

Environmental Effects of Alternate Locations

December 2016

Prepared by: Golder Associates Ltd.

OPG CD# 00216-REP-07701-00015-R000

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Document History

Title:	Environmental Effects of Alternate Locations		
Report Number:	00216-REP-07701-00015		
Revision:	R000	**Date:**	December 2016
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EXECUTIVE SUMMARY

Ontario Power Generation (OPG) is currently seeking a licence to prepare the site and construct a Deep Geologic Repository (DGR) for its low and intermediate level radioactive waste (L&ILW) at the Bruce Nuclear Generating Station site in the Municipality of Kincardine (the DGR Project at the Bruce Nuclear site).

This document details the environmental effects of the technically and economically feasible alternate locations, including a sedimentary alternate location and at a crystalline alternate location. These alternate locations have different geographical and hydrological features as compared with the Bruce Nuclear site.

A DGR at an alternate location could be constructed without any likely significant environmental effects. However, environmental effects of a DGR at an alternate location (both sedimentary and crystalline rock) are likely to be greater as compared to the DGR Project at the Bruce Nuclear site. Increased environmental effects include:

- increased effects on air quality, including greenhouse gases, during waste transportation from OPG's Western Waste Management Facility (WWMF) to the alternate location;
- increased effects on noise levels due to likelihood of lower 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 (up to 900 ha) 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.

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1. INTRODUCTION

Ontario Power Generation Inc. (OPG) is currently seeking a licence to prepare the site and construct a Deep Geologic Repository (DGR) for its low and intermediate level radioactive waste (L&ILW) at the Bruce Nuclear Generating Station site in the Municipality of Kincardine (the DGR Project at the Bruce Nuclear site).

In 2015 a Joint Review Panel (Panel) issued the Environmental Assessment Report on the DGR Project at the Bruce Nuclear site, which concluded that provided certain mitigation measures were implemented "*the project is not likely to cause significant adverse environmental effects*". 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*."

In February 2016 the Federal Minister of Environment and Climate Change requested OPG provide additional information prior to making a decision on the Environmental Assessment (EA) of the DGR Project at the Bruce Nuclear site. In particular the Minister requested:

"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."

In response to OPG's letter dated April 15, 2016 describing OPG's proposed approach to responding to the Minister request, the Canadian Environmental Assessment Agency (Agency) provided clarification as follows:

"*[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 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."

The response to the information requested is documented in four reports, a main submission and three technical documents. The main submission provides context, describes the project for study purposes, summarizes the studies, and presents the overall findings. The technical documents, of which this is one, 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

These 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.

The purpose of this document (the Environmental Effects of Alternate Locations) is to describe the environmental effects of the DGR at two technically and economically feasible alternate locations: the crystalline alternate location and the sedimentary alternate location. These alternate locations have different geographical and hydrological features as compared with those of the Bruce Nuclear site.

2. METHODOLOGY

The approach to identifying and considering environmental effects of alternate locations considers, to the extent relevant, guidance provided by the Agency in its Operational Policy Statement *Addressing "Purpose of" and "Alternative Means" under the Canadian Environmental Assessment Act, 2012* [CEAA 2015].

'Alternative means' are the various technically and economically feasible ways under consideration by the proponent that would allow a designated project to be carried out [CEAA 2015]. This is broader than just alternate locations. While the approach followed the key steps in the alternative means analysis, this approach was limited to only alternate locations**.** The Operational Policy Statement outlines the following key steps in considering alternative means:

- Step 1: Identify technically and economically feasible alternative means;
- Step 2: List their potential effects on valued components (VCs); and
- Step 3: Select the approach for the analysis of alternative means (i.e., identifying a preferred means or carrying forward multiple means).

These steps are also largely consistent with the former 2007 Operational Policy Statement *Addressing "Need for", "Purpose of", "Alternatives to" and "Alternative Means" under the Canadian Environmental Assessment Act* [CEAA 2007].

This report is focused on providing information to meet the requirements of completing Step 2 set out in the Operational Policy Statement, namely identifying potential effects of alternate locations on the environment. This is achieved through an identification of potential interactions between the alternate locations and the environment (i.e., the VCs), and a description of potential effects where an interaction is identified. The description of effects is provided in a narrative format for each VC, to permit a sufficient understanding of potential environmental effects of the alternate locations under consideration. Within each narrative the following is provided:

- a summary of relevant information related to the environmental setting;
- a description of potential project-environment interactions;
- a description of potential effects of the DGR at an alternate location on the VCs; and
- a description of mitigation measures that could be implemented to reduce or avoid these effects.

Finally, for each VC, the potential effects on the environment of the DGR at the alternate locations are compared to those predicted in the Environmental Impact Statement (EIS) for the DGR Project at the Bruce Nuclear site [OPG 2011].

2.1 IDENTIFICATION OF VALUED COMPONENTS

Valued Components (VCs) refer to environmental features that may be affected by a project [CEAA 2014]. 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. These VCs include the environmental components as defined in section 5(2)(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.

The alternate locations encompass a range of environmental settings; therefore, in many cases grouped VCs are proposed (e.g., wildlife and wildlife habitat) to facilitate comparisons between alternate locations. 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 2.1-1 presents the VCs that are the subject of this assessment.

Table 2.1-1: Valued Components Identified for Evaluation of the Alternate Project

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

Changes in environmental conditions as represented by the above VCs has 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 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.

2.2 IDENTIFICATION OF POTENTIAL INTERACTIONS

DGR related works and activities at an alternate location, which provide the basis for the identification of environmental effects, are described in Section 3. The works and activities build on the Basis for EA included in the EIS [OPG 2011]. Taking into consideration this description, potential interactions between the environment (as represented by VCs) and the DGR are identified and summarized in a matrix. A potential interaction, denoted with a ‘●’ in the matrix, is one where there is a feasible pathway with a VC. In addition to these potential direct interactions, the potential to affect a VC indirectly through a change in another VC (e.g., changes in water quality) is also considered. This allows the description of the environment and 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 based on the general understanding of existing environmental conditions in the alternate locations under consideration. In addition, as the works and activities for the alternate locations are similar to those of a DGR Project at the Bruce Nuclear site, with some additions, the screening also considered potential interactions identified for the DGR Project at the Bruce Nuclear site with the environment as described in the EIS [OPG 2011].

2.3 DESCRIPTION OF POTENTIAL EFFECTS

Where potential interactions between the alternate location’s works and activities and the environment are identified, the potential environmental effects, mitigation measures and residual adverse effects on the environment are described.

The environment may be affected by the Alternate Project’s works and activities during all phases of the project, specifically site selection and licensing, site preparation and construction, operation, decommissioning, and postclosure. Both direct effects (e.g., removal of vegetation) and indirect effects (e.g., effects on surface water quality due to changes in groundwater quality) are described.

For the purpose of assessing environmental effects, the range of site conditions and environmental features described in the Description of Alternate Locations technical document [OPG 2016] has been considered and effects presented. Effects are described in a narrative format, referencing supporting quantitative analyses where applicable, and citing applicable literature.

2.4 COMPARISON OF EFFECTS OF THE DGR AT ALTERNATE LOCATIONS TO THE DGR PROJECT AT THE BRUCE NUCLEAR SITE

Following the description of potential environmental effects of the DGR at each of the alternate locations, the predicted effects, or range of effects, are compared to those identified in the EIS for the DGR Project at the Bruce Nuclear site [OPG 2011]. This comparison is presented in a tabular format, and summarizes additional mitigation, monitoring or management measures that may be required.

3. DESCRIPTION OF ALTERNATE PROJECT WORKS AND ACTIVITIES

This section provides a summary description of the works and activities for the DGR at an alternate location to provide context for the identification of potential interactions. The environmental setting for the alternate locations is summarized in Sections 4 and 5 where appropriate for each VC. Further details on the alternate locations are provided in the Description of Alternate Locations technical document [OPG 2016].

Project related works and activities provide the basis for the identification of environmental effects. They are the systems, components and activities of the project that may be expected to affect the environment during the different phases of the project. The descriptions of the DGR works and activities are focused on identifying and characterizing aspects that have the potential to interact, and thus result in a likely change to the surrounding environment during all phases of the project.

DGR-related works and activities for an alternate location are summarized in Table 3-1. For the purposes of this environmental effects assessment, the DGR at an alternate location would require the same works and activities, and the same phases, as proposed for the DGR Project at the Bruce Nuclear site and as described in the EIS [OPG 2011]. However, the alternate locations would have additional works and activities due to their geographical locations being separated from the current storage location of L&ILW, at the Western Waste Management Facility, at the Bruce Nuclear site. These works and activities would be largely related to the packaging and transport of nuclear wastes from the current storage at the Bruce Nuclear site to the DGR at the alternate location. The alternate locations would also have additional infrastructure to accommodate the receipt and temporary storage of the waste packages and would also need infrastructure that already exists at the Bruce Nuclear site. Additional works and activities specific to a DGR at an alternate location are highlighted in green in Table 3-1.

Table 3-1: Basis for the Effects Assessment of the DGR at Alternate Locations

Project Works and Activities	Description of Project Works and Activities Green NEW incremental Works and Activities for the DGR at Alternate Locations relative to EIS
Site Selection and Licensing	Site acquisition would begin once the site selection process has been completed, including identifying a willing host community and supportive Indigenous community. Activities would include the preparation of the site licence application, and regulatory approvals to obtain an environment assessment approval and a site preparation and construction licence. Activities would also include: • initial site technical evaluations and social/Aboriginal engagement; • preliminary site investigation activities including geological and environmental mapping, borehole drilling, environmental investigations, conceptual designs, etc.; • acquisition of up to approximately 900 ha of land; • conduct detailed site characterization activities including additional deep boreholes, shallow groundwater wells, environmental baseline investigations, preliminary design, preliminary safety assessment, shaft pilot holes, etc.

Project Works and Activities	Description of Project Works and Activities Green NEW incremental Works and Activities for the DGR at Alternate Locations relative to EIS
Site Preparation	Site preparation would begin after receipt of a Site Preparation Licence and would include clearing approximately 40 ha of the Alternate Project site and preparing the construction lay down areas. Activities would include: • removal of brush and trees; • excavation of topsoil, and truck transfer of soil to stockpile on-site; • grading of sites, including roads, construction lay down areas, storm water management area, ditches; • receipt of materials including gravel, concrete, and steel; • installation of on-site construction roads and fencing; • receipt and installation of construction trailers and associated temporary services; and • install and operate fuel depot for construction equipment; • install site boundary fences; • install off-site environmental monitoring; • construct access road and power corridor to site if required.
Construction of Surface Facilities	Construction of surface facilities would include the construction of the waste transfer, material handling, shaft head-frames and all other temporary and permanent facilities at the site. Activities would include: • establish a concrete batch plant; • receipt of construction materials, including supplies for concrete, gravel, and steel by road transportation; • excavation for and construction of footings for permanent buildings, and for site services such as domestic water, sewage, electrical; • construction of permanent buildings, including headframe buildings associated with main and ventilation shafts; • receipt and set up of equipment for shaft sinking; • fuelling of vehicles; • construction of electrical substation and receipt and installation of standby generators; • establish security facilities and additional on-site facilities (i.e. maintenance shop, back-up fire water storage tank, etc.); • install on-site Low Level Waste Storage Buildings (LLSBs) and Intermediate Level Waste staging area.
Excavation and Construction of Underground Facilities	Excavation and construction of underground facilities. Activities would include: • drilling, blasting (use of explosives) and excavation for construction of main and ventilation shafts, service area, and access tunnels and emplacement rooms; • receipt and placement of grout and concrete, steel and equipment; • dewatering of the shaft construction area by pumping and transfer to the above-ground stormwater management facility; • temporary storage of explosives underground for construction of emplacement rooms and tunnels; • receipt and installation of underground services including ventilation systems, power and communications • installation of shotcrete, rock bolts and other ground support as required.

Project Works and Activities	Description of Project Works and Activities **Green NEW incremental Works and Activities for the DGR at Alternate Locations relative to EIS**

Transportation of Waste Packages to the DGR Location	Transportation would occur during the operations phase and would include three main activities – preparation for transportation from the Western Waste Management Facility (WWMF), transportation to the DGR location, and receipt and temporary holding of waste containers. Activities would include:
	• Road transport preparation activities at the WWMF
	  ○ repackage bulk waste in road-worthy containers as necessary;
	  ○ install waste packages into transport packaging
	  ○ place and secure transport package on truck conveyance
	• Transportation
	  ○ truck transport packages to the DGR location
	  ○ return empty transport packaging (if reusable) and truck to the WWMF
	• Receipt and temporary holding of waste containers at the DGR alternate location
	  ○ supply/Install site equipment to support transport package receipts
	  ○ mobilization/demobilization
	  ○ remove transport package from truck conveyance
	  ○ remove waste package from transport packaging (if reusable)
	  ○ prepare empty reusable transport packaging for return
	  ○ temporarily store waste packages awaiting emplacement as necessary

Above-ground Transfer of Waste	Above-ground handling of wastes would occur during the operations phase of the DGR Project and would include receipt of L&ILW at the staging area in the DGR Waste Package Receiving Building (WPRB) and onsite transfer to shaft. Activities would include: • receipt of disposal-ready waste packages directly from transport or from the on-site LLSBs by forklift at the WPRB; • offloading of waste packages at the WPRB; • transfer of waste packages within the WPRB by forklift or rail cart; • temporary storage of waste packages inside the WPRB.
Underground Transfer of Waste	Underground handling of wastes would take place during the operations phase of the DGR Project. Activities would include: • receipt of waste packages at the main shaft station; • offloading from cage and transfer of waste packages by forklift to emplacement rooms; • rail cart transfer of some large packages (Heat Exchangers/Shield Plug Containers) to emplacement rooms; • installation of end walls on full emplacement rooms as necessary; • remedial rock bolting and rock wall scaling; • fuelling and maintenance of underground vehicles and equipment; • receipt and storage of fuel for underground vehicles; • backfilling of some rooms with cement if necessary (depends on host rock conditions at alternate location). Emplacement activities would be followed by a period of monitoring to ensure that the DGR facility is performing as expected prior to decommissioning.
Decommissioning	Decommissioning would require a separate environmental assessment before any activities can begin. Decommissioning would include all activities required

Project Works and Activities	Description of Project Works and Activities Green NEW incremental Works and Activities for the DGR at Alternate Locations relative to EIS
and Closure	to seal shafts and remove surface facilities including: • removal of fuels from underground equipment; • removal of surface buildings, including foundations and equipment; • receipt and placement of materials, including concrete, asphalt, sand, bentonite for sealing the shaft; • construction of concrete monolith at base of two shafts, removal of shaft infrastructure and concrete liners, and reaming of some rock from the shafts and shaft stations; • sealing the shaft; • grading of the site and revegetation as necessary; • waste rock pile (limestones) would be covered and remain on-site.
Postclosure of the DGR Facility	During the postclosure period, the repository would remain under institutional control with any postclosure monitoring installed and operated as defined as part of the decommissioning and closure approvals process.
Presence of the DGR Project	Presence of the DGR Project represents the meaning people may attach to the existence of the DGR Project in their community and the influence its operations may have on their sense of health, safety and personal security over the life cycle of the DGR Project. This includes the aesthetics and vista of the DGR Project facility.
Waste Management	Waste management represents all activities required to manage all wastes generated by the DGR Project. Activities include: • transfer of waste rock by truck to the Waste Rock Management Area (WRMA); • placement of waste rock on the storage pile, and management of the WRMA; • collection and transfer of construction waste to on-site or licensed off-site facility; • collection and transfer of domestic waste to licensed facility; • collection, processing and management of any radioactive waste produced at the DGR facility; • collection, temporary storage and transfer of toxic/hazardous waste to a licensed facility.
Support and Monitoring of DGR Life Cycle	Support and monitoring would include all activities to support the safe construction, operation, and decommissioning of the DGR Project. This includes operation and maintenance of the ventilation fans, heating system, electrical systems, fire protection system, communications services, sewage and potable water system and the standby generator; • collection, storage, and disposal of water from underground sumps, and of wastewater from above-and below ground facilities; • management of surface drainage in a stormwater management facility; • monitoring of air quality in the facility, exhaust from the facility, water quality of run-off from the developed area around the shafts and Waste Rock Management Area, water quality from underground shaft sumps and geotechnical monitoring of various underground openings;

Project Works and Activities	**Description of Project Works and Activities** **Green NEW incremental Works and Activities for the DGR at Alternate Locations relative to EIS**
	• maintenance and operation of fuel depots above-ground (construction only) and below-ground; • administrative activities above- and below-ground involving office space, lunch room and amenities space; • occupational, radiological and environmental monitoring.
Workers, Payroll and Purchasing	Workers, payroll and purchasing would include all workers required during each phase to implement the DGR Project. Activities include: • spending in commercial and industrial sectors; • transport of materials purchased to the site; and • workers travelling to and from site.

4. ENVIRONMENTAL EFFECTS OF THE DGR AT THE SEDIMENTARY ALTERNATE LOCATION

This section describes the potential environmental effects related to the DGR at the sedimentary alternate location. Potential interactions are identified for the VCs defined in Section 2 and works and activities described in Section 3. Where interactions with the VC are plausible, the potential environmental effects are described, as well as relevant mitigation. Following description of the effects, these effects are assessed relative to the comparable effects of the DGR Project at the Bruce Nuclear site.

4.1 ATMOSPHERIC ENVIRONMENT

This section describes the potential effects related to the DGR at the sedimentary alternate location on the air quality and noise levels VCs. The potential interactions between the DGR works and activities at the sedimentary alternate location and the atmospheric environment are summarized in Table 4.1-1 and described below.

Table 4.1-1: Potential Interactions between a DGR at the Sedimentary Alternate Location and the Atmospheric Environment

DGR-related Works and Activities at Sedimentary Alternate Location	Atmospheric Environment	
	Air Quality	Noise
Site Selection and Licensing	●	●
Site Preparation	●	●
Construction of Surface Facilities	●	●
Excavation and Construction of Underground Facilities	●	●
Transportation of Waste Packages to the DGR	●	●
Above-ground Transfer of Waste	●	●
Underground Transfer of Waste	●	●
Decommissioning and Closure	●	●
Postclosure of the DGR Facility		
Presence of the DGR Project		
Waste Management	●	●
Support and Monitoring of the DGR Life Cycle	●	●
Workers, Payroll and Purchasing	●	●

Note:
'●' = Plausible interaction between the DGR work and activity, and the environment

Most DGR-related works and activities have the potential to affect air quality and noise levels. During site selection and licensing, field investigations, such as drilling, would be undertaken, which may require construction of access clearings. Drilling equipment as well as heavy equipment used for land clearing would result in air and noise emissions.

During site preparation, there would be a number of earth moving activities as part of land clearance, grubbing and preparation of laydown areas, stormwater management system construction, and road network construction. As part of the construction of surface facilities and excavation of underground facilities, various types of construction equipment would be used to construct temporary and permanent surface structures and excavate the shafts, underground access ways and emplacement rooms. All of these activities may cause temporary increases in emissions of combustion products, dust and noise into the atmosphere, which could affect the air quality and noise levels.

The transportation of waste packages to the DGR at the sedimentary alternate location from the Bruce Nuclear site, as well as above-ground and underground transfer of waste, would require a fleet of waste transport vehicles. These vehicles would release emissions, and have the potential to affect air quality and noise.

Waste management represents all activities required to manage waste during all phases of the DGR's development and operation until closure. During construction, waste management would include managing the waste rock along with conventional waste management. Material handling of waste rock during construction, as well as transportation-related effects from the waste management activities may interact with air quality and noise levels through tailpipe and fugitive dust emissions, and through noise from vehicles and work activities.

Support and monitoring of the DGR lifecycle would include operation of the ventilation system, as well as support services such as the compressed air supply, electrical and lighting, operation of the emergency diesel generator, electric heating supply. These systems would result in combustion product and noise emissions.

The workers, payroll and purchasing activity includes consideration of worker vehicles and their travel to the DGR. These vehicles would produce tailpipe, road dust and noise emissions, and consequently may affect air quality and noise.

Decommissioning and closure of the DGR would require similar activities to those outlined for the construction phase. Therefore, the potential interactions with air quality and noise would be similar (i.e., emissions of combustion products, dust and noise). Following closure of the DGR, no equipment or sources of emissions to air quality or noise would remain at the alternate location and there would be no potential interaction.

4.1.1 Environmental Effects on Air Quality

Existing air quality in southern Ontario is influenced by anthropogenic atmospheric emissions sources in the area. It is assumed that background air quality at the sedimentary alternate location would be similar to that described for the Regional Study Area as part of the EIS (Section 6.7.5.1, Table 6.7.5-6) [OPG 2011], which is considered representative of air quality in southern Ontario.

The proximity of the closest receptor (e.g., residences) to the project activities is important for considering the magnitude of air quality effects. For the purposes of this assessment, it is assumed that there would be buffer land around the property such that the closest point of compliance would be approximately 1 km from DGR site activities, which is consistent with the closest receptor for the DGR Project at the Bruce Nuclear site [OPG 2016]. It is also assumed that surface activities would be arranged in a similar manner to those at the DGR Project at the Bruce Nuclear site, with the exception of additional site activities specific to the alternate location (e.g., waste transportation).

During site preparation and construction, the operation of vehicles, equipment and material handling as a part of all works and activities 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.

An assumption has been made here and in other air quality sections of this report that increased emissions would result in increased effects, while decreased emissions would result in lower effects. Increases in ambient concentrations of a number of air quality indicator compounds are likely during the site preparation and construction and operations phases, as summarized in Table 4.1-2[1]. These peak increases are representative of predictions at the property boundary (i.e., approximately 1 km from the surface facilities and associated activities). Should the buffer distance be reduced, this may increase the magnitude of effects on air quality and/or increase the need for further in-design mitigation measures, as the point of compliance (fence line) would be closer to emissions related to the DGR.

Increases in ambient concentrations of air quality indicators during decommissioning and closure activities are assumed to be similar to those identified for site preparation and construction.

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 greenhouse gases (GHGs). As described in the Cost and Risk Estimate for Packaging and Transporting Waste to Alternate Locations technical document [ENERGY SOLUTIONS 2016], two waste transportation distances are assumed to represent the range of transport from the WWMF that could be encountered.

Transportation between the WWMF and the alternate location would have the potential to cause localized emissions of combustion by-products and dust in the vicinity of the transport vehicles. A variety of receptor distances are anticipated along the route as some houses may be located closer or further set back from roads; emissions would be reduced the further away from the road the receptors are. However, 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 relative GHG emissions for the alternatives presented for the sedimentary alternate location were calculated based on the total estimated fuel use [ENERGY SOLUTIONS 2016] and current Environment and Climate Change Canada emission factors.

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1 Peak hourly emissions are assumed to be the same as modelled in the EIS [OPG 2011] for the DGR Project at the Bruce Nuclear site.

Table 4.1-2: Predicted Peak Increases in Ambient Air Quality Indicators during Site Preparation, Construction and Operations Phases of the DGR at its Property Boundary

Indicator Compound	Increase Over Existing Concentration (µg/m³) during Site Preparation and Construction Phase (a)	Increase Over Existing Concentration (µg/m³) during Operations Phase (b)
1-hour NO_2	+211.3	+41.2
24-hour NO_2	+114.7	+41.3
Annual NO_2	+11.7	+0.8
1-hour SO_2	0	0
24-hour SO_2	0	0
Annual SO_2	0	0
1-hour CO	+923.6	+17.2
8-hour CO	+393.9	+0.5
24-hour SPM	+205.9	+0.5
Annual SPM	+5.6	0
24-hour PM_{10}	+49.3	+0.9
24-hour $PM_{2.5}$	+30.3	+0.5

Notes:
Assumes a fence line approximately 1 km from the DGR site.
(a) From Table 8.2.3-6 in [OPG 2011]
(b) From Table 8.2.3-7 in [OPG 2011]

Table 4.1-3 provides the emission factors for GHG emissions from mobile (on-road) diesel combustion, based on the heavy-duty diesel vehicle category from Environment Canada. Also presented is the Global Warming Potential (GWP) for each GHG species.

Table 4.1-3: Greenhouse Gas Emission Factors

GHG Species	Emission Factor (Heavy Duty Diesel Vehicles) (kg/L)	Global Warming Potential (GWP)
Carbon Dioxide (CO_2)	2.69	1
Methane (CH_4)	0.00015	25
Nitrous Oxide (N_2O)	0.000075	298

Source: ENVIRONMENT AND CLIMATE CHANGE CANADA 2016b

The form of the GHG calculation was as follows:

$$GHG\ \left(\frac{tonnes}{year}\right) = EF\left(\frac{kg}{L}\right) \times FuelUse\left(\frac{L}{yr}\right) \times \left(\frac{1\ tonne}{1000\ kg}\right)$$

The different GWPs were taken into account by calculating the emission factor (EF) for the equation above as follows:

$$EF\left(\frac{kg}{L}\right) = EF(CO_2) \times GWP(CO_2) + EF(CH_4) \times GWP(CH_4) + EF(N_2O) \times GWP(N_2O)$$

The emission of GHGs from fuel combustion is directly related to the consumption of the fuel, and is calculated assuming complete combustion of the fuel. The overall emission factor for carbon dioxide equivalents is therefore 2.7161 kg per litre of fuel consumed (1 kt = 1,000,000 kg). Waste transportation distances for the sedimentary alternate location would be up to 300 km, one way, from the WWMF. Table 4.1-4 presents the summary of GHG emissions for the 100 km and 300 km scenarios identified for the DGR at the sedimentary alternate location, to capture the range of transportation distances. The totals presented represent 22,000 truck transport trips (i.e., 11,000 trips with cargo and 11,000 return trips empty).

Table 4.1-4: Summary of GHG Emissions for Waste Transportation to the DGR at the Sedimentary Alternate Location

Waste Transportation Scenario (One-Way Transport Distance)	Cumulative Fuel Consumed (L/30-yr)	CO_2 Equivalents (kt/30-yr)
100 km	220,432	0.6
300 km	661,295	1.8

Note: Fuel consumption from ENERGY SOLUTIONS [2016]

Based on the information provided, 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 (approximately 30 years), 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.

A number of air quality mitigation measures are inherent in the prediction of effects, including assumed emission controls and best management practices (e.g., dust control measures). In addition, as a permitting requirement, the concentrations of air quality indicator compounds from stationary sources during all project phases would be required to meet all Ministry of Environment and Climate Change (MOECC) criteria in accordance with Ontario Regulation 419/05 Local Air Quality. Taking into consideration mitigation and the magnitude of effects, potential effects on air quality are not likely to be significant.

4.1.2 Environmental Effects on Noise Levels

Existing environmental noise levels are determined through establishing the lowest 1-hour day equivalent noise level (1-hour L_{eq}). It is anticipated that the existing noise levels in the vicinity of the sedimentary alternate location would be generally free of or have limited influence from existing industrial activities. Therefore, background levels are likely to be less than or equal to 35 dBA 1-hour L_{eq} (i.e., less or equal to that monitored in the Local Study Area for the EIS [OPG 2011, Section 6.8.4]).

The sedimentary alternate location is assumed to be in a Class 3 (Rural) area in accordance with MOECC guidelines [MOECC 2016]. The proximity of the closest receptor (e.g., residences) to the DGR activities is important for considering the magnitude of noise level effects. As with air quality, for the purposes of this assessment, it is assumed that the closest receptor would be approximately 1 km from the DGR activities [OPG 2016]. Should the distance be shorter, this would increase the magnitude of effects on noise levels and/or increase the need for further in-design mitigation measures.

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. It is assumed that the activities associated with the site preparation and construction and operations phases for the sedimentary alternate location would be staged in the same or similar manner as the DGR Project at the Bruce Nuclear site and involve comparable equipment. The predicted change in noise levels associated with a DGR at the sedimentary alternate location are summarized in Table 4.1-5. Based on the requirement that the project will comply with the MOECC noise guideline limit for Class 3 areas during night-time hours, the noise emissions from the DGR would be no greater than 40 A-weighted decibels (dBA).

Table 4.1-5: Increase in Noise Levels at the DGR at the Sedimentary Alternate Location

Baseline Noise Levels (dBA)	Site Preparation and Construction Phase		Operations Phase	
	DGR Contribution (dBA) (a)	DGR-Related Change (dB)	DGR Contribution (dBA) (b)	DGR-Related Change (dB)
≤35	Up to 40	≥5	32 to 37	≥5

Notes:
(a) From Table 8.3.3-4 in [OPG 2011]
(b) From Table 8.3.3-5 in [OPG 2011]

When a background noise level of 35 dBA, or less, is combined with emissions from the project that cannot exceed 40 dBA (i.e., MOECC NPC-300 guideline night-time noise level limit), the predicted change in noise level for the sedimentary location would be equal to or greater than 5 decibels (dB). This is considered noticeable, as increases in noise levels greater than 3 dB and less than 6 dB are considered noticeable [Hansen 2001]. 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[2].

The additional handling and transportation of waste from the WWMF to the DGR at the sedimentary alternate location represents a likely effect on noise levels during transportation. As described in Section 3, 22,000 truck transport trips (11,000 inbound with waste packages and 11,000 outbound returning) would be required to and from the alternate location; over one-way distances of up to 300 km. Transport vehicles would cause localized emissions of noise levels in the vicinity of the vehicle while en route. A variety of receptor distances are anticipated along the route as some houses may be located closer to or further set back from roads.

2 For comparison, the DGR Project, which has existing ambient noise levels of 35 to 37 dBA, the project-related change relative to baseline is predicted to be between 2 and 3 dB.

Transportation between the WWMF and alternate location 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. In addition, as a permitting requirement, the noise level emissions from the DGR-related works and activities would need to meet MOECC NPC-300 noise guidelines for a Class 3 (rural) area [MOECC 2016]. 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.

4.1.3 Comparison of Atmospheric Effects Relative to the DGR Project at the Bruce Nuclear Site

Overall, as summarized in Table 4.1-6, DGR-related 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 in the EIS, as a peak hourly activity was used to predict a bounding emission rate (i.e., additional equipment emissions are likely to be captured within the EIS predictions). However, as background air quality concentrations at the sedimentary alternate location are likely to be lower, the cumulative ambient air quality concentrations are likely to be lower as compared to those at the Bruce Nuclear site. Less mitigation may be required to maintain compliance with air quality standards.

Additional effects on air quality and noise levels are possible as result of waste transportation. The transportation of wastes would also result in the emission of GHGs.

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. The lower background levels may require the implementation of additional mitigation measures to meet applicable regulatory requirements for noise.

Table 4.1-6: Summary of Effects of a DGR at the Sedimentary Alternate Location on the Atmospheric Environment Relative to the DGR Project at the Bruce Nuclear Site

Valued Component	Environmental Effects	Mitigation Requirements	Comments
Air Quality	↔ (site preparation, construction, operations) ▲ (waste transportation)	▼	• Increased effects on air quality are anticipated as a result of 22,000 truck transport trips (11,000 inbound, and 11,000 outbound) over one-way distances of up to 300 km • Potential nuisance related effects to adjacent residences along the waste package transport route (2 shipments per day) • Increases in concentrations of air quality indicator compounds at the DGR fence line are likely to be similar at both locations • Lower background air quality may necessitate less mitigation to meet relevant air quality criteria
Noise Levels	▲	▲	• Although noise emissions are likely to be similar, effects on noise levels are likely to be of higher magnitude due to lower background noise levels • Additional mitigation may be required to meet relevant noise criteria

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

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 sedimentary alternate location. The potential interactions between the DGR at the sedimentary alternate location works and activities and the surface water environment are summarized in Table 4.2-1 and described below.

Table 4.2-1: Potential Interactions between the DGR at the Sedimentary Alternate Location and the Surface Water Environment

DGR-related Works and Activities at Sedimentary Alternate Location	Surface Water Quality	Surface Water Quantity and Flow
Site Selection and Licensing		
Site Preparation	●	●
Construction of Surface Facilities	●	●
Excavation and Construction of Underground Facilities	●	●
Transportation of Waste Packages to the DGR	●	
Above-ground Transfer of Waste	●	
Underground Transfer of Waste		
Decommissioning and Closure	●	●
Postclosure of the DGR Facility		
Presence of the DGR Project		
Waste Management	●	
Support and Monitoring of the DGR Life Cycle	●	●
Workers, Payroll and Purchasing	●	

Note:
'●' = Plausible interaction between a DGR work and activity, and the environment

During site preparation and construction of surface facilities, there are likely to be earth moving activities and changes to site drainage patterns. These may affect surface water quantity and flow through changes in catchment areas, and also have the potential increase sediment load in drainage discharges and cause a change in water quality.

During excavation and construction of underground facilities, dewatering is assumed to be released to the environment through ditches and a stormwater management pond. This may cause an increase flow in the receiving water body. In addition, water collected from underground, or that has come in contact with material in the waste rock piles (included in the waste management work and activity) may release water with an alternate chemistry into adjacent drainage ditches. Particular parameters of concern include suspended solids, saline groundwater and residual explosives (i.e., Ammonium Nitrate/Fuel Oil [ANFO]).

During the above-ground movement of waste, including transportation of waste to the DGR from the WWMF, it is possible that vehicle traffic could lead to increased sediment loads to the adjacent drainage ditches. Similarly, worker vehicle traffic (workers, payroll and purchasing) may interact with water quality through increased sedimentation.

Support and monitoring of the DGR life cycle includes the collection, storage and disposal of water from underground sumps, and of wastewater from above- and below- ground facilities. It also includes the operations of the surface drainage in a stormwater management system throughout the DGR life. This includes discharge from the stormwater management system to the environment, therefore there is a potential interaction with both surface water VCs.

Potential interactions with surface water during decommissioning and closure are likely to be similar to those identified during site preparation and construction of surface facilities, as the nature of the activities would be similar. During closure, the site would be restored to some desired end point. Following this, there would be no specific activities occurring at the site other than monitoring, which would be unlikely to affect surface water flow or quality.

Changes in groundwater flow or groundwater quality may also interact with surface water quality through groundwater discharge to surface water bodies.

4.2.1 Environmental Effects on Surface Water

The DGR at the sedimentary alternate location is located in southern Ontario. There are extensive networks of small rivers, streams and creeks feeding into one of the Great Lakes in the region. Most of the land is developed for livestock and cash crop farming, with areas not developed for agriculture generally either forested or consisting of small rural communities.

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).

The site preparation and construction of the DGR at a sedimentary location 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
- site runoff and runoff from the waste rock stored in the waste rock management area (WRMA).

For the sedimentary alternate location, the waste rock pile is assumed to be similar in size and composition as the DGR Project at the Bruce Nuclear site and that any runoff would be treated for suspended solids as a minimum. Therefore, it is expected that all the runoff from the waste rock pile and any water from underground would be discharged from the site at a single location to a local watercourse.

The specific magnitude of likely effects on surface water quantity and flow depends on the specific receiving water body. Regardless of the location, 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 and surface facilities. 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 existing site 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 effects on water quality are likely.

During operations, the DGR has the potential to continue to affect surface water quality and quantity through continued operation of the SWMP and its discharge to the environment. It is assumed that effects identified above would persist into the operations phase.

During transportation of waste packages between the WWMF and the DGR, 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 effects on water quality are not likely to be measurable.

As described in Section 4.5, no measurable changes to groundwater quality or flow are anticipated outside of the project footprint. Therefore, no indirect effects on surface water are 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 site-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.

4.2.2 Comparison of Effects Relative to the DGR Project at the Bruce Nuclear Site

Overall, as summarized in Table 4.2-2, effects on surface water are likely to be similar to those identified for the DGR Project at the Bruce Nuclear site [OPG 2011], as the water volumes and quality to be managed are similar, and discharge is likely to a drainage ditch feature in both cases. The magnitude of effects may be slightly higher or lower, depending on the specific characteristics of the receiving waterbody. In both cases, these are 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, which would have a lower assimilative capacity as compared to Lake Huron at the Bruce Nuclear site. Waste transportation introduces the potential for additional off-site conventional spills (e.g., small quantities of oil).

Table 4.2-2: Summary of Effects of a DGR at the Sedimentary Alternate Location on Surface Water Relative to the DGR Project at the Bruce Nuclear Site

Valued Component	Environmental Effects	Mitigation Requirements	Comments
Surface Water Quality	↔	▲	• Effects on surface water quality are likely to be similar at the Bruce Nuclear site and the sedimentary alternate location as there would be similar water quality characteristics and releases would be required to meet discharge limits protective of the environment • Site-specific discharge limits may be more restrictive for the sedimentary alternate location 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 Bruce Nuclear site and the sedimentary alternate location as there would be similar water volumes to be managed • Additional mitigation may be required to minimize potential effects related to changes in flows in the receiving water body

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

4.3 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 potential interactions between the DGR-related works and activities at the sedimentary alternate location and the aquatic environment are summarized in Table 4.3-1 and described below.

Table 4.3-1: Potential Interactions between the DGR at the Sedimentary Alternate Location and the Aquatic Environment

DGR-related Works and Activities at Sedimentary Alternate Location	Aquatic Habitat	Aquatic Biota
Site Selection and Licensing		
Site Preparation	●	●
Construction of Surface Facilities	●	●
Excavation and Construction of Underground Facilities	●	●
Transportation of Waste Packages to DGR		
Above-ground Transfer of Waste		
Underground Transfer of Waste		
Decommissioning and Closure	●	
Postclosure of the DGR Facility		
Presence of the DGR Project		
Waste Management		
Support and Monitoring of the DGR Life Cycle		
Workers, Payroll and Purchasing		

Note:
'●' = Plausible interaction between a DGR work and activity, and the environment

During site preparation and construction, activities would include the clearing and grubbing of vegetation and installation of culverts at new roads, where required. This may include removal of riparian vegetation, which is a direct loss of aquatic habitat, and may also have an indirect effect on aquatic biota. As described in Section 4.2.1, these activities may also cause an increase in sedimentation, which could cause a reduction in the quality of aquatic habitat.

Excavation and construction of underground facilities would be undertaken through drill and blast techniques. Changes in vibration levels associated with the blasting during construction could affect aquatic biota associated with nearby habitats.

Waste transportation is not likely to directly affect aquatic VCs as no in-water works are likely (i.e., the existing transportation/road system would not require improvements).

The decommissioning of the DGR includes the removal of all surface facilities and the re-vegetation of the affected area. The re-vegetated/re-naturalized sedimentary alternate location has the potential to have a beneficial effect on aquatic habitat.

Changes in surface water VCs (i.e., surface water quality and surface water quantity and flow) would also interact with aquatic VCs. Reductions in water quality have the potential to degrade the quality of aquatic habitat. In addition, notable changes in flow may change the quality of aquatic habitats, causing it to be potentially less suitable for use by aquatic biota.

Some aquatic invertebrates rely on groundwater (e.g., burrowing crayfish). Therefore changes in groundwater quality or groundwater levels have the potential to affect the habitat for these species. In addition, changes in groundwater quality can, in turn, affect surface water quality, which has the potential to affect the VCs within the receiving water bodies.

4.3.1 Environmental Effects on the Aquatic Environment

A DGR at the sedimentary alternate location is in southern Ontario. The ecozone (mixed wood plains) of this alternate location is generally well drained. Most watercourses in the area of the sedimentary alternate location are cool to coldwater and are considered to be more sensitive to disturbances than warmwater systems [Crins et al. 2009]. In this ecozone, the characteristic fish species include white sucker, smallmouth bass, walleye, northern pike, yellow perch, rainbow darter, emerald shiner and pearl dace [Crins et al. 2009].

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 would be located in an agricultural area and 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).

Changes in surface water conditions may also indirectly affect aquatic VCs. As described in Section 4.2.1, 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 effects from changes in surface water quality are likely as discharges would meet criteria established considering aquatic toxicity thresholds (see Section 4.2.1).

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 effects are anticipated.

As described in Section 4.5, 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 effects through this pathway are anticipated.

During operations, the potential to affect aquatic VCs is reduced as there are no potential direct habitat loss, and potential for effect is only through indirect effects from changes in surface water quantity and quality. As described in Section 4.2.1, 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 effects on surface water quality are likely. Therefore, no effects on aquatic VCs are 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. As described in Section 4.2.1, effects on surface water quantity are not likely following the closure of the DGR. In addition, no adverse effects on groundwater or surface water quality are likely. Therefore, no effects on aquatic VCs are likely in the long-term performance phase.

Mitigation and monitoring strategies identified for surface water (Section 4.2.1) 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 effects on the aquatic environment are likely.

4.3.2 Comparison of Effects Relative to the DGR Project at the Bruce Nuclear Site

As shown in Table 4.3-2, overall effects on the aquatic environment of a DGR at the sedimentary alternate location are likely to be similar to those of the DGR Project at the Bruce Nuclear site. Effects are dependent on the receiving water and could be effectively managed through mitigation measures. Depending on the sensitivity and size of nearby aquatic habitat, additional mitigation may be required.

Table 4.3-2: Summary of Effects of a DGR at the Sedimentary Alternate Location on the Aquatic Environment Relative to the DGR Project at the Bruce Nuclear Site

Valued Component	Environmental Effects	Mitigation Requirements	Comments
Aquatic Habitat	↔	▲	• Effects on aquatic habitat are likely to be similar at both the sedimentary alternate location and the Bruce Nuclear site • The magnitude of effects may be slightly higher, or additional mitigation may be required, at the sedimentary alternate location if discharged to a smaller watershed, but is highly dependent on the discharge location identified
Aquatic Biota	↔	↔	• Effects on the aquatic environment are likely to be similar at both the sedimentary alternate location and the Bruce Nuclear site • Potential mitigation denoted above for aquatic habitat would be protective of aquatic biota

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

4.4 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. The potential interactions between the works and activities at a sedimentary alternate location and the terrestrial environment are summarized in Table 4.4-1 and described below.

Table 4.4-1: Potential Interactions between the DGR at the Sedimentary Alternate Location and the Terrestrial Environment

DGR-related Works and Activities at Sedimentary Alternate Location	Vegetation Communities	Wildlife Habitat and Biota
Site Selection and Licensing	●	●
Site Preparation	●	●
Construction of Surface Facilities		
Excavation and Construction of Underground Facilities		●
Transportation of Waste Packages to the DGR		●
Above-ground Transfer of Waste		●
Underground Transfer of Waste		
Decommissioning and Closure		●
Post-closure of the DGR Facility		
Presence of the DGR Project		
Waste Management		
Support and Monitoring of the DGR Life Cycle		
Workers, Payroll and Purchasing		●

Note:
'●' = Plausible interaction between a DGR work and activity, and the environment

During site selection and licensing, drilling investigations may require localized vegetation clearing. The removal of brush and trees interacts directly with the vegetation community VC by physically removing them, and may indirectly affect wildlife habitat and biota VCs by limiting habitat utilization opportunities (i.e., foraging, reproducing, sheltering). Site preparation would include removal of vegetation and grading in all areas required for construction, which would result in similar effects, however on a larger scale. In addition, the excavation, transfer and stockpiling of topsoil has the potential to interact with burrowing species of mammals and herpetofauna.

In addition to land clearing, during site preparation site boundary fencing would be installed around the perimeter of the site, which may be up to 900 ha. This fencing has the potential to introduce new barriers to wildlife movement.

The movement of wastes, including the above-ground transfer of wastes, and waste transportation to the sedimentary alternate location from the WWMF, as well as worker vehicles, has the potential to directly interact with the ground-dwelling terrestrial environment wildlife VCs through the increased potential for vehicular strikes of wildlife species including wild turkey, mammals and herpetofauna.

Wildlife habitat and wildlife species VCs also have the potential to be indirectly affected through changes in:

- soil quality – vegetation community VCs could be indirectly affected by changes in soil quality caused by the uptake of contaminants in the soil; wildlife habitat and biota VCs could also be indirectly affected by changes in soil quality if they are burrowing animals, largely ground-dwelling animals or consume species that come into direct contact with soil (e.g., earthworms);
- surface water flow, quality and quantity – changes in surface water quantity and flow could potentially interact with those vegetation community and wildlife VCs that reside in or use the waterbodies on-site;
- air quality – increased emissions of airborne pathogens or dust have the potential to affect the health of wildlife VCs through inhalation, and affect vegetation community VCs through deposition of dust;
- noise levels – changes in noise levels and/or patterns have the potential to disrupt wildlife species;
- vibrations levels – blasting of the rock during the excavation of underground facilities has the potential to affect ground-dwelling wildlife through vibrations; and
- light levels – changes in light levels could potentially interact with those wildlife VCs that reside in or near the site.

4.4.1 Environmental Effects on the Terrestrial Environment

A DGR at the sedimentary alternate location is located in southern Ontario. This alternate location corresponds with the mixed wood plains ecozone. The climate of this ecozone is cool to mild, with cool winters and relatively warm summers [Crins et al. 2009]. 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 [Crins et al. 2009].

For the purposes of this assessment, 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). As noted in Crins et al. [2009], the land cover in this ecozone is fairly disturbed and it is likely that fewer natural plant communities or smaller, remnant pockets of natural plant communities would be potentially affected.

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 does increase 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.

As described in Section 4.5, no measurable changes to soil quality, groundwater quality or groundwater flow are likely outside of the immediate footprint of the DGR. Similarly, as described in Section 4.2, 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 effects on vegetation or wildlife VCs are 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, as described in Section 4.1.2, 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. As described in Section 4.1.1, 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 ecozone is fairly disturbed [Crins et al. 2009], it is likely that this effect would be of low magnitude.

Transport of waste packages to the sedimentary alternate location from the WWMF would result in an additional 22,000 truck transport trips over more than 30 years over one-way transport distances of up to 300 km. This would result in an increased potential for wildlife strikes during transport between the WWMF and alternate location. Although this is a small number relative to existing traffic (an additional two trips per day), over the culmination of the DGR operations, it 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. No additional vegetation removal or habitat loss is likely during decommissioning. Following decommissioning there would be no measurable indirect effects likely on vegetation or wildlife VCs. As described in Section 4.2 and Section 4.5, no measurable changes to surface water or groundwater are likely, and therefore there is no potential effect on the terrestrial environment.

Site-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 such as Significant Wildlife Habitat (as defined in MNR 2000), Areas of Natural and Scientific Interest (ANSIs), habitat of threatened or endangered species under the *Endangered Species Act, 2007* and the *Species at Risk Act*, 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 effects on terrestrial environment VCs are likely at the sedimentary alternate location.

4.4.2 Comparison of Effects Relative to the DGR Project at the Bruce Nuclear Site

Overall effects on the terrestrial environment, including vegetation and wildlife VCs, are likely to be greater as a result of a DGR at the sedimentary alternate location, as summarized in Table 4.4-2. Vegetation removal would be greater than that required at the Bruce Nuclear site, and the need for a separate and independent licensed nuclear site will require the establishment of a new large secured (i.e., fenced) area. 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 are not currently habituated to anthropogenic disturbances. The biodiversity of the sedimentary alternate location is assumed to be similar to that of the Bruce Nuclear site, as the region is already anthropogenically altered and fragmented.

Table 4.4-2: Summary of Effects of a DGR at the Sedimentary Alternate Location on the Terrestrial Environment Relative to the DGR Project at the Bruce Nuclear Site

Valued Component	Environmental Effects	Mitigation Requirements	Comments
Vegetation Communities, including both upland and wetland	▲	↔	• Increased area of vegetation removal for additional surface facilities • Sensitive wetland features likely to experience a greater degree of impact from developmental activities • Increased effects on habitat connectivity due to additional fenced areas and onsite roads
Wildlife and Wildlife Habitat	▲	↔	• Increased area of habitat loss due to vegetation clearing • Increased effects on habitat connectivity due to additional fenced areas and onsite roads • Greater potential for adverse effects from changes in air quality, noise, light, vibrations, as location is not likely already influenced by anthropogenic disturbances • Greater potential for wildlife-vehicle interactions due to additional waste transport

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

4.5 GEOLOGY AND HYDROGEOLOGY

This section considers potential effects on geology, hydrogeology and soil quality of a DGR at the sedimentary alternate location. Potential interactions between the DGR and the geology VCs occur on two broad timescales, 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 postclosure of the DGR). The potential interactions between the works and activities at the sedimentary alternate location and geology and hydrogeology are summarized in Table 4.5-1 and described below. Changes in groundwater quality and flow are considered in the overburden (i.e., unconsolidated surficial material, such as till), shallow bedrock, where the bedrock may be more fractured, and deep bedrock.

Table 4.5-1: Potential Interactions between the DGR at the Sedimentary Alternate Location and Geology and Hydrogeology

DGR-related Works and Activities at Sedimentary Alternate Location	Soil Quality	Groundwater Quality	Groundwater Flow/ Transport
Site Selection and Licensing			
Site Preparation	●	●	●
Construction of Surface Facilities		●	●
Excavation and Construction of Underground Facilities			●
Transportation of Waste Packages to the DGR			
Above-ground Transfer of Waste			
Underground Transfer of Waste			
Decommissioning and Closure	●	●	●
Postclosure of the DGR Facility	●	●	●
Presence of the DGR Project			
Waste Management	●	●	●
Support and Monitoring of the DGR Life Cycle	●	●	●
Workers, Payroll and Purchasing			

Note:
'●' = Plausible interaction between a DGR work and activity, and the environment

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 as a result of site grading;
- direct effects on overburden groundwater transport and shallow bedrock groundwater and solute transport as a result of excavation and construction of underground facilities;

- indirect effects on overburden groundwater quality as a result of changes in overburden groundwater transport; and
- indirect effects on shallow bedrock groundwater quality as a result of changes in overburden groundwater quality and shallow bedrock groundwater and solute transport.

Site preparation and construction of surface facility activities, including earth-moving activities and conventional construction activities, have the potential to interact with soil quality and the shallow geologic/hydrogeologic regime (i.e., overburden), through removal of soils during grading, and the alteration of groundwater recharge areas through construction of roads or buildings. In addition, groundwater flow in the overburden and shallow bedrock will be affected through excavation and construction activities during shaft sinking.

The waste management and support and monitoring of the DGR lifecycle activities include the waste rock management piles and the operation of the stormwater management pond. These areas have the potential to affect shallow groundwater quality through the infiltration of surface runoff. As described in Section 4.2, surface runoff may have increased concentrations of suspended solids, saline groundwater and residual explosives relative to background.

Waste transportation is not likely to affect geology and hydrogeology VCs. No ground movement is likely (e.g., from road upgrades). During transportation, there is the incremental risk of a conventional spill (e.g., a small volume of fuel or oil) as a result of an accident or malfunction scenario, which could affect soil quality. A spills management plan would be put into place so that in the case of an event it is contained and responded to quickly.

The DGR would remain in place upon completion of decommissioning and closure activities. Therefore, there is the potential for the DGR to interact with groundwater in the long-term.

4.5.1 Environmental Effects on Geology and Hydrogeology

The Description of Alternate Locations technical document [OPG 2016] describes the geologic conditions of a sedimentary alternate location. In particular, the sedimentary alternate location is defined by a suitable thickness of low permeability Ordovician sediments below ground surface in which the DGR could be positioned.

For the purpose of identifying potential effects, it is assumed that the geology over this area would demonstrate similar behavior as at the Bruce Nuclear site (i.e., the site specific geology would have low permeability layered rock around repository, with permeable features near surface). A site-specific DGR design would be developed that, through a combination of engineered and natural barriers, would ensure regulatory criteria were met with an appropriate margin of safety.

The main potential effects on geology for the DGR at a sedimentary alternate location 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 [OPG 2011], which would be in close proximity to the DGR. 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 is even further reduced.

Potential effects are also identified during the postclosure phase of the DGR at the sedimentary alternate location, analogous to those identified in the assessment completed for the Bruce Nuclear site in the EIS [OPG 2011, Section 7.2.2]. Given the engineered and natural barriers inherent in the design, including shaft seals, no residual adverse effects are likely on the geology and hydrogeology VCs are likely of a DGR at the sedimentary alternate location during post-closure.

4.5.2 Comparison of Effects Relative to the DGR Project at the Bruce Nuclear Site

Overall effects on soil quality, geology and groundwater of a DGR at the sedimentary alternate location are likely to be similar to those for the DGR Project at the Bruce Nuclear site, as shown in Table 4.5-2, given that in both cases the repository would be located and sealed within a thick low-permeability sedimentary rock sequence. The DGR at the sedimentary alternate location is unlikely to result in residual adverse effects.

Table 4.5-2: Summary of Effects of a DGR at the Sedimentary Alternate Location on Geology and Hydrogeology Relative to the DGR Project at the Bruce Nuclear Site

Valued Component	Environmental Effects	Mitigation Requirements	Comments
Soil Quality	↔	↔	• Given the similar geologic setting, effects on soil quality are expected to be similar between the alternate location and the Bruce Nuclear site
Groundwater Quality	↔	↔	• Given the similar geologic setting, effects on groundwater quality are expected to be similar between the alternate location and the Bruce Nuclear site
Groundwater Flow	↔	↔	• Given the similar geologic setting, effects on groundwater flow are expected to be similar between the alternate location and the Bruce Nuclear site

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

4.6 RADIATION AND RADIOACTIVITY

This section considers potential effects on the radiation and radioactivity VCs of the DGR at the sedimentary alternate location. The potential interactions between the works and activities at the sedimentary alternate location and radiation and radioactivity are summarized in Table 4.6-1 and described below.

Table 4.6-1: Potential Interactions between the DGR at the Sedimentary Alternate Location and Radiation and Radioactivity

DGR-related Works and Activities at Sedimentary Alternate Location	Humans	Non-human Biota
Site Selection and Licensing		
Site Preparation		
Construction of Surface Facilities		
Excavation and Construction of Underground Facilities	●	●
Transportation of Waste Packages to DGR	●	●
Above-ground Transfer of Waste	●	●
Underground Transfer of Waste	●	●
Decommissioning and Closure	●	●
Post-closure of the DGR Facility	●	●
Presence of the DGR Project		
Waste Management	●	●
Support and Monitoring of the DGR Life Cycle	●	●
Workers, Payroll and Purchasing		

Note:
'●' = Plausible interaction between a DGR work and activity, and the environment

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 (i.e., site preparation, construction of surface facilities, and excavation of underground facilities), 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 sedimentary 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.

Waste management in Table 4.6-1 includes the management of materials that may have become contaminated with radioactivity through over the course of the DGR operations. The support and monitoring of the DGR life cycle activities would include operation of the ventilation systems, monitoring air and water quality, and groundwater and surface water management, and would therefore have the potential to interact with radiation and radioactivity VCs during operations and decommissioning.

Decommissioning of the DGR would include all activities required to seal the shafts and remove surface facilities. This includes dismantling the equipment, sealing the repository and access ways and decontaminating and demolishing the surface facilities. Therefore, there is a potential mechanism through which this work and activity may directly interact with radiation and radioactivity VCs.

Releases of radionuclides from the DGR during the operations and decommissioning phases are possible and could lead to human and non-human exposure via different pathways such as ingestion or immersion in contaminated surface water, inhalation of air and indirectly through groundwater. In addition, workers may be exposed to naturally occurring radioactive material (NORM), in particular radon, during the construction and operations phases.

4.6.1 Environmental Effects on Radiation and Radioactivity

The site preparation, construction, operation, decommissioning and postclosure activities at the DGR at the sedimentary alternate location would be broadly similar to those at the DGR Project at the Bruce Nuclear site and therefore the radiological effects are predicted to be similar as those predicted for the DGR Project at the Bruce Nuclear site. To minimize the radiological effects on humans, mitigation measures would be developed during the design of the DGR and establishment of support facilities. Dose to workers would be minimized in the context of As Low As Reasonably Achievable (ALARA). Doses to members of the public from the DGR would be well below the 1 mSv/a regulatory limit. Similarly, dose rates for non-human biota would be well below criteria for adverse effects [OPG 2011]. Thus, based on this and OPG's operating performance at existing facilities and commitment to keep public and worker dose ALARA, radioactivity releases from the DGR to the terrestrial and aquatic environment 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. However a fundamental underpinning of the transportation packaging regulations that ensure the safe transportation of radioactive materials on public roads is compliance with the rigorous standards for packaging of such materials [ENERGY SOLUTIONS 2016]. Transportation of L&ILW to the sedimentary alternate location, 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 effects are 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 any 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 [OPG 2016]. These processes are very slow in low permeability rock. Since the specific site would be selected to ensure safety, no residual adverse effects during postclosure are expected, and predicted dose rates would be much less than the public dose criterion under normal operations.

4.6.2 Comparison of Effects Relative to the DGR Project at the Bruce Nuclear Site

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, as shown in Table 4.6-2, given the geological similarity between the locations.

The DGR at a sedimentary alternate location would introduce new radiological exposure pathways, which was previously not a nuclear site; this would be expected to persist through post-closure. The total effect on radiation and radioactivity at the sedimentary alternate location may be lower than that at the Bruce Nuclear site, as there would be no existing sources of radiation other than naturally occurring background. However, for comparison, the total existing dose rate at the site boundary from the Bruce Nuclear site operations is approximately 0.004 mSv/a [OPG 2011], which is small compared to the natural background dose rate of about 1.8 mSv/a across Canada.

Table 4.6-2: Summary of Effects of a DGR at the Sedimentary Alternate Location on Radiation and Radioactivity Relative to the DGR Project at the Bruce Nuclear Site

Valued Component	Environmental Effects	Mitigation Requirements	Comments
Humans	↔ (members of the public) ▲ (workers)	▲	• Incremental worker dose related to the handling, packaging and transportation of waste • Given the similar geologic setting, effects on dose to members of the public are expected to be similar, and would have similar mitigation and design requirements
Non-human Biota	↔	↔	• Given the similar geologic setting, effects on dose to non-human biota are expected to be similar, and would have similar mitigation and design requirements

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

4.7 LAND AND RESOURCE USE (TRADITIONAL AND NON-TRADITIONAL)

This section considers potential effects of a DGR at the sedimentary alternate location on land and resource use, including both traditional and non-traditional uses. The potential interactions between the works and activities at the sedimentary alternate location and land use are summarized in Table 4.7-1 and described below.

Table 4.7-1: Potential Interactions between the DGR at the Sedimentary Alternate Location and Land and Resource Use

DGR-related Works and Activities at Sedimentary Alternate Location	Use of Land and Resources
Site Selection and Licensing	●
Site Preparation	●
Construction of Surface Facilities	●
Excavation and Construction of Underground Facilities	
Transportation of Waste Packages to the DGR	●
Above-ground Transfer of Waste	
Underground Transfer of Waste	
Decommissioning and Closure	
Post-closure of the DGR Facility	●
Presence of the DGR Project	●
Waste Management	
Support and Monitoring of the DGR Life Cycle	
Workers, Payroll and Purchasing	●

Note:
'●' = Plausible interaction between a DGR work and activity, and the environment

Site selection and licensing activities would involve the acquisition of at least 40 ha, and up to approximately 900 ha of land. This would change the existing use of the land from agricultural, or other non-industrial land uses, to industrial. Furthermore, 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. Based on the size of the site required, it is also possible that there may be archaeological or cultural resources within this area that could be directly affected during site preparation.

The construction of surface facilities would result in new structures, including headframes, which may be visible from adjacent areas. The presence of a DGR Project may also result in a potential effect on the compatibility with surrounding land uses. The introduction of additional traffic from waste transportation and worker vehicles has the potential to directly affect the local transportation network.

Changes to the biophysical environment VCs also have the potential to indirectly affect land and resource use. Potential effects identified in Sections 4.1 through 4.6 may affect the use of surrounding lands through their potential to effect, for example, recreational or traditional uses (e.g., fishing, camping, hunting) through increased nuisance-related effects (e.g., dust, noise, light) or effects to resources (e.g., loss of fisheries, displacement of wildlife).

A DGR at the sedimentary alternate location is likely to be located in the established territory of one or multiple Indigenous communities. There is therefore potential to adversely affect potential or established Aboriginal or Treaty Rights.

4.7.1 Environmental Effects on Land and Resource Use

The sedimentary alternate location contains a variety of settings and land use areas. For this assessment, it is assumed to be in a rural, non-urban area, and on agricultural land [OPG 2016]. The land would likely be currently private land. The change in land use for the site (up to 900 ha including buffer zones) 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.

Additional workers would be required for the DGR, including for all supporting site facilities (e.g., security, environmental monitoring). Measurable change in transportation infrastructure function 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.

As described in Section 4.1, potential changes in the biophysical environment are likely to be confined to the immediate vicinity of the DGR. However, 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 traditional territory of one or multiple Indigenous communities. It is also 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.

4.7.2 Comparison of Effects Relative to the DGR Project at the Bruce Nuclear Site

Overall effects on land use are likely to be much higher for a DGR at the sedimentary alternate location than at the Bruce Nuclear site, as shown in Table 4.7-2. Given that the DGR Project is located within the Bruce Nuclear site, an existing nuclear facility with supporting infrastructure, there are no likely effects on land use. However, in the case of the sedimentary alternate location, 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.

Table 4.7-2: Summary of Effects of a DGR at the Sedimentary Alternate Location on Land and Resource Use Relative to the DGR Project at the Bruce Nuclear Site

Valued Component	Environmental Effects	Mitigation Requirements	Comments
Use of Lands and Resources (Traditional and Non-traditional)	▲	▲	• New site required (up to 900 ha) • Additional traffic from waste transport and workers • Increased indirect nuisance-related effects due to lower 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

5. ENVIRONMENTAL EFFECTS OF A DGR AT A CRYSTALLINE ALTERNATE LOCATION

This section describes the potential environmental effects of the DGR at the crystalline alternate location in the Canadian Shield in central to northern Ontario. Potential interactions are identified for the VCs defined in Section 2 and works and activities described in Section 3. Where interactions with the VC are plausible, the potential environmental effects are described, as well as relevant mitigation. Following description of the effects, these effects are assessed relative to the comparable effects of the DGR Project at the Bruce Nuclear site.

5.1 ATMOSPHERIC ENVIRONMENT

This section describes the potential effects of the DGR at the crystalline alternate location on the air quality and noise levels VCs. The potential interactions between the DGR works and activities at the crystalline alternate location and the atmospheric environment are similar in type and nature to those summarized in Table 4.1-1 and described in the sedimentary alternate location.

Most project works and activities have the potential to affect air quality and noise levels. During site selection and licensing, field investigations, such as drilling, would be undertaken, which may require construction of access clearings, use of drilling equipment as well as heavy equipment used for land clearing. There would also be emissions to the environment during site preparation and construction, operations and decommissioning. The crystalline alternate location would also require the provision of power to the site. This is assumed via the construction of a transmission line connecting to the existing grid, rather than on-site power generation (e.g., through diesel generators).

5.1.1 Environmental Effects on Air Quality

Anticipated ambient concentrations of air quality parameters at the crystalline alternate location (i.e., central to northern Ontario) are likely to be low, as this location is more removed from influence by anthropogenic atmospheric emissions sources. Air quality monitors in northwestern Ontario indicate that ground-level ozone and particulate matter are comparable to the national average but lower than southern Ontario [ENVIRONMENT AND CLIMATE CHANGE CANADA 2016a].

The crystalline alternate location would have buffer land from the surface facilities that defined the property boundary and closest point of compliance. At this alternate location, it is assumed that the closest receptor could be within approximately 1 km of DGR activities, which is consistent with the closest receptor for the DGR Project at the Bruce Nuclear site. However, because of the more remote nature of northern Ontario, the closest human receptor for a crystalline rock location is likely to be further from DGR activities. Regardless, compliance would need to be demonstrated at the property boundary as part of permitting through the MOECC's Environmental Compliance Approval process.

During site preparation and construction, the operation of vehicles, equipment and material handling as a part of all works and activities 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.

The magnitude of DGR-specific effects of the site preparation and construction and operations phases at the crystalline alternate location are summarized in Table 4.1-2. As this alternate location would require construction of up to 20 km of new access road, and up to a 50 km power corridor, effects would also extend to all areas of site preparation and construction. Effects on air quality from decommissioning and closure 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 effects on air quality.

The additional handling and transportation of waste from the WWMF to the DGR at the crystalline alternate location would result in the emission of combustion by-products, dust and GHGs. Waste transportation distances are assumed to be up 2,000 km one-way from the WWMF for approximately 24,000 truck transport trips (12,000 inbound and 12,000 outbound) over the life of the DGR operations [ENERGY SOLUTIONS 2016].

Effects on air quality would be localized to the vicinity of the transport vehicles. A variety of receptor distances are anticipated along the route as some houses may be located closer or further set back from roads; emissions would be reduced the further away from the road the receptors are. However, all waste package transportation would be 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 relative GHG emissions for the alternatives presented for the DGR at the crystalline alternate location were calculated based on the total estimated fuel use [ENERGY SOLUTIONS 2016] and current Environment and Climate Change Canada emission factors using the same methods outlined in Section 4.1.1.

The emission of GHGs from fuel combustion is directly related to the consumption of the fuel, and is calculated assuming complete combustion of the fuel. Table 5.1-1 presents the summary of GHG emissions for the 200 km and 2,000 km scenarios identified for the crystalline alternate location. The totals presented represent 24,000 truck transport trips (i.e., 12,000 inbound trips with cargo and 12,000 outbound return trips empty).

Table 5.1-1: Summary of GHG Emissions for Waste Transportation to the Crystalline Alternate Location

Waste Transportation Scenario (One-Way Transport Distance)	Cumulative Fuel Consumed (L/30-yr)	CO_2 Equivalents (kt/30-yr)
200 km	466,042	1.2
2,000 km	4,660,424	11.7

Note: Fuel consumption from ENERGY SOLUTIONS [2016]

Based on the information provided, a 200 km shipping distance to the crystalline alternate location is approximately equivalent to an increase of 1.2 kt of CO_2 equivalent over the life of the

DGR operations (approximately 30 years), 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.

A number of air quality mitigation measures are inherent in the prediction of effects, including assumed emission controls and best management practices (e.g., dust control measures). In addition, as a permitting requirement, the concentrations of air quality indicator compounds from stationary sources during all DGR phases would be required to meet all MOECC criteria in accordance with Ontario Regulation 419/05 Local Air Quality. Taking into consideration mitigation and the magnitude of effects, potential effects on air quality are not likely to be significant.

5.1.2 Environmental Effects on Noise Levels

Background noise levels at the crystalline alternate location could be below 30 dBA during the quietest night-time hour. As described in Section 4.1.2, lower baseline levels may result in higher magnitude project effects. The crystalline alternate location would also be considered to be a Class 3 (Rural) area in accordance with MOECC guidelines [MOECC 2016]. As for air quality, it is assumed that the closest receptor to the project activities would be approximately 1 km from DGR activities [OPG 2016]. However, due to the generally remote nature of the region, this distance could be greater, which would reduce the predicted effects.

Operation of equipment and vehicles, as well as blasting activities during site preparation and construction, has the potential to affect noise levels. It is assumed that the activities associated with the site preparation and construction phase for the crystalline alternate location would be staged in the same or similar manner as the DGR Project at the Bruce Nuclear site and involve comparable equipment, with the exception of construction of additional supporting infrastructure. Therefore, the DGR contribution to noise levels is assumed to be the same as predicted in the EIS [OPG 2011]. Construction equipment for supporting infrastructure would be further removed from the DGR site surface facilities, and may affect different receptors.

The DGR contribution would be no greater than 40 dBA, in accordance with MOECC noise guideline limit for Class 3 areas during night-time hours. However, when combined with a background noise level of 30 dBA, or less, the predicted change in noise level for the crystalline alternate location may be greater than 10 decibels (dB), as shown in Table 5.1-2. Changes in noise levels greater than 10 dB are considered disturbing by the MOECC [Hansen 2001].

Table 5.1-2: Increase in Noise Levels at the Crystalline Alternate Location

Baseline Noise Levels (dBA)	Site Preparation and Construction Phase		Operations Phase	
	Project Contribution (dBA) [(a)]	Project-Related Change (dB)	Project Contribution (dBA) [(b)]	Project-Related Change (dB)
≤30	Up to 40	≥10	32 to 37	≥3

Notes:
(a) From Table 8.3.3-4 in [OPG 2011]
(b) From Table 8.3.3-5 in [OPG 2011]

Similar to the site preparation and construction phase, the operation of equipment at surface, including shaft ventilation fans, would result in DGR-related noise emissions. DGR contributions to noise levels are likely to be lower than during the site preparation and construction phase, and would be similar to that estimated for the DGR Project at the Bruce Nuclear site (i.e., between 32 and 37 dBA, depending on receptor location).

However, as noted above, the crystalline alternate location is likely to have background noise levels lower than 30 dBA, therefore the magnitude of effects on noise levels would be greater than 3 dB, assuming receptors located approximately 1 km from the DGR works and activities.

Effects on noise levels from decommissioning and abandonment 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.

The additional transportation of waste from the WWMF to a DGR at the crystalline alternate location represents a likely effect on noise levels during transportation. Over 24,000 truck transport trips would be required to the DGR, over one-way distances of up to 2,000 km. Transport vehicles would cause localized emissions of noise levels in the vicinity of the transport vehicles while en route, resulting in increased noise levels. All waste package transportation would be along existing roads with existing truck traffic, and the frequency of shipments is small (two shipments per day) as compared to existing traffic levels.

A number of noise mitigation measures are inherent in the prediction of effects, including assumed emission control measures. In addition, as a permitting requirement, the noise level emissions from the project works and activities would need to meet MOECC NPC-300 noise guidelines for a Class 3 (rural) area [MOECC 2016]. 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. The specific distance to the closest receptor may vary (i.e., closer than or further than 1 km) from the DGR at the crystalline alternate location. Regardless, compliance would need to be demonstrated at the receptor location through the MOECC's Environmental Compliance Approval process.

To limit the potential for nuisance-related noise effects along the transportation route and during construction of supporting site infrastructure (e.g., access road, transmission lines), a noise management plan may be developed and implemented.

5.1.3 Comparison of Effects Relative to the DGR Project at the Bruce Nuclear Site

With the exception of waste transport, the DGR-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, as shown in Table 5.1-3. As background air quality concentrations at the crystalline alternate location are likely to be lower, 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 a DGR 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, including GHGs, and noise levels at the crystalline alternate location are possible as result of waste transportation.

Table 5.1-3: Summary of Effects of a DGR at the Crystalline Alternate Location on the Atmospheric Environment Relative to the DGR Project at the Bruce Nuclear Site

Valued Component	Environmental Effects	Mitigation Requirements	Comments
Air Quality	↔ (site preparation, construction, operations) ▲ (waste transportation)	▼	• Increased effects on air quality are anticipated as a result of 24,000 truck transport trips (12,000 inbound, 12,000 outbound) over one-way distances of 200 to 2,000 km • Potential nuisance related effects to adjacent residences along the waste package transport route (2 shipments per day) • Project-related increases in concentrations of air quality indicator compounds at the DGR site fence line are likely to be similar at both locations • Lower background air quality may necessitate less mitigation to meet relevant air quality criteria
Noise Levels	▲	▲	• Although project noise emissions are likely to be similar, effects on noise levels are likely to be of higher magnitude due to lower background noise levels • Additional mitigation may be required to meet relevant noise criteria

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

5.2 SURFACE WATER ENVIRONMENT

This section considers potential effects on surface water quality and hydrology (i.e., surface water quantity and flow) of a DGR at the crystalline alternate location. The potential interactions between the works and activities at the crystalline alternate location would be similar to those summarized in Table 4.2-1 and described in Section 4.2.

Overall surface water quantity and quality may be affected through changes in drainage areas and ground moving activities, which may change flows and result in increased sedimentation. In addition, runoff that comes into contact with waste rock may affect local water chemistry. The construction of a supporting infrastructure (i.e., road, power) to the crystalline alternate location would result in additional interactions with the site preparation work and activity, as there may be need for additional watercourse crossings.

5.2.1 Environmental Effects on Surface Water

A DGR at the crystalline alternate location is located in central to northern Ontario. This ecozone is generally well drained with an abundance of lakes, wetlands and rivers. Water quality in this region is generally good with limited anthropogenic influences, and therefore limited exceedances of Provincial Water Quality Objectives (PWQO) and Ontario Drinking Water Standards (ODWS). This alternate location is within the Great Lakes and Hudson Bay watersheds, with a small portion within the Ottawa River watershed.

Given the more rugged bedrock-controlled terrain of the Canadian Shield in northern Ontario and the expected size of the waste rock pile and surrounding infrastructure (up to 40 ha), it may be difficult to site the facility without affecting and/or encroaching to some degree on a creek or stream.

The DGR at the crystalline alternate location may affect surface water directly through the requirement to redirect drainage patterns during site preparation and construction. As noted above, surface water features are abundant in this region. 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. The magnitude of the effect from discharges would depend on specific characteristics of the location. However, as there is a greater likelihood for direct changes to drainage pathways (i.e., through redirection of streams or wetlands), overall, there is a likely adverse effect on surface water quantity and flow.

In addition to the infrastructure that would be required at the DGR, additional linear infrastructure (up to 20 km of new road construction and up to 50 km of transmission line corridor) is assumed to be required. This linear infrastructure would require both temporary (e.g., construction equipment) and permanent (e.g., culverts) water crossings. These have the potential to temporarily affect localized drainage patterns (i.e., surface water quantity and flow) and surface water quality.

For the crystalline alternate location, the waste rock pile is assumed to be similar, or slightly larger, in size as that at the DGR Project at the Bruce Nuclear site, and any runoff would be treated for suspended solids as a minimum. It is assumed that waste rock would not be acid generating. The underground water volumes would dictate the requirements of these systems. 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). Therefore, it is assumed that the volumes of water to be managed at the crystalline alternate location would be greater than the DGR Project at the Bruce Nuclear site.

It is expected that all the runoff from the waste rock pile and any water from underground would be discharged 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.

At the crystalline alternate location, water would also be stored on the surface in a SWMP. 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 from blasting that may increase concentrations of nitrate and ammonia.

During operations and decommissioning, the DGR has the potential to continue to affect surface water quality and quantity through continued operation of the SWMP and monitoring and management of discharges to the environment. It is assumed that effects identified above would persist into the operations phase; however, water volumes to be managed would likely be lower than observed during construction as applicable mitigation measures would be in place (e.g., shaft liners).

Waste package transportation would be required over a distance of up to 2,000 km. During transportation, there is the potential for increased sedimentation to local ditches, as well as incremental risk of a conventional spill (e.g., a small amount of fuel or oil) as a result of an accident or malfunction scenario. As the increase in traffic would be small relative to existing levels (i.e., two vehicles per day), adverse effects on water quality are not likely to be measurable.

During operations, the project has the potential to continue to affect surface water quality and quantity through continued operation of the SWMP and monitoring and management of discharges to the environment. It is assumed that effects identified above will persist into the operations phase.

As described in Section 5.5, no measurable changes to groundwater quality or flow are anticipated outside of the DGR footprint. Therefore, no indirect effects on surface water are likely.

Where possible, infrastructure would be sited to avoid watercourses. The best management measures to control sediment transport would be put in place during site preparation and construction to minimize effects on water quality downstream of the DGR's works and activities.

The acceptability of the quality of water for discharge from the SWMP would be determined through the Environmental Compliance Approval process with the MOECC and would consider site-specific conditions. In addition to specific discharge concentrations, no water that is acutely toxic to aquatic life would be permitted for discharge. Provided that the terms of the

Environmental Compliance Approval are met, no adverse effects on surface water quality expected from a DGR at the crystalline alternate location. 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.

5.2.2 Comparison of Effects Relative to the DGR Project at the Bruce Nuclear Site

As summarized in Table 5.2-1, overall, effects on surface water quantity and flow are likely to be higher in magnitude for a DGR at the crystalline alternate location than a DGR Project at the Bruce Nuclear site, as it is 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, it is assumed that there would be higher volumes of water to be managed from underground, at least initially. It is therefore expected that the DGR would affect some drainage patterns and would likely change flows. The magnitude of the effect from discharges would vary.

Table 5.2-1: Summary of Effects of a DGR at the Crystalline Alternate Location on Surface Water Relative to the DGR Project at the Bruce Nuclear Site

Valued Component	Environmental Effects	Mitigation Requirements	Comments
Surface Water Quality	↔	▲	• Changes in drainage patterns resulting in adverse effects from the DGR site footprint and site infrastructure at the crystalline alternate location, and larger volumes of water to be managed from underground • Site-specific discharge limits may be more restrictive for the crystalline alternate location 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 larger at a crystalline location as there may be more water to manage and greater likelihood of drainage area changes

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

5.3 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. Where aquatic VCs are referred to, these may be to fish, benthic invertebrates and/or macrophytes and their habitats as well as species at risk. The potential interactions between the works and activities at the crystalline alternate location would be similar to those summarized in Table 4.3-1 and described in Section 4.3.

Potential interactions with the aquatic environment are predominantly through direct effects of riparian vegetation removal, and indirect effects of changes in surface water quality and vibrations from blasting. As noted in Section 5.2, it is assumed that although wherever possible, the project design will avoid watercourses, it may not be feasible in this terrain to avoid encroaching on waterbodies with the project footprint. In addition, during site selection and licensing, access to drilling locations may result in disturbance to aquatic habitat. Furthermore, it is assumed that up to 20 km of new access roads and up to 50 km of new transmission lines would be required, which would require permanent crossings of watercourses (e.g., culverts). These activities have the potential to cause direct effects to the aquatic environment through the direct removal of aquatic habitat and vegetation.

5.3.1 Environmental Effects on the Aquatic Environment

As described in Section 5.2.1, the ecozone of the crystalline alternate location are generally well drained with an abundance of wetlands, lakes and rivers [Crins et al. 2009]. Characteristic fish include species such as lake trout, northern pike, and burbot [Crins et al. 2009]. Water quality in this region is generally good with limited anthropogenic influences.

Changes in surface water conditions may indirectly affect aquatic VCs. As described in Section 5.2, 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 at the crystalline alternate location 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 effects are anticipated.

During operations and decommissioning, no new potential effects on aquatic VCs are introduced; however, the potential for indirect effects from changes in surface water quantity and quality from the SWMP would continue. As described in Section 5.2.1, effects on surface water quantity are expected to persist through the operations phase, but at a reduced level from those observed during construction. No adverse effects on surface water quality are likely. Therefore, no effects on aquatic VCs are likely in the operations phase.

No changes in groundwater flow or quality at aquatic feature locations are likely as a result of the DGR at the crystalline alternate location (see Section 5.5). Therefore no adverse effects through this pathway are anticipated.

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. In addition, for these watercourse crossings, all standard mitigation measures to protect fish and fish habitat during the construction of any watercourse crossings, as described in Section 7.5.2.1 of the EIS [OPG 2011] would be implemented.

5.3.2 Comparison of Effects Relative to the DGR Project at the Bruce Nuclear Site

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, as summarized in Table 5.3-1. 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.

Table 5.3-1: Summary of Effects of the DGR at the Crystalline Alternate Location on the Aquatic Environment Relative to the DGR Project at the Bruce Nuclear Site

Valued Component	Environmental Effects	Mitigation Requirements	Comments
Aquatic Habitat	▲	▲	• Assumed that direct habitat loss is probable as a result of siting of surface facilities and infrastructure • The magnitude of effects may be slightly higher, or additional mitigation may be required, at the alternate location if discharged to a smaller watershed, but is highly dependent on the discharge location identified
Aquatic Biota	↔	↔	• Effects on the aquatic environment are likely to be similar at both locations

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

5.4 TERRESTRIAL ENVIRONMENT

This section considers potential effects of the DGR at the crystalline alternate location on the terrestrial environment, specifically vegetation and wildlife VCs. Potential interactions between the works and activities at the crystalline alternate location are similar to those identified in Table 4.4-1 and discussed in Section 4.4. This potentially includes effects on wildlife species, including species at risk, such as wolverine, woodland caribou and eastern cougar.

The construction of additional site access infrastructure (i.e., road, transmission line) introduces additional potential for habitat fragmentation, as well as associated indirect effects of changes in air quality, noise levels and water quality during construction and operation.

5.4.1 Environmental Effects on the Terrestrial Environment

A DGR at the crystalline alternate location is located in central to northern Ontario, which corresponds with the Boreal shield ecozone within Ontario. Although the climate in this ecozone is relatively cold and moist, with long, cold winters and short, warm summers, there is a wide range of weather patterns. The climate in the central to northern Ontario ecoregions in which the alternate location is located can range from cool and relatively dry to moist and cold. 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. Although there are many towns and villages in this ecozone, they tend to be small with low populations. 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 [Crins et al. 2009].

In general, characteristic wildlife in the crystalline rock location ecozone are likely to have a large home range and movement corridors. In addition, as there are fewer anthropogenic sources of light, noise and airborne pathogens/dust, wildlife are less habituated to these sources of stimuli.

For this assessment it is assumed that surface facilities will 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 Wetlands. Where possible, the surface facilities 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 relative permitting.

Loss of vegetation during site preparation would have an adverse effect on the vegetation community VC, as well as the wildlife and wildlife VC due to loss of habitat. For the crystalline alternate location, the land is assumed to be undeveloped natural lands. Therefore, 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. In general, the spatial extent of wetlands communities at the crystalline alternate location would likely be more extensive than at the alternate sedimentary location. 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.

The construction of infrastructure to this DGR would require additional vegetation and habitat removal and there may be an increased measurable effect on factors such as habitat fragmentation, which may affect species such as woodland caribou. In general, characteristic wildlife in these ecoregions have a larger home range and movement corridors are larger than for wildlife in southern Ontario.

As described in Section 5.5, no measurable changes to soil quality, groundwater quality or groundwater flow are likely outside of the immediate DGR footprint. Similarly, as described in Section 5.2, 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 effects on vegetation or wildlife VCs are likely through these pathways.

Direct effects on wildlife VCs may occur during the operations phase as a result of additional worker traffic and construction vehicle operation at the crystalline alternate location. In addition, as described in Section 5.2, during site preparation and construction, increased noise levels are possible at levels potentially considered disturbing 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 construction are predicted; however, background air quality is assumed to be lower at the crystalline alternate location, and therefore indirect effects from changes in air quality would similarly be lower (Section 5.1).

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.

Direct effects on wildlife VCs may occur as a result of worker traffic, however, traffic levels are assumed to be less than those experienced during the site preparation and construction phase. In addition, changes in noise levels are likely to be of a lower magnitude than during site preparation and construction. By the operations phase, wildlife may have habituated to the increased noise and activity levels. Changes in air quality are predicted to also be of lower magnitude than during construction and within applicable regulatory limits. Therefore, no adverse effects on biodiversity as a result of the operations phase are likely.

Transport of waste packages to the crystalline alternate location from the WWMF will result in an additional 24,000 truck transport trips over more than 30 years. This will result in an increased potential for wildlife strikes during transport between the locations. Although this is a small number relative to existing traffic (an additional two trips per day), over the culmination of the DGR operations, it represents up to an additional 44,000,000 km travelled and associated incremental risk of wildlife-vehicle strikes.

Indirect effects on the terrestrial environment VCs during decommissioning activities would be similar to or lower than those identified for site preparation and construction. No additional vegetation removal or habitat loss is likely during decommissioning. Following decommissioning there are no measurable indirect effects likely on vegetation or wildlife VCs. As described in Section 5.2 and 5.5, no measurable changes to surface water or groundwater are likely, and therefore there is no potential effect on the terrestrial environment.

Site-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 such as Significant Wildlife Habitat (as defined in MNR 2000), Areas of Natural and Scientific Interest (ANSIs), habitat of threatened or endangered species under the *Endangered Species Act* and the *Species at Risk Act*, not be possible, further mitigation measures would be required to reduce or eliminate adverse 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).

5.4.2 Comparison of Effects Relative to the DGR Project at the Bruce Nuclear Site

Overall effects on the terrestrial environment, including vegetation and wildlife VCs, are likely to be greater as a result of the DGR at the crystalline alternate location than at the Bruce Nuclear site, as summarized in Table 5.4-1. Vegetation removal would be greater than that expected for the Bruce Nuclear site and also includes additional linear infrastructure. As the crystalline alternate location is assumed to be in an area largely unaffected by existing developments, increases in traffic, noise and light levels may have a proportionally larger effect on wildlife VCs, as they are not currently habituated to anthropogenic disturbances.

Table 5.4-1: Summary of Effects of the DGR at the Crystalline Alternate Location on the Terrestrial Environment Relative to the DGR Project at the Bruce Nuclear Site

Valued Component	Environmental Effects	Mitigation Requirements	Comments
Vegetation Communities	▲	↔	• Increased area of vegetation removal for additional surface facilities, including two infrastructure corridors • Increased effects on habitat connectivity due to additional fenced areas and onsite roads
Wildlife and Wildlife Habitat	▲	↔	• Increase habitat loss due to vegetation clearing • Increased effects on habitat connectivity due to additional fenced areas and onsite roads • Greater potential for adverse effects from changes in air quality, noise, light, vibrations, as location is not likely already influenced by anthropogenic disturbances • Greater potential for wildlife-vehicle interactions due to additional waste transport

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

5.5 GEOLOGY AND HYDROGEOLOGY

This section considers potential effects of the DGR at the crystalline alternate location on geology, hydrogeology and soil quality. Potential interactions between the DGR at the crystalline alternate location and the geology VCs occur on two broad timescales, 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 postclosure of the DGR). The potential interactions with geology and hydrogeology for the crystalline alternate location are the same as identified in Table 4.5-1 and described in Section 4.5.

5.5.1 Environmental Effects on Geology and Hydrogeology

The Description of Alternate Locations technical document [OPG 2016] describes the suitable geologic conditions in the crystalline alternate location in central to northern Ontario. Such a location is expected to have the following key characteristics:

- a thin overburden overlying the bedrock;
- the bedrock would comprise primarily crystalline rock (such as granitic or gneissic rock) which would be a relatively homogenous volume of rock at least 300 m thick, with some variation in composition both vertically and laterally;
- the bedrock would have low primary porosity; and
- groundwater flow at repository depth may exhibit some advective flow through a fracture network, in zones where fractures are present, rather than exhibiting entirely diffusion dominated flow.

Geology, hydrogeology and soil quality have the potential to be affected by site preparation and construction activities, through the same potential pathways as outlined for the sedimentary alternate location (see Section 4.5). 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.

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 [Singer and Cheng 2002]. For example, in Manitoba’s Lac du Bonnet batholith, groundwater movement is largely controlled by a fractured zone down to about 200 m depth [Everitt et al. 1996].

Water inflow into the repository will be minimized by the repository layout, and also by grouting or sealing of intersected fracture zones. Given the expected groundwater flow regimes in a crystalline rock environment that has been determined to be suitable for a repository, the potential effects on geology and hydrogeology VCs are unlikely to result in residual adverse effects. A site-specific DGR design would be developed that, through a combination of engineered and natural barriers, would ensure regulatory criteria were met with an appropriate margin of safety.

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.

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.

Waste transportation is not likely to affect geology and hydrogeology VCs. No ground movement is likely (e.g., from road upgrades). During transportation, there is the incremental risk of a conventional spill as a result of an accident or malfunction scenario, which could affect soil quality. A spills management plan would be put into place so that in any event is contained and responded to quickly.

Potential effects are also identified during the postclosure phase of the DGR at the crystalline alternate location, analogous to the assessment completed for the Bruce Nuclear site in Section 7.2.2 of the EIS [OPG 2011]. 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.

5.5.2 Comparison of Effects Relative to the DGR Project at the Bruce Nuclear Site

While there are geological differences, an important similarity between the crystalline alternate location and the Bruce Nuclear site is that the shallow and intermediate bedrock zones are expected to be the most permeable zones, and the deep bedrock zones are expected to exhibit very low permeability and diffusion dominated flow.

Overall effects on soil quality, geology and groundwater of the DGR at the crystalline alternate location are likely to be similar to those identified for the DGR Project at the Bruce Nuclear site, as shown in Table 5.5-1. Given the expected groundwater flow regimes in a crystalline rock environment in northern Ontario, residual adverse effects are unlikely.

Table 5.5-1: Summary of Effects of the DGR at the Crystalline Alternate Location on Geology, Hydrogeology and Soil Quality Relative to the DGR Project at the Bruce Nuclear Site

Valued Component	Environmental Effects	Mitigation Requirements	Comments
Soil Quality	↔	↔	• Effects on soil quality are expected to be similar between locations
Groundwater Quality	↔	↔	• Effects on groundwater quality are expected to be similar between locations
Groundwater Flow	↔	▲	• Residual effects on groundwater flow are expected to be similar between locations; however, additional mitigation may be required as part of the crystalline rock location

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

5.6 RADIATION AND RADIOACTIVITY

This section considers potential effects of the DGR at the crystalline alternate location on the radiation and radioactivity VCs. The potential interactions between the works and activities at the crystalline alternate location and radiation and radioactivity are as summarized for the sedimentary alternate location in Table 4.6-1.

There is no potential interaction with radioactivity during the construction phase activities (i.e., site preparation, construction of surface facilities, and excavation of underground facilities), with the exception of potential worker exposure to NORM, in particular radon. All works and activities that involve movement, handling and long-term management of the L&ILW have the potential to interact directly and contribute to the dose to humans and non-human biota.

5.6.1 Environmental Effects on Radiation and Radioactivity

The site preparation, construction, operation, decommissioning and postclosure activities at the DGR at the crystalline alternate location would be broadly similar to the DGR Project at the Bruce Nuclear site. However, there are some additional requirements as a result of the differences in the nature of crystalline rock. Crystalline rock is typically fractured; therefore the repository position within the rock would be dependent on the nature of the fractures at the site. This fracturing varies throughout the crystalline alternate location. The DGR would be designed at a depth that ensured isolation from natural and human activities, and in a sufficiently large volume of competent rock. Within the crystalline alternate location, evidence suggests that large domains of low permeability rock at nominal repository depths exist.

To minimize the radiological effects on humans, mitigation measures would be developed during the design of the DGR and establishment of support facilities. Dose to workers would be minimized in the context of ALARA. Depending on the conditions, additional engineered barrier(s) would likely be provided to ensure safe containment and isolation, because of the fractured, more permeable nature typical of crystalline rock (e.g., additional grouting to control water inflow from fractures).

An important topic requiring evaluation for the crystalline alternate location is whether engineered barriers are required to ensure sufficient retention of carbon-14. This radionuclide has a long half-life (5700 years), and is relatively mobile in groundwater and as a gas. In crystalline rock, it is likely that groundwater will eventually contact the ion exchange resins leading to the release of carbon-14 sooner than expected in the sedimentary alternate location. Ideally, the rooms containing these resins would be in very low permeability and unfractured volumes of crystalline rock to delay both inflow of groundwater, and subsequently the release of carbon-14. However, for a more fractured permeable crystalline rock, it is likely that additional engineered barriers would be required including (a) processing of the resins (e.g., solidification) and (b) backfilling the space within or around the waste packages with cement. These additional barriers would minimize contact with groundwater and mitigate carbon-14 waste from release rates.

Ultimately, a site-specific DGR design would be developed that, through a combination of site selection, and engineered and natural barriers, would ensure regulatory criteria were met with an appropriate margin of safety. Specifically, doses to members of the public from the DGR would be well below the 1 mSv/a regulatory limit. Similarly, predicted dose rates for non-human biota would need to meet screening criteria for adverse effects during operations. Thus, the assessment determined the radioactivity releases from the DGR at the crystalline alternate location are not likely to have an adverse effects on the human and non-human biota VCs.

Waste package transportation has the potential to affect dose to members of the public and non-human biota off-site. However, a fundamental underpinning of the transportation packaging regulations that ensure the safe transportation of radioactive materials on public roads is compliance with the rigorous standards for packaging of such materials [ENERGY SOLUTIONS 2016]. Transportation of L&ILW to the DGR at the crystalline alternate location, 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 effects are predicted.

The higher uranium levels in granitic rock could lead to higher levels of natural radon. Appropriate mitigation would be put into place to ensure no adverse effects on workers during construction or operation of the DGR from naturally occurring radiation.

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 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. 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.

5.6.2 Comparison of Effects Relative to the DGR Project at the Bruce Nuclear Site

Overall residual effects on radiation and radioactivity of the DGR at the crystalline alternate location are likely to be similar to that at the Bruce Nuclear site, as shown in Table 5.6-1.

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 than the Bruce Nuclear site sedimentary rock. As a consequence, there would be greater use of other engineered barriers for a crystalline location, such as extensive cement backfill, and upfront processing of the wastes. It is likely that the crystalline alternate location's margin of safety would inherently be lower than that of a repository at the Bruce Nuclear site in sedimentary rock, if the crystalline rock was more permeable.

This alternate project 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 existing sources of radiation other than naturally occurring background. However, for comparison the total existing dose rate at site boundary from the Bruce Nuclear site operations is approximately 0.004 mSv/a [OPG 2011], which is small compared to the natural background dose rate of about 1.8 mSv/a across Canada.

Table 5.6-1: Summary of Effects of the DGR at the Crystalline Alternate Location on Radiation and Radioactivity Relative to the DGR Project at the Bruce Nuclear Site

Valued Component	Environmental Effects	Mitigation Requirements	Comments
Humans	↔ (members of the public) ▲ (workers)	▲	• Incremental worker dose due to waste package handling and transportation • No residual effects are likely as site-specific mitigation would be implemented to protect workers and members of the public • Mitigations for the crystalline alternate location are likely to be more extensive than for the sedimentary alternate location based on the different geological 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 geological settings

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

5.7 LAND AND RESOURCE USE

This section considers potential effects of the DGR at the crystalline alternate location on land and resources, including both traditional and non-traditional uses. The potential interactions between the works and activities at the crystalline alternate location and land use are the same in nature as those summarized in Table 4.7-1 for the sedimentary alternate location.

The primary interactions would be through the acquisition of at least 40 ha and up to approximately 900 ha of land. This will change the existing use of the land from boreal forest or logging, to industrial.

The construction of surface facilities has the potential to affect existing resources, such as archaeological or cultural heritage features. Changes to the biophysical environment VCs also have the potential to indirectly affect land and resource use. Potential effects identified in Sections 5.1 through 5.6 may affect the use of surrounding lands through their potential to effect, for example, recreational or traditional uses (e.g., fishing, camping, hunting) through increased nuisance-related effects (e.g., dust, noise, light) or effects to resources (e.g., loss of fisheries, displacement of wildlife).

5.7.1 Environmental Effects on Land and Resource Use

The DGR at the crystalline alternate location could be in a variety of settings or land use areas. However, consistent with typical Canadian Shield settings in central to northern Ontario, the current environment at the crystalline alternate location is likely a boreal forest setting on Crown land. The change in use of the land 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.

Additional workers would be required for the DGR, including for all supporting site facilities (e.g., security, environmental monitoring). 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 DGR cannot be accommodated within the current transportation infrastructure, mitigation would be recommended to upgrade intersections accordingly and mitigate the potential effect.

The lands that would be cleared and/or secured as part of site development may also be subject to current use for traditional or recreational purposes. The potential changes in the biophysical environment identified in Sections 5.1 through 5.6 may affect the use and enjoyment of this and the surrounding land. Based on the setting, background noise and light levels are likely to be low because of limited anthropogenic influences. Therefore, changes to patterns of use may occur and it may take time for wildlife to habituate to changes, such as changes in noise levels. Selection of a site would be undertaken in consultation with local communities to minimize these potential effects.

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.

5.7.2 Comparison of Effects Relative to the DGR Project at the Bruce Nuclear Site

Overall effects on land use are likely to be much higher for a DGR at the crystalline alternate location than at the Bruce Nuclear site, as shown in Table 5.7-1. Given that the DGR Project at the Bruce Nuclear site is located within an existing nuclear facility with supporting infrastructure, there are no likely effects on land use. However, in the case of the crystalline alternate location, up to 900 ha will need to be repurposed from its existing land use (likely forest) 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 DGR may be more pronounced, potentially necessitating additional mitigation.

Table 5.7-1: Summary of Effects of the DGR at the Crystalline Alternate Location on Land and Resource Use Relative to the DGR Project at the Bruce Nuclear Site

Valued Component	Environmental Effects	Mitigation Requirements	Comments
Use of Lands and Resources (Traditional and Non-traditional)	▲	▲	• New site required (up to 900 ha) • Additional traffic from waste transport and workers • Potential disruption to current use of lands and resources • 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. SUMMARY OF ENVIRONMENTAL EFFECTS OF ALTERNATE LOCATIONS AS COMPARED TO THE DGR PROJECT AT THE BRUCE NUCLEAR SITE

Table 6-1 summarizes the potential effects on the environment of a DGR at an alternate location in sedimentary rock in southern Ontario, or in crystalline rock in central to northern Ontario. Overall, there would be greater environmental effects at these alternate locations than at the DGR Project at the Bruce Nuclear site. Increased environmental effects would 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.

Table 6-1: 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 waste package 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

Environmental Component	Valued Component	Sedimentary Location		Crystalline Location		Notes
		Environmental Effects	Mitigation Requirements	Environmental Effects	Mitigation Requirements	
Geology and Hydrogeology	Soil Quality	↔	↔	↔	↔	• Effects on soil quality are expected to be similar between all three locations
	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

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8. ABBREVIATIONS AND ACRONYMS

ALARA	As Low As Reasonably Achievable
CEAA	Canadian Environmental Assessment Agency
DGR	Deep Geologic Repository
DFO	Fisheries and Oceans Canada
EA	Environmental Assessment
ECCC	Environment and Climate Change Canada
EF	Emission Factor
EIS	Environmental Impact Statement
GHG	Greenhouse Gas
GWP	Global Warming Potential
JRP	Joint Review Panel
L&ILW	Low and Intermediate Level Waste
LLSB	Low Level Waste Storage Buildings
MOECC	Ministry of Environment and Climate Change
MNRF	Ministry of Natural Resources and Forestry
NORM	Naturally Occurring Radioactive Material
ODWS	Ontario Drinking Water Standards
OPG	Ontario Power Generation
PWQO	Provincial Water Quality Objectives
SWMP	Stormwater Management Pond
TDS	Total Dissolved Solids

VC	Valued Component
WPRB	Waste Package Receiving Building
WRMA	Waste Rock Management Area
WWMF	Western Waste Management Facility