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March 9, 2012

File: 00216-00531 P
CD#: 00216-CORR-00531-00108
Project ID: 10-60004

Dr. Stella Swanson
Chair, Joint Review Panel
Deep Geologic Repository Project

c/o Canadian Nuclear Safety Commission
280 Slater Street
Ottawa, Ontario
K1P 5S9

Dear Dr. Swanson:

Deep Geologic Repository Project for Low and Intermediate Level Waste – Submission of Responses to Information Requests

References:

1. JRP letter from Dr. Stella Swanson for Deep Geologic Repository Project to Albert Sweetnam, "Information Package Request 1 from the Deep Geologic Repository Joint Review Panel", March 7, 2012, CD# 00216-CORR-00531-00109.

2. CNSC letter from Don Howard to Albert Sweetnam, "DGR Project for OPG's LILW – Initial Comments and Concerns from CNSC Staff on the EIS and Licensing Submission", December 7, 2011, CD# 00216-CORR-00531-00097.

3. OPG letter from Albert Sweetnam to Don Howard, "OPG's DGR for Low and Intermediate Level Waste – Acknowledgement of Initial Comments and Concerns on the EIS/Licensing Submission from CNSC Staff", December 14, 2011, CD# 00216-DGR-00531-00098.

The purpose of this letter is to acknowledge receipt of your request for additional information contained in Reference 1 and, furthermore, to submit the attached responses to these Information Requests.

We are in a position to provide these responses expeditiously because we received the same requests earlier from the Canadian Nuclear Safety Commission (CNSC) in Reference 2. We had indicated to the CNSC in our response (Reference 3) that we would be initiating the preparation of responses to these requests.

If you have questions on the above, please contact Mr. Allan Webster, Senior Manager, Licensing, at (905) 837-4500, ext. 5200.

Sincerely,

<original signed by>

Albert Sweetnam
Executive Vice-President
Ontario Power Generation

Attach.

cc. Dr. J. Archibald – Joint Review Panel c/o CNSC (Ottawa)
Dr. G. Muecke – Joint Review Panel c/o CNSC (Ottawa)
P. Elder – CNSC (Ottawa)
F. King – NWMO (Toronto)

ATTACHMENT 1

Attachment to OPG letter, Albert Sweetnam to Dr. Stella Swanson, “Deep Geologic Repository Project for Low and Intermediate Level Waste – Submission of Responses to Information Requests”

March 9, 2012

CD#: 00216-CORR-00531-00108

Enclosures that form part of this Attachment:

No.	Title	Associated with IR #
1	Sykes, J., OPG DGR: Analysis of the Impact on the WWMF of Groundwater Withdrawal Associated with the Construction of the DGR Shafts, NWMO Technical Memorandum DGR-TM-03400, February 2012	IR-EIS-01-01
2	Sedor, K., OPG DGR: Key Radionuclide Activity Uncertainty, NWMO Technical Memorandum DGR-TM-03130, February 2012	IR-EIS-01-06
3	Avis, J. and R. Walsh, OPG DGR: Glaciation Analysis, NWMO Technical Memorandum DGR-TM-03640, January 2012	IR-EIS-01-17
4	GRG Letter, Delay, J., A. Gautschi, D. Martin and F.J. Pearson to M. Jensen, Final Report on Activities of Geoscience Review Group (with attachment: Site Characterization for a Bruce Nuclear Site DGR Final Report on 2005 - 2010 Activities), April 22, 2011	IR-EIS-01-18
5	NWMO Letter, M. Jensen to F.J. Pearson, Ontario Power Generation's Deep Geologic Repository for Low & Intermediate Level Waste - Geoscience Review Group's Final Report on Activities 2011, November 4, 2011	IR-EIS-01-18
6	Medd, M., B. Smyth, W. Seidler, E. Hoek and P. Tiley, TRG Review of Preliminary Engineering Phase I, Deep Geological Repository Project, October 2009	IR-EIS-01-18
7	Medd, M., B. Smyth, E. Hoek, D. Martin and P. Tiley, TRG Review of Preliminary Engineering Phase I, Deep Geological Repository Project, March 2010	IR-EIS-01-18
8	Heystee, R., OPG DGR: TRG Reviews of Preliminary Design for Deep Geologic Repository – Documentation of Comment Resolution, NWMO Technical Memorandum DGR-TM-01530, February 2012	IR-EIS-01-18
9	Hickford, G., P. De Preter, P. Smith and J. Talandier, OPG’s Deep Geologic Repository for Low & Intermediate Level Waste: Postclosure Safety Assessment. International Peer Review Report, November 2010	IR-EIS-01-18
10	NWMO Letter, P. Gierszewski to P. De Preter, M. Kelly/G. Hickford, P. Smith and J. Talandier, Peer Review of the OPG DGR Postclosure Safety Assessment, October 25, 2011	IR-EIS-01-18
11	Humphreys, P., Conceptual Basis of the Microbial Aspects of the GGM Model, Quintessa Technical Report QRS-1335B-TR1, Version 1.0, December 2011	IR-EIS-01-21
12	Humphreys, P., P. Suckling and J. Avis, OPG DGR: Resin Degradation Review and Additional Analysis, NWMO Technical Memorandum DGR-TM-03640, January 2012	IR-EIS-01-22
13	Humphreys, P., M. Thorne and J. Wilson, The Speciation of H-3, C-14 and Cl-36 in the DGR System, Quintessa Technical Report QRS-1335B-TR4, Version 1.0, December 2011	IR-EIS-01-23
14	Medri, C., OPG: DGR: Supporting Information on Selected DGR Dose Rate Examples, NWMO Technical Memorandum DGR-TM-03630, December 2011	IR-EIS-01-27

OPG Response to the Joint Review Panel EIS Information Requests Package 1

IR#	EIS Guidelines Section	Information Request and Response
EIS-01-01	▪ EIS Guidelines: Section 8.2, Site Preparation and Construction; ▪ Section 10.1.1, Geology and Geo-morphology; ▪ Section 11.1, Effects Prediction	***Information Request:*** *Provide additional information on the surface facility construction and the excavation of overburden associated with the development of the shaft collar in relation to geotechnical and hydrogeological considerations. Sufficient data or information is required to enable confirmation of the possible impacts of the excavation and associated dewatering (e.g. zone of influence or ZOI and rate and quality of groundwater seeping into the excavation). Where on-site data is not available, the evidence needs to be sufficient to indicate it is conservative in nature for the EIS. In particular information is needed in the following areas:* ▪ *the expected safe slope and general design for excavations in the tills and dense sand overburden expected at the site, supported by geotechnical data;* ▪ *the proposed method(s) to dewater the excavation, particularly if the middle sand is encountered at the location, with information supporting flow estimates;* ▪ *any proposed overburden ground improvement associated with overburden excavation activities and during the shaft sinking (following backfilling);* ▪ *a description of the backfilling of the excavation, including the fill material and its placement;* ▪ *areal recharge distribution before and after excavation* ▪ *groundwater flow patterns, seepage rate and water quality resulting from the potential interactions with any existing groundwater contaminant plume adjacent to the DGR site; and* ▪ *surface water/groundwater interactions (e.g., recharge rate to, and water level of, Stream C).* ***Context:*** *OPG concludes that the impact of surface construction on the groundwater flow and contaminant transport is negligible. For the impact of dewatering during shaft sinking, OPG concludes that "The ZOI was estimated to be approximately 54 m, with an inflow of approximately 50 L/min over the top 170 m of the shaft."* *The information in the EIS is not sufficient to allow reviewers to confirm the predicted effects on groundwater from surface construction and the dewatering associated with excavation of the overburden for the shaft collar.* *There is an existing groundwater contaminant plume associated with several low level storage buildings at the adjacent Western Waste Management Facility. Whether and how the project would interact with the plume (e.g., whether it would change the plume migration path and intercept the contaminant plume into the seepage to be dewatered), needs to be assessed.* *EIS Guidelines section 10.1.1 indicates "Geotechnical properties of the overburden must also be provided … to allow the assessment of slope stability…". No general information was provided on the geotechnical properties of the overburden in the EIS or in Geology TSD.*

IR#	EIS Guidelines Section	Information Request and Response
		OPG Response: In order to construct the two shaft collars, the conservative reference approach requires temporary excavation(s) to be made through nominally 14 m of overburden, principally comprised of dense glacial till, down to bedrock surface. It is currently envisaged that this excavation would have sideslopes no greater than 1V to 1H. Sideslopes would be protected, as required, to prevent erosion of the soils and to maintain stability of sideslopes. Based on soil investigations, the Middle Sand Aquifer was not encountered in any of the boreholes within the vicinity of the two shafts. Site-specific geotechnical data for overburden has been collected to support the design of this excavation. Measures will need to be taken to control ground water inflow into the excavation from the underlying permeable bedrock. It is likely that grouting will be the primary method used to control groundwater inflow and pumping will be used to remove any groundwater inflow through the grouted bedrock into the excavation bottom. Once the two shaft collars are established, the excavation around the collars will be backfilled with compacted fill material. Type of fill material and method of placement will be largely dictated by foundation design requirements for buildings to be founded on this fill material. Engineered fill will be comprised of native soils or imported granular material that meet project requirements. Native subgrade material will be suitably prepared prior to backfilling. The approved engineered fill will be placed in approximately 200 mm thick loose lifts and uniformly compacted. When surface-based shaft sinking infrastructure is in place, the shaft excavation will proceed through the shaft collars into the underlying bedrock. However, prior to establishing the shaft collars and the start of shaft sinking, the upper 180 m of bedrock around each shaft will be treated by either ground freezing or grouting (refer to IR-LPSC-01-31). This surface-based ground treatment, as well as, localized cover grouting, if required during sinking, will be used to minimize the amount of groundwater flow into the two shaft excavations. A target inflow of approximately 3 L/s into either shaft during shaft excavation has been established to provide suitable shaft sinking conditions and minimize the need for additional in-shaft water handling equipment. Water will be removed from the shaft excavations by pumping to ground surface. An impact assessment of DGR main and vent shaft construction on the groundwater system is provided in the enclosed document (Sykes 2012). As part of the assessment, a numerical model (MODFLOW) was used to predict the hydraulic influence of dewatering during shaft collar construction and shaft excavation on groundwater flow patterns and tritium migration in the vicinity of the Western Waste Management Facility (WWMF). Predicted collar and shaft seepage rates, and resultant zone of hydraulic influence within the uppermost groundwater system are described. Results indicate that the vertical construction activities will temporarily influence groundwater conditions in the immediate vicinity of the shafts. Base case and sensitivity analyses indicate the temporary drawdown created by shaft collar and shaft construction will extend tens of meters from the shafts. Base case simulations (grout curtain K = 10^{-7} m/s) yield predicted inflow rates consistent with target rates described above. The temporary drawdown created by shaft construction is not

IR#	EIS Guidelines Section	Information Request and Response
		expected to influence hydraulic head distributions within the bedrock beneath the WWMF, areal recharge or surface water recharge. Tritium concentrations within the uppermost bedrock surface in the vicinity of the WWMF, on the order of 500 Bq/L, if captured by the temporary shaft drawdown, are estimated to be diluted by a factor of 2 to more than 10 in excavation discharge. Once the hydrostatic shaft liners are installed and sealed (nominal depth 230 m below ground surface), the shafts will be hydraulically isolated and no longer influence the groundwater system. Verification of assessment results will be achieved through proposed routine groundwater and shaft discharge monitoring programs. **Reference:** Sykes, J.F. 2012. Analysis of the Impact on the WWMF of Groundwater Withdrawal Associated with the Construction of the DGR Shafts. NWMO Technical Memorandum DGR-TM-03400. Toronto, Canada. (enclosed)
EIS-01-02	▪ EIS Guidelines: Section 8.2, Site Preparation and Construction	***Information Request:*** *Provide additional information describing:* ▪ *the possible above ground storage of explosives at the Bruce site; and* ▪ *any potential effects from the above ground storage site.* ***Context:*** *The information in the EIS describing surface storage of explosives at the Bruce site, prior to the establishment of underground storage, is not sufficient to allow the assessment of any potential effects of such storage.* *While section 4.7.5.2 indicates “During shaft construction, explosives are required on a daily basis. Explosives will be delivered as required by the explosive supplier to the underground magazine once the underground services area is completed. … Handling explosives on the DGR Project site (both surface and underground) will be in accordance with Part VI of the Mines and Mining Plants Regulations (O. Reg. 854 [29]).”, no information is provided on what, if any, storage on the Bruce site will take place prior to the establishment of the underground storage area.*
		OPG Response: The project will require explosives to be brought to the Bruce nuclear site for the development of the shafts and underground repository openings. Until the underground explosives storage is developed, explosives and initiating devices could be stored in a purpose-built storage building on surface at the Bruce nuclear site, with periodic replenishment, or provided directly to the construction activities on an as-needed basis. It should be noted that there will be no facilities for the production of explosives at the Bruce nuclear site, only storage. At this time it has not been determined whether a suitable location is available at the Bruce nuclear site for on-site storage. If on-site storage were to be pursued, the location and quantity of explosives that

IR#	EIS Guidelines Section	Information Request and Response
		could be stored would be derived from the Quantity-Distance Table for Storing Blasting Explosives as outlined in Appendix A of the Natural Resources Canada (NRCan) Blasting Explosives and Initiation Systems – Storage, Possession, Transportation, Destruction and Sale (NRCan 2008). In determining whether a suitable location is available, the presence of other facilities at the Bruce nuclear site would be fully considered. Should on-site storage be found practical for storage of explosives and initiating devices, the storage magazines will be installed to meet the above NRCan requirements. There is no expected environmental impact as the explosive magazines are self-contained structures and the contents are packaged with no possibilities of emissions or leakage. **References:** Natural Resources Canada (NRCan). 2008. Blasting Explosives and Initiation Systems – Storage, Possession, Transportation, Destruction and Sale.
EIS-01-03	▪ EIS Guidelines: Section 12, Accidents, Malfunctions and Malevolent Acts	***Information Request:*** *Provide additional information on initiating event frequencies as follows:* ▪ *provide an explanation on how the initiating event frequencies were determined;* ▪ *provide specific explanations for any non-credible events that are not being assessed further; and* ▪ *clarify how an explosion is a non-credible initiating event.* ***Context:*** *Initiating events are an important component of the assessment of malfunctions and accidents.* *In the documentation, all initiating events are assigned a frequency and then ranked as possible events, unlikely events and non-credible events. Given the information provided, it is unclear how these frequencies were determined. Also, any initiating events with an annual frequency* $\leq 10^{-7}$ *were classified as non-credible events and were not considered further. These non-credible initiating events were listed but no further explanation was provided.* *Finally, the list of non-credible initiating events includes "explosion"; however, in the EIS, page 4-46, the project plan discusses using explosives and storing 30 to 40 tonnes underground during the construction phase. Natural and waste generated methane is identified as a concern in the same report. So it is unclear how an explosion can be a non-credible event.*
		OPG Response: <u>1. Initiating event frequency explanation</u> The Environmental Impact Statement (EIS) (Section 8.1) includes a summary list of potential initiating events and an estimate of frequency range, Table 8.1-1. This list is duplicated from the Malfunctions, Accidents and

IR#	EIS Guidelines Section	Information Request and Response
		Malevolent Acts (MAMA) TSD (Section 3.2), Table 3.2-1. The initiating event and frequency list (Section 8.1 of EIS and Section 3.2 of the MAMA TSD) are intended to provide a high-level overview of initiating events considered, and a general indication of likelihood to help inform the subsequent discussion. The “frequency” scale is simplified - possible, unlikely, or non-credible - and represents wide frequency ranges rather than precise estimates. The likelihood is primarily the frequency of events that could lead to radiological releases. Frequencies for events were estimated based on regional information for meteorology and seismicity, and on operating experience in nuclear waste management facilities, including OPG’s, and the mining industry. The risk from surface flooding was specifically assessed in the Maximum Flood Hazard Assessment (AMEC 2011). More specific analyses of the events and consequent malfunctions and accidents are provided in subsequent chapters. With respect to <u>radiological accidents</u>, as noted in the EIS, Section 8.2.1.3 (Radiological Malfunctions and Accidents / Potential Effects) and in MAMA TSD, Section 4.1.1.1 (Identification and Screening of Radiological Accidents), the justification for the radiological accidents is provided in Chapter 7 of the Preliminary Safety Report. *In particular, the discussion of initiating events and the basis for the qualitative frequency estimate is presented in PSR, Section 7.5.1 (Hazard Identification).* With respect to the initiating event frequency, the estimates are only used to identify non-credible accidents, as both the possible and the unlikely events are considered within the bounding accident scenarios, and the same dose constraints apply. With respect to <u>conventional accidents</u>, as noted in the EIS, Section 8.3.1 (Conventional Malfunctions and Accidents / Screening) and in MAMA TSD, Section 5.2 (Identification of Conventional Malfunctions and Accidents), the justification for the conventional accidents is provided within these sections, in Tables 8.3.1-1 (EIS) and Tables 5.2-1 and 5.3-1 (MAMA TSD), respectively. Initiating event frequency is not used. <u>2. Non-credible events</u> It is noted that the initiating event summary Table 8.1-1 in EIS and Table 3.2-1 in MAMA TSD indicate that the following events are not credible at the DGR site: criticality, explosion, tornado, external fire affecting the DGR Project, aircraft crash and meteor impact. The assessment is primarily based on the likelihood of events that could lead to radiological releases, and the justification is provided in PSR, Section 7.5.1, Hazard Identification. The relevant text is repeated and extended below. ***Criticality*** A criticality accident is not credible, because there will be very little fissile material in the DGR (it contains low and intermediate level waste, not used fuel waste), and the fissile material is distributed across multiple waste packages and not concentrated in any one place.

IR#	EIS Guidelines Section	Information Request and Response
		Explosion See discussion below. ***Tornado*** Tornadoes are very localized severe wind events. A tornado striking within the DGR site area would be very unlikely but possible. A direct tornado impact on the WPRB (i.e., leading to radiological risk) is not credible based on the WPRB footprint of approximately 0.001 km^2 and the reported annual frequency of approximately 1 tornado per 10,000 km^2 in southern Ontario (PSR, Section 2.5.4.8). Wind-generated missile striking a waste package would require a hurricane or tornado near the WPRB plus the generation of a wind missile that hits a waste package in the WPRB. The latter is a non-credible event in part because packages are not normally stored in the WPRB, and because they are a small surface area target. Once underground, waste packages are naturally protected from tornadoes. However, collapse of the WPRB leading to breach of packages is considered as an accident scenario and assessed. The specific cause of this event could include high winds. ***External Fire*** There will be no large forest fires near the DGR Facility, as there is no forest in the vicinity, nor are there large diesel or propane tanks nearby, or roads/rails within 1 km where large amounts of flammable materials are carried. (Propane will be used for heating the DGR during construction, but only electrical heat will be used during operation.) Therefore, the risk of an off-site external fire affecting the waste packages is not credible. ***Aircraft Crash*** The Bruce region has low levels of general aviation – typically small non-commercial, non-military aircraft. The nearest fields are at Kincardine and Port Elgin airport, about 16 km distant. Using the U.S. DOE approach (USDOE 2006), the aircraft crash frequency can be estimated based on: • Number of flight operations in area; • Probability that an aircraft will crash during a flight operation; and • Conditional probability that the aircraft crashes into the facility. Based on the U.S. DOE approach (USDOE 2006), and since the local airports are small and distant, the risk of aircraft crash into the DGR can be estimated based on a general aviation crash rate of about 10^{-4} per square mile per year and a DGR (waste handling) structure footprint of 0.0004 square miles, giving 10^{-4} x 0.0004 ~ 4 x 10^{-8} per year risk of impact. Therefore, an aircraft crash accidentally impacting on the DGR waste handling structures (WPRB and main shaft headframe) is not credible, due to small footprint of the above ground structures and low levels of general aviation in the Bruce region.

IR#	EIS Guidelines Section	Information Request and Response
		Meteor Impact Meteor impact is not credible due to the small footprint of above ground structures and the very low likelihood of large meteors (capable of damaging rock to 680 m) hitting the site. 3. Explosions The statement in the initiating event summary Table 8.1-1 in EIS and Table 3.2-1 in MAMA TSD that explosions are not credible is with respect to the Operations phase and radiological accidents. It should have been stated that explosions are considered credible during the Site Preparation and Construction stage. Explosions are considered as a credible accident during the Site Preparation and Construction phase, as identified in EIS Tables 8.2.1-1 and 8.3.1-1. This is because there are explosives on site being used in creating excavations. Explosions are therefore considered in the environmental assessment for this phase. The justification that explosions are not credible during the Operations phase is presented in Section 7.5.1 (p.423) of the Preliminary Safety Report. Briefly, this is due to the lack of explosives in or near the repository during operations, the very low rate for methane gas generation from the wastes under aerobic conditions, and the lack of ignition sources in filled rooms. **References:** AMEC NSS. 2011. Maximum Flood Hazard Assessment. AMEC NSS Ltd. report for the Nuclear Waste Management Organization NWMO DGR-TR-2011-35 R000. Toronto, Canada. U.S. DOE. 2006. Accident analysis for aircraft crash into hazardous facilities. U.S. Department of Energy report DOE-STD-3014-2006. USA.
EIS-01-04	▪ EIS Guidelines: Section 12, Accidents, Malfunctions and Malevolent Acts	***Information Request:*** *Provide additional information regarding contingency planning that specifically addresses the radiological event bounding scenarios. Each bounding scenario requires a description of any contingency, clean-up or restoration work in the surrounding environment that would be required during or immediately following the postulated malfunctions and accidents.* ***Context:*** *The EIS Guidelines includes a requirement to provide a description of any contingency, clean-up or restoration work in the surrounding environment that would be required during or immediately following the postulated malfunctions and accidents.* *The EIS and the Malfunctions, Accidents and Malevolent Acts TSD's radiological malfunctions and accidents sections do not give specifics on possible contingency, clean up or restoration work. There are generic statements on mitigation measures and that contingency plans will be in place for accidents with larger consequences. The statements do not address the specific bounding scenario events that were identified in*

IR#	EIS Guidelines Section	Information Request and Response
		the EIS and the supporting documentation. *The Preliminary Safety Report had identified 5 above ground bounding scenarios and 6 underground bounding scenarios that should be addressed. Sufficient information is needed to allow the assessment of any potential effects from the contingency clean-up or restoration work.*
		OPG Response: The preclosure safety assessment identifies two basic types of radiological events - fire and container breach. The likelihood of these accidents occurring is reduced through mitigation measures as noted in the EIS, Sections 8.2.3 and 8.3.3. These include: • Design mitigation (e.g., minimizing combustible materials); • Controls installed on equipment to restrain their movement (e.g., limit switches); • Administrative controls (mainly through procedures); and • Worker training. With respect to any type of radiological incident, OPG's Nuclear Waste Management Division and Western Waste Management Facility (WWMF) follow the OPG Radiation Protection Requirements- Nuclear Facilities (OPG N-RPP-03415.1-10001), in particular Chapter 8 (Incidents and Emergencies), and the Radiation Protection program (OPG N-PROG-RA-0013). Associated procedures at WWMF are the Employee Emergency Response (W-PROC-ES-0002), Western Spill Response (W-PROC-ES-0003) and Fire Protection (W-PROC-ES-0011). See also the response to IR-LPSC-01-15 for information on the response to a fire or spill underground. OPG does not have, beyond these, specific procedures for response to radiological incidents at WWMF, and the DGR would use this same framework. As with any radiological incident, immediate response would be to stop work and back out. Hazards and mitigations, including those to the surrounding environment, would then be assessed based on the specific accident. It should be noted that waste packages are only handled within a Zone 2 area. **References:** OPG Radiation Protection Requirements- Nuclear Facilities, OPG N-RPP-03415.1-10001. OPG Radiation Protection Program, OPG N-PROG-RA-0013. WWMF Procedure. Employee Emergency Response, W-PROC-ES-0002. WWMF Procedure. Western Spill Response, W-PROC-ES-0003. WWMF Procedure. Fire Protection, W-PROC-ES-0011.

<table>
<tr><th>IR#</th><th>EIS Guidelines Section</th><th>Information Request and Response</th></tr>
<tr><td rowspan="2">EIS-01-05</td><td rowspan="2">EIS Guidelines: Section 8.1, General Information and Design Description: 12th and 14th bullets</td><td>Information Request:
Provide additional information/clarification on the following items regarding the characterization of the inventory of radionuclides:
methods or procedures used to measure important beta and alpha emitters (e.g. difficult to measure (DTM) radionuclides, other than gamma spectrometry) during the characterization of radionuclides in the wastes to develop the inventory.
cross-checking of radionuclide measurements made by the proponent with those made by independent laboratories on the same samples.
Context:
It is essential in the assessment of environmental effects that there is confidence that post closure safety assessment predictions are reasonably conservative. This requires confidence that the activity concentration of radionuclides has been adequately bounded in each waste stream based on sufficient measurements of waste packages.
It is unclear why gamma spectrometry was used to "measure" DTM radionuclides. The docmentation indicates that "The scaling factors were generally based on actual measurements of difficult-to-measure radionuclides obtained from gamma spectrometry of waste packages and/or samples of waste". As most DTM radionuclides are alpha or beta emitters, this statement is questionable.
Confidence is also required in the quality assurance/quality control of the radionuclide measurements One check on quality assurance/quality control is to cross check a specimen through analysis by a number of laboratories.
Information indicating the cross-checking of radionuclide measurements is important in understanding the postclosure safety assessment.</td></tr>
<tr><td>OPG Response:
<u>1. Measurement procedures</u>
Difficult-to-Measure (DTM) radionuclides are measured using a variety of radiochemical processes, in particular, liquid scintillation and alpha/beta proportional flow counting.
Most of the measurements were conducted at Kinectrics Inc. Radiochemical characterization is performed by measuring alpha/beta and gamma activities of composite samples by procedures accredited through Standards Council of Canada (SCC). The methods are summarized in Table 1.
Note that the Reference Inventory report (OPG 2010), Section 2.2, states that "The scaling factors were generally based on actual measurements of difficult-to-measure radionuclides obtained from <u>gamma spectrometry</u> of waste packages and/or samples of waste." The sentence should have said "The scaling</td></tr>
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factors were generally based on gamma-spectroscopy of waste packages/samples and actual measurements of difficult-to-measure radionuclides in samples of waste.”

Table 1: Methods Used to Determine Activity of Difficult-to-Measure Radionuclides
<table>
<tr><th>Radionuclide</th><th>Type of Matrix</th><th>Principles of Determination</th><th>Methodology of Chemical Separation</th><th>Corrections – Verifications</th></tr>
<tr><td>Sr-90</td><td>• Solid
• Sample dissolved in acid; insoluble material is heat fused and combined with acid digested sample.</td><td>• Liquid scintillation or beta counting is used to measure Y-90, the daughter product in equilibrium with Sr-90.
• Beta counting is the preferred technique; it is particularly useful for lower activity samples.</td><td>• Solvent extraction is performed to separate Sr-90 from other radionuclides including the existing daughter product Y-90.
• Y-90 is allowed to re-equilibrate with Sr-90. The time period for this is 7-10 days.
• Sr-90 is estimated from the measured Y-90 activity.</td><td>• The decay curve of Y-90 is monitored over 2-3 days to determine if interferences exist.
• Gamma counting may also be used to identify interfering radionuclides (especially Co-60 and Cs-137).
• Repeated extractions are required to eliminate interferences from other radionuclides.
• Known amount of inactive carrier is added to determine recovery.</td></tr>
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IR#	EIS Guidelines Section	Information Request and Response				
		Pu-238 Pu-239/40 Am-241 Cm-242 Cm-244 (alpha emitters)	• Solid • Sample dissolved in acid; insoluble material is heat fused and combined with acid digested sample.	• Alpha Spectrometry	• Precipitations are performed to remove undesired elements and radionuclides (including Ni-63 if present). The aqueous acidic phase contains the desired alpha emitting radionuclides along with Fe-55 if present. • The aqueous phase radionuclides are transferred on to ion exchange media and then sequentially eluted. All Pu species are thus separated from Am-241 and Cm species. Fe-55 if present is also separated out. • The radionuclides are then precipitated, filtered and counted.	• NIST traceable Pu-242 tracer added to sample before processing. Recovery is determined and a correction factor is applied to Pu-238 and Pu239+240. • Similar for Am-241, Cm-242 and Cm-244 except Am-243 used as the tracer. • Yield is typically 80% - 100%.
		Pu-241	• Solid • Sample dissolved in acid; insoluble material is heat fused and combined with acid digested sample.	• Liquid Scintillation Counting or Induction Coupled Plasma	• See method for determining alpha emitters. • Filtered precipitates containing Pu species are re-dissolved and prepared for Pu-241 analysis.	• NIST traceable Pu-242 tracer added to sample before processing. Recovery is determined and a correction factor is applied to Pu-241. • Yield is typically 80% - 100%.
		Fe-55	• Solid • Sample dissolved in acid; insoluble material is heat fused and combined with acid digested sample.	• Liquid Scintillation Counting	• See method for determining alpha emitters. • Eluant from ion exchange resin column is prepared for analysis.	• Samples typically contain inactive Fe. Its concentration is tracked to determine recovery. A correction factor is then applied to measured Fe-55.

IR#	EIS Guidelines Section	Information Request and Response				
		Ni-63	• Solid • Sample dissolved in acid; insoluble material is heat fused and combined with acid digested sample.	• Liquid Scintillation Counting	• See method for determining alpha emitters. • N-63 is extracted from the precipitates (see first bullet under alpha emitters).	• Samples typically contain inactive Ni. Its concentration is tracked to determine recovery. A correction factor is then applied to measured Ni-63.
		C-14	• Solid	• Liquid Scintillation Counting	• C-14 is stripped from sample using acid. • If C-14 in non-CO_2 form is also required, then sample must be combusted to convert all C-14 into its CO_2 form.	-
		Cl-36	• IX Resins	• Liquid Scintillation Counting	• Chlorine in the chloride form is stripped from the resin. • Series of precipitations and extractions are performed to remove interferences. • A large sample (~50 g) is typically required to obtain an appropriate Minimum Detection Limit (MDL).	• Results are corrected for sample yield. • Cl-36 in perchlorate or chlorate form, if any, is not accounted for.
		Tc-99	• IX Resins	• Liquid Scintillation Counting	• Technetium is stripped from the resin using acid. • Series of chemical purifications are performed to isolate Tc-99 and remove interferences. • Sufficient time is needed to allow added Tc-99m tracer to decay. • A large sample of resin is required to obtain appropriate MDL.	• Results are corrected for sample yield. • Tc-99 contribution from Tc-99m decay will elevate background measurements.

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I-129	• IX Resins	• Liquid Scintillation Counting	• Iodine is stripped using a basic solution. • Series of extractions are performed to remove interferences; also chemical treatments are performed to convert all the iodine to the highest oxidation state. • A large sample (~50 g) is typically required to obtain an appropriate MDL.	• Tritium and C-14 must be removed from analyte. • Results are corrected for sample yield.

2. Cross-checking

Most of the measurements were conducted at Kinectrics Inc. Kinectrics is certified to ISO 17025 (General Requirements for the Competence of Testing and Calibration Laboratories).

Radiochemical characterization is performed by measuring alpha/beta and gamma activities of composite samples by procedures accredited through Standards Council of Canada. The measurements follow a strict QC regimen including checking of blanks, calibration of instruments, and records checks. The main calibrations are described in more detail below:

Gamma Analysis – Calibrations are performed using certified standards from Eckert and Ziegler once a year. Quality Control (QC) checks are performed twice a week to ensure that calibrations are correct (within 5%). All standards are certified and traceable. To calibrate gamma detectors, a mixed radionuclide standard is created and calibrated for a variety of geometries. Calibrations for filter geometries are performed using a mixed radionuclide standard deposited on a glass fibre filter.

DTMs – Calibrations are performed with NIST (U.S. National Institute of Standards and Technology) traceable standards under NIST traceable QC checks. Standards and blanks undergo separation procedures and are measured. A QC sample and blank is run with each batch of samples and calibration is completed at least once a year. For Am and Cm, NIST traceable standards are deposited onto a resolve filter and counted for efficiency and for energy calibration. Once the energy calibration and efficiencies have been determined, Am and Cm from a different source are deposited onto 4 or 5 filters and counted for validation purposes. The same procedure is used for Pu.

H-3 and C-14 – The liquid scintillation counters (LSC) are calibrated at least once per year using NIST traceable standards. NIST traceable QC samples are run with every batch of samples along with a blank. QC samples for the LSC are run multiple times a week and often multiple times a day.

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		Reference: OPG. 2010. Reference Low and Intermediate Level Waste Inventory for the Deep Geologic Repository. Ontario Power Generation report 00216-REP-03902-00003-R003. Toronto, Canada.
EIS-01-06	▪ EIS Guidelines: Section 8.1, General Information and Design Description: 12th and 14th bullets	***Information Request:*** *Provide additional information on the characterization of uncertainty with the radionuclide measurements as follows:* ▪ *provide graphical relationships between easy to measure (ETM) radionuclides and difficult to measure (DTM) radionuclides for each nuclide in waste streams that most contribute to dose in the post-closure safety assessment; and* ▪ *elaborate from Appendix D of the Reference Low – and Intermediate-Level Waste Inventory for the Deep Geologic Repository by providing a discussion of the level of confidence in each scaling factor, based on the number of samples analysed to derive the scaling factors and to characterize the inventory, and whether the number of samples and the confidence in the scaling factors is sufficient or not.* ***Context:*** *A thorough understanding of the uncertainty associated with the radionuclide measurements is needed in order to be confident that the post closure safety assessment predictions are reasonably conservative. This is in alignment with IAEA (2011), section 5.3 that indicates: "Waste intended for disposal has to be characterized to provide sufficient information to ensure compliance with waste acceptance requirements and criteria".* *OPG needs to elaborate on the analyses that were done to derive each scaling factor in order to better describe the current uncertainty in the inventory measurements. The uncertainty in the estimated activity of radionuclides is provided in tables in Appendix D of the Reference Low – and Intermediate-Level Waste Inventory for the Deep Geologic Repository. OPG states that an uncertainty of a least square distance less than 10 is acceptable uncertainty. However, it is difficult for the reviewer to fully grasp what a least distance of 10 really means in terms of uncertainty. Graphical relationships for ETM and DTM radionuclides (similar to IAEA 2009 and Thierfeldt and Deckert 1995) would more clearly depict the amount of data used to derive each scaling factor. Comparisons with other available databases supporting scaling factors may also facilitate a better understanding of the uncertainties. For instance, how does this database compare to the EPRI database (Best 1986; Deltete 1987; Best and Miller 1987).* *Clearer presentation of uncertainties is needed to increase CNSC staff confidence around the uncertainty associated with each scaling factor for radionuclides in waste streams that contribute significantly to the dose in the environment or humans at any given time into the future.*

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		OPG Response: The projected total inventory of radionuclides in the DGR is provided in the OPG Reference Inventory report (OPG 2010). It is based on radionuclide specific activities in the various waste types, and the projected total volume of the waste types. The specific activities are derived from measurements and calculations for the OPG waste types. The projected total volume is based on the existing waste volume and a reference scenario for future operation of the OPG owned or operated reactors; a significant fraction of these wastes are already present at the Western Waste Management Facility site. Radionuclide activities typically vary significantly between waste packages of a given type. However, the total repository inventory is less uncertain because it is based on the inventories summed over a large number (often thousands) of packages. From the DGR postclosure safety assessment, the key radionuclides with respect to potential dose impacts are C-14, Cl-36, I-129, Nb-94, Ni-59 and Zr-93. The characterization of uncertainty in these radionuclide activities is addressed in the enclosed report (NWMO 2012). For these radionuclides, the uncertainty is estimated to be within a factor of 10 relative to the Reference Inventory value. This is considered to provide sufficient confidence in the scaling factors and inventory to support the postclosure safety assessment because the peak dose results for the postclosure Normal Evolution Scenario are many orders of magnitude below the dose criterion, and the unlikely Disruptive Scenarios are well within the risk criterion (Chapter 8, Preliminary Safety Report). The conclusion on the repository safety is not sensitive to these inventory uncertainties. Continuing work is underway which will improve the estimates of total projected DGR radionuclide activity. A revised reference inventory will be presented as part of the application for the Operating Licence. **References:** NWMO. 2012. OPG DGR: Key Radionuclide Activity Uncertainty. NWMO Technical Memorandum NWMO-TM-03130. Toronto, Canada. (enclosed) OPG. 2010. Reference Low and Intermediate Level Waste Inventory for the Deep Geologic Repository. Ontario Power Generation report 00216-REP-03902-00003-R003. Toronto, Canada.
EIS-01-07	▪ EIS Guidelines: Section 8.1 ▪ CNSC Regulatory Guide G-320:	***Information Request:*** *Provide all the necessary information in order to verify calculations leading to the quantity of radionuclide in the current and past inventory. More specifically:* ▪ *provide specific dates from which OPG starts to account for decay in their calculations;* ▪ *OPG should clearly indicate the sources of their half-life data and verify their consistencies within the documentation; and*

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	Section 4.3.3	▪ *provide the approach used to consolidate the types of wastes and the data to support the consolidation, the sources of data presented in the tables and an explanation for any changes.* ***Context:*** *It is important to the assessment of environmental effects that there is confidence that the post closure safety assessment of long term performance is reasonably conservative. Confidence can be achieved by tracing the use of supporting data through different calculations and through independent calculations to verify the values used and to confirm results. The reporting of some of the radionuclide inventory in the submission is not consistent and could not be fully verified. The elemental inventory could also not be fully verified. Sufficient detail should be included to allow independent calculations to confirm assessment results, whether by means of simplified calculations or by complete reproduction of the results.* *Tables 2.4 to 2.7 in the document, Reference Low and Intermediate Level Waste Inventory for the Deep Geologic Repository, summarize the estimated total decay corrected radionuclide inventory of the projected wastes in storage in the DGR at two future dates. However, specific dates are not provided that start the accounting process for decay and are necessary to permit verification of inventories.* *The aforementioned report presents the half-life of radionuclides in Tables 2.4, 2.5, 2.6, 2.7, 3.2, 3.3, B.1, B.2 and B.3, which are important to the process of accounting for decay. However, another table in a secondary reference containing waste inventory data, the Postclosure Safety Assessment: Data report provides somewhat different half-life values supported by their source. As no source was provided for the half life values presented in the Inventory report it was not possible to check their validity.* *In the Reference Low and Intermediate Level Waste Inventory for the Deep Geologic Repository report, the information presented in Tables 2.4 through 2.7 are identified as based on Appendix B, Tables B1 through B.3 which present the nuclides in each waste 'as received'. Appendices C through E provide additional information on the wastes (data sheets in E). An examination to the information indicates that the waste 'types' vary somewhat in description through the sequence of appendices and vary with the types presented in Tables 2.4 to 2.7 of the report. It is not apparent how to rationalize and verify the information. As an example, from Appendix E in the 'Reference Inventory' the net volume of old bottom ash is 950 m^3 in 2018, and the net volume of new bottom ash is 671 m^3 in 2018 for a total of 1621 m^3, but Tables 2.4 and 2.5 give the volume of bottom ash in 2018 as 1352 m^3.* *In the Post closure Safety Assessment report, Table 4.4 presents inventory data extracted from the 'Reference Inventory' report, however it is not stated where in the referenced report the data are from. Tables 2.5, 2.7 and 3.3 in the Reference Low and Intermediate Level Waste Inventory for the Deep Geologic Repository and Table 4.4 in the Post closure Safety Assessment report are not in agreement. There is more difficulty in finding the source for the elemental inventory since no tables in the reference inventory report presents the data as entered into Table 4.4. Again, data cannot be readily verified.*

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		OPG Response: 1. Dates for accounting for radioactive decay A reference inventory is defined for each waste type in the Reference Inventory report (OPG 2010) based on a reference date. For operational wastes, the wastes are characterized on an "as-received" basis, which refers to when they are typically received at OPG's Western Waste Management Facility (WWMF) from the stations. This means that the inventories already include decay typical for that due to the time delay in routine station storage, handling and shipment to WWMF. For refurbishment wastes, such as steam generators or retube wastes, the inventories are characterized based on a defined time after reactor shutdown. The radionuclide inventories at WWMF are tracked within the OPG Integrated Waste Management Tracking System (IWTS). As packages are received at WWMF, they are entered into IWTS with their as-received date and reference inventory. IWTS can also incorporate future projections of waste package arrivals. At any future date, IWTS can then calculate the radionuclide inventory incorporating the radioactive decay from the arrival of each package to the given future date. In the Reference Inventory report (OPG 2010), this calculation of total radioactive inventory is presented for two dates, the end of 2018 and the end of 2062, representing assumed start of operations and closure. The DGR will eventually contain over 50,000 packages. IWTS contains information on the arrival date of each package and can provide this list; it would be very long. However, for verification purposes this level of detail is not required. Except for radionuclides that have a short half-life (several years or less) relative to the duration of WWMF and DGR operations, it is a good approximation to assume that operational wastes arrive in roughly equal amounts each year while refurbishment wastes arrive according to the Scenario B reference case (Section A.2.0 Reference Inventory report, OPG 2010). We provide an example below to illustrate this approach. **Example** - Radionuclide inventory in Moderator IX resins at 2018 **Verification** - In this verification example, inventories of C-14, Cl-36, Co-60, Fe-55, H-3, Pu-239 and Zr-93 are calculated at 2018. The specific activity of as-received moderator resin can be obtained from Table B.2 of the Reference Inventory report. Assume that moderator IX resins are shipped to WWMF in approximately equal amounts each year since its opening in 1976. The DGR starts operation in 2018, and the last package is received at DGR in 2052. Closure is assumed to be completed in 2062. The waste volumes shipped per year are therefore on average as shown in Table 1.

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Table 1: Moderator IX Resins Volume Inventory

Inventory volume at 2018 (m^3)	1174	Table 2.6 *
Inventory volume at 2052 (m^3)	1929	Table 2.7 *
Volume received per year between 1976 and 2018 (m^3/yr)	=1174/(2018-1976) = 28	calculated
Volume received per year between 2018 and 2052 (m^3/yr)	=(1929-1174)/(2052-2018) = 22	calculated
Volume received per year between 2052 and 2062 (m^3/yr)	0	monitoring and decommissioning period

* Reference Inventory report (OPG 2010).

Assuming constant shipment to WWMF of 28 m^3/yr of moderator resins as in Table 1, and accounting for decay from each year to 2018, the calculated total amount at 2018 is listed in Table 2 below. This is compared with the Reference Inventory report value in Table 2. It can be seen that the agreement is very good for long-lived radionuclides, and poorer (but still good) for shorter-lived radionuclides for which the variation in waste volume from year-to-years is more significant. A similar comparison can be prepared for the radionuclide inventory in 2062 (not shown) with similar conclusions.

This example illustrates how the inventories can be independently verified with available information.

Table 2: Estimated Radionuclide Inventory in 2018

Radionuclide	Half-life (a)	Specific Activity of Moderator IX Resin "as-received" Table B.2 * (Bq/m^3)	Estimated 2018 Inventory (with decay) (Bq)	Reference Inventory Report (2018) Table 2.6 * (Bq)
C-14	5.7E+03	2.7E+12	3.2E+15	3.2E+15
Cl-36	3.0E+05	3.4E+05	4.0E+08	4.0E+08
Co-60	5.3E+00	5.1E+10	1.2E+13	1.7E+13
Fe-55	2.7E+00	1.4E+10	1.7E+12	2.2E+12
H-3	1.2E+01	1.4E+11	6.4E+13	8.8E+13
Pu-239	2.4E+04	1.3E+03	1.5E+06	1.5E+06
Zr-93	1.5E+06	4.5E+02	5.3E+05	5.3E+05

* Reference Inventory report (OPG 2010).

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2. Source of Half-Life Data

The DGR Reference Inventory is based on results from the OPG Integrated Waste Tracking System (IWTS). The radionuclide half-live values used by IWTS are consistent with ICRP Publication 72 (1996), except for Se-79 and Sn-126 which were updated to current literature values a few years ago. These half-lives are listed in the Reference Inventory report and in the DGR Preliminary Safety Report (PSR, Table 5-8, p.274). These half-lives were used for all the reference inventory calculations.

Postclosure safety assessment calculations use the 2062 reference inventory as the starting point. All subsequent amounts are calculated using half-life data from a more recent reference source, ICRP Publication 107 (2008). This half-life data is documented in the DGR Postclosure SA Data report, Table 3.12, p.23 (Quintessa and Geofirma 2011).

There are approximately 50 radionuclides tracked in IWTS and in the Postclosure Safety Assessment (SA). For 40 of these radionuclides, the half-lives are the same within reporting precision. For the other 10 radionuclides as shown in Table 3, the differences in half-lives used in the Reference Inventory and Postclosure SA reports are more than the reporting precision. These differences reflect more recent half-life measurements or evaluations for these radionuclides.

Table 3: Comparison of Several Half-Life Values with Other Literature Values *

Radionuclide	ICRP 72 (ICRP 1996)	Ref. Inventory report (IWTS)	Postclosure SA (ICRP 2008)	US NNDC (2011)
Ni-59	7.50E+04	7.5E+04	1.01E+05	7.6E+04
Ni-63	96.0	9.6E+01	1.00E+02	100.1
Se-79	6.50E+04	3.8E+05	2.95E+05	2.95E+05
Mo-93	3.50E+03	3.5E+03	4.00E+03	4.0E+03
Nb-93m	13.6	1.4E+01	1.61E+01	16.13
Sn-121m	55.0	5.5E+01	4.39E+01	43.9
Ag-108m	1.27E+02	1.3E+02	4.18E+02	418
U-232	72.0	7.2E+01	6.89E+01	68.9
Pu-240	6.54E+03	6.5E+03	6.56E+03	6561
Am-242m	1.52E+02	1.5E+02	1.41E+02	141

* Numbers are reported in their source format and precision.

The effect of using the postclosure safety assessment half-lives (i.e., from ICRP 2008), rather than the default IWTS half-lives (i.e., from ICRP 1996) in calculating the reference radionuclide inventories was approximately assessed. The effect on most of the radionuclides is less than a few percent. The Reference Inventory would decrease by about 15% for Sn-121m, and would increase by about 20% for Ag-108m and 30% for Nb-93m. Note that for the other ~40 nuclides considered, there is no difference.

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		In summary, the effect of the change in half-lives is of no significance to the postclosure safety assessment. It is emphasized that the postclosure assessment uses a current consistent half-life dataset. But even if the older half-life values were adopted, it would have no effect on the postclosure safety conclusion. <u>3. Approach to Consolidate Waste Inventories</u> The reference total DGR radionuclide inventories at 2018 and at 2062 are presented in Tables 2.4 to 2.7, and Tables 3.2 and 3.3 in the Reference Inventory report (OPG 2010). These are based on the as-received waste package inventories presented in Tables B.1 to B.3 (OPG 2010). The same waste types are identified in these tables, except that the old and new ashes are combined into total ash inventories in Tables 2.4 and 2.5 (OPG 2010). Appendix E (OPG 2010) is primarily a container description, not a waste inventory description. As noted in the introduction to this appendix (p.74), the waste properties and container forecast given on the datasheets are nominal, and the main report provides the reference forecasts. More specific comments related to this Information Request follow. <u>3a. Ash volumes.</u> *The Information Request notes the following specific point. “From Appendix E in the ‘Reference Inventory’ the net volume of old bottom ash is 950 m^3 in 2018, and the net volume of new bottom ash is 671 m^3 in 2018 for a total of 1621 m^3, but Tables 2.4 and 2.5 give the volume of bottom ash in 2018 as 1352 m^3.”* Appendix E of the Reference Inventory report notes the number of ash containers (old and new ash bins) that will be emplaced in the DGR. It also summarizes the net ash volume that will be stored in these containers, but does <u>not</u> specify the fraction that is bottom ash or baghouse ash. As per Appendix E, the projected net volume of old bottom ash <u>and</u> old baghouse ash is 950 m^3 in 2018. The net volume of new bottom ash <u>and</u> new baghouse ash is 671 m^3 in 2018. The total volume of ash is therefore 1621 m^3 in 2018. From Table 2.4, the total volume of ash at 2018 is 1352 m^3 bottom ash plus 291 m^3 baghouse ash = 1643 m^3. These totals differ by about 1%, which is within the accuracy of these estimates since they are derived from different bases (waste volume versus container types). Similarly, from Appendix E, the net volume of old ash is 950 m^3 in 2052 and the net volume of new ash is 1447 m^3 for a total ash volume of 2397 m^3. From Table 2.5, the total ash volume in 2052 is 2033+364 = 2397 m^3. From Table 2.1, the total volume of ash at 2052 is 806+55+1227+309 = 2397 m^3. These totals are in agreement. However, there is a small inconsistency between the Appendix E data sheets and Table 2.1. The net volume of ash (old) is overstated by 89 m^3 (10%) in Appendix E, while the net volume of ash (new) is understated by 89 m^3 (6%) in Appendix E.

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		Again, as noted in the introduction to the appendix, the inventory information in the Appendix E is approximate and the reference values are stated in the main body of the report. <u>3b. Inventory Data - Radionuclides.</u> *The Information Request notes the following specific point. "Table 4.4 presents inventory data extracted from the 'Reference Inventory' report, however it is not stated where in the referenced report the data are from. Tables 2.5, 2.7 and 3.3 in the Reference Low and Intermediate Level Waste Inventory for the DGR and Table 4.4 in the Postclosure Safety Assessment report are not in agreement."* The Reference Inventory report provides a breakdown of the inventory into about 20 types of waste. These are grouped into Operational LLW, Operational ILW and Refurbishment L&ILW, reflecting that operational wastes arrive continuously while refurbishment waste arrives in specific years. For the postclosure safety assessment, the arrival time of the wastes at the DGR is not relevant. Therefore, in the inventory summary Table 4.4 in the Postclosure Safety Assessment report (Quintessa et al. 2011), the wastes are grouped into LLW and ILW for reporting purposes. That is, the refurbishment wastes are divided between the LLW and ILW categories. The categorization of the refurbishment waste into LLW and ILW is as presented in Table 4.1 of the Postclosure Safety Assessment report. (Note that the postclosure analyses track and use the individual waste type inventories.) Agreement between the tables can be illustrated by an example. For example, the C-14 inventory at 2062 is stated as 1.4E12 Bq in Operational LLW (Table 2.5 of Reference Inventory report), 5.4E15 Bq in Operational ILW (Table 2.7 of Reference Inventory report), and 6.6E14 Bq in Refurbishment Inventory (Table 3.3 of Reference Inventory report). The latter is based on 1.0E12 Bq in refurbishment LLW (steam generators) and 6.6E14 Bq in refurbishment ILW (retube waste) according to Table 3.3. This results in a total inventory at 2062 as follows: 1.4E12 Bq in Operational LLW + 1.0E12 Bq in Refurbishment LLW = 2.4E12 Bq in LLW 5.4E15 Bq in Operational ILW + 6.6E14 Bq in Refurbishment ILW = 6.1E15 Bq in ILW These agree with the 2.42E12 Bq in LLW and 6.07E15 Bq in ILW noted in Table 4.4 of the Postclosure SA report (the latter was derived from an exact sum by waste types and includes more significant figures). <u>3c. Inventory Data - Elements.</u> *The Information Request notes the following specific point. "There is more difficulty in finding the source for the elemental inventory since no tables in the reference inventory report presents the data as entered into Table 4.4. Again, data cannot be readily verified."* In the inventory summary in Table 4.4 in the Postclosure Safety Assessment report (Quintessa et al. 2011), the wastes are grouped into LLW and ILW for reporting purposes. That is, the refurbishment wastes are divided between the LLW and ILW categories. The categorization of the refurbishment waste into LLW and ILW is as presented in Table 4.1 of the Postclosure Safety Assessment report. The detailed elemental

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		inventories are provided in the Reference Inventory report (OPG 2011) in Table 2.8 and Table 3.4 (plus Appendix C). These tables are in agreement, as can be illustrated by an example. For example, for chromium, the inventories in the operational wastes are identified in Table 2.8 in the Reference Inventory report. Adding the values in kg for ash (3.8E3, 0, 2.5E3, 12), compacted bales/boxes (8.5E3), Non-processible (3.9E5), HX (2.8E2), LL/ALW resin (2.8) and ALW sludge (1.1) gives a total of 4.0E5 kg in operational LLW. Adding the values in kg for resins (17, 11, 26, 21), filters (3.1E4) and core components (4.8E3) gives a total of 3.6E4 kg in operational ILW. From Table 3.4 in the Reference Inventory report, the amount in Refurbishment LLW is 3.8E5 kg in steam generators, while the amount in Refurbishment ILW is 1.7E5+1.5E3= 1.7E5 kg in retube (smaller amounts are also in the Zircaloy pressure tubes as can be estimated from the data in Appendix C). This results in a total chromium inventory at 2062 as follows: 4.0E5 kg in Operational LLW + 3.8E5 kg in Refurbishment LLW = 7.8E5 kg in LLW 3.6E4 kg in Operational ILW + 1.7E5 kg in Refurbishment ILW = 2.1E5 kg in ILW These agree with the chromium totals of 7.85E5 kg in LLW and 1.98E5 kg in ILW in Table 4.4 of the Postclosure SA report. (As with the radionuclide data, the latter values were derived from the source data, without rounding for presentation, so have more precision). **References:** ICRP. 1996. Age-dependent Doses to Members of the Public from Intake of Radionuclides. ICRP Publication 72. ICRP. 2008. Nuclear Decay Data for Dosimetry Calculations. ICRP Publication 107. Quintessa and Geofirma. 2011. Postclosure Safety Assessment: Data. Quintessa Ltd. and Geofirma Engineering Ltd. report for the Nuclear Waste Management Organization NWMO DGR-TR-2011-32 R000. Toronto, Canada. (available at www.nwmo.ca/dgrpostclosuresafetyassessmentreports) Quintessa, Geofirma and SENES. 2011. Postclosure Safety Assessment. Quintessa Ltd., Geofirma Engineering Ltd. and SENES Consultants Ltd. report for the Nuclear Waste Management Organization NWMO DGR-TR-2011-25 R000. Toronto, Canada. OPG. 2010. Reference Low and Intermediate Level Waste Inventory for the Deep Geologic Repository. Ontario Power Generation report 00216-REP-03902-00003-R003. Toronto, Canada. US NNDC. 2011. On-line "Interactive Chart of the Nuclides" from the US National Nuclear Data Centre at http://www.nndc.bnl.gov/chart/. From ENDF/B VII.0.

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EIS-01-08	▪ EIS Guidelines: Section 8.1 ▪ CNSC Regulatory Guide G-320: Section 6.2.1	***Information Request:*** *Provide summary data on measurements of fugitive emissions of H-3 species from low level storage buildings in the context of existing radioactivity and contaminant releases and mobility. Information should include a discussion of whether levels are consistent with tritium inventories (i.e. any species present are only a very small fraction of total inventories). Where useful measured data are available, there should also be a discussion on inventory sources (i.e., which waste category might be responsible) and on mechanisms (microbial, chemical, radiological) for formation of species other than tritiated water (HTO).* *If no site-specific data are available, then the general literature on tritium speciation in the environment should be discussed and used for whatever inferences might be applicable to low and intermediate level wastes (e.g., Akata et al., 2011).* ***Context:*** *EIS section 6.6.4.1, Releases to Air, provides information on radiological releases from the four major sources at the Bruce site. It includes measurements of tritium oxide (HTO) releases from the Western Waste Management Facility, but does not include the quantity of fugitive emissions from the waste in the low level storage buildings (LLSBs). Nor does it include the “difficult to measure” species of tritium such as HT. The very high levels of HTO, known to accumulate in the air inside the LLSBs, suggest that fugitive emissions of the tritium gas HT are also occurring from the diverse wastes stored there (e.g. OPG 2007).* *A better understanding is needed of ongoing releases of “difficult to measure” species of tritium from different categories of wastes to make a risk informed decision about dose consequences to both workers and the public from these same wastes in the DGR through all phases of the project.*
		OPG Response: <u>1) Emission rate</u> Data from measurements of fugitive emissions of H-3 from the Low Level Storage Buildings (LLSBs) (OPG 2007) are summarized in the DGR Preliminary Safety Report (PSR), Section 7.4.2.1, p.387. These H-3 release rates have been compared with the tritium inventories in the LLSBs. The calculated average fractional release rate is presented in PSR, Table 7-9, p.386. The average tritium fractional release rate is 0.0042 (Bq/yr)/Bq or 0.4%/yr. As expected, this is a small fraction of the total inventory. As noted in the PSR, this value is also consistent with French data of about 1%/yr for tritium emission from medium activity L&ILW (Douche 2007). This rate is also consistent with Chang et al. (1984) who reported tritium offgassing from a simulated landfill of about 1%/yr. <u>2) Speciation</u> Emissions of tritium from LLSBs are expected to be primarily in the form of HTO. This is because the source

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		of the tritium in most of the LLW waste packages is from exposure to tritiated water from the reactors, because of the aerobic conditions in these closed but unsealed LLW containers, and because of the low levels of radiation (low radiolysis production of HT). The dominance of HTO in LLSB emissions is supported by measurements at Western Waste Management Facility (WWMF). Previous measurements at WWMF have indicated that any airborne water-soluble organic bound component is a small component of the fugitive emissions (PSR, Section 7.4.2.1). Recent measurements have been undertaken by OPG at the LLSBs, and no elemental tritium was measured (OPG 2011). Also, previous measurements at WWMF on ion exchange resin container headspace found that the non-HTO portion was 30% on average of the tritiated gases (Kinectrics 2003). These ILW results should be bounding for LLSBs, since more HT would be expected due to more anaerobic conditions in IC containers, Furthermore, the low levels of non-HTO species in the LLSB emissions are consistent with the literature on other wastes. Measurements by Molnar et al (2006) on headspace gas in drums of L&ILW indicated that HTO was the dominant form of released tritium, with small levels of tritium-bearing CH_4 and (lesser) H_2. Measurements on medium-activity waste storage at CEA, France (Douche 2007) reported about 80-90% HTO, with balance HT. Higher HT in the latter case is expected since the facility handles some tritium as elemental gas. Chang et al (1984) indicated the primary tritiated gas species released from their simulated landfill were water vapor and methane. In L&ILW gas measurements, Molnar et al (2006) concluded that the methane gas was primarily produced by microbial degradation (based on the C-13 signature), with corrosion also providing gas and radiolysis a minor role. <u>3) Waste source</u> The primary LLW package in the DGR (by both number and waste volume) is non-processible bins and drums. These also are expected to have the largest overall tritium inventory (OPG DGR Reference Inventory report, OPG 2010). While the number and types of waste packages vary between LLSBs, as a general estimate, non-processible wastes are also the most common waste at WWMF and likely the main source of tritium emissions. This is consistent with Molnar et al (2006), whose measurements indicated that non-compacted pressurized water reactor L&ILW (i.e., roughly similar to the OPG non-processible waste type) released more tritium than corresponding sludge waste or compacted waste. **References:** Chang, K.C., E. Chian, F. Pohland, W. Cross, L. Roland and B. Kahn. 1984. Behavior of radionuclides in sanitary landfills. Health Physics 46(1) 45-53. Douche, C. 2007. Interim storage for tritiated wastes. Proc. 8th Inter. Conf. on Tritium Science and Technology, Rochester USA.

<table>
<tr><th>IR#</th><th>EIS Guidelines Section</th><th>Information Request and Response</th></tr>
<tr><td></td><td></td><td>Kinectrics. 2003. Chemical, radiochemical and microbiological characterisation of the contents of resin liners sampled at the Western Waste Management Facility in 2002. Kinectrics Inc., 9820-090-RA-0001-R00. Toronto, Canada.

Molnar, M., L. Palcsu, E. Svingor, I. Futo, Z. Major and L. Rinyu. 2006. Isotope-analytical results of a study of gas generation in L/ILW. Czechoslovak Journal of Physics 56, Suppl. D, D637-D6444.

OPG. 2007. An Overview of Tritium Release and Mitigation for the Western Waste Management Facility. OPG report W-REP-00531-00005-R000. Toronto, Canada.

OPG. 2010. Reference Low and Intermediate Level Waste Inventory for the Deep Geologic Repository. Ontario Power Generation report 00216-REP-03902-00003-R003. Toronto, Canada.

OPG. 2011. Letter to CNSC, "Western Waste Management Facility - WSH231 - Request for Additional Information Item #3 ", CD# W-CORR-00531-00708. December 22, 2011.</td></tr>
<tr><td rowspan="2">EIS-01-09</td><td rowspan="2">▪ EIS Guidelines: Section 11, Effects Prediction, Mitigation Measures and Significance of Residual Effects</td><td>Information Request:

Provide information on the baseline conditions and subsequent effect predictions, for acrolein from an air quality perspective.

Context:

Acrolein is discussed from a human health context (i.e., Section 6.11, Table 6.12-1 of the EIS; Appendix C of the EIS; Appendix J of the Atmospheric Environment TSD) but is not discussed relative to air quality. Background conditions and predicted emissions are required to put the effects analysis into perspective for air quality.</td></tr>
<tr><td>OPG Response:

Section 4.2.1 of the Atmospheric Environment TSD describes the indicators used when evaluating the effects of the DGR Project on air quality. Acrolein was not identified as an air quality indicator (see Table 4.2.1-1 on page 31 of the Atmospheric Environment TSD). One reason for the exclusion of acrolein is that there are no relevant ambient air quality criteria to use for acrolein. Although there are acrolein criteria listed in Ontario Regulation 419, Air Pollution – Local Air Quality (O.Reg. 419/05), the methods by which these criteria are applied, as guided by the Ontario Ministry of Environment (MOE 2009), would not be appropriate for evaluating the changes in air quality associated with the DGR Project.

As stated on page 31 of the Atmospheric Environment TSD "… O. Reg 419/05 considers the emissions from selected stationary sources only. Ontario exempts emission sources associated with construction activities from evaluation (MOE 2007). Similarly, evaluations in accordance with O. Reg. 419/05 do not include considerations of background concentrations." When evaluated in the context of the O.Reg. 419/05 guidance, the acrolein emissions from construction activities and mobile emissions sources would have to have been excluded.</td></tr>
</table>

IR#	EIS Guidelines Section	Information Request and Response
		Since the air quality assessment considers all of the sources of the Bruce nuclear site (i.e., stationary and mobile) and evaluates the effects of construction, it is not appropriate to apply O.Reg.419/05 criteria. Only those compounds with Canada-wide standards or National Air Quality Objectives for Canada have been used as indicators for evaluating air quality, hence acrolein is not used as an air quality indicator. There are no Canada-wide standards or National Air Quality Objectives for Canada for acrolein. Although acrolein was not identified as an air quality indicator, and thus was not used in evaluating the effects of the DGR Project on air quality, acrolein was used as an input to the human health assessment presented in the EIS. The following table shows the predicted 1-hour existing, construction and operations acrolein predictions (including background acrolein [MOE 2005]) that would result for all of the emission sources (including stationary, mobile and construction sources). The predictions show that once operations start, the acrolein concentrations are unchanged from existing conditions. The reason is largely because motor vehicles are the primary source of acrolein emissions at the Bruce nuclear site, and the operations of the DGR Project will result in only a nominal increase in motor vehicle traffic each day.

IR#	EIS Guidelines Section	Information Request and Response
		(continued below)

Maximum 1-Hour Acrolein Concentrations for Health Assessment (includes stationary, construction and mobile sources)

Receptor	Maximum Modelled Existing Concentration (μg/m³)	Background Acrolein (μg/m³)	Existing Acrolein (μg/m³)
AR1	1.22	0.25	1.47
AR2	1.58	0.25	1.83
AR3	1.18	0.25	1.43
AR4	1.26	0.25	1.51
AR5	0.66	0.25	0.91
AR6	1.38	0.25	1.63
Receptor	**Maximum Modelled Construction Concentration (μg/m³)**	**Background Acrolein (μg/m³)**	**Constuction Acrolein (μg/m³)**
AR1	1.63	0.25	1.88
AR2	2.86	0.25	3.11
AR3	1.20	0.25	1.45
AR4	2.00	0.25	2.25
AR5	1.00	0.25	1.25
AR6	3.26	0.25	3.51
Receptor	**Maximum Modelled Operations Concentration (μg/m³)**	**Background Acrolein (μg/m³)**	**Operations Acrolein (μg/m³)**
AR1	1.22	0.25	1.47
AR2	1.60	0.25	1.85
AR3	1.18	0.25	1.43
AR4	1.26	0.25	1.51
AR5	0.66	0.25	0.91
AR6	1.38	0.25	1.63

Notes: Background acrolein from MOE 2005.
Receptor Locations are shown in Figure C2.3.1-1 of the EIS (Volume 2).

The following table shows the predicted 24-hour existing, construction and operations acrolein predictions (including background acrolein) that would result for all of the emission sources (including stationary, mobile and construction sources). The predictions show that the acrolein concentrations from the sources at the site are less than the background value in all but two cases during site preparation and construction. The site preparation and construction concentrations are higher than in both the existing and operations phase as a result of the acrolein emitted from the diesel equipment used in the construction activities.

IR#	EIS Guidelines Section	Information Request and Response

Maximum 24-Hour Acrolein Concentrations for Health Assessment (includes stationary, construction and mobile sources)

Receptor	Maximum Modelled Existing Concentration (µg/m³)	Background Acrolein (µg/m³)	Existing Acrolein (µg/m³)
AR1	0.14	0.25	0.39
AR2	0.15	0.25	0.40
AR3	0.17	0.25	0.42
AR4	0.16	0.25	0.41
AR5	0.09	0.25	0.34
AR6	0.22	0.25	0.47
Receptor	**Maximum Modelled Construction Concentration (µg/m³)**	**Background Acrolein (µg/m³)**	**Constuction Acrolein (µg/m³)**
AR1	0.22	0.25	0.47
AR2	0.22	0.25	0.47
AR3	0.18	0.25	0.43
AR4	0.30	0.25	0.55
AR5	0.10	0.25	0.35
AR6	0.33	0.25	0.58
Receptor	**Maximum Modelled Operations Concentration (µg/m³)**	**Background Acrolein (µg/m³)**	**Operations Acrolein (µg/m³)**
AR1	0.15	0.25	0.40
AR2	0.16	0.25	0.41
AR3	0.17	0.25	0.42
AR4	0.16	0.25	0.41
AR5	0.09	0.25	0.34
AR6	0.24	0.25	0.49

Notes: Background acrolein from MOE 2005.
Receptor Locations are shown in Figure C2.3.1-1 of the EIS (Volume 2).

If acrolein were to be evaluated from an air quality perspective, it would need to be done in accordance with O.Reg. 419/05 and the acrolein emissions used when calculating the values used in the health assessment. As stated on page 31 of the Atmospheric Environment TSD "*… O. Reg 419/05 considers the emissions from selected stationary sources only. Ontario exempts emission sources associated with construction activities from evaluation (MOE 2007). Similarly, evaluations in accordance with O. Reg. 419/05 do not include considerations of background concentrations.*" When evaluated in the context of the O.Reg. 419/05 guidance,

IR#	EIS Guidelines Section	Information Request and Response
		the acrolein emissions from construction activities and mobile emissions sources would have to have been excluded.

The following table shows the acrolein emissions that were considered in calculating the health assessment numbers presented previously, as well as the acrolein emissions that would have been considered in evaluating acrolein in accordance with O.Reg. 419/05. The overall emissions of acrolein that would be considered when evaluating air quality in accordance with O.Reg. 419/05 are slightly lower than those used for the health assessment predictions; however, the O.Reg. 419/05 emissions from the DGR Project are effectively zero.

Scenario	All Acrolein Emissions (kg/d)		O.Reg. 419/05 Acrolein Emissions (kg/d)	
	On-site Sources	DGR Only	On-site Sources	DGR Only
Baseline	5.5	-	5.4	-
Construction: Stage 1	6.1	0.5	5.4	0.0
Construction: Stage 2	5.9	0.4	5.4	0.0
Construction: Stage 3	6.1	0.6	5.4	0.0
Construction: Stage 4	6.1	0.6	5.4	0.0
Construction: Stage 5	6.2	0.7	5.4	0.0
Operations	5.6	0.1	5.4	0.0
Decommissioning	5.6	0.0	5.4	0.0

Since concentrations are proportional to the emissions, the acrolein concentrations that would be used for an assessment of air quality effects in accordance with O.Reg. 419/05 (i.e., excluding mobile and construction sources) can be estimated by scaling on the basis of emissions. The following table presents the 1-hour acrolein concentrations for evaluation of air quality effects in accordance with O.Reg. 419/05.

IR#	EIS Guidelines Section	Information Request and Response

Maximum 1-Hour Acrolein Concentrations for O.Reg. 419/05 Air Assessment (includes stationary sources only)			
Receptor	**Maximum Modelled Existing Concentration (µg/m³)**	**Background Acrolein (µg/m³)**	**Existing Acrolein (µg/m³)**
AR1	1.19	—	1.19
AR2	1.55	—	1.55
AR3	1.16	—	1.16
AR4	1.24	—	1.24
AR5	0.64	—	0.64
AR6	1.35	—	1.35
Receptor	**Maximum Modelled Construction Concentration (µg/m³)**	**Background Acrolein (µg/m³)**	**Constuction Acrolein (µg/m³)**
AR1	1.45	—	1.45
AR2	2.55	—	2.55
AR3	1.07	—	1.07
AR4	1.79	—	1.79
AR5	0.89	—	0.89
AR6	2.91	—	2.91
Receptor	**Maximum Modelled Operations Concentration (µg/m³)**	**Background Acrolein (µg/m³)**	**Operations Acrolein (µg/m³)**
AR1	1.18	—	1.18
AR2	1.55	—	1.55
AR3	1.14	—	1.14
AR4	1.22	—	1.22
AR5	0.64	—	0.64
AR6	1.33	—	1.33

Note: Receptor Locations are shown in Figure C2.3.1-1 of the EIS (Volume 2).

References:

Ontario Ministry of the Environment (MOE). 2005. Ontario Air Standards for Acrolein. Standards Development Branch.

IR#	EIS Guidelines Section	Information Request and Response
		Ontario Ministry of the Environment (MOE). 2007. Certificate of Approval Exemptions - Air. Ontario Regulation 524/98. Ontario Ministry of the Environment (MOE). 2009. Procedure for Preparing an Emission Summary and Dispersion Modelling Report.
EIS-01-10	▪ EIS Guidelines: Section 11, Effects Prediction, Mitigation Measures and Significance of Residual Effects	***Information Request:*** *Provide the following air quality-related information / clarifications:* ▪ *a description of the quality assurance/quality control performed on the meteorological data to check on accuracy, reliability, etc.;* ▪ *clarify whether any correction has been done due to temperature being taken by the on-site tower at a 10 metre height compared to that taken at a 2 metre height at the Wiarton and Paisley stations;* ▪ *clarify why the data from the 10 metre height on the on-site tower was used in the model when the 50 metre height data from the same tower are more reliable and what kind of changes in the predictions of air quality effect would be noted due to this change; and* ▪ *a list of parameters taken from the on-site tower and the parameters taken from other sources (with references) for use in modeling.* ***Context:*** *Modeling is an important method to allow for the assessment of environmental effects and confidence is needed that the appropriate inputs have been used to accurately predict effects (e.g., to air quality).* *Further information and rationalization are needed on various items with respect to the air quality modeling to allow for the confirmation that appropriate and accurate data are used for the predictions of air quality effects.*
		OPG Response: <u>1. QA/QC Process for Meteorological Data</u> Given the importance of meteorological inputs to the dispersion modelling, considerable care and effort was expended to ensure the quality and validity of the dispersion meteorology. The following four steps were involved in the QA/QC process, each described in more detail below: • Selecting the appropriate data source; • Ensuring that there is a continuous set of meteorological data by substituting missing or questionable data with appropriate readings from an alternative station; • Producing appropriate dispersion meteorology using the continuous data set and local land use information; and • Processing graphical summaries of the dispersion meteorology to review and identify possible anomalies.

IR#	EIS Guidelines Section	Information Request and Response
		1.1 Selecting Appropriate Data Source As described in Section C2.3 of the Atmospheric Environment Technical Support Document (TSD), prior to developing a dispersion meteorology data set, on-site meteorological observations from both the 10 and 50 m level at the 50 m on-site tower, and the 10 m tower adjacent to the site were compared to selected archived weather maps to identify whether the data recorded at the Bruce nuclear site matched with regional weather patterns. This was done by a Canadian Meteorological and Oceanographic Society (CMOS) certified meteorologist. Generally, archived weather patterns matched the on-site observations reasonably well, with data from the 50 m tower showing a better correlation than from the 10 m tower. Of the two levels of data available from the 50 m tower, both showed good agreement with archived weather maps and data, with one exception. Under certain conditions, the data from the 10 m level on the 50 m tower showed the influence of local topographic features and influences of lake-land interactions (e.g., lake breezes). These local phenomena will influence emissions from low-level releases such as those present at the DGR. Therefore, data from the 10 m level of the 50 m tower were considered to be most appropriate for generating the dispersion meteorology since they include these localized phenomena. Although the 10 m tower located adjacent to the site showed good agreement with archived weather maps, there were inconsistencies in the data record covering the period 2005 to 2009 that suggested that this was not a reliable source for dispersion meteorological data. Some parameters were not available from the on-site station, specifically the following: • Cloud ceiling height; • Cloud cover; • Cloud opacity; • Barometric pressure; • Precipitation; • Humidity; and • Upper air soundings. For the above parameters nearby high-quality Environment Canada or National Oceanic and Atmospheric Administration (NOAA) stations with the necessary parameters were identified (MSC 2010, NOAA 2010). The first six parameters were obtained from Wiarton Airport (approximately 60 km from the DGR Project site). This station was the closest, is adjacent to a lake, and considered to have similar conditions for those parameters. The closest upper air station was Gaylord, Michigan (approximately 260 km). *1.2 Ensuring Continuous Set of Meteorological Data* • Look at the 10 m data and identify readings that were either missing or invalid. Readings were flagged as being invalid or questionable when: ○ Wind speeds <0 or >30 m/s;

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		○ Wind direction <0 or >360°; ○ Either a wind speed or wind direction missing; and ○ Temperatures <-40°C or >40°C. • For all flagged values, the validity of the reading was confirmed, and if deemed invalid, an appropriate replacement reading was identified using the following priority: ○ When 10 m winds were not available, data from the 50 m level on the 50 m tower was used. However, the corresponding hourly value was rarely available at the 50 m level (i.e., both the 10 and 50 m winds were missing). ○ If the 50 m winds were not available, data from Wiarton Airport was used. ○ When the on-site temperatures were not available, data from Wiarton Airport was used. *1.3 Producing Dispersion Meteorology* In order to use the meteorological data in the AERMOD dispersion model, processing using the AERMET pre-processor is required. The AERMET pre-processor produces two meteorological data files. The first file contains boundary layer scaling parameters (e.g., surface friction velocity, mixing height, and Monin-Obukhov length) as well as wind speeds, wind directions, and temperature at a reference-height. The second file contains one or more levels (a profile) of winds, temperature, and the standard deviation of the fluctuating components of the wind. This was illustrated in Appendix C of the Atmospheric Environment TSD (Figure C2.2-2, shown below).

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		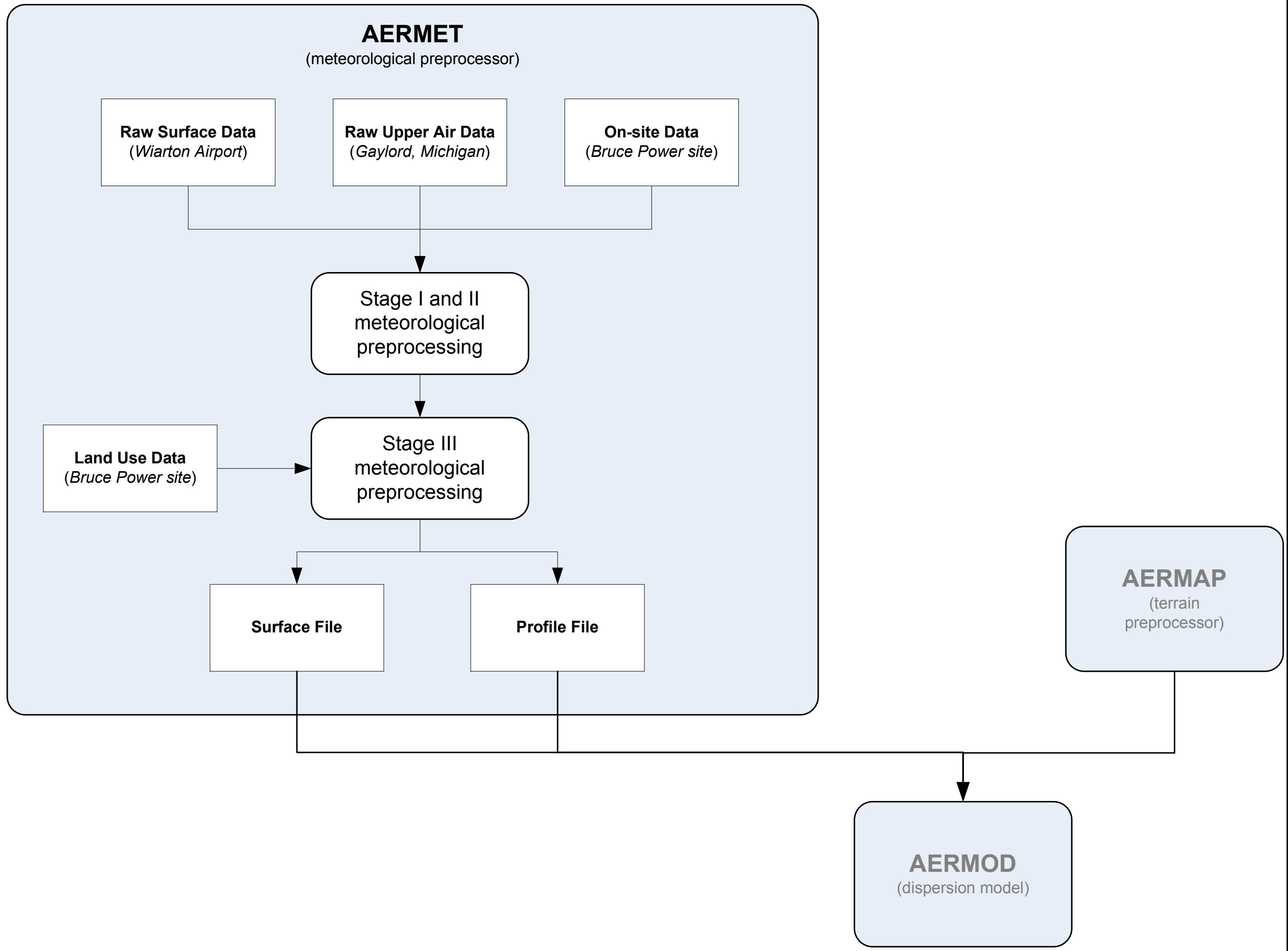 **Figure C2.2-2**: Flow Diagram for the AERMET Pre-Processor (reproduced from Atmospheric Environment TSD)

IR#	EIS Guidelines Section	Information Request and Response
		<u>*1.4 Processing Graphical Summaries and Identify Anomalies*</u> The graphical summaries and discussion of possible anomalies in the dispersion meteorology were discussed in detail in Appendix C of the Atmospheric Environment TSD. The analysis was complete and included comparisons of the dispersion meteorological data developed for use in assessing the DGR Project to climate normals data from both the stations in Wiarton and Paisley. The following conclusions were made: • Temperature: The temperatures for the dispersion meteorology fall within the range of the climate normals for both Wiarton and Paisley. • Precipitation: The precipitation used in the dispersion modelling comes from hourly observations at Wiarton. The five year dispersion meteorology falls within the range of the climate normals observed at Wiarton. Observed normals at Paisley are also similar to those for Wiarton and the dispersion meteorology. Wind speed and direction: Monthly wind speeds and directions for the dispersion meteorology are compared to the climate normals for both Wiarton and Paisley. This comparison shows a good agreement on a monthly basis. <u>2. Temperature Data</u> No adjustments or modifications were made to the data set for correcting apparent anomalies. As noted above, data from the 10 m level on the 50 m on-site tower did show an influence of lake-land winds and local topography, both of which are real local phenomena affecting the dispersion from low elevation sources at the Bruce nuclear site. Where data were missing, or identified to be invalid, readings were substituted as described above and below. No specific correction was considered necessary to adjust the on-site temperatures (collected at a height of 10 m at the 50 m on-site tower) to the World Meteorological Organization (WMO) reference height of 2 m (the temperatures collected at Wiarton and Paisley were both collected at the WMO reference height). The reasoning was the small difference in heights (8 m) and the expected change is temperature per unit of height (i.e., the dry adiabatic lapse rate for air) of -9.8 K/km or -9.8 °C/km. Therefore, the average adjustment that would apply to the on-site temperatures collected at 10 m using the difference from the reference height of 8 m and the dry adiabatic lapse is: $$Correction = -9.8\frac{°C}{km} \times (2m - 10m) \times \frac{1km}{1000m} = 0.078°C$$ <u>3. Use of 50 m Height Meteorological Data</u> As described in Section C2.3 of the Atmospheric Environment TSD, both the 10 m and 50 m readings from the 50 m on-site tower were considered reliable. However, the data from the 10 m level on the 50 m tower showed the influence of local topographic features and influences of lake-land interactions (e.g., lake

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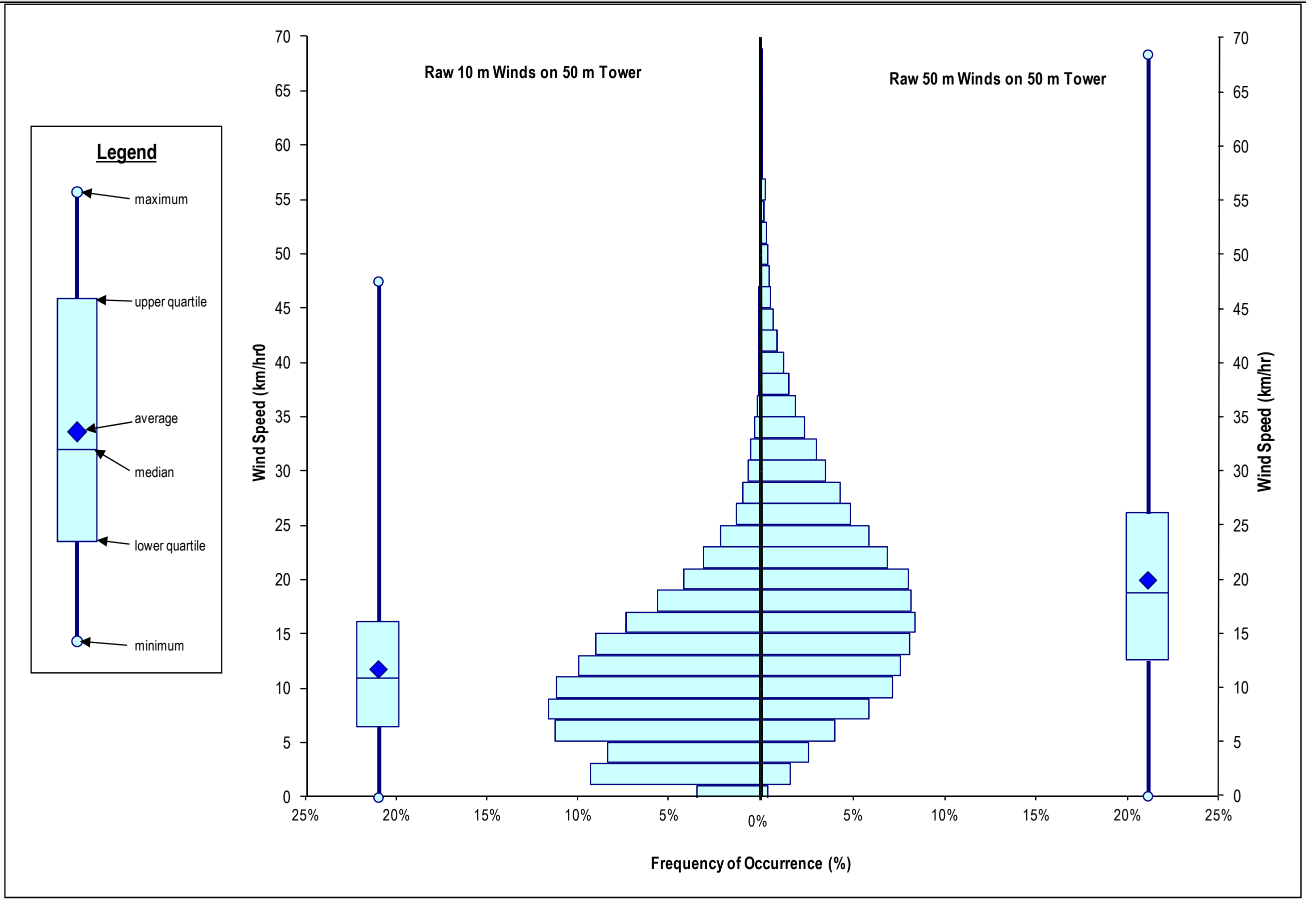
		breezes). Because these local phenomena will influence emissions from low-level releases such as those present at the DGR, the data from the 10 m level of the 50 m tower were considered to be most appropriate for generating the dispersion meteorology since they include these localized phenomena. If the data from the higher 50 m level from the on-site 50 m tower was used, the most likely parameter affected would have been the wind speed. As wind speeds generally increase with height, it is reasonable to assume that the dispersion meteorology based on the 50 winds would have had higher average wind speeds. This assumption is confirmed when the data are analyzed, as shown in the following figure, which compares the raw 10 m and 50 m wind speeds collected from the on-site 50 m tower for the period from 2005 through 2009. Given that concentrations are proportional to emissions and inversely proportional to wind speeds, the use of the higher wind speeds observed at the 50 m level (approximately twice the speed of winds observed at the 10 m level) would have resulted in prediction of lower concentrations. In addition, the analysis of the data by a Canadian Meteorological and Oceanographic Society (CMOS) certified meteorologist, as described in Section C2.3 of the Atmospheric Environment TSD, found that the influence of local topography and lake-land interactions (e.g., lake breezes) were only evident in the 10 m data collected from the on-site 50 m tower.

IR#	EIS Guidelines Section	Information Request and Response
		 4. Meteorological Parameters and Data Sources Section C2.2 of the Atmospheric Environment TSD describes the data sources used for each parameter in the dispersion meteorology. These are listed below: • Wind speed and direction – 10 m readings from the on-site 50 m tower; • Temperature – 10 m readings from the on-site 50 m tower; • Cloud ceiling height – Wiarton airport; • Cloud cover – Wiarton airport;

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		(continued below)

- Cloud opacity – Wiarton airport;
- Barometric pressure – Wiarton airport;
- Precipitation – Wiarton airport;
- Humidity – Wiarton airport; and
- Upper air soundings – NOAA station in Gaylord Michigan.

For hours where data from the on-site tower were not available or identified as being invalid, an appropriate replacement reading was identified using the following priority:

- When 10 m winds were not available, data from the 50 m level on the 50 m tower was used. However, the corresponding hourly value was rarely available at the 50 m level (i.e., both the 10 and 50 m winds were missing).
- If the 50 m winds were not available, data from Wiarton Airport was used.
- When the on-site temperatures were not available, data from Wiarton Airport was used.

Table C2.2-1 of the Atmospheric Environment TSD (reproduced below) listed the number of hours when data were used from the primary and secondary data sources. The data sets for Wiarton and Gaylord were complete, so substitution for missing data was not necessary.

Table C.2.2-1 Number of Hours of Data for Dispersion Modelling

Parameter	Period	Hours of Data Used		
		On-site 50 m-Tower (10 m height)	On-site 50 m-Tower (50 m height)	Wiarton Station
Wind Direction	2005-2009	43,216	0	608
Wind Speed	2005-2009	43,216	0	608
Surface Temperature	2005-2009	42,062	0	1,762

References:

Meteorological Services of Canada (MSC). 2010. Surface Observation Data for Wiarton Airport Covering the Period from 2005 through 2009. Environment Canada National Climate Data and Information Archive. March 2010.

National Oceanic and Atmospheric Administration (NOAA). 2010. Upper Air Sounding Observations from Gaylord, Michigan Covering the Period from 2005 through 2009. Earth System Research Laboratory (ESRL) Radiosonde Database. March 2010.

<table>
<tr><th>IR#</th><th>EIS Guidelines Section</th><th>Information Request and Response</th></tr>
<tr><td rowspan="2">EIS-01-11</td><td rowspan="2">EIS Guidelines: Section 11, Effects Prediction, Mitigation Measures and Significance of Residual Effects</td><td> Information Request: Provide information on the relevance of any lake-land effect at the site, and subsequent possible impacts on emissions and predictions of air quality effects from the project. Context: Influence from shoreline fumigation on atmospheric dispersion is considered minimal as per CSA Standard N288.1-08, Guidelines for Calculating Derived Release Limits for Radioactive Material in Airborne and Liquid Effluents for Normal Operation of Nuclear Facilities. However, consideration of other characteristics that may affect plume transport, specifically land/lake breeze wind circulation, are not discussed in the EIS. It is unclear whether this phenomenon is of relevance to this project. </td></tr>
<tr><td> OPG Response: The phenomena associated with lake-land interfaces, lake breezes and the formation of thermal internal boundary layers (TIBLs) are discussed in Section C8.3 of the Atmospheric Environment Technical Support Document (TSD). Lake breezes that form in daylight hours during the late spring and summer months because the waters of Lake Huron do not warm as quickly as the surrounding land surfaces can have an influence on the dispersion of emissions from both short and tall sources. In contrast, the TIBLs that can also form at lake-land interfaces are primarily an issue for tall stacks. Because most coal fired power plants in Ontario were situated on the shores of the Great Lakes, the issues regarding “shoreline fumigation”, “lake breezes” and Thermal Internal Boundary Layers (TIBLs) in Ontario are well researched and documented in literature (see Section C8.3 of the Atmospheric Environment TSD). All of the sources at the DGR Project would be considered “short sources”, and could be influenced by lake breezes. Therefore, the DGR Project does not have any “tall sources” that could be influenced by the formation of TIBLs. As described in Section C2.3 of the Atmospheric Environment TSD, a comparison of on-site meteorological observations from both the 10 and 50 m level at the 50 m on-site tower, and the 10 m tower adjacent to the site were compared to selected archived weather maps to identify whether the data recorded at the Bruce nuclear site matched with regional weather patterns. Generally, archived weather patterns matched the on-site observations reasonably well, with data from the 50 m tower showing a better correlation than from the 10 m tower. However, only the data from the 10 m level on the 50 m tower showed the influence of local topographic features and influences of lake-land interactions (e.g., lake breezes). Because these local phenomena will influence emissions from “short sources” present at the DGR Project, data from the 10 m level of the 50 m tower were considered to be most appropriate for generating the dispersion meteorology. </td></tr>
</table>

IR#	EIS Guidelines Section	Information Request and Response
EIS-01-12	▪ EIS Guidelines: Section 11, Effects Prediction, Mitigation Measures and Significance of Residual Effects	***Information Request:*** *Adjust the bounding scenario to be more conservative (i.e., include the highest emission estimates per parameter, regardless of the stage within the site preparation and construction phase) and describe the subsequent effects to the dispersion modeling and air quality predictions; or provide the rationale for the derived air emission bounding scenario, outlined in the Atmospheric Environment TSD, which is used as inputs for dispersion modeling.* ***Context:*** *The bounding case should reflect the most conservative parameters based on the available information. It is not clear, based on the documentation provided, that this is the case for air emissions during the site preparation and construction phase. This is important as it serves as the inputs to the air dispersion modeling used in predicting effects to air quality.* *Table F4.2-1 breaks down emission rates for various air quality parameters by stage within the Site Preparation and Construction Phase. Table F4.2-2, which represents the bounding values used as inputs into the dispersion modeling, did not use the most conservative emission estimates from Table F4.2-1. Rather, it used the emission estimates from Stage 1 of the Site Preparation and Construction Phase reported in this table, which did not always represent the most conservative emission estimate for a given parameter.*
		OPG Response: The scenario used as the bounding case in the Atmospheric Environment Technical Support Document (TSD) was selected so that a common source configuration could be used for all of the indicator compounds modelled. During site preparation and construction, the magnitude, location and configuration of the emissions sources change from one stage of the activity to the next. No single stage of the Site Preparation and Construction Phase had the highest emissions for all of the individual indicator compounds. If a bounding case were to use emissions from different stages of construction, the source configurations for each compound modelled would need to be different. Therefore, a single stage was identified for the modelling that had close to the highest emissions for all compounds so a common source configuration could be used for all of the indicator compounds modelled. The stage of activity selected to assess the effects of the project on air quality was Stage 1: Site Preparation, Construction of Surface Structures and Excavation of Shafts. During this stage of construction all activity will be occurring at or near the surface. This stage of construction has the highest particulate emissions and thus would result in the highest particulate concentrations (TSP, PM_{10} and $PM_{2.5}$). A listing of the construction phase emissions for each of the stages of construction are presented in Table 8.2.3-1 of the Atmospheric Environment TSD and reproduced below.

IR#	EIS Guidelines Section	Information Request and Response

Table 8.2.3-1: Daily Site Preparation and Construction Phase Emissions

Indicator Compound [a]	Daily Emission Rate (kg/d) [b]				
	Stage 1: Site Preparation, Construction of Surface Structures and Excavation of Shafts	Stage 2: Excavation of Shafts	Stage 3: Construction of Emplacement Rooms	Stage 4: Installation of Underground Infrastructure	Stage 5: Installation of Underground Infrastructure and Road Network Construction
NO_X	243.5	157.7	250.7	271.4	297.5
SO_2	0.5	0.3	0.5	0.5	0.6
CO	168.6	113.9	172.2	189.4	207.2
SPM	207.3	59.2	82.7	83.8	120.8
PM_{10}	49.3	18.7	26.5	27.6	35.4
$PM_{2.5}$	32.3	14.0	19.2	20.3	25.1

Notes:
a Emissions of NO_X from the DGR Project include both the emissions of NO_2 (an indicator compound) and NO. A portion of the NO emissions will be converted to NO_2 in the atmosphere; therefore, the combined emissions of NO_2 and NO, collectively referred to as NO_X, are of concern.
b The numbers in the above table were calculated by summing the emissions associated with the individual activities, as shown in Section 7, that occur concurrently during each phase.

The air quality predictions for the site preparation and construction phase are presented in Table 7.7.2-3 of the Environmental Impact Statement (EIS) (reproduced below). The only indicators that exceed the relevant criteria during the site preparation and construction phase are the 24-hour SPM, 24-hour PM_{10} and 24-hour $PM_{2.5}$ concentrations. Stage 1 of the site preparation and construction phase is the stage with the largest amount of particulate emissions. Therefore, the predictions for particulate that were presented in the EIS are conservative.

IR#	EIS Guidelines Section	Information Request and Response

Table 7.7.2-3: Site Preparation and Construction Phase Adverse Effects to Air Quality in the Local Study Area

Indicator Compound	Maximum Existing Concentration (µg/m³) in Local Study Area	Maximum Site Preparation and Construction Phase Concentration (µg/m³) in Local Study Area	Increase Over Existing Concentration (µg/m³) in Local Study Area	Likely Adverse Effect?
1-hour NO_2	110.4	321.7	+211.3	**adverse effect**
24-hour NO_2	26.5	141.2	+114.7	**adverse effect**
Annual NO_2	6.8	18.5	+11.7	**adverse effect**
1-hour SO_2	318.9	318.9	0	no adverse effect
24-hour SO_2	51.3	51.3	0	no adverse effect
Annual SO_2	5.0	5.0	0	no adverse effect
1-hour CO	1,580.6	2,504.2	+923.6	**adverse effect**
8-hour CO	1,201.8	1,595.7	+393.9	**adverse effect**
24-hour SPM	71.0	276.9	+205.9	**adverse effect**
Annual SPM	25.1	30.7	+5.6	**adverse effect**
24-hour PM_{10}	26.0	75.3	+49.3	**adverse effect**
24-hour $PM_{2.5}$	15.4	45.7	+30.3	**adverse effect**

Estimated Potential Effect of Higher Emissions for NO_x, SO_2, and CO

The emissions of NO_X, SO_2 and CO for the other stages of construction are higher than during Stage 1. Specifically, the emissions during Stage 5 are 22% higher for NO_X, 18% higher for SO_2, and 23% higher for CO. The potential effect of the slightly higher emissions on the predictions can be estimated by scaling up the increase over existing concentrations in the above table, and adding the result to the existing predictions, as shown below.

- The increase over existing for 1-hour NO_2 would go from 211.3 to 258.2 µg/m³, with the resulting site preparation and construction phase concentration being 368.6 µg/m³. This concentration remains below the 1-hour NO_2 criteria of 400 µg/m³.
- The increase over existing for 1-hour SO_2 would remain zero, with the resulting site preparation and

IR#	EIS Guidelines Section	Information Request and Response
		construction phase concentration remains unchanged from the existing conditions at 318.9 µg/m³. • The increase over existing for 1-hour CO would go from 923.6 to 1,135.3 µg/m³, with the resulting site preparation and construction phase concentration being 2,715.9 µg/m³. This concentration remains below the 1-hour CO criteria of 35,000 µg/m³. Therefore, adjusting the stage of construction by indicator compound would have resulted in minor changes to the resulting predictions but would not have altered the conclusions of the air quality assessment.
EIS-01-13	▪ EIS Guidelines: Section 11, Effects Prediction, Mitigation Measures and Significance of Residual Effects	***Information Request:*** *Provide the basis for the predictions that air quality standards will be exceeded 1% of the time for NO_2 and 5.5% of the time for particulate matter.* ***Context:*** *Table 7.4.2-1 shows NO_2 and particulate matter exceeding standards during the site preparation and construction phase; however, it is reported that the exceedance would not be continuous. This is presented as 1% of the time for NO_2 and 5.5% of the time for particulate matter on page 7-59 of the EIS. The basis for these estimates is not provided, and therefore, the exceedance predictions cannot be verified.*
		OPG Response: Section 7.4.2 of the EIS presents the findings of the terrestrial effects assessment for the DGR Project. The air quality assessment for the DGR Project is presented in Section 7.7. Specifically, the predicted air concentrations from the site preparation and construction phase are presented in Table 7.7.2-3 of the EIS (reproduced below).

IR#	EIS Guidelines Section	Information Request and Response

Table 7.7.2-3: Site Preparation and Construction Phase Adverse Effects to Air Quality in the Local Study Area

Indicator Compound	Maximum Existing Concentration (µg/m³) in Local Study Area	Maximum Site Preparation and Construction Phase Concentration (µg/m³) in Local Study Area	Increase Over Existing Concentration (µg/m³) in Local Study Area	Likely Adverse Effect?
1-hour NO_2	110.4	321.7	+211.3	**adverse effect**
24-hour NO_2	26.5	141.2	+114.7	**adverse effect**
Annual NO_2	6.8	18.5	+11.7	**adverse effect**
1-hour SO_2	318.9	318.9	0	no adverse effect
24-hour SO_2	51.3	51.3	0	no adverse effect
Annual SO_2	5.0	5.0	0	no adverse effect
1-hour CO	1,580.6	2,504.2	+923.6	**adverse effect**
8-hour CO	1,201.8	1,595.7	+393.9	**adverse effect**
24-hour SPM	71.0	276.9	+205.9	**adverse effect**
Annual SPM	25.1	30.7	+5.6	**adverse effect**
24-hour PM_{10}	26.0	75.3	+49.3	**adverse effect**
24-hour $PM_{2.5}$	15.4	45.7	+30.3	**adverse effect**

The table shows that the DGR Project will result in increases for most of the indicator compounds, however, only the 24-hour SPM, 24-hour PM_{10} and 24-hour $PM_{2.5}$ concentrations were predicted to exceed the criteria. The frequency with which the SPM, PM_{10} and $PM_{2.5}$ criteria were exceeded is described on page 7-110 of the EIS as being less than 0.5% of the time (9 days where 24-hour concentrations were predicted to exceed the criteria out of the five years of daily predictions).

The predicted concentrations used in the air quality assessment for the operations phase were presented in Table 7.7.2-5 of the EIS, reproduced below. None of the predicted concentrations exceed the relevant criteria.

IR#	EIS Guidelines Section	Information Request and Response

Table 7.7.2-5: Operations Phase Adverse Effects to Air Quality in the Local Study Area

Indicator Compound	Maximum Existing Concentrations (µg/m³) in Local Study Area	Maximum Operations Phase Concentrations (µg/m³) in Local Study Area	Increase Over Existing Concentrations (µg/m³) in Local Study Area	Likely Adverse Effect?
1-hour NO_2	110.4	151.6	+41.2	**adverse effect**
24-hour NO_2	26.5	67.8	+41.3	**adverse effect**
Annual NO_2	6.8	7.6	+0.8	**adverse effect**
1-hour SO_2	318.9	318.9	0	no adverse effect
24-hour SO_2	51.3	51.3	0	no adverse effect
Annual SO_2	5.0	5.0	0	no adverse effect
1-hour CO	1,580.6	1,597.8	+17.2	**adverse effect**
8-hour CO	1,201.8	1,202.3	+0.5	**adverse effect**
24-hour SPM	71.0	71.5	+0.5	**adverse effect**
Annual SPM	25.1	25.1	0	no adverse effect
24-hour PM_{10}	26.0	26.9	+0.9	**adverse effect**
24-hour $PM_{2.5}$	15.4	15.9	+0.5	**adverse effect**

Table 7.4.2-1 (reproduced below) referred to in the rationale of the Information Request does not present air quality predictions that were used in assessing the effects of the DGR Project on air quality; rather, the table presents predicted air concentrations at selected ecological receptor locations within the Bruce nuclear site (including predictions in the Project Area). The text on page 7-59 of the EIS indicates that the 1-hour NO_2 predictions during the site preparation and construction phase at ecological receptors within the Bruce nuclear site would exceed the effects threshold for vegetation of 400 µg/m³ less than 1% of the time. The frequency of exceedance was calculated by counting the number of hours where concentrations at the ecological receptors were predicted to exceed 400 µg/m³ (<438 hours) by the number of hours modelled (43,824 hours). In a similar manner, the 24-hour SPM concentrations were predicted to exceed the ecological threshold of 120 µg/m³ less than 5.5% of the time. The frequency of exceedance was calculated by counting the number of days where concentrations at the ecological receptors were predicted to exceed 120 µg/m³ (<100 days) by the number of days modelled (1,826 days).

IR#	EIS Guidelines Section	Information Request and Response

Table 7.4.2-1: Maximum Predicted Concentration at Ecological Receptors During the Site Preparation and Construction Phase

Indicator	Maximum Existing Concentrations ($\mu g/m^3$)	Maximum Site Preparation and Construction Phase and Concentrations ($\mu g/m^3$)	Maximum Operations Phase Concentrations ($\mu g/m^3$)	Criteria ($\mu g/m^3$)
1-hour NO_2	81.6	499.5	184.0	400[a]
24-hour NO_s	22.9	154.1	96.8	200[a]
Annual NO_s	7.1	32.6	11.1	100[a]
24-hour SO_s	40.5	40.6	40.5	150[a]
Annual SO_2	5.7	5.8	5.8	30[a]
24-hour SPM	63.3	182.5[d]	63.5	120[a,b,c]
Annual SPM	25.0	46.5	25.1	70[a]

Notes:
a National Ambient Air Quality Objectives
b O.Reg. 419 Schedule 3
c Exceeds the criteria less than 1% of the time
d Exceeds the SPM criteria less than 5.5% of the time
Source: Appendix J, Table J1.1.1-1 of the Atmospheric Environment TSD

Concentrations predicted to exceed criteria used for evaluating effects on ecological receptors should not be construed as representing exceedances of air quality criteria in the receiving environment as the ecological receptors are located within the Bruce nuclear site, including the Project Area. Predictions for use and comparison to environmental criteria for air quality to determine compliance and air quality effects were presented in Section 7.7, as detailed above.

EIS-01-14

- EIS Guidelines: Section 10, Existing Environment

Information Request:

Provide summarized quantitative fish and fish community data in the site study area especially in Stream C, south and north railway ditch, from 2007 fish survey and any other historical fish studies.

Context:

In order to properly assess effects, sufficient information on the baseline environment is needed. Section 10 of the EIS Guidelines requires the proponent to summarize all pertinent historical information on the size and geographic extent of animal populations as well as density. This information is lacking for fish species and communities from the documentation submitted to date.

IR#	EIS Guidelines Section	Information Request and Response
		OPG Response: The North Railway Ditch is dry much of the year and does not support a fish population; thus it was not surveyed for fish species or communities. The South Railway Ditch has some standing pools that are wet and supports a warm water fish population. The Aquatic Environment Technical Support Document (Golder 2011) Tables C-1 through C-3 provide quantitative results of the fish surveys conducted in 2007 in MacPherson Bay and the South Railway Ditch. Section 5.3.2.4 of the Aquatic Environment Technical Support Document (Golder 2011) summarizes the results of fish surveys completed in 2007 in Stream C (specifically in the pools located immediately downstream of the railway line [Reach B] and upstream of the Bruce A access road [Reach C]). The table below provides a summary of the results of this survey.

Total Catch (Number by species) by Electrofishing Event at Pools in Reaches B and C (Stream C), 2007 (Golder 2007)

Species	Upper Pool (N=45)	Lower Pool; Bruce A Access Road (N=70)
Common white sucker	7	2
Spottail shiner	2	0
Pumpkinseed	2	0
Brook trout	0	6
Northern red belly dace	1	7
Rainbow darter	0	10
Creek chub	12	4
Central stoneroller	4	0
Central mudminnow	2	13
Brook stickleback	3	6
Brassy minnow	2	0
Bluntnose minnow	8	7
Blacknose dace	0	10
Banded killifish	2	5

In addition to the fish community sampling in 2007 in Stream C, there were electofishing surveys in 1981 and 1987-1989. Wismer (1999) reports that 27 species of fish were captured in Stream C during the electrofishing surveys of these years. The results from all fish surveys between 1961 and 1993 are grouped in the table in Appendix C (Wismer 1999) and the 27 species captured in Stream C are not differentiated.

IR#	EIS Guidelines Section	Information Request and Response
		During the fall of 2000, fish species observations in all reaches of Stream C within the Bruce nuclear site perimeter fence were made and the following species were recorded through casual observations: rainbow trout parr (*Oncorhychus mykiss*), white sucker (*Catostomus commersoni*), hog sucker (*Hypentelium nigricans*), blacknose dace (*Rhinichthys atratulus*) and creek chub (*Semotilus atromaculatus*) (LGL 2002). **References:** Golder Associates Ltd. 2007. Bruce New Nuclear Power Plant Project Environmental Assessment, Aquatic Environment Technical Support Document. Table 4.2.2.3.4. Golder Associates Ltd. 2011. Aquatic Environment Technical Support Document. Golder Associates Ltd. report for the Nuclear Waste Management Organization NWMO DGR-TR-2011-01 R000. Toronto, Canada. LGL. 2002. Bruce Nuclear Power Development Bioinventory Study. Wismer, D.A. 1999. Bruce Nuclear Site Biodiversity and Natural Areas Management Plan. Ontario Power Generation document B-PLAN-07811-00001-R00. Toronto, Canada.
EIS-01-15	▪ EIS Guidelines: Section 10, Existing Environment; Section 11 Effects Prediction, Mitigation Measures and Significance of Residual Effects	***Information Request:*** *Describe any aquatic species of natural conservation status within the site study area and include an assessment of the likely environmental effects of the project on these species.* ***Context:*** *The EIS Guidelines direct the proponent to identify any biological species of natural conservation status (e.g., rare, vulnerable, endangered, threatened, and uncommon) at a federal, provincial, regional or local level and their critical habitats; and to describe the effects of the project on these species.* *The proponent has not provided any information on aquatic species of natural conservation status in the documentation submitted to date.*
		OPG Response: There are no aquatic species considered to be at risk (endangered, threatened, special concern), federally and/or provincially recorded utilizing the habitats within the Project Area. Natural Heritage Information Centre (NHIC) records do not indicate element occurrence records for fish or mussel species at risk in the Site or Local Study Area. However, the Fisheries and Oceans Canada (DFO) Aquatic Species at Risk mapping developed as a geo-referenced distribution database for Ontario fishes and mussels, with emphasis on species at risk, indicates the potential for habitat of three species that are listed federally by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and/or provincially by Ministry of Natural Resources (MNR) Committee of the Status of Species at Risk in Ontario (COSSARO). These species are:

IR#	EIS Guidelines Section	Information Request and Response
		• American eel (*Anguilla rostrata*) designated as special concern federally and endangered provincially; • Silver shiner (*Notropis photogenis*) designated as threatened federally and special concern provincially; and • Northern brook lamprey (*Ichthyomyzon fossor*) special concern both federally and provincially. The DFO mapping is based on range maps and available landscape level mapping data and not necessarily site specific habitat data or fish community data. Therefore, this mapping needs to be related back to the Site Study Area. As American eel have a catadromous life strategy (breed in the Atlantic Ocean), it is unlikely that Lake Erie and the upper Great Lakes formed part of the historic range, given the formidable obstacle posed by Niagara Falls (MacGregor et al. 2010). Silver shiner inhabits deep runs, riffles and pools of relatively clear, medium to large streams with swift currents over variable (clay to boulder) substrates which may occur in the Site and Local Study Area. Northern brook lamprey inhabits clean, clear riffles and runs of small rivers with gravel and sand substrates and their ammocoetes (larvae) occupy quiet water with sand, silt and detritus substrates. These types of habitat also occur within the Site and Local Study Areas. The surface runoff from the DGR site that currently drains towards natural streams will be diverted through a stormwater management pond and drainage ditch to MacPherson Bay. This will be a 0.8% decrease in flow predicted for Stream C. Therefore, it is not anticipated that the DGR Project will have an effect on the designated species noted above. In addition to the above, OPG is aware that two reptile species found in aquatic habitats within Bruce County are considered to be at risk (endangered, threatened, special concern). Based on a review of the Natural Heritage Information Centre (NHIC) database two sensitive species found in the local study area are spotted turtle (*Clemmys guttata*) and snapping turtle (*Chelydra serpentina*). Spotted turtle is listed both provincially and federally as an "endangered species". This status designation was determined because spotted turtle occurs at low density, has an unusually low reproductive potential, and occurs in small numbers in bogs and marshes that are fragmented and disappearing. Further, there is a clear threat to population persistence from collection for the pet trade. Snapping turtle is designated Special Concern under the Species At Risk Act in 2008; however, in Ontario, snapping turtles may be hunted with a license or captured and/or killed if a person believes it is damaging the person's property. This is regulated under the Ministry of Natural Resources fishing license program. In order to reduce the risk of collection for the pet trade to spotted turtles documented in the Project study areas, the EIS excludes any specific reference to species locations. **References:** MacGregor, R., J. Casselman, L. Greig, W. A. Allen, L. McDermott and T. Haxton. 2010. DRAFT Recovery Strategy for the American Eel (Anguilla rostrata) in Ontario. Ontario Recovery Strategy Series. Prepared for Ontario Ministry of Natural Resources. Peterborough, Ontario.

<table>
<tr><th>IR#</th><th>EIS Guidelines Section</th><th>Information Request and Response</th></tr>
<tr><td rowspan="2">EIS-01-16</td><td rowspan="2">EIS Guidelines: Section 13.2, Selection of Assessment Scenarios</td><td>Information Request:
Provide an assessment of how the Lake Huron coastal line would migrate in relation to the DGR site due to geomorphologic changes in the future (e.g. before the next glaciation arrives) and how the coastal line change would impact on the DGR, during the Normal Evolution Scenario.
Context:
In accordance with section 13.2 of the EIS Guidelines, “Long term assessment scenarios should be sufficiently comprehensive to account for all of the potential future states of the site and the environment.”
Geomorphologic studies (e.g., Lewis et al, 2008) have shown that the coastal line of Lake Huron has been going through constant geomorphologic changes in the past 10,000 or so years. It is essential to have an understanding on how the trend will continue, even before the next glaciation arrives. The effect of the change on the DGR project needs to be considered in the Normal Evolution Scenario, given that this scenario represents the most likely long-term outlook.</td></tr>
<tr><td>OPG Response:
The response is provided in two parts, a discussion of shoreline evolution processes and a discussion of impacts on the DGR safety assessment results.
<u>1. Shoreline evolution</u>
Presently the DGR surface facilities are approximately 1 km inland and 10 m above the Lake Huron shoreline. There are a number of factors that will influence the evolution of the shoreline.
Erosion - Erosion of shoreline is not expected to be significant in the near term (hundreds of years) since the Lake Huron shoreline fronting the Bruce nuclear site consists of either beaches armoured with cobbles and boulders or exposed bedrock (AMEC 2011, Section 3.3.7).
Global warming - The effect of global climate change on the lake level is not certain. Based on several recent projections, the range in lake level is 0.5 m rise to a 1.5 m fall in the next 50-100 years (AMEC 2011, p.46). These would cause the shoreline to move slightly farther away or slightly closer towards the DGR site.
Glacial rebound - The weight of the ice during the previous glaciation caused continental-scale crustal depression (Peltier 2011, Section 4.2.5). After the ice sheet melted, the crust has been slowly rebounding, with the rate decreasing with time. In the Great Lakes region, the rebound rate is about 1.5 mm/yr (NWMO 2011, Section 2.2.7.1). The rate is slightly higher to the north, so that the northern part of Lake Huron (e.g., Georgian Bay) is rising slightly faster than southern Lake Huron (e.g., Lake St. Clair area). This could move the shoreline away from the site over thousands of years.</td></tr>
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IR#	EIS Guidelines Section	Information Request and Response
		• Climate change (glacial cycles) - The historical record indicates that there have been large fluctuations (approximately +/- 50 m) in the Great Lakes' water levels in the last 10,000 years as the ice sheet retreated, due to natural climate changes (including an early Holocene dry climate), the extent of ice sheet coverage, and glacial depression of the land (Lewis et al. 2008, Slattery 2011). As illustrated in Figure 2.7 from Slattery (2011) (provided at the end of the responses to EIS IRs), these changes have led to a range of lake shorelines, from several kilometres distance from the site, to the site being fully covered. If glaciation resumes in the longer term (tens of thousands of years), the lake shoreline would initially move away from the DGR site as the climate became cooler and drier. Eventually it would be covered by an ice sheet, land or water as the ice sheet advanced or retreated across the site. Peltier (2011, Section 4.2.4) provides estimates of lake depth at the repository site over the course of a glacial cycle. <u>2. Influence of lake shoreline changes on DGR safety assessment</u> The postclosure impacts for the Normal Evolution and Disruptive Scenarios are primarily based on an assumed self-sufficient farming family living on top of the repository site, and extracting water from a well located downstream from the repository. This family obtains fish from the near-shore region of the lake. In the model, the shallow groundwater system (Bass Island Formation and above) discharges into the near-shore of the lake after a transit of about 1 km, the current horizontal distance to the shoreline. This is less than the likely distance at which these formations intercept the lake bottom, but this maximizes potential dose as there is less dilution in the near-shore region. If the shoreline were further away, the well-based receptor exposure model would still apply. The reference 1-km transport assumption for shallow groundwater-to-lake would become more conservative. There would be little effect on calculated doses as the lake water exposure is a minor pathway compared with the well water pathway. If the shoreline were much closer to the site, the family would be more likely to extract water from the lake rather than the well. Contaminants would be dispersed within the lake and would have overall more dilution relative to the reference farmer model using a well. This would result in a lower dose than presently calculated. If the repository site was fully covered by the lake, there would be no possibility of living on top of the repository. Contaminants would also be dispersed within the lake and would have overall more dilution relative to the reference self-sufficient farmer model. In this circumstance the dose consequence would be lower than calculated for the reference case. The assessment also considers a future periglacial (cold) climate state associated with glacial cycles. In this case, the shoreline is assumed to be some distance from the site, with groundwater discharge into a nearby stream. The receptor in this case still uses a well for domestic water and some garden crops, but uses less irrigation water as the climate is not suitable for general agriculture. Fish are obtained from the local stream, as well as the lake. This alternative climate state results in about 3-4 time higher dose than those calculated

IR#	EIS Guidelines Section	Information Request and Response
		from the reference case temperate biosphere, but it remains many orders of magnitude smaller than the dose criterion (Quintessa et al. 2011, Section 7.3.2.11). Therefore, the receptor model for assessing impacts is appropriate and sufficiently conservative to account for changes in the lake shoreline relative to the DGR site. **References:** AMEC NSS. 2011. Maximum Flood Hazard Assessment. AMEC NSS Ltd. report for the Nuclear Waste Management Organization NWMO DGR-TR-2011-35 R000. Toronto, Canada. Lewis, C.F.M, P. Karrow, S. Blasco, F. McCarthy, J. King, T. Moore and D. Rea. 2008. Evolution of lakes in the Huron basin: deglaciation to present. J. Aquatic Ecosystem Health & Management 11(2), 127-136. NWMO. 2011. Geosynthesis. Nuclear Waste Management Organization report NWMO DGR-TR-2011-11 R000. Toronto, Canada. Peltier, W. 2011. Long-Term Climate Change. Nuclear Waste Management Organization report NWMO DGR-TR-2011-14 R000. Toronto, Canada. (available at www.nwmo.ca/dgrgeoscientificsitecharacterization) Quintessa, Geofirma and SENES. 2011. Postclosure Safety Assessment. Quintessa Ltd., Geofirma Engineering Ltd. and SENES Consultants Ltd. report for the Nuclear Waste Management Organization NWMO DGR-TR-2011-25 R000. Toronto, Canada. Slattery, S. 2011. Neotectonics Features and Landforms Assessment. Nuclear Waste Management Organization report NWMO DGR-TR-2011-19 R000. Toronto, Canada. (available at www.nwmo.ca/dgrgeoscientificsitecharacterization)
EIS-01-17	▪ EIS Guidelines: Section 13.2, Selection of Assessment Scenarios	***Information Request:*** *Assess the impact of future glaciation cycles on the groundwater regime with the presence of the repository, shafts, seals and associated zones disturbed through excavation.* ***Context:*** *The EIS Guidelines, section 13.2, requires that the anticipated evolution of the repository has to be supported by a combination of expert judgement, field data, and also mathematical models. Glaciation cycles are expected to occur during the lifetime of the DGR, and mathematical modelling should be performed to assess their impact on the flow regimes around the repository, and verify that contaminant transport would remain diffusion-dominant. Currently, the proponent concludes that the effects of glaciations at the depth of the repository would be unimportant based on arguments derived from field data and mathematical modeling. However the above arguments are applicable for the geosphere without the presence of the deep geological repository.*

IR#	EIS Guidelines Section	Information Request and Response
		OPG Response: The potential effects of glaciation on the repository are assessed through various analyses within the Geosynthesis (NWMO 2011) and Postclosure Safety Assessment (SA) (Quintessa et al. 2011). The key results are: • *Evidence gathered during site specific investigations with respect to physical and chemical hydrogeology strongly suggests that solute migration within the proposed hosting and enclosing Ordovician formations is diffusion controlled.* This condition has likely existed for geologic periods of time that extend beyond the Quaternary (2.53 Ma), during the latter half of which the site was perturbed by nine glacial cycles (Geosynthesis, Sections 4.5 and 5.4.10). • *Geomechanical numerical simulation (Geosynthesis; sections 6.4.4 and 6.4.5) provides evidence that the DGR shaft Excavation Damaged Zone (EDZ) and seals are not materially influenced by glacial loading (Geosynthesis Section 6.4.3.4).* As a conservatism in the postclosure SA, the EDZ geometry along the entire shaft was assumed consistent with worst case (maximum extent) predicted in the Cabot Head Formation (Geosynthesis, Figure 6.17). • *Geomechanical numerical simulation (Geosynthesis, Section 6.4.6) of the unbackfilled repository openings indicate that the vertical displacement due to glacial loading are sufficiently small such that fracturing of the overlying Ordovician shale cap is unlikely to occur.* All damage remains confined within the host Cobourg Formation. The postclosure SA model assumed the maximum extent of rockfall from the geomechanical models, and assumed that this rockfall occurred immediately after closure. • *Paleohydrogeologic simulations of ice-sheet advance and retreat across the Bruce site strongly suggest that the deep groundwater system, as it exists today, is materially unaffected and that the system remained diffusion dominant (Geosynthesis, Section 5.4.6 and 5.4.10).* • *Postclosure safety modelling of the effects of various assumptions about the behaviour of the repository with degraded shaft seals showed that relevant criteria were not exceeded.* The cases considered included instant resaturation of the repository (NE-RS), higher permeable shaft EDZ (NE-EDZ1), and failed shaft seals (SF-BC). In all cases, the degraded conditions were assumed to occur at closure. The potential damage to the repository or shafts due to glacial loads would be represented by these cases, but would occur much later in time. In the Normal Evolution (NE) cases, the maximum calculated dose remained many orders of magnitude below the dose criterion (Section 8.8.2.11, PSR). In the Shaft Seal Failure base case (SF-BC), the peak dose to a person living directly above a repository shaft was estimated at about 1 mSv/yr, assuming the shaft seals were degraded at closure (Section 8.7.2, PSR). If the shafts failed as a result of glaciation, then the dose would be less due to decay - in particular, for failure due to ice sheet coverage of the site in 60,000 years,

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		radioactive decay of C-14 would reduce this dose by at least two orders of magnitude. • *The postclosure safety assessment considered the effects of removing 100-m of surface rock due to glacial erosion.* This case was modelled by assuming that there was no Shallow Bedrock Groundwater Zone, and all of the radionuclide flux from the Intermediate Bedrock Groundwater Zone was intercepted by a well used by a self-sufficient family living at the site in the future. The case results in an approximate two order of magnitude increase in the maximum calculated dose compared with the Reference Case, but still remains many orders of magnitude below the dose criterion (Section 8.8.2.11, PSR). These results, presented in the PSR and further documented in the Geosynthesis and Postclosure Safety Assessment, provided evidence that the natural barriers and proposed DGR concept would provide long-term passive isolation and containment of the waste even under glacial cycling conditions. Subsequent to the submission of the PSR, additional calculations have been performed. As per the Information Request, these explicitly include the effect of glaciation on groundwater and gas transport in and around the repository, including the presence of the repository, the shaft, seals and EDZ. The results from these calculations show that the effect on groundwater flow and gas transport around the repository due to glaciation are minimal. Details are given in the enclosed NWMO document (NWMO 2012). **References:** NWMO. 2011. Geosynthesis. Nuclear Waste Management Organization report NWMO DGR-TR-2011-11 R000. Toronto, Canada. NWMO. 2012. OPG DGR: Glaciation Analysis. NWMO Technical Memorandum DGR-TM-03640. Toronto, Canada. (enclosed) Quintessa, Geofirma and SENES. 2011. Postclosure Safety Assessment Report. Quintessa Ltd., Geofirma Engineering Ltd. and SENES Consultants Ltd. report for the Nuclear Waste Management Organization NWMO DGR-TR-2011-25 R000. Toronto, Canada.
EIS-01-18	▪ EIS Guidelines: Section 13.4, Confidence in Mathematical Models ▪ CNSC Regulatory Guide G-320:	***Information Request:*** *Provide peer review summaries from the Geoscience Review Group, the Design Technical Review Group, and the International Review Group for Safety Assessment. These summaries should contain the overall conclusions of the Review Groups, their recommendations, and a description of how the proponents addressed those recommendations.* ***Context:*** *Peer review is an important process in building confidence in the safety assessment and the safety case, as mentioned in both the EIS Guidelines and in CNSC Regulatory Guide G-320. Although the proponent mentioned peer review by the Geoscience Review Group, the Design Technical Review Group, and the*

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	Section 4.3.3	*International Review Group for Safety Assessment, no summaries from the above groups regarding their main findings have been submitted; nor is any information provided on how the proponent considered the findings.*
		OPG Response: The final reports containing the overall conclusions, comments, and recommendations of the independent review groups, as well as the responses to their comments and recommendations are enclosed as follows: **Geoscience Review Group**: • Final Report: GRG Letter, Delay, J., A. Gautschi, D. Martin and F.J. Pearson to M. Jensen, "Final Report on Activities of Geoscience Review Group" (with attachment: Site Characterization for a Bruce Nuclear Site DGR Final Report on 2005 - 2010 Activities), April 22, 2011. • DGR Project Response: NWMO Letter, M. Jensen to F.J. Pearson, "Ontario Power Generation's Deep Geologic Repository for Low & Intermediate Level Waste - Geoscience Review Group's Final Report on Activities 2011", November 4, 2011. **Technical Review Group**: • Final Reports: Medd, M., B. Smyth, W. Seidler, E. Hoek and P. Tiley. 2009. TRG Review of Preliminary Engineering Phase I, Deep Geological Repository Project. Medd, M., B. Smyth, E. Hoek, D. Martin and P. Tiley. 2010. TRG Review of Preliminary Engineering Phase I, Deep Geological Repository Project. • DGR Project Disposition: NWMO. 2012. OPG DGR: TRG Reviews of Preliminary Design for Deep Geologic Repository – Documentation of Comment Resolution. NWMO Technical Memorandum DGR-TM-01530. **International Peer Review Team**: • Final Report: Hickford, G., P. De Preter, P. Smith and J. Talandier. 2010. OPG's Deep Geologic Repository for Low & Intermediate Level Waste: Postclosure Safety Assessment. International Peer Review Report.

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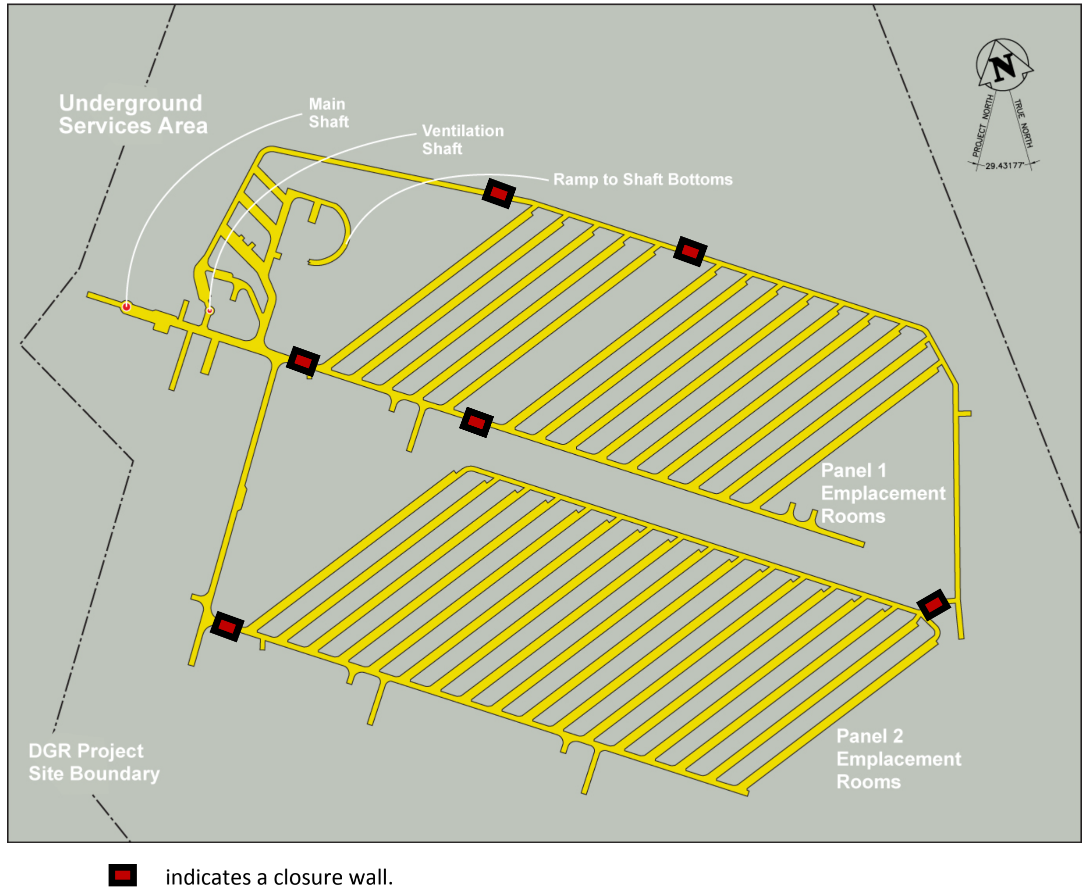
		• <u>DGR Project Response</u>: NWMO Letter, P. Gierszewski to P. De Preter, M. Kelly/G. Hickford, P. Smith and J. Talandier, "Peer Review of the OPG DGR Postclosure Safety Assessment", October 25, 2011.
EIS-01-19	▪ EIS Guidelines: Section 13, Long-Term Safety of the DGR	***Information Request:*** *Assess the implication of the reduced volume and discontinuous nature of the repository created by the access tunnel closure walls on gas generation and migration.* *Demonstrate that the model assumption of waste homogeneity and uniform distribution across the panel, and subsequent application of repository averaged values for gas impact and transport modelling, captures effects of localized pressures and concentrations that may develop as a result of uneven waste distribution (along with reduced/restricted volumes created by access tunnels).* ***Context:*** *Gas generation and transport modelling is used to evaluate source term pressures and concentrations that influence contaminant migration in and around the repository mainly for post-closure safety assessment. The gas generation model does not take into account the presence of closure walls in the repository that will serve as a barrier to gas flow; the repository has been modelled as a contiguous void space. The Post Closure Safety Assessment indicates that the purpose of the closure walls, which consist of thick concrete walls to be placed in the access tunnels (up to six walls may be required), is to isolate parts of the repository to limit the release of gases and any potentially contaminated water during the operational period; they are not designed to provide any long-term postclosure isolation and containment.* *The gas modelling also does not take into account spatial differences in waste composition; the model assumes that the waste composition is spatially homogeneous.* *The post-closure safety assessment needs to assess the impact of access barriers on gas generation and migration. The analysis should also demonstrate that the repository averaged values used for gas modelling and impact effectively capture elevated pressures or concentrations that may develop from spatial differences in waste composition and/or reduced volumes.*
		OPG Response: <u>1. Background</u> The DGR design calls for construction of six closure walls in the access tunnels and ventilation drifts to isolate a group of emplacement rooms during the operations (see Figure 1 below): • Panel 1a Rooms 1 to 5 • Panel 1b Rooms 6 to 14 • Panel 2 Rooms 1 to 17.

IR#	EIS Guidelines Section	Information Request and Response
		 **Figure 1: Proposed Locations of the Closure Walls in DGR** Although the physical/chemical barrier presented by the closure walls is not represented in the postclosure gas generation and migration models (Geofirma and Quintessa 2011, Quintessa et al. 2011), the closure wall volume has been taken into account when calculating the overall volume of the repository and the amount of concrete and steel in the repository that is used in the postclosure gas calculations (see Tables 4.5, 4.8 and 4.9 of Quintessa and Geofirma 2011).

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		The wastes are separated into three panels by concrete closure walls. Once installed, these walls are designed to be tight during the preclosure operating phase. However, in the postclosure safety assessment, concrete walls are assumed to degrade in the long term. Consequently, these closure walls do not represent a significant long-term barrier to gas or water movement within the repository. In addition, the surrounding more permeable damaged rock zone (see Section 5.2 of Quintessa and Geofirma 2011) would allow the closure walls to be by-passed (these may be grouted at the closure wall locations, but would still be more permeable than the far-field rock). (The emplacement rooms may have end walls, but are not fully closed.) Consequently, gas can diffuse freely across the repository in the postclosure gas generation and migration model. Ignoring the panel closure walls is conservative with respect to long-term contaminant transport as it allows contaminants to reach the shaft bases more easily. This is relevant since the (sealed) shafts are the main pathway for contaminants to leave the repository. Ignoring the panel closure walls is also conservative because it allows any water that migrates down the shafts to directly reach the wastes and support degradation and radionuclide release. However, if the closure walls were to remain gas tight in the long term (i.e., beyond several decades), they would separate the repository into different domains of waste and available void volume. These differences could in principle lead to higher gas pressures in a panel with more gas-generating wastes per available void volume than in an undivided repository, if the rock damaged zone does not allow effective by-passing of the walls. This potential has been assessed and shown not to be a concern. The assessment is described below. First, it is assumed that the panel closure walls remain gas tight indefinitely, and simple analytical models are used to estimate the peak gas pressures in each of the three panels, taking into account the reference waste distribution between the panels and the panel volumes. This provides a bound on the potential heterogeneity effect. Second, the rate of gas permeation across the concrete walls is calculated as a function of gas pressure, and compared with the gas generation rate from waste degradation. It is shown that this gas permeation rate is sufficient to maintain pressure differences between panels within modest ranges. <u>2. Estimated Peak Gas Pressures in Panels Isolated by Closure Walls</u> Simple calculations, similar to Appendix B.1 of Geofirma and Quintessa (2011), were performed to estimate the peak gas pressure in repository sections, which are separated by closure walls. Calculations are presented in Table 1 for two gas generation cases: anaerobic corrosion and degradation with methanogenic reactions, and corrosion only with no microbial activity. In both cases, sufficient water is assumed available to support the reactions.

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Table 1: Estimated Peak Gas Pressure for Preliminary Design for Rooms Isolated by Closure Walls

Panel	Peak Gas Pressure (MPa)	
	Anaerobic Corrosion & Degradation with Methanogenic Reaction	**No Microbial Activity - Corrosion Only**
Panel 1a, Rooms 1 to 5	5.8	8.3
Panel 1b, Rooms 6 to 14	5.5	8.7
Panel 2 , Rooms 1 to 17	9.3	9.4
Panel 1 & 2 connected	6.9	8.6

Table 1 shows that the peak gas pressure is higher in Panel 2 when isolated by gas-tight closure walls, than compared to a homogenized repository. This is because of the uneven waste distribution in the repository.

The gas generating potentials for isolated repository sections are given in Table 2. Panel 2 has the highest gas generating potential, because it contains most of the LLW, which have more cellulose, plastics/rubbers and metals, and metal containers. These gas generation rates are the maximum rates.

Table 2: Maximum Gas Generation Rates for Isolated Sections of the DGR

	Gas Generation Rate (Molar Basis)	Gas Generation Rate (Mass Basis)
Panel 1a Rooms 1 to 5	1.7E-03 mol/s	1.5E-05 kg/s
Panel 1b Rooms 6 to 14	2.6E-03 mol/s	3.8E-05 kg/s
Panel 2 Rooms 1 to 17	9.7E-03 mol/s	1.5E-04 kg/s

3. Estimated Gas Flow Rates through Closure Walls

As illustrated by Table 1, if the closure walls are fully gas tight, there would be some differential gas pressure produced in different panels. This pressure difference would lead to gas permeation through the closure walls and the surrounding excavation damaged zone and near-field rock. In the following analysis, the rate of gas permeation through the concrete closure wall alone is calculated as a function of differential gas pressure and concrete permeability. (Gas permeation rate would be significantly higher including the damaged rock zone and the surrounding host rock.) This permeation rate is then compared with the maximum gas generation rates from Table 2, to estimate the maximum pressure difference that could be maintained by intact closure walls.

For the Normal Evolution Scenario Reference Case, and most other cases analysed, the repository is essentially dry for the assessment time frame (and in particular for the shorter period relevant to C-14 in gas). Therefore, the gas flow through the closure wall is analysed as single (gas) phase. For the estimate below, the properties of methane gas were used as this is expected to be the dominant gas at long timeframes.

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		When the gas entry pressure through the concrete is exceeded, gas can then flow through the closure wall. Depending on the type and condition of concrete, the gas entry pressure through concrete varies from few tens of kPa to 5 MPa (Table 4.29 of Quintessa and Geofirma 2011 using $1/\alpha$). To estimate the mass flow of gas through the closure wall, the 1-D Darcy flow equation can be written as (Section B.2 of Geofirma and Quintessa 2011): $$Q_{gas} = \frac{m_{gas}P}{RT}\frac{k}{\mu}k_{rg}A\frac{dP}{dl} \quad (1)$$ where Q_{gas} = gas flow (kg/s) m_{gas} = molar weight of gas (kg/mol) P = average gas pressure on the both sides of the closure wall (Pa) dP = gas pressure difference between both sides of the closure wall (Pa) dl = thickness of the closure wall (m) T = temperature (K) k = intrinsic permeability (m^2) k_{rg} = relative gas permeability (-) μ = gas viscosity (Pa s) A = flow area (m^2) R = gas constant (J/(K mol)) k_{rg} is calculated from the following equations (Section 4.7 of Quintessa and Geofirma 2011): $$k_{rg} = (1 - S_{ek})^{1/3}\left[1 - S_{ek}^{1/m}\right]^{2m} \quad (2)$$ $$S_{ek} = \frac{S_l - S_{lr}}{1 - S_{lr} - S_{gr}} \quad (3)$$ where S_l = liquid saturation (volume ratio) S_{lr} = residual liquid saturation (volume ratio) S_{gr} = residual gas saturation (volume ratio) m = a van Genuchten fitting parameter (unitless)

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		S_{lr} , S_{gr}, and m are taken to be 0.2, 0.1 and 0.5 respectively (Table 4.28 of Quintessa and Geofirma 2011). With initial water saturation of 0.5 in concrete (Section 4.7.5 of Quintessa and Geofirma 2011), k_{rg} is estimated to be 0.68. Values used in the calculations are given in Table 3. The key parameters are intrinsic permeability, relative gas permeability, surface area of the concrete closure wall, thickness of the closure wall, the pressure difference and average gas pressure. The permeability values were based on undegraded and degraded structural concrete hydraulic conductivity of $1x10^{-10}$ and $1x10^{-8}$ m/s respectively (Table 4.22 of Quintessa and Geofirma 2011). The estimated mass gas flow through the concrete walls is given in Table 4 for a range of average gas pressure and pressure difference for undegraded and degraded concrete walls. These rates can be compared to the gas generation rates (Table 2) to see how strongly the closure walls impede gas flow. Due to the higher LLW inventory in Panel 2, it is expected that gas generation will be higher in this panel. The results indicate that closure walls would allow sufficient gas flow out from this panel such that the pressure difference would not exceed about 1 MPa across the closure walls at absolute gas pressures of around 5-8 MPa. This calculation also did not take into account the gas flow through the damaged rock zone around the concrete, which would further reduce the maximum pressure difference.

Table 3: Gas Flow Parameters through Concrete Closure Walls

Parameter	Value	Unit	Source
m_{gas}	0.016	kg/mol	molecular weight of methane
R	8.314472	J/(K mol)	
T	295	K	Table 6.8 of Quintessa et al. (2011)
k (undegraded)	1.2E-17	m^2	Based on hydraulic conductivity of undegraded and degraded structural concrete (Table 4.22 of Quintessa and Geofirma 2011). Hydraulic conductivity (m/s) is divided by a factor of 8.6E6 /m/s to obtain permeability (m^2).
k (degraded)	1.2E-15		
k_{rg}	0.68		See calculation above.
μ	1.12E-05	Pa s	methane CRC (1992)
A	60	m^2	Sum of cross-sectional area of the access tunnel and the return air drift (Table 4.3 of Quintessa and Geofirma 2011)
l	20	m	Figure 6-30 of the PSR

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Table 4: Estimated Gas Flow Rate through Concrete Closure Walls

Undegraded Concrete (Permeability of 1.2E-17 m^2):			
Pressure difference (MPa)	**Gas flow rate through the closure walls (m^3/s)**	**Average gas pressure (MPa)**	**Mass gas flow rate through the closure walls (kg/s)**
0.1	2.2E-07	8	1.1E-05
1	2.2E-06		1.1E-04
4	8.7E-06		4.6E-04
0.1	2.2E-07	5	7.1E-06
1	2.2E-06		7.1E-05
4	8.7E-06		2.9E-04
0.1	2.2E-07	1	1.4E-06
0.2	4.4E-07		2.9E-06
Degraded Concrete (Permeability of 1.2E-15 m^2):			
0.1	2.2E-05	8	1.1E-03
1	2.2E-04		1.1E-02
4	8.7E-04		4.6E-02
0.1	2.2E-05	5	7.1E-04
1	2.2E-04		7.1E-03
4	8.7E-04		2.9E-02
0.1	2.2E-05	1	1.4E-04
0.2	4.4E-05		2.9E-04

4. Conclusions

The impact of the closure walls on the gas transport and consequence was assessed. Localized gas pressures and concentrations could develop as a result of the uneven waste distribution and use of closure walls isolating the panels and minimizing the volume available for gas to that in each panel. In particular, a higher pressure could develop in Panel 2 because of its larger amount of LLW, assuming the closure walls are gas-tight and the rock damaged zone does not act as high permeability pathway.

However, the maximum pressure difference between panels would be limited by gas permeation across the closure walls. The 1-D Darcy flow equation was used to estimate the gas permeation rates through the closure walls between two panels due to a gas pressure difference. These gas permeation rates were

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		compared to the gas generation rates. The results show that even an undegraded closure wall would allow sufficient gas movement when the gas pressure on the higher pressure side reaches 5-8 MPa and the pressure difference is around 1 MPa across the closure walls. Higher differential pressures would not be possible; lower differential pressures are likely, taking into account some degradation of the concrete closure walls as well as the presence of the damaged rock zone. Therefore, considering the slow rates of gas generation, there would be sufficient gas permeation through and around the closure walls to homogenize the gas pressures across the repository over the thousands of years relevant to the buildup of gas pressure. **References:** CRC. 1992. CRC Handbook of Chemistry and Physics, 73rd edition, p.6-164. CRC Press, Ann Arbor, USA. Geofirma and Quintessa. 2011. Postclosure Safety Assessment: Gas Modelling. Geofirma Engineering Ltd. and Quintessa Ltd. report for the Nuclear Waste Management Organization NWMO DGR-TR-2011-31 R000. Toronto, Canada. (available at www.nwmo.ca/dgrpostclosuresafetyassessmentreports) Quintessa and Geofirma. 2011. Postclosure Safety Assessment: Data. Quintessa Ltd. and Geofirma Engineering Ltd. report for the Nuclear Waste Management Organization NWMO DGR-TR-2011-32 R000. Toronto, Canada. (available at www.nwmo.ca/dgrpostclosuresafetyassessmentreports) Quintessa, Geofirma and SENES. 2011. Postclosure Safety Assessment. Quintessa Ltd., Geofirma Engineering Ltd. and SENES Consultants Ltd. report for the Nuclear Waste Management Organization NWMO DGR-TR-2011-25 R000. Toronto, Canada.
EIS-01-20	▪ EIS Guidelines: Section 13, Long-Term Safety of the DGR ▪ CNSC Regulatory Guide G-320: Section 6.2.1	***Information Request:*** *Provide the degree of conservatism used in the scenarios considered in Postclosure Safety Assessment and Preliminary Safety Report, and supporting rationale.* ***Context:*** *It is not clear if the uncertainties and the necessary conservatism in the radionuclide inventory have been carried into the postclosure safety assessments and preliminary safety report. The documentation should provide reasonable assurance that the regulatory radiological dose limit for public exposure (currently 1 mSv/a) will not be exceeded.* *The uncertainties arising from direct measurements and the use of scaling factors, used fuel ratios and neutron activation calculations and from the apparent inconsistencies in the reported inventories have been highlighted in proposed IR #s 6 and 7.* *The Postclosure Safety Assessment includes scenario NE-IV, having 10 times the radionuclide inventory. This is intended to compensate for the uncertainty in estimating the radionuclide inventory, but it is not clear whether that is sufficient to compensate for the uncertainty in most estimates of radionuclide inventory, the*

IR#	EIS Guidelines Section	Information Request and Response
		inconsistencies in reporting the inventory estimates and the uncertainties in future generation rates. Further, it is not specified for the other scenarios, what degree of conservatism was used to account for uncertainty.
		OPG Response: First, as described in the responses to IR-EIS-01-05, IR-EIS-01-06, IR-EIS-01-07 and IR-EIS-01-08, there is a reasonable basis behind the inventory estimates. There is also further waste characterization underway which will improve on this basis. Second, it is emphasized that reasonable assurance that the dose limits are not exceeded, given the uncertainties in the assessment, is provided through the overall approach including consideration of both likely and unlikely scenarios, as well as various conservatisms in models and data. See Section 8.6.2.7 of the Preliminary Safety Report (PSR) for discussion of the calculation cases (especially Figure 8-15) and assumptions (Table 8-7). Important conservative assumptions in the Normal Evolution Scenario assessment are: • Containers are not credited for any barrier effectiveness. • Nutrients and microbes are assumed present in sufficient amounts to fully support waste degradation. The high salinity is not assumed to limit microbial activity within the repository. • Wastes are assumed to completely degrade so as to maximize the production of gas, which is an important potential C-14 release pathway. • In most calculations, sufficient water is assumed available to support degradation reactions, even if that is inconsistent with the calculated water supply rate. (Faster degradation means earlier radionuclide release and gas generation.) • Radionuclides are all released to gas or water. Subsequent incorporation of key radionuclides, in particular C-14 and Cl-36, into minerals within the repository concrete or the surrounding carbonate rock is not credited (some C-14 is incorporated into $FeCO_3$). • A permeable pathway is assumed to exist from the wastes to the base of the shaft, along the access tunnels and past the concrete monolith. • In many calculations, a vertically upwards steady hydraulic head gradient to surface is assumed to exist at the site (i.e., the measured Ordovician underpressure is ignored). • Impacts are calculated for a person assumed to be living directly on top of the repository in the future, growing local food and getting water from a local well. This maximizes the calculated impacts by several orders of magnitude compared to someone living off site. Other scenario-specific conservative assumptions are adopted for each Disruptive Scenario. These are summarized in the PSR, Section 8.7 with the discussion of each scenario. With respect to the radionuclide inventories in particular, the basis for these is described in the Reference Inventory report (OPG 2010) and summarized in Chapter 5 of the PSR. This is composed of information on

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		wastes presently stored at WWMF and projections for future wastes from the continued operation and refurbishment of the OPG-owned reactors. Confidence in this projection comes in part because about half of the wastes are already in storage at WWMF, and the waste generation rates are relatively predictable based on past history and planned refurbishments. The Reference Inventory report (OPG 2010) provides an estimate for the total DGR inventory of over 50 radionuclides with half-lives of about one year or longer that have been measured in the wastes. The reference inventory is a best-estimate. It is not specifically intended to be conservative, although some aspects are conservative. The DGR inventory is the sum of a large number (about 50,000) of waste packages, representing a range of different wastes. While there is significant variability in the radionuclide content between individual waste packages, there is much less uncertainty in the total inventory as it is the sum of thousands of individual packages. (Statistically, the Central Limit Theorem indicates that the uncertainty in the total inventory decreases as $1/N^{0.5}$ when the number of packages N is large.) It is this total inventory that is relevant to the postclosure safety assessment. Furthermore, as the postclosure safety analysis indicates, most of the radionuclides are negligible in terms of potential impact. The radionuclides with the largest potential for release and impact are C-14, Cl-36, Ni-59, Zr-93, Nb-94 and I-129. These radionuclides are reasonably well known - the basis for confidence in the values for these important radionuclides is provided in the response to IR-EIS-01-06. However the uncertainty all the radionuclide inventories has not been quantified at present. Therefore, the assessment has used the best-estimate reference inventory for most calculations. The results of case NE-IV (Section 8.8.2.2 and Figure 8-56, PSR) are important because they show that the peak dose rates are directly proportional to the radionuclide inventories - if all the inventories are 10 times higher than the reference inventory, the peak dose rate would increase by a factor of 10. If the inventories are higher or lower, the peak dose rate would change by a similar amount. While the exact inventory is uncertain, it is still possible to provide reasonable assurance that the radiological dose criteria will not be exceeded. This is based in part on the other conservatisms noted above, plus also the conclusion from the postclosure safety assessment. In particular, the likely impacts from the DGR (i.e., the Normal Evolution Scenario) are more than 6 orders of magnitude below the CNSC dose limits (Figure 8-56 of the PSR), and for the very unlikely Disruptive Scenarios, the risk remains well below the risk criteria. That is, there is a large safety margin. The uncertainty in the inventories in the important radionuclides is much less than this safety margin. During DGR operations, an updated current inventory of waste volume and total radioactivity stored at the DGR will be provided on a quarterly or annual basis, similar to the quarterly reports presently issued by the Western Waste Management Facility to the CNSC. Closure of the repository will require a future decommissioning licence, and will be based on knowledge of the actual wastes that had been received.

IR#	EIS Guidelines Section	Information Request and Response
		References: OPG. 2010. Reference Low and Intermediate Level Waste Inventory for the Deep Geologic Repository. Ontario Power Generation report 00216-REP-03902-00003-R003. Toronto, Canada.
EIS-01-21	▪ EIS Guidelines: Section 13, Long-Term Safety of the DGR ▪ CNSC Regulatory Guide G-320: Section 6.2.1	***Information Request:*** *Provide a detailed review of the international literature on expected microbial effects (features, events and processes) in gas generation and corrosion processes in a deep geological repository setting for low and intermediate level waste in order to assess the appropriateness of how microbial effects have been modeled and quantified for the DGR project.* ***Context:*** *Due to the presence of considerable organic matter in wastes, microbial processes will account for a significant proportion of the gas generation that will occur in the repository through both the degradation of organic matter and through enhanced corrosion of metals. For scenarios that could result in releases of contaminants to the surface environment within about 60,000 years of closure, C-14 (mostly from intermediate-level waste moderator resins) is the key radionuclide, largely generated from methane and carbon dioxide by microbial processes.* *A full understanding of microbial processes (known and possible) and confidence in the levels of conservatism incorporated into gas modeling is fundamental to the safety case.* *Presently, in the submitted documentation, there is very little data or review/discussion on microbes and their complex roles in gas generation and corrosion processes in a repository setting (e.g. Small et al. 2008). In the DGR site-specific context, there is only brief reference to the preliminary experiments of Stroess-Gascoyne (2008) in the documentation. The EIS recognizes the importance of microbial processes in modeling contaminant releases, but it fails to inform the reader of what has been discovered or inferred for analogous situations. For an example, see Humphreys et al. (2010). This major review was prepared for the Nuclear Decommissioning Authority in the United Kingdom for high level waste, but contains considerable information on geomicrobiology of general relevance to repository issues.* *The need for this type of information is critical in a site-specific context, given the location of the repository in sedimentary rocks, and the clear biogenic signature of microbial activity (methane and stable isotope signatures) near the proposed location of the repository (see section 4.4.3 in the Geosynthesis Report). These issues should be thoroughly discussed in the EIS, based on site-specific data and/or analogy and extrapolation from other situations.*
		OPG Response: An up-to-date review of the international literature on relevant microbial processes is provided in the enclosed

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		report (Humphreys 2011), which draws on recent international reviews in this area, such as Humphreys et al. (2010). Humphreys (2011) provides an update of the detailed description of the key microbial processes and their modelling within the DGR, as provided in the Postclosure Assessment: T2GGM Version 2 Gas Generation and Transport Code report, Section 4 (Quintessa and Geofirma 2011). The microbial model used in the DGR is consistent with those used in the UK L&ILW program, as described in the Humphreys et al. (2010) review for the UK Nuclear Decommissioning Authority. The model has been compared with experimental data for gas production from L&ILW. For example, Small et al. (2008) summarize a gas generation experiment underway for several years in a L&ILW repository in Finland. The DGR model is compared with this experiment in the T2GGM Code report, Appendix B (Quintessa and Geofirma 2011). The DGR gas generation model has also been presented to peers in technical conferences, including the 12th International Conference on Environmental Remediation and Radioactive Waste Management (Suckling et al. 2009) and the Geological Disposal of Radioactive Waste: Underpinning Science and Technology for Radioactive Waste conference (Humphreys et al. 2011). The reference DGR microbial model adopts several simplifications that provide a conservative representation of microbial activity leading to waste degradation and gas generation within the repository: • all nutrients other than carbon and water are assumed available; • all relevant microbial groups are assumed to be present in the repository; • microbes are assumed active in spite of high groundwater salinity, dissolved metals and possibly high alkalinity; • it is assumed that microbes are active in unsaturated regions, i.e., there is enough humidity; and • organic degradation reactions proceed to gas generation, i.e., there is no significant carbon in intermediate solid or soluble species. **References:** Humphreys, P. 2011. Conceptual Basis of the Microbial Aspects of the GGM Model. Prepared for Nuclear Waste Management Organization. Quintessa Technical Report QRS-1335B-TR1, Version 1.0. Henley-on-Thames, United Kingdom. (enclosed) Humphreys, P.N., J.M. West and R. Metcalfe. 2010. Microbial Effects on Repository Performance. Prepared for UK Nuclear Decommissioning Authority. Quintessa Report QRS-1387Q-1, Version 3.0. Henley-on-Thames, United Kingdom. Humphreys, P.N., P. Suckling, F. King, J. Avis and N. Calder. 2011. Modelling Gas Generation in Deep Geologic Repository for L&ILW. Presented at Geological Disposal of Radioactive Waste: Underpinning Science and Technology for Radioactive Waste Conference, Loughborough University, United Kingdom.

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		Quintessa and Geofirma. 2011. T2GGM Version 2: Gas Generation and Transport Code. NWMO DGR-TR-2011-33 R000. Toronto, Canada. (available at www.nwmo.ca/dgrpostclosuresafetyassessmentreports) Small, J., M. Nykyri, M. Helin, U. Hovi, T. Sarlin and M. Itavaara. 2008. Experimental and Modelling Investigations of the Biogeochemistry of Gas Production from Low and Intermediate Level Radioactive Waste. Applied Geochem. 23, 1383-1418. Suckling, P., N. Calder, P. Humphreys, F. King and H. Leung. 2009. The Development and Use of T2GGM: A Gas Modelling Code for the Postclosure Safety Assessment of OPG's Proposed L&ILW Deep Geologic Repository, Canada. Proceedings 12th International Conference on Environmental Remediation and Radioactive Waste Management, ICEM '09/DECOM '09, Liverpool, United Kingdom.
EIS-01-22	▪ EIS Guidelines: Section 13, Long-Term Safety of the DGR ▪ CNSC Regulatory Guide G-320: Section 6.2.1	***Information Request:*** *Provide additional information and analyses on the nature and relevance of the experimental data supporting degradation rates of ion exchange resins as follows:* ▪ *discuss the applicability of key references from the Post-closure Safety Assessment: Data report on degradation of ion exchange resins (i.e., Bracke et al., (2004), Husain and Jain (2003) and Wiborgh et al. (1986)) and any ongoing research on this issue nationally or internationally to the DGR-specific issues, and summarize any insights that can be gained relative to other studies on ion exchange resin stability and gas generation; for example the headspace gases quantified in OPG (2003); and* ▪ *analyze and discuss the consequences to the EIS prediction of "containment" of gases in the geosphere for a degradation rate in gas modeling that is higher than the value chosen as an upper bound.* ***Context:*** *The summary information provided on the degradation of ion exchange resins is not sufficient for CNSC staff to assess whether the parameters chosen are applicable to the main resin of interest. It is also not clear if this information is applicable to all resins for the diverse environmental conditions under which they will degrade in the long term.* *Table 2.7 of the Reference Low- and Intermediate-Level Waste Inventory for the Deep Geologic Repository report indicates that 96% of the C-14 inventory is found in Moderator IX resins. Gas generation from these exact materials (under postclosure repository conditions), and the resulting dose from C-14 to humans (in the long term), is a critical pathway for certain scenarios. It is not clear why minimal quantitative, experimental information has been provided and/or why this topic has not been addressed in the follow-up program.* *Altogether, more information is needed on the sensitivity of gas generation predictions to extreme ion exchange degradation rates which may evolve in the repository with time (microbial, corrosion, oxidation, etc.). The foundation for this key process needs to be better justified and then the consequences of uncertainties discussed. In particular, more clarity is needed on whether high degradation rates are plausible;*

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		the upper bound chosen for modeling is not justified. *The most important question to specifically address is: would high degradation rates compromise the predictions for low doses in the biosphere as a result of the prediction for effective containment of gases in the geosphere (e.g., Table 5.5 of the Post-closure Safety Assessment)? Similar clarity is needed on whether this issue has been or can be addressed in a simpler way, e.g. through a bounding calculation.*
		OPG Response: Degradation rate data for ion exchange (IX) resins, summarized in the Postclosure Safety Assessment Data report (Quintessa and Geofirma 2011), show that IX resins degrade slowly but measurably under aerobic conditions, and at best very slowly under anaerobic conditions, consistent with the behaviour of polystyrene which forms the resin backbone. These include data from two recent field studies - Bracke et al (2004) and Husain and Jain (2003). From these studies on actual IX resin wastes, the data (gas generation) were used to estimate resin degradation rates. The latter includes headspace gases measured in IX resin containers at the Western Waste Management Facility (WWMF), so is directly applicable to the DGR. As per the Information Request, in addition to the references previously summarized in the Postclosure Safety Assessment Data report (Quintessa and Geofirma 2011), the literature was further surveyed for other data relevant to ion exchange resin, including polystyrene degradation. The review is presented in NWMO (2012) (enclosed). The review included values adopted for resin degradation in other safety assessments. In summary, there is limited data for anaerobic degradation of IX resins, but the rate is clearly low. The range of values considered in the Postclosure Safety Assessment is consistent with the literature and with values used in other safety assessments. The uncertainty in resin degradation rates in particular and gas generation in general, is considered in the Postclosure Safety Assessment (Quintessa et al. 2011; Chapter 8 of the PSR). The postclosure reference model adopts the following conservative assumptions with respect to gas generation: • All organics including resins are assumed to completely degrade; • All organics including resins are assumed to degrade to form gas rather than intermediate species; • Sufficient water is assumed present to support degradation (no rate reduction for unsaturated conditions); and • Other conditions are assumed to support degradation processes (e.g., microbes are active even under the potentially high salinity, and other nutrients are available). The uncertainty was further addressed through evaluation of variant cases in which the gas generation rates and related parameters are varied. These are described in Section 8.8.2.4 of the PSR. The conclusion from these variant cases is that the repository tends to stabilize at generally similar pressures, independent of the specific gas generation rate assumptions.

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		In addition, as per the Information Request, a calculation case with upper bound values of the resin degradation rate was analysed (NWMO 2012). The resin (and plastics and rubber) degradation rate was set to 0.04 a^{-1} under aerobic conditions and $7x10^{-4}$ a^{-1} under anaerobic conditions. These are the maximum reported values from the updated review (NWMO 2012), and are about a factor of 80 and 14 higher than the PSR reference values for aerobic and anaerobic conditions, respectively. The results for this high degradation rate case show the gas pressure is generally higher initially than for the reference case, but reaches the same long-term pressure. The calculation results, including this high resin degradation rate case, show that the resulting gas is contained within the geosphere and does not compromise the predictions for low doses in the biosphere. With respect to obtaining additional data, it is expected that the low degradation rate would be most accurately measured under in-situ conditions with real waste materials, and that the measurements would take several years to equilibrate as the microbial conditions within the resins become anaerobic and stabilized. Short-term laboratory tests are useful but not definitive. The preferred approach is to conduct long term studies within the repository under actual field conditions, such that some decades of data would be available to help support the decision to close the repository. The studies have not been defined as part of the Construction Licence application. However, they are described in general in the response to IR-EIS-01-32. Finally, it is emphasized that the release of C-14 from the moderator IX resins, the largest source of C-14, is modelled as occurring independently from the actual degradation of the bulk polymer. Since the C-14 is primarily present as surface sorption on the resins, the C-14 release is modelled as off-gassing at constant rate from the unsaturated resins, or as instantly released for the portion of the resins that become saturated with water filling the repository. **References:** Bracke, G., W. Muller, K. Kugel and D. Cologne. 2004. Derivation of Gas Generation Rates for the Morsleben Radioactive Waste Repository (ERAM). Proceedings of DisTec 2004, April 26-28, Berlin, Germany. Husain, A. and D. Jain. 2003. Chemical, Radiochemical and Microbiological Characterisation of the Contents of Resin Liners Sampled at the Western Waste Management Facility in 2002. Kinectrics Report 9820-090-RA-0001-R00. Toronto, Canada. NWMO. 2012. OPG DGR: Resin Degradation Review and Additional Analysis. NWMO Technical Memorandum DGR-TM-03640. Toronto, Canada. (enclosed) OPG. 2011. OPG's Deep Geologic Repository for Low and Intermediate Level Waste - Preliminary Safety Report. Ontario Power Generation report 00216-SR-01320-00001 R000. Toronto, Canada. Quintessa and Geofirma. 2011. Postclosure Safety Assessment: Data. Quintessa Ltd. and Geofirma Engineering Ltd. report for the Nuclear Waste Management Organization report NWMO DGR-TR-2011-32 R000. Toronto, Canada. (available at www.nwmo.ca/dgrpostclosuresafetyassessmentreports)

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		Quintessa, Geofirma and SENES. 2011. Postclosure Safety Assessment. Quintessa Ltd., Geofirma Engineering Ltd. and SENES Consultants Ltd. report for Nuclear Waste Management Organization NWMO DGR-TR-2011-25 R000. Toronto, Canada.
EIS-01-23	▪ EIS Guidelines: Section 13, Long-Term Safety of the DGR ▪ CNSC Regulatory Guide G-320: Section 6.2.1	***Information Request:*** *Provide an analysis of the probability of formation of unique species of gases in the repository (e.g. containing both C^{14} and H^3 as in methane ($C^{14}H^3T$)) relative to chemical and/or biological processes that may occur in the long-term.* *Similarly, the formation of organochlorines (Cl^{36}) should be discussed in terms of any relevant impacts on how Cl^{36} environmental behaviour is modeled (e.g. the relevance of literature Kd values and their uncertainties).* *The dosimetry of any credible complex species should be discussed and put into an appropriate risk context if information is lacking. If any issues or major uncertainties are encountered on environmental behaviour or dosimetry; follow-up program activities should be identified.* ***Context:*** *Gas generation is important in assessment of a repository's ability to keep contaminants contained, and the kinds of gases produced influence possible impacts on persons and the environment in the event of releases from the repository. While the EIS assesses a number of gases, the possibility of microbial or other processes causing unusual species of C^{14}, H^3 and Cl^{36} compounds being formed is not addressed in the documentation provided.* *The presence of organic wastes with high inventories of C^{14} may provide the right conditions for unique chemical and biological processes. Features, events and processes related to this topic should be analyzed in a quantitative sense based on whatever insights are available from the literature and the effect on the performance of repository determined.*
		OPG Response: A more detailed discussion is provided in the enclosed report Humphreys et al. (2011). Key points are summarized below. Data on the formation of gas species due to degradation of L&ILW indicate that the main species are H_2, CO_2 and CH_4; smaller amounts of C_2H_6 (ethane), CO and H_2S have been reported. These gases are the primary gaseous breakdown products from metal corrosion and microbial degradation of organic materials. Since the amounts of H-3 and C-14 in the DGR are small compared to the amounts of non-radioactive H and C that would be present in gaseous species, only a very small fraction of gas species is likely to contain both H-3 and C-14. A simple estimate indicates that if all the gas in the repository were methane, which is the most common molecule that contains both C and H, the fraction of methane gas molecules with both H-3 and

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		C-14 would be on the order of 10^{-10}. The dominant form for Cl-36 release from the DGR is as chloride. The safety assessment uses a conventional biosphere concentration ratio model to estimate bioaccumulation and dose impacts, consistent with CSA N288.1-08. This model does not distinguish between the forms of chlorine in the soil; however, chloride is the main path into plants. Since the amounts of Cl-36 released from the repository are very small (less than natural background levels of Cl-36 under normal evolution scenario), the dose impacts are negligible and more detailed modelling would not change the overall conclusion. Nonetheless, the models used in the OPG DGR postclosure assessment are being maintained by the Nuclear Waste Management Organization (NWMO). The NWMO participates in activities to improve its database and models. These include participation in the international BIOPROTA biosphere modelling working group, as well as for example recent measurements of background levels of Cl-36 and updating biota transfer factors including chlorine (Sheppard et al. 2006, Sheppard and Sanipelli 2011). Dose coefficients are available or can be conservatively estimated for the main species of H-3, C-14 and Cl-36 as discussed in Humphreys et al (2011). **References:** Humphreys, P., M. Thorne and J. Wilson. 2011. The Speciation of H-3, C-14 and Cl-36 in the DGR System. Prepared for NWMO. Quintessa Technical Report QRS-1335B-TR4, Version 1.0. Henley-on-Thames, United Kingdom. (enclosed) Sheppard, S.C., M.I. Sheppard, J.C. Tait and B.L. Sanipelli. 2006. Revision and meta analysis of selected biosphere parameter values for chlorine, iodine, neptunium, radium, radon and uranium. Journal of Environmental Radioactivity 89, 115-137. Sheppard, S.C. and B. Sanipelli. 2011. Environmental Radioactivity in Canada - Measurements. Nuclear Waste Management Organization report NWMO TR-2011-16. Toronto, Canada.
EIS-01-24	▪ EIS Guidelines: Sections 12, 13.2 and 15 ▪ CNSC Regulatory Guide G-320: Section 7.5.2	***Information Request:*** *Provide an assessment of undiscovered oil, gas and mineral resources at the regional, local and site scale and also the uncertainties that are associated with this assessment.* *In providing the above assessment, the proponent should clearly distinguish between resources and reserves. Reserves are generally understood to comprise those accumulations that have been discovered and measured, and that can be produced economically under present-day conditions. Reserves are only a sub-set of total resources, which also include potential future additions to reserves that are currently sub-commercial and/or that have yet to be discovered and measured.* *The requested quantitative assessment should also be correlated to the geological processes responsible for the formation of the resources.*

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		Context: *In the EIS Guidelines, section 13 outlines the expectations with respect to the long term safety of the DGR, for which isolation is an important factor. The absence of natural resources reduces the likelihood of inadvertent intrusion that can jeopardize the isolation function of the DGR system. In addition, if natural resources exist at or in the vicinity of the site, the EIS should identify how the proposed project could affect their use (i.e. land use).* *The exploratory boreholes that penetrated the Middle Ordovician strata at the Bruce nuclear site seemed to indicate the presence of liquid and gaseous hydrocarbons (Table 2.8 of the Geosynthesis Report). The above observations are consistent with the findings of Obermajer et al. (1999), who reported that the Middle Ordovician limestones of southwestern Ontario are expected to have "good to excellent petroleum source potential" and to be "within the zone of prolific oil generation". The petroleum liquids and gases that were observed in cores from recent exploratory boreholes at the Bruce nuclear site may be an indication of a potential future petroleum resource that could be extracted using new technologies such as horizontal drilling and hydro fracturing. The proponent indicates, however, that the presence of these potential resources is not such that there will be future intrusions; however, no supporting evidence is provided.*
		OPG Response: A discussion related to the assessment of oil, gas and mineral resource occurrences beneath and in the vicinity of the Bruce nuclear site is summarized in the Geosynthesis (NWMO 2011; Sections 2.28 and 2.36). A detailed explanation of the supporting evidence is provided in Engelder (2011; Section 3.3), AECOM and Itasca (2011; Sections 8 and 10) and Intera (2011; Section 3.7.4.2). Key evidence that leads to an assessment of low resource potential, particularly within the middle Ordovician limestones, is outlined below. • Hydrocarbon occurrences within core obtained from beneath the Bruce nuclear site is described by Intera, (2011; Section 3.7.4.2, Table 3.10 and Figure 3.16). The observation of discrete hydrocarbon occurrences within the low hydraulic conductivity (<10^{-12} m/s) Middle Ordovician limestones suggests a low commercial oil and gas potential. • Within the middle Ordovician limestones of southern Ontario, commercial liquid and gaseous hydrocarbons primarily occur within fault controlled Hydrothermal Dolomitized (HTD) Reservoirs. No evidence for the occurrence of HTD reservoirs was found within the Middle Ordovician Black River or Trenton Group limestone beneath the Bruce nuclear site (Intera 2011; NWMO 2011). This evidence includes: i) an absence of fault controlled vertical structural within the sedimentary sequence as evaluated through seismic reflection surveys (NWMO 2011; Section 2.3.9.2) and stratigraphic correlation in core across the site (NWMO 2011; Section 2.3.4); ii) consistently low in-situ hydraulic conductivities (<10^{-12} m/s) and low matrix porosities (0.005 – 0.02) observed in these sediments; and iii) the occurrence of anomalous hydraulic heads and gradients observed in the sediments consistent with the occurrence of low hydraulic conductivities at formation scale. Such conditions are not

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		consistent with reservoir quality rocks. • The ability to extrapolate these site-specific observations beyond the DGR borehole footprint is based on the predictable and traceable nature of the Paleozoic stratigraphy across the Regional Study Area as discussed in the Geosynthesis (NWMO 2011; Section 2.3.4; Intera 2011; Section 3.1.3). The nearest neighbour exploratory wells to the Bruce site (Texaco #6 and Kincardine #1) were dry and this is consistent with the fact that no documented commercially viable oil or natural gas hydrocarbon deposits (27 exploratory wells) are found within a 40 km radius of the Bruce nuclear site (OGSR 2004; 2006; AECOM and Itasca 2011). • The probability of the occurrence of commercial shale gas beneath the Bruce nuclear site is considered low for three reasons: i) the Total Organic Carbon (TOC) concentration within the Ordovician strata is low ca. < 2.5%; ii) the low thermal maturity due to shallow (approximately 1.5 km) burial in the Bruce region; and iii) lack of extensive natural hydraulic fracturing in the Ordovician shales associated with gas generation typical of shale gas plays in the Appalachian basin (Engelder 2011). • The Paleozoic sediments within southern Ontario are subdivided into two structural domains; the Niagara megablock and the Huron Domain (see Figure 1 provided at the end of the responses to EIS IRs). The Huron Domain, which encompasses the DGR Regional Study Area (Figure 1 herein), is structurally less complex than the faulted Niagara megablock (Figure 1 provided at the end of the responses to EIS IRs; AECOM and Itasca 2011, p. 116). The structural provenance of the Huron Domain suggests a lower possibility of HTD formation and occurrence for oil and gas accumulation. Further, Bailey (2005) noted that the best prospecting for Ordovician HTD reservoirs should occur on the south east side of the Algonquin Arch where the presence of porous Cambrian sediments have facilitated the transport and migration of fluids within the fault and fracture systems. Active and abandoned gas pools within the Regional Study Area are listed in NWMO (2011), Table 8.2. • Present industry exploration for Ordovician HTD reservoirs is focused almost exclusively in Essex and Kent counties in the Niagara Megablock (AECOM and ITASCA CANADA 2011, p. 126). Hydrocarbon resources to the northeast of this area, in the Huron Domain, particularly within the Black River Group tend to be largely related to gas discoveries (NWMO 2011; Table 8.2). • In terms of mineral resources, no evidence was discovered during regional or site specific investigations to suggest economically viable base mineral or salt deposits exist beneath or in the vicinity of the Bruce nuclear site (e.g., Silurian Saline salt). The observation that base minerals occur as trace gangue mineral assemblages indicates that the likelihood of undiscovered base mineral resources is considered negligible (NWMO 2011; Sections 2.2.8 and 2.3.6).

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		With respect to Obermajer et al. (1999), as cited above, broad application of conclusions to understanding petroleum resource potential within the vicinity of the Bruce nuclear site and more regionally within the Huron Domain, to the northwest of the Algonquin Arch is not straightforward. Obermajer et al. (1999) principally explored hydrocarbon occurrence in the middle Ordovician limestone to the southeast of the Algonquin Arch in the Niagara Mega Block, in sediments associated with the Appalachian basin (Figure 1 provided at the end of the responses to EIS IRs; sample locations). Differences in hydrocarbon rock thermal maturity, structural provenance (as described above) and occurrence of underlying Cambrian sediments indicate that direct transferability of observations from Obermajer et al. (1999) to the Huron Domain is not well supported. **References:** AECOM and ITASCA CANADA. 2011. Regional Geology – Southern Ontario. AECOM Canada Ltd. and Itasca Consulting Canada, Inc. report for the Nuclear Waste Management Organization NWMO DGR-TR-2011-15 R000. Toronto, Canada. (available at www.nwmo.ca/dgrgeoscientificsitecharacterization) Bailey, S.M.B. 2005. A Comparison of Cambrian Reservoir Rocks Onlapping the S.E. and N.W. Sides of the Algonquin Arch in SW Ontario: A Regional Correlation Project. Proceedings 44th Annual Ontario Petroleum Institute Conference, Technical Paper 5. London, Canada. Engelder, T. 2011. Analogue Study of Shale Cap Rock Barrier Integrity. Nuclear Waste Management Organization Report NWMO DGR-TR-2011-23 R000. Toronto, Canada. (available at www.nwmo.ca/dgrgeoscientificsitecharacterization) Intera Engineering Ltd. 2011. Descriptive Geosphere Site Model. Intera Engineering Ltd. report for the Nuclear Waste Management Organization NWMO DGR-TR-2011-24 R000. Toronto, Canada. NWMO. 2011. Geosynthesis. Nuclear Waste Management Organization report NWMO DGR-TR-2011-11 R000. Toronto, Canada. Obermajer, M., M.G. Fowler and L.R. Snowdon. 1999. Depositional environment and oil generation in Ordovician source rocks from southwestern Ontario, Canada: Organic geochemical and petrological approach. AAPG Bulletin 83 (9), 1426-1453. Ontario Oil, Gas and Salt Resources (OGSR) Library. 2004. Cumulative oil and gas production in Ontario to the end of 2004. Excel format data. In: Members Package Dataset. Petroleum Resources Centre, Ministry of Natural Resources Oil, Gas & Salt Resources Library. Ontario Oil, Gas and Salt Resources (OGSR) Library. 2006. Oil and Gas Pools and Pipelines of Southern Ontario, revised October 2006. Petroleum Resources Centre, Ministry of Natural Resources Oil, Gas & Salt Resources Library UTM NAD83. Ontario Digital Base Data.

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		Sanford, B.V., F.J. Thompson and G.H. McFall. 1985. Plate tectonics – A possible controlling mechanism in the development of hydrocarbon traps in southwestern Ontario. Bulletin of Canadian Petroleum Geology 33(1), 52-71.
EIS-01-25	▪ EIS Guidelines: Section 14, Cumulative Effects	***Information Request:*** *Assess the cumulative effects from past and existing projects and activities, certain and planned projects and activities, and reasonably foreseeable projects and activities, on DGR workers (nuclear energy workers (NEWs) and non-NEWs), or provide a rationale for why a cumulative effects assessment was not conducted.* ***Context:*** *In the EIS Guidelines, section 14 outlines the expectations with respect to cumulative effects.* *Section 10 of the EIS addresses cumulative effects related to exposure to radiation by members of the public from the DGR project and other existing and reasonably foreseeable projects, but similar information related to exposure to radiation by workers (NEWs and non-NEWs) is not presented. This information is needed, given the greater exposure to radiation that NEWs and non-NEWs are predicted to receive.*
		OPG Response: Based on the screening of cumulative effects presented in Section 10 of the EIS, seven existing projects, five certain/planned projects and four reasonably foreseeable projects may act cumulatively with the DGR Project. The site preparation and construction phase of the DGR Project may overlap with the Bruce A and Bruce B refurbishment activities, ongoing operation of the Western Waste Management Facility (WWMF), and the ongoing safe storage of Douglas Point. No other projects would affect radioactive emissions. As the DGR Project will not contribute to radioactive emissions during this phase, there is no cumulative effect on workers, either Nuclear Energy Workers (NEWs) or non-NEWs. The operations phase of the DGR Project may overlap with operation of Bruce A and B, the refurbishment of Bruce A and B, Safe Storage of Bruce A and B, decommissioning of Bruce A and B, safe storage of Douglas Point, and operation of the WWMF including transfer of used fuel from the Bruce nuclear site to a long-term repository. However, not all of these activities would be occurring simultaneously. For NEWs the dose contributions from all past, present and future nuclear projects and operations at the Bruce nuclear site will be included in the occupational dose measurements when those activities occur. Since each NEW's dose is individually monitored and recorded, regardless of where the dose originates, cumulative doses to individual workers are inherently addressed through the dosimetry program, as well as ALARA initiatives. The dose planning and monitoring program for the DGR Project will implicitly incorporate the dose contributions from all licensed activities.

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		The annual cumulative doses to DGR NEWs at the Bruce nuclear site are expected to remain well below regulatory limits (100 mSv per five-year dosimetry period with a maximum of 50 mSv in any one-year dosimetry period, i.e., an average of 20 mSv per year). In addition, doses will be further controlled to ALARA using OPG's administrative and procedural controls. The DGR Facility will ensure that dose rates in Zone 1 areas will have "a general radiation background as low as possible and in any case shall have an average monthly radiation field level less than 0.5 mrem/h" (0.5 μSv/h) (OPG2001). This helps to ensure that the cumulative dose to non-NEWs is maintained below 1,000 μSv/yr, the regulatory dose limit for members of the public. Therefore, no mitigation measures beyond those already identified are considered necessary to meet regulatory limits and no residual adverse cumulative human health effects associated with doses to workers from the DGR Project are considered likely. **References**: OPG. 2001. Radiation Protection Requirements – Nuclear Facilities. OPG Requirements N-RPP-03415.1-10001-R07, Section 4.7.1.1. Toronto, Canada.
EIS-01-26	▪ EIS Guidelines: Section 11, Effects Prediction, Mitigation Measures and Significance of Residual Effects	***Information Request:*** *Indicate whether workers will be carrying out activities associated with more than one receptor location, within a given scenario (summarized in the Preliminary Safety Report: Table 7-22, page 415). If so, the annual estimated dose to the maximally exposed worker(s) should be provided, based on activities at more than one receptor location.* ***Context:*** *Table 7-22 in the Preliminary Safety Report identifies estimated dose rates at specific receptor locations across various scenarios. It is not clear whether a representative worker could undertake activities at more than one receptor location within a given scenario. All activities which will result in exposure that a representative worker may carry out should be considered. This ensures that estimated doses are conservative.* *Section 11.5.6 of the EIS Guidelines states that the predicted doses to workers resulting from activities within the scope of the project must be included.*
		OPG Response: In the Preliminary Safety Report (PSR) Table 7-22, the dose rates at various receptor locations are calculated based on reasonably maximum exposure conditions - e.g., maximum number of nearby containers. These dose rates are calculated on an hourly basis, and provide an indication of how long a worker could be at each location while remaining within the OPG dose limits, which are consistent with or less than the CNSC regulatory dose limits. This does not consider how long workers would actually spend at each location, nor

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		the times when fewer packages would be present. A more detailed description of worker activities involved in waste package handling is provided in the Preliminary ALARA assessment (SENES 2011). This includes preliminary estimates of the time for each task, number of personnel, typical distances of personnel from packages, and typical package dose rates. This was used to provide a preliminary estimate of total collective dose. This identifies the higher dose activities, and therefore where there is the most benefit from ALARA optimization. Again this is not a description of an individual's work activities, but of the total list of activities by all workers. In practice, each worker would be involved with various activities, at varying dose rate locations. The activities will be controlled such that the worker's cumulative dose exposure will be within OPG's Administrative Dose Limits (OPG 2006). This is demonstrated by current practice at the Western Waste Management Facility (WWMF), where similar waste packages are currently handled and stored, and workers activities are managed such that they remain within these dose limits. The specific OPG Administrative Dose Limits depend somewhat on the type of worker. A complete description is provided in OPG (2006), and a summary is provided in Table 4.3 of the DGR Preliminary ALARA Assessment (SENES 2011). For example, for many Nuclear Energy Workers, the OPG Administrative Dose Limit would be 50 mSv per five year period. A more detailed description of worker dose will be provided in the Final ALARA Assessment as part of the Operating Licence application. **References:** OPG. 2006. Dose Limits and Exposure Control. OPG procedure N-PROC-RA-0019-R004. Toronto, Canada. SENES. 2011. Preliminary ALARA Assessment. SENES Consultants Ltd. report for the Nuclear Waste Management Organization NWMO DGR-TR-2011-36 R000. Toronto, Canada.
EIS-01-27	▪ EIS Guidelines: Section 11, Effects Prediction, Mitigation Measures and Significance of Residual Effects	***Information Request:*** *Provide supporting information for selected examples of the worker and public dose estimates presented.* ***Context:*** *Section 11.5.6 of the EIS Guidelines states that predicted doses to workers, including doses to contract workers, and to members of the public resulting from activities within the scope of the project must be included.* *While doses have been provided, sufficient information has not been included to permit CNSC staff to conduct any verification of the calculated doses to workers and to the public. Additional information in the form of selected case summaries, which include information concerning any calculations completed using Micro Shield and Sky Shine, is needed for this verification.*

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		OPG Response: Supporting information is provided for the following two examples: 1. Direct and skyshine dose rates to public and non-Nuclear Energy Workers from 24 Feeder Pipe containers temporarily staged in the Waste Package Receiving Building (WPRB) (Preliminary Safety Report, PSR, Section 7.4.4, Scenario 1). 2. Direct dose rate to a worker in the underground ILW emplacement room that is exposed to Moderator IX Resin waste packages (PSR, Section 7.4.4, Scenario 4). This supporting information is documented in NWMO (2011) (enclosed). **References:** NWMO. 2011. OPG DGR: Supporting Information on Selected DGR Dose Rate Examples. NWMO Technical Memorandum, DGR-TM-03630. Toronto, Canada. (enclosed)
EIS-01-28	▪ EIS Guidelines: Section 11, Effects Prediction, Mitigation Measures and Significance of Residual Effects	***Information Request:*** *Provide dose estimates to persons who will be transferring waste from the Western Waste Management Facility to the DGR.* ***Context:*** *Section 11.5.6 of the EIS Guidelines requires that the EIS provide information on the predicted doses to workers, including doses to contract workers, and to members of the public resulting from activities within the scope of this project.*
		OPG Response: The annual dose has been estimated for a nuclear worker who will be transferring waste packages from the Western Waste Management Facility (WWMF) to the DGR Waste Package Receiving Building (WPRB). The calculation followed the methodology used in the Preliminary ALARA report (NWMO 2011). The results are shown in Table 1. The table shows that the total annual collective dose to workers transferring the waste from the WWMF to the WPRB is estimated to be 4.1 mSv. Because this dose would likely be shared between a few workers, the total annual individual dose for the transfer of packages from the WWMF to the WPRB would be lower.

IR#	EIS Guidelines Section	Information Request and Response
		Table 1: Annual Dose Estimate for Workers Transferring Waste Packages from the WWMF to the WPRB

Group	Waste Package	Weighting Factor	Number of packages delivered per year	Transport Dose Rate (mSv/hr)	Annual Dose Rate (mSv/yr)
A (LLW Bin Type Waste)	Non-Pro Bin 47" High (NPB47)	0.98	3000	1.83E-03	**2.2E-01**
	Non-Pro High Capacity (NPHC)	0.02		2.69E-01	**6.5E-01**
B (Heavy Non-Forkliftable)	Heat Exchanger (HX)	0.79	5	2.10E-03	**3.3E-04**
	Shield Plug Container (SPC)	0.21		8.65E-01	**3.6E-02**
C (Light Forkliftable)	ILW Shield (ILWSHLD)	0.85	180	4.09E-01	**2.5E+00**
	Stainless Steel Resin Liner (RLSS)	0.15		1.78E-01	**1.9E-01**
D (Heavy Forkliftable)	Retube Waste (RWC (EF))	0.58	100	7.01E-02	**1.6E-01**
	Resin Liner- Shield 1 (RLSHLD1)	0.42		2.15E-01	**3.6E-01**
Total Annual Dose Rate					**4.1E+00**

The following assumptions were used to calculate the dose to workers transferring waste from the WWMF to the WPRB:

- Four different waste package groups were used, each assigned with a weighting factor due to its relative number of packages transferred in each group (Table C.1 of the Preliminary ALARA Assessment report, SENES 2011).
- The package transfer rate is the same as in the Preliminary ALARA Assessment report (Table A.1). This schedule is based on the transfer of most of the existing WWMF wastes into the DGR over an initial 10-year period.
- Group A, C and D are transported to the DGR by forklift one at a time. The single package dose rates to the forklift driver are found in Tables C.2-C.3 and C.6-C.9 of the Preliminary ALARA Assessment report (SENES 2011).

IR#	EIS Guidelines Section	Information Request and Response
		• Group B packages are transported by truck. The preliminary ALARA assessment does not make an estimate of the dose rate to the truck driver. Therefore, for this estimate, the 1 m dose rate from the package was conservatively assumed to represent the dose rate to the truck driver (See Tables C.4-C.5 of SENES 2011). • Based on an approximate travel distance from the WWMF to the WPRB of 200 m and an assumed forklift/truck travel speed of 5 km/h (same assumption used in NWMO 2011), each transfer would take 0.04 hours (2.4 minutes). The total annual transfer dose calculated herein does not include the package loading and unloading doses at the WWMF and the WPRB. The package unloading dose at the WPRB has already been included in the Preliminary ALARA Assessment (see Tables C.2-C.9, SENES 2011). Activities performed at the WWMF (i.e., package loading) were not included in the Preliminary ALARA Assessment as they were within the WWMF licenced activities. However, allowing for 2 minutes per package, the WWMF package loading activity would have about 4 mSv/yr collective dose. **References:** SENES. 2011. Preliminary ALARA Assessment. SENES Consultants Ltd. report for the Nuclear Waste Management Organization NWMO DGR-TR-2011-36 R000. Toronto, Canada.
EIS-01-29	▪ EIS Guidelines: Section 11, Effects Prediction, Mitigation Measures and Significance of Residual Effects	***Information Request:*** *Provide an assessment of the inhalation risk of acrolein to persons on-site.* ***Context:*** *Inhalation Hazard Quotients (HQs) for acrolein during site preparation, construction phase, and operations phase of the project exceed 2.0 (an HQ of 1.0 is an acceptable health-based limit) for local residents and members of aboriginal communities. Persons on-site would be exposed to higher levels of acrolein and may result in even higher HQs for acrolein. This information is needed to properly assess the effects to human health from the project.*
		OPG Response: The health assessment (Appendix C of the EIS) did consider the potential effects to members of the public including aboriginal peoples spending extended periods of time on the site. Specifically, receptor AR6 (approximately 1.3 km south of the DGR Project site and shown on Figure C2.3.1-1 of the EIS) of the health assessment considered persons spending extended time at the burial ground. Other persons on the site for extended periods of time would be considered workers. Governmental agencies, specifically the Ontario Ministry of Labor (MOL) and non-governmental agencies like the American Conference of Governmental Industrial Hygienists (ACGIH) establish occupational exposure

IR#	EIS Guidelines Section	Information Request and Response
		guidelines that are intended to inform decisions related to worker exposures to chemicals in the workplace. The MOL occupational exposure limits (OELs) are enforceable while the ACGIH Threshold Limit Values (TLVs) are guidelines for use to manage worker exposures. Both the MOL OEL and the ACGIH TLV values for acrolein are set at 0.23 mg/m³ (230 µg/m³). The occupational exposure limits for acrolein are ceiling limits that should not be exceeded during any part of the working hours. They are based on protection of worker health against irritation of the eyes, mucous membrane, respiratory tract and the development of pulmonary edema.

Predicted 1-hour and 24-hour concentrations within the Bruce nuclear site varied by a factor of less than two. Since the predicted concentrations of acrolein at the burial ground within the Bruce nuclear site (see table below) are well below (two orders of magnitude) the occupational exposure limits established by MOL and ACGIH, inhalation risks to workers from acrolein are considered negligible. Exposure for visitors at the burial ground (AR6) was assumed to be for a period of 8 hours, 12 times per year. Other visitors to the Bruce nuclear site would typically have lower exposure durations and therefore lower inhalation risk. Persons at the burial ground are considered to have negligible risks based on hazard quotients (HQs) that are well below the acceptable target of 1.0.

Maximum 8-Hour Acrolein Concentrations for Health Assessment (includes stationary, construction and mobile sources)

Receptor	Maximum Modelled Existing Concentration (µg/m³)	Background Acrolein (µg/m³)	Existing Acrolein (µg/m³)
AR6	0.42	0.25	0.67
Receptor	**Maximum Modelled Construction Concentration (µg/m³)**	**Background Acrolein (µg/m³)**	**Constuction Acrolein (µg/m³)**
AR6	0.86	0.25	1.11
Receptor	**Maximum Modelled Operations Concentration (µg/m³)**	**Background Acrolein (µg/m³)**	**Operations Acrolein (µg/m³)**
AR6	0.42	0.25	0.67

Note: AR6 is located at the burial ground on the Bruce nuclear site.

References:

ACGIH. 2010. 2010 TLVs and BEIs Threshold Limit Values for Chemical Substances and Physical Agents & Biological Exposure Indices with 7th Edition Documentation.

IR#	EIS Guidelines Section	Information Request and Response
		Ontario Ministry of Labour (MOL) Occupational Exposure Limits for Ontario Workplaces. November 2010. (downloaded from MOL website http://www.labour.gov.on.ca/english/hs/pubs/oel_table.php).
EIS-01-30	▪ EIS Guidelines: Section 11.5.2, Land Use and Value	***Information Request:*** *Provide the following information on the housing/rental market:* • *confirm that the proponent's use of the term 'permanent private dwellings' is referring to the number of private dwellings that are occupied by usual residents (i.e. year-round / usual place of residence vs. seasonal);* • *provide details on the number of 'permanent private dwellings' there were in Kincardine and the other area municipalities as of the 2006 census;* • *provide details on what proportion of the 'permanent private dwellings' the other area municipalities were owner-occupied vs. rental units; and* • *provide historic and existing vacancy rates for rental housing for the local and regional study area; or, provide a rationale for why it was not collected / considered.* ***Context:*** *Additional information is required on the effects on the housing/rental market in alignment with expectations of the EIS Guidelines (i.e., Section 11.5.2); more specifically on permanent private dwellings and historic and existing vacancy rates for rental units.* *Table 5.6.1-1 of the TSD illustrates the 'Housing Stock' within the Local and Regional Study Area for 2001 and 2006. For 2006 a total of 5,447 housing units are shown in this table for Kincardine and that as of the 2006 census, approximately 82% of the permanent private dwellings in Kincardine were owner-occupied and that the remainder were rental units. However, no definition is provided for the term 'permanent private dwelling'. Based on IBI Group's review of Statistics Canada data it appears that the proponent is suggesting that 82% of the private dwellings occupied by usual residents in Kincardine were owner-occupied, and therefore 18% were rental. Neither the TSD nor the EIS present the actual number of permanent private dwellings (i.e. dwellings occupied by usual residents) in Kincardine or the other area municipalities or the proportions of owner-occupied vs. rental dwellings for the municipalities of South Bruce, Saugeen Shores, Brockton, Arran-Elderslie and Huron-Kinloss.* *Section 7.10.2.13 of the EIS and Section 8.6.2.4 of the Socio-Economic Environment TSD, notes that, "The demand for rental and permanent housing across the Local Study Area is not expected to be substantial and so is not expected to indirectly contribute to adverse effects on community cohesion." However, Section 8.4.1 of the TSD does show that an estimated 24,330 person years of direct, indirect and induced employment may result from the DGR project. As such, the existing availability of rental housing should be identified in the EIS.*

IR#	EIS Guidelines Section	Information Request and Response
		It is noted that the Bruce County Census Update (prepared by SHS Consulting for the Bruce County Housing Services Affordable Housing Division) includes some residential vacancy data for Kincardine and Saugeen Shores (prepared by the Community Mortgage and Housing Corporation), but only for the years 2007 and 2008. The Canada Mortgage and Housing Corporation Rental Market Report 2011, which is available on-line, shows vacancy rates for these two municipalities.

OPG Response:

Permanent Private Dwellings

The definition of the term ‘permanent private dwellings’ used in the EIS is consistent with the Statistics Canada definition of ‘total private dwellings’: “A set of living quarters which has a private entrance either directly from outside or from a common hall, lobby, vestibule or stairway leading to the outside, and in which a person or a group of persons live permanently.” Statistics Canada defines ‘private dwelling occupied by usual residents’ as “A separate set of living quarters which has a private entrance either directly from outside or from a common hall, lobby, vestibule or stairway leading to the outside , and in which a person or a group of persons live permanently”. The term “private households” used in the EIS is consistent with Statistics Canada’s “private dwelling occupied by usual residents”.

Number of Permanent Private Dwellings

Table 5.4.1-4 of the Socio-economic Environment TSD (NWMO DGR-TR-2011-08) reproduced below provides the number of “private dwellings occupied by usual residents”.

Table 5.4.1-4: Private Household by Size (2006) (1)

Category	Municipality of Kincardine		Regional Study Area Municipalities										Total	
			Arran-Elderslie		Brockton		Huron-Kinloss		Saugeen Shores		South Bruce			
	#	%	#	%	#	%	#	%	#	%	#	%	#	%
1 person	1,160	25.3	605	23.2	925	24.7	560	22.7	1,285	26.1	450	20.9	4,985	24.3
2 people	1,870	40.8	985	37.7	1,360	36.4	1015	41.1	2,035	41.3	755	35	8,020	39.2
3 people	615	13.4	410	15.7	540	14.4	305	12.3	655	13.3	300	13.9	2,825	13.8
4-5 people	850	18.5	515	19.7	830	22.2	485	19.6	885	18	545	25.3	4,110	20.1
6 or more people	95	2.1	95	3.6	90	2.4	110	4.5	70	1.4	105	4.9	565	2.8
Total	4,585	100	2,610	100	3,740	100	2,470	100	4,925	100	2,155	100	20,485	100

Note: Numbers may not appear to add up to totals because of rounding.
Source: [1] Statistics Canada 2006a.

IR#	EIS Guidelines Section	Information Request and Response
		Owned versus Rented Private Dwellings The following table summarizes published information on the numbers of owned and rented dwellings in 2006 in each of the municipalities in Bruce County. With respect to the Local Study Area, the Socio-economic Environment TSD (NWMO DGR-TR-2011-08) notes that the Official Plan for the Municipality of Kincardine recognizes that the housing mix of the municipality is heavily weighted to single detached dwellings and identifies a need to encourage a greater range of housing to meet the needs of both young families and retirees. The proposed housing mix is to include 70% low density development, 25% medium density and 5% high density. The municipality shall strive to achieve a housing tenure mix of 70% ownership and 30% rental (Meridian Planning Consultants 2006).

Occupied Dwelling Types by Municipality 2006

Dwelling Type	Kincardine (Municipality)	Arran-Elderslie	Brockton (Municipality)	Huron-Kinloss	Saugeen Shores (Town)	South Bruce
Total Private Households(1)	4,585	2,610	3,740	2,470	4,925	2,155
Number of Owned Dwellings(1)	3,765	2,160	3,020	2,100	4,035	1775
Number of Rented Dwellings(2)	835	450	715	365	885	380

Notes: Numbers of owned and rented dwellings do not add to total private dwellings because of differences in sources.
Sources: [1] Statistics Canada 2006b. [2] SHS Consulting 2009 (Table 19).

Vacancy Rates

As described in the following quote from the 2005 Bruce County Housing Study, the Canadian Housing and Mortgage Corporation (CMHC) conducts rental vacancy surveys, however, it does not collect data specifically for Bruce County.

> *"In larger centres, CMHC conducts rental vacancy surveys. However, it does not collect data specifically for Bruce County. In order to assess vacancy trends, we spoke with local real estate agents familiar with the rental market. From the discussion, it appears there are variations in vacancies in different parts of the County.*
> *In the lakeshore area, vacancies have grown in the past year and are currently estimated at about 5%. It is anticipated that this situation will grow tighter in future, especially of the Bruce Power expansion occurs. This suggests that efforts are needed to expand the rental supply in the lakeshore area.*

IR#	EIS Guidelines Section	Information Request and Response
		In the more rural areas, it is suggested that vacancy rates are higher. In some smaller rural communities, in fact, Bruce Housing Corporation itself is having difficulty filling geared-to income units, primarily due to declining population in such areas." (Social House Strategists 2005) Data for the two larger centres of Kincardine and Saugeen Shores is provided for the years 2007 through 2010 as follows: <table><tr><th rowspan="2">Year</th><th colspan="2">Vacancy Rate (%)</th></tr><tr><th>Saugeen Shores</th><th>Kincardine</th></tr><tr><td>2007 (October)</td><td>2.0[1]</td><td>No units[1]</td></tr><tr><td>2008 (Fall)</td><td>1.0[1] 1.2[2]</td><td>1.0[1] 1.0[2]</td></tr><tr><td>2009 (Fall)</td><td>1.7[2,3]</td><td>2.5[2,3]</td></tr><tr><td>2010 (Fall)</td><td>0.2[3]</td><td>0.0[3]</td></tr></table>***Sources***: [1] SHS Consulting 2009. [2] Canada Mortgage Housing Corporation 2009. [3] Canada Mortgage Housing Corporation 2011. **References:** Canada Mortgage Housing Corporation. Fall 2009. Rental Market Report – Ontario Highlights. Canada Mortgage Housing Corporation. Fall 2011. Rental Market Report – Ontario Highlights. Meridian Planning Consultants. 2006 (Office Consolidation September 2007). Official Plan of the Municipality of Kincardine. Social House Strategists (SHS) Inc. 2005. Bruce County Housing Study. Final Report. May 2005, s. 5.6. SHS Consulting. 2009. Bruce County Housing Services, Affordable Housing Division. Bruce County Census Update. Statistics Canada. 2006a. Statistics Canada Profile of Marital Status, Comon-law Status, Families, Dwellings and Households. 2006 Census. Statistics Canada. Statistics Canada. 2006b Community Profiles. Accessed on the website November 2, 2011. http://www12.statcan.gc.ca/census-recensement/2006/dp-pd/prof/92-591/search-recherche/lst/page.cfm?Lang=E&GeoCode=35
EIS-01-31	▪ EIS Guidelines: Section 2.2, Public Participation	***Information Request:*** *Provide additional information on seasonal residents as follows:* ▪ *confirm if the 2009 Public Attitude Research and telephone poll of 800 residents included permanent and seasonal residents, and if yes, confirm the proportion of the poll responses were made by*

IR#	EIS Guidelines Section	Information Request and Response
	and Aboriginal Engagement; Section 11.5.2, Land Use and Value	*seasonal residents; and* ▪ *clarify what proportion of the 2005 poll responses were made by seasonal residents in the Strategic Counsel telephone poll and provide the breakdown of response by resident type (i.e., seasonal vs. permanent) if available.* ***Context:*** *Section 2.2 of the EIS Guidelines stresses how public participation is a central objective of the overall review process. It is unclear if and how seasonal resident views were taken into consideration.* *The Socio-Economic Environment TSD describes how Public Attitude Research was undertaken in 2009 that involved a telephone interview of ‘residents in the local and regional study areas’. Appendix D2 of the EIS includes a summary of the survey findings. It is not clear if the survey included permanent and seasonal residents.* *The EIS also includes the findings of a community telephone poll of permanent residents of Kincardine that was conducted in January and February 2005 by an independent company called The Strategic Counsel. The EIS notes that seasonal residents were mailed a copy of the question and asked to respond by mail. The combined survey results (shown in Appendix D3 of the EIS) are not broken down by type of respondent/resident (i.e., permanent and seasonal).* *For the two above public engagement activities, it would be beneficial to know whether or not the seasonal residents anticipated greater/different changes in expectations, attitudes or behaviours (e.g. use and enjoyment of private property, use of beaches or boating, tolerance for disturbance resulting from the DGR, economic benefits) than permanent residents.*
		OPG Response: OPG Engagement Activities Engagement activities for the DGR Project were planned to provide opportunities for year-round and seasonal residents to be informed and participate. Feedback from both categories of residents was taken into consideration. Typically cottage owners associations have a proportionally higher seasonal resident membership. At presentations to these groups the level of support for the project was similar to that expressed by year-round residents. One difference noted was that questions about employment opportunities were less frequent among seasonal residents. Feedback from presentations to cottage owners associations is included in Table 2.5.1-1 of the EIS. Attendees at other presentations were not asked to identify themselves as either year-round or seasonal residents. 2009 Public Attitude Research The 2009 Public Attitude Research was a random survey. It did not distinguish between year-round and seasonal residents and included both. The survey instrument included a “screening” question in an attempt to identify and analyze responses from potential seasonal residents (i.e., Have I reached you at your home

IR#	EIS Guidelines Section	Information Request and Response
		telephone number or your family-owned cottage telephone number ?). In the 2009 Public Attitude Research, there were only 14 respondents whom identified themselves as being contacted at their cottage. As a result, no specific analyzes were undertaken due to the small sample. It cannot be assumed that many more seasonal residents would have interviewed through a random survey approach if the study was during the tourist season.

A separate Tourist/Day User Survey was conducted in MacGregor Point and Inverhuron Provincial Parks, and Brucedale and Stoney Island Conservation Areas with one of the objectives being to determine potential concerns regarding the DGR Project among persons that are not permanent residents but visitors to the Local and Regional Study Areas. The vast majority of respondents to this field survey identified themselves as tourists to the area. In response to the question "What would be your 3 main concerns with respect to the presence of a Deep Geologic Repository at the Bruce nuclear site?", the top three unprompted responses were damage to/contamination of the environment (45%), long-term threat to human and health and safety (20%), and construction, operations and management (16%).

2005 Telephone Poll

In reporting the results of the 2005 telephone poll to the Municipality of Kincardine, The Strategic Counsel provided the following breakdown of eligible households and of participating households.

	Total Year Round and Seasonal	Year Round	Seasonal
Number of Eligible Households: Consultation Sample	5282	4285	997
Number of Households in Assessment Roll	5473	4370	997
Number of Households in Statistics Canada 2001 Census	5257	4315	492
Total Residents (Stats Canada 2001)		8319	
Total Residents Participated		6208	570
Households Contacted	5282	4285(1)	997 (by mail)
Number of Households Responding	3763	3470	293

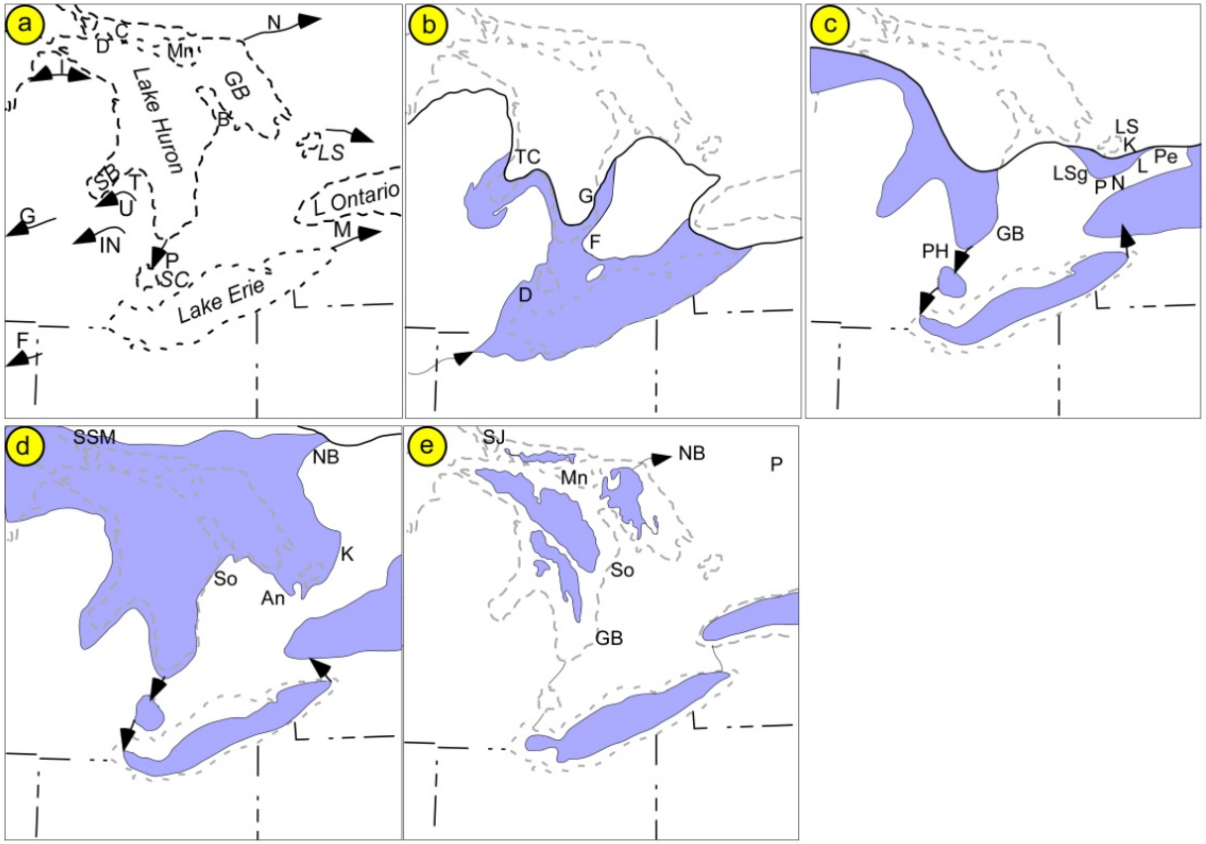
Note: [1] Of Year-round households, 18% were incomplete. For 9%, no contact was able to be made and 9% refused.

The response rate among year-round residents was higher than among seasonal residents. The survey results were not reported separately for year-round and seasonal residents.

IR#	EIS Guidelines Section	Information Request and Response
EIS-01-32	▪ EIS Guidelines: Section 16, Follow-Up Program	***Information Request:*** *Describe how the proponent plans to monitor waste degradation rates (gas consumption, generation) within the sections of the repository to be closed off during operations in order to verify the EIS predictions on this matter.* ***Context:*** *The EIS indicates that the general air quality of the underground DGR will be monitored under the Environmental Management Program to ensure that the health and safety of personnel within the DGR is not compromised during underground construction and operations. The preliminary safety report indicates that concrete closure walls will be placed in the access tunnels at several places within the repository in order to isolate sections of the panel. Specifically they are: "designed to limit release of tritiated air, natural and waste-generated methane, and other off-gases from waste packages (e.g., H_2 and CO_2), as well as potentially contaminated water. In the remote event that explosive gases build up behind the closure wall and an explosion occurs, the air blast from the explosion will be contained by the closure wall."* *Since the first access tunnel closure wall is expected to be built several years before decommissioning, they will provide the opportunity to monitor waste degradation rates (O_2 consumption and CO_2/CH_4 production). This monitoring is important for operational safety and for verification of gas model EIS predictions and therefore should be included in the EIS Follow-up Program.*
		OPG Response: Plans to monitor waste degradation within the repository will be provided as part of submissions supporting the Operating Licence application. However, the following types of measurements would likely be undertaken. • Placement of (non-radioactive) waste materials in monitored in-situ test boreholes at the repository horizon. These tests would likely be conducted in the Geoscience testing niche. • Periodic measurements of gas composition at exits of some waste filled but ventilated rooms, which would provide, with ventilation rate data, integrated information on waste degradation under largely aerobic conditions. • Measurements on the first closed panel, to monitor its evolution from aerobic to anaerobic after the closure wall is installed, and the initial period of gas consumption, generation and water flow in a closed panel. Since this instrument would not be installed for many years (i.e., at least 10 years into the operations phase), the specific measurement technique would be selected from those available at that time. These measurements would provide a few decades of data before DGR decommissioning was initiated, to help validate the waste degradation rates and, in particular, the related gas generation rates.

IR#	EIS Guidelines Section	Information Request and Response
EIS-01-33	▪ EIS Guidelines: Section 8.1, General Information and Design Description: 12th and 14th bullets.	***Information Request:*** *Describe how the proponent plans to verify the waste inventories (radiological and hazardous) during the DGR operational period, including radionuclides levels in the refurbishment waste, in order to confirm predictions of the inventory at the repository closure in 2062.* ***Context:*** *The radionuclide and hazardous substance inventory that is forecast is part of the basis for the safety assessment of both the preclosure and postclosure phases of the DGR. The inventory predictions made in the EA need to be verified for both the current inventory and also once refurbishment waste is sent to the DGR. There is currently no indication of a follow-up program element to deal with this matter.*
		OPG Response: Currently, OPG manages its waste inventory through Waste Acceptance Criteria which include the requirement for data on received wastes. The measurement data are integrated into OPG's waste tracking database. This information will be used to generate an updated estimate of the projected DGR inventory, which will be provided as part of the Operating Licence application. The update will include actual waste in storage at the time of the update, along with the latest forecasts of future volumes and characteristics, based on the then-current operating plan for the reactor fleet. The waste tracking system will continue to track the waste packages emplaced in the DGR and can provide a running inventory of total waste emplaced at any time along with the characteristics of the emplaced waste. During DGR operations, all waste packages sent to the DGR will be checked against the DGR waste acceptance criteria, which will include measuring the waste package dose rate to ensure it is within specified limits. If required for some waste types, inventories for individual waste packages can be estimated from the measured dose rates and waste-type specific scaling factors or from additional analyses. A program for verifying waste inventories during the operational phase will be developed and provided as part of the Operating Licence application. During DGR operations, an updated current inventory of waste volume and total radioactivity stored at the DGR will be provided on a quarterly or annual basis, similar to the quarterly reports presently issued by the Western Waste Management Facility to the CNSC. An updated projected inventory based on the received waste packages and future forecast packages would be provided in support of subsequent licence renewal applications.

FIGURES ASSOCIATED WITH RESPONSES TO EIS IRs



Note: **(a)** Paleodrainage outlets related to the Lake Huron Basin. Arrows indicate direction of outflow. Outlets: F – Ft. Wayne, G – glacial Grand River, I – Indian River Lowland, IN – Imlay City-North Branch, M – Mohawk, N – North Bay, P – Port Huron, T – Trent Lowland, U – Ubly. Other letters indicate: B – Bruce Peninsula, C – Cockburn Island, D – Drummond Island, GB – Georgian Bay, Mn – Manitoulin Island, SC – Lake St. Clair, LS – Lake Simcoe and T – Michigan’s “thumb”. **(b)** Maximum areal extent of Lake Warren (210 m). D – Detroit, F – Forest, G – Goderich and TC – Tawas City. **(c)** Maximum aerial extent of early glacial Lake Algonquin and Schomberg. Letters refer to GB – Grand Bend, K – Kirkfield, LS – Lake Simcoe, LSg – Lake Schomberg, L – Lindsay, N – Newmarket, P – Palgrave, Pe – Peterborough and PH – Port Huron. **(d)** Areal extent of Main Lake Algonquin (184 m). Letter symbols: An – Alliston, K – Kirkfield, M –Mackinac Island, NB – North Bay, SJ – St. Joseph Island, So – Southhampton, SSM – Sault Ste. Marie and Su – Sudbury. **(e)** Lakes Stanley (~45 m) and Hough. Letter symbols: GB – Grand Bend, Mn – Manitoulin Island, NB – North Bay, P – Petawawa, SJ – St. Joseph Island, So – Southhampton (modified from Eschman and Karrow 1985).

Figures (b) to (e) show several lake boundaries in the Lake Huron Basin as the ice retreated after last glacial maximum. Eventually subsequent to Figure (e), the basins filled to their present level, with outlet through Lake Erie and Lake Ontario.

Figure 2.7 (associated with IR-EIS-01-16). Ancestral Lakes of the Lake Huron Basin (Slattery 2011)

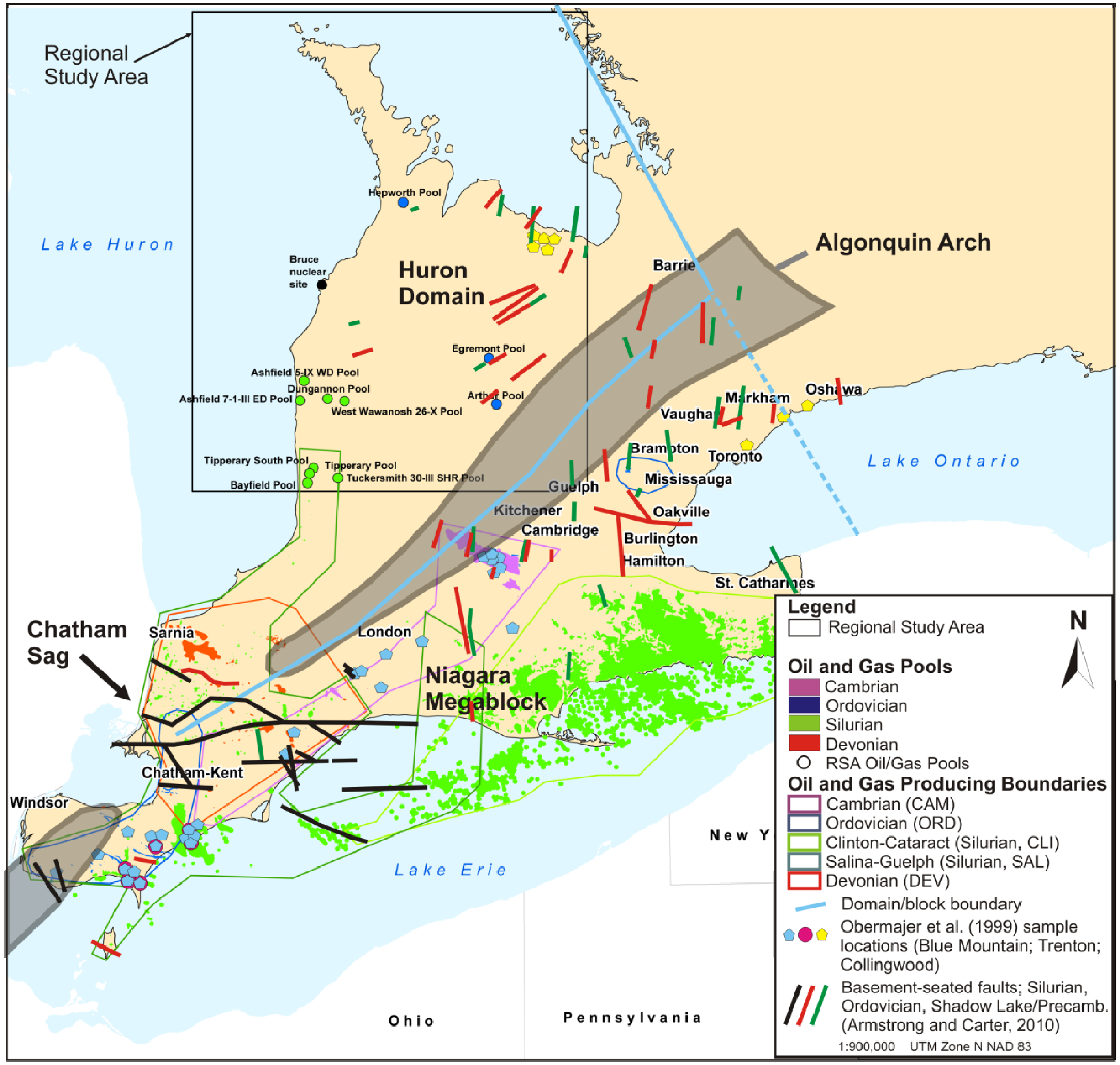


Figure 1 (associated with IR-EIS-01-24). Petroleum occurrences, mapped faults and prominent tectonic features of southern Ontario. Also shows the sample locations from Obermajer et al. (1999) and the interpreted block boundaries of Sanford et al. (1985).

ATTACHMENT 2

Attachment to OPG letter, Albert Sweetnam to Dr. Stella Swanson, “Deep Geologic Repository Project for Low and Intermediate Level Waste – Submission of Responses to Information Requests”

March 9, 2012

CD#: 00216-CORR-00531-00108

OPG Response to the Joint Review Panel LPSC Information Requests Package 1

<table>
<tr><th>IR#</th><th>NSCA Regulations Section #</th><th>Information Request and Response</th></tr>
<tr><td rowspan="2">LPSC-01-01</td><td rowspan="2">Class 1 Nuclear Facilities Regulations (C1NFR) 5(a) and (d)</td><td> Information Request:
For surface structures, provide clarification on the required application of the current edition (2010) of the National Building Code of Canada (NBCC) to all surface building and structures, including those surface buildings and structures that relate to mining activities.
Context:
Table 6-1, in PSR 6.1.2 Applicable Regulatory Standards and Codes, identifies the application of the National Building Code of Canada (NBCC). The Project Requirements, section 19.2 titled Buildings and Structures, states that
“(a) Surface facilities (except “mine-specific”) - NBCC (2005)
(a) Surface facilities - Ontario Regulation 213/91, Construction Projects (applicable to construction work to a nominal depth of 50 m below ground surface)
(b) Surface facilities and underground waste handling - Ontario Regulation 851/90, Industrial Establishments
(c) Underground facilities - Ontario Regulation 854/90, Mines and Mining Plants.”
While the text identifies NBCC (2005) for surface facilities excepting mine-specific, CNSC staff notes that <u>all</u> surface facilities, including those that relate to mining activities and are described in the document as ‘mine-specific’, are required to comply with the current editions (2010) of the National Building Code of Canada.
Assurance is needed on the application of the current editions of the NBCC to all surface structures, including those that relate to mining activities. </td></tr>
<tr><td> OPG Response:
The design activities supporting the preparation of the Preliminary Safety Report (PSR) were completed prior to the issuance of the National Building Code of Canada (NBCC), 2010 edition. As stated in Section 19.0 of the Project Requirements, DGR-PDR-00120-0001 (NWMO 2010), the most current version of referenced regulations, codes and standards are to be applied to the project, hence any future design work will be compliant with the 2010 edition, or later, as appropriate.
The NBCC is applied to all of the surface buildings and structures with the exception of the application to headframes with respect to the NBCC live load factors. The Ontario mining regulations, Regulation 854/90, </td></tr>
</table>

IR#	NSCA Regulations Section #	Information Request and Response
		Mines and Mining Plants, Section 208(d), state "A headframe on surface or underground in an underground mine shall, (d) be of sufficient strength to safely withstand all loads to which it is likely to be subjected". The NBCC does not have applicable live load factors specific to headframes or the loading of the hoisting equipment. For this requirement, the headframe designs assume a rope break scenario as being the limiting load to design. For the DGR headframes, the design uses a factor of 1.1 for the conveyance rope breaking load as the most significant load, which is consistent with mining industry practice. **Reference:** NWMO. 2010. Ontario Power Generation's Deep Geologic Repository for Low and Intermediate-Level Waste Project Requirements. Nuclear Waste Management Organization document DGR-PDR-00120-0001 R002. Toronto, Canada.
LPSC-01-02	▪ C1NFR 5(d) and (e)	***Information Request:*** *For fire protection, provide clarification on the application of the current edition (2010) of the National Fire Code of Canada (NFCC) to the fire protection systems of all surface facilities, including those described as mine specific; and the application of the current edition (2010) of the NFCC to below ground areas. Also confirm the correction to reference the current edition of the NBCC which is 2010.* ***Context:*** *Table 6-1 of PSR 6.1.2 identifies the application of the National Fire Code of Canada (NFCC). The Project Requirements, section 19.3 titled Fire Protection System, states that:* *"(a) Surface facilities (except "mine-specific") - NBCC (2005)* *(b) Underground mine-specific (e.g., head frames, hoist rooms) facilities – Ontario Regulation 854/90, Mines and Mining Plants* *(c) Surface facilities – National Fire Code (2005)* *The text indicates 'underground' facilities as complying with O. Reg. 854/90 for the fire protection system. It is CNSC staff's opinion that the National Fire Code of Canada requirements are applicable to the underground portion of the facility also. This is to ensure that the appropriate inspection, testing and maintenance of the fire protection features are implemented.* *<u>All</u> surface facilities, including those that relate to mining activities and are described in the document as 'mine-specific', are required to comply with the current edition (2010) of the NBCC. Further, the current edition (2010) of the NFCC also applies to fire protection systems of the surface facilities.*

<table>
<tr><th>IR#</th><th>NSCA Regulations Section #</th><th>Information Request and Response</th></tr>
<tr><td></td><td></td><td>For the fire protection system, assurance is needed as to the codes to be applied to the surface and below ground facilities.</td></tr>
<tr><td></td><td></td><td>OPG Response:

The design activities supporting the preparation of the Preliminary Safety Report (PSR) were completed prior to the issuance of the National Building Code of Canada (NBCC) and the National Fire Code of Canada, 2010 editions. In accordance with Section 19.0 of the Project Requirements, which states that ‘The latest version of all regulations, standards and codes listed in this section will be used; the newer codes; National Building Code of Canada – 2010 (NBCC) and the National Fire Code of Canada - 2010 (NFCC) will be used for future design of the DGR, along with more stringent applicable requirements in the Ontario Health and Safety Act (OHSA) regulations.

OPG concurs with CNSC staff’s opinion that NFCC requirements are applicable to the underground portion of the DGR. NFCC will be followed and alternative solutions (Ref. NFCC A.1.2.1.1.(1)(b)) will be pursued if needed. As well, for the underground portions of the facility, the inspection, testing, and maintenance of the fire protection systems is covered by the OHSA Mines and Mining Plants Regulations (O.Reg. 854/90). The Mine Regulations require monthly inspections of fire extinguishing equipment, fire suppression systems, fire hydrants, and fire doors both below-grade (Section 28.3) and above-grade (Section 41.5), and monthly inspections of the escapement exit (Section 37.2(f)). These inspections are required to be carried out by a competent person and the results reported in writing to the mine supervisor. Reference to the inspection, testing, and maintenance requirements of the NFCC will be included in the inspection program for the underground portion of the facility to provide added assurance that the inspections required by the OHSA Mines and Mining Plants Regulations are being carried out in accordance with all recognized and accepted practices.

Please see the response to Information Request IR-LPSC-01-01 for use of the NBCC for the design of surface facilities. On the surface, the facility has supporting headframe structures for the mine hoists. The occupancy classification has been determined to be a low hazard since it is not an occupied building, however there are periodic inspections and maintenance activities. The structure is classified as a Group F division 3 classification. In locations of fire hazards, local dry type suppression systems will be used, as well as fire detection systems. This will minimize moisture into the mines. This interpretation is consistent within the mining industry across Canada.</td></tr>
<tr><td>LPSC-01-03</td><td>▪ C1NFR 5(d)</td><td>Information Request:

With respect to seismic hazards, provide information clarifying the edition of the NBCC that will be used in design the DGR surface buildings and structures to withstand earthquakes and identify the peak ground</td></tr>
</table>

IR#	NSCA Regulations Section #	Information Request and Response
		acceleration that will used for the design and include information on the basis for its use. ***Context:*** *PSR 6.1.2 specifies that the DGR design will comply with the National Building Code of Canada (NBCC). Table 4-10 of PSR 4.5.2.2 provides peak ground acceleration from a seismic hazard assessment that refers to the 2005 edition of the NBCC. The Project Requirements, section 6.1, states that 'the occurrence of a seismic ground motion event, as specified in the NBC (2005) shall not lead to a structural failure in DGR surface facilities …'.* *CNSC staff can not confirm the application of appropriate seismic accelerations to the detailed DGR design.*
		OPG Response: The design supporting the Preliminary Safety Report (PSR) development was completed before the latest National Building Code of Canada – 2010 (NBCC) edition was released. As per Section 19.0 of the Project Requirements, DGR-PDR-00120-0001 (NWMO 2010), the most current version of referenced regulations, codes and standards are to be applied to the project. Future design activities will use the latest NBCC seismic requirements as provided in NBCC (2010) Appendix C, Volume 2 as follows: • Sa (0.2): 0.11 • Sa (0.5): 0.075 • Sa (1.0): 0.049 • Sa (2.0): 0.016 • PGA: 0.036 Sa(T) is a series of factors summarized as being the 5%-damped horizontal spectral acceleration values for 0.2, 0.5, 1.0, and 2.0 second time periods (T), expressed as a ratio of gravitational acceleration. PGA is: Peak Ground Acceleration (also expressed as a ratio of gravitational acceleration). **Reference:** NWMO. 2010. Ontario Power Generation's Deep Geologic Repository for Low and Intermediate-Level Waste Project Requirements. Nuclear Waste Management Organization document DGR-PDR-00120-0001 R002. Toronto, Canada.

IR#	NSCA Regulations Section #	Information Request and Response
LPSC-01-04	▪ C1NFR 5(e)	***Information Request:*** *With respect to pressure retaining systems, provide information clarifying the application of Canadian Safety Association, General Requirements for Pressure Retaining Systems and Components for Candu Nuclear Reactors (CSA 285-08) and its updates, to the design effective date, in the DGR Project Requirements and PSR.* ***Context:*** *OPG indicates in PSR 6.1.2, Table 4-10, and in section 19.4 of Project Requirements, their application of Canadian Safety Association, General Requirements for Pressure Retaining Systems and Components for Candu Nuclear Reactors CSA N285-08 to pressurized systems in the DGR. CNSC staff note that Update No. 2 to this standard has been issued.* *Assurance is needed that CSA N285-08 and associated updates will be applied to pressurized systems and components in the DGR facility design.*
		OPG Response: As stated in Section 19.0 of the Project Requirements, DGR-PDR-00120-0001 (NWMO 2010), the most current version of referenced regulations, codes and standards are to be applied to the project. The use of the CSA N285.0-08 Standard and the two (2) updates; No.1 (2009) and No.2 (2010) will be documented in the System Classification List (SCL) for the pressure retaining systems of the DGR. This requirement will then be translated into the design documentation, as appropriate. Control and compliance with the CSA standard will be accomplished through governance, project management and oversight of the DGR Project. For pressure boundary systems identified in the design, a package will be submitted to the Technical Standards & Safety Authority (TSSA) for registration and will include a copy of the SCL, flow diagrams, calculations, etc. The TSSA will review the design of the pressure boundary systems for compliance with the CSA standard before issuing a Canadian Registration Number for the piping system(s). **Reference:** NWMO. 2010. Ontario Power Generation's Deep Geologic Repository for Low and Intermediate-Level Waste Project Requirements. Nuclear Waste Management Organization document DGR-PDR-00120-0001 R002. Toronto, Canada.

IR#	NSCA Regulations Section #	Information Request and Response
LPSC-01-05	▪ C1NFR 5(a)	***Information Request:*** *Provide information on the design standard that will be used for concrete structures.* ***Context:*** *Table 6-1 in the PSR identifies CSA A23.1 and A23.2 (titled Concrete materials and methods of concrete construction/Test methods and standard practices for concrete, respectively) but did not reference a standard for the design of concrete structures. CSA A23.3, Design of Concrete Structures, is standard that is considered by CNSC staff to be acceptable for the detailed engineering of the concrete structures.* *Confirmation is needed that appropriate standards are applied to the design of concrete structures for the DGR facility.*
		OPG Response: CAN/CSA A23.3, Design of Concrete Structures is applicable to the design of surface structures for the DGR facility. The one exception to the application of this standard is the design of the shaft liner. Applying the standard to the shaft liner could require that the concrete be reinforced with rebar which is detrimental to the long-term performance of the liner. The use of steel reinforcing in the shaft liner, specifically in the DGR application where contact water will be brine, can result in the corrosion of the reinforcing steel as this water saturates the concrete. This will result in spalling of the concrete and allowing water to enter the shaft. The shaft liner design takes guidance from geomechanical modeling of the shafts including aspects such as swelling pressures, seismic effects, etc. It is common practice in the Canadian mining industry to construct non-reinforced concrete liners and adjust the thickness of the liner to account for changes in compressive loads.
LPSC-01-06	▪ C1NFR 5(d)	***Information Request:*** *Provide a description of the foundations for the surface structures, including information addressing their suitability for the general ground conditions.* ***Context:*** *The general design of the surface structures is provided in PSR 6.2, but no description of the foundations for the surface structures is included.*

IR#	NSCA Regulations Section #	Information Request and Response
		Descriptions of the foundations for the surface structures are needed to complete the description of the general design of the DGR facility.
		OPG Response: A geotechnical field investigation program was conducted at the DGR project site in 2011 in support of the design (refer to the response to IR-EIS-01-01). On the DGR project site where surface facilities will be located, the overburden is generally comprised of a layer of topsoil or fill that overlies a thick layer of dense to very dense glacial till. At some locations, layers of silt, sand, clayey silt, or sand and gravel were present between the fill and the till deposit or at the ground surface directly above the till deposit. Beneath the overburden is dolostone bedrock. It is planned that the headframes will be founded on bedrock as part of the shaft collar construction. All other permanent surface structures are planned to be founded on the glacial till and/or an engineered fill material. Planned column foundations will generally be of spread footing type; supplemented with strip footings for masonry wall elements and with an option for providing concrete grade beams as required for areas where ground settlement may be a consideration or other special conditions dictate. Equipment foundations for specific installations, such as emergency power generators, surface mounted hoisting installations and ventilation equipment will generally be of monolithic concrete construction with a ground bearing interface on the sub-grade.
LPSC-01-07	▪ C1NFR 5(d) and (4) ▪ Radiation Protection Regulations (RPR) 4	***Information Request:*** *Provide information demonstrating that the regulatory equivalent dose limits for Nuclear Energy Workers (NEWs), non-news and members of the public are part of the radiation protection requirements for DGR design and operation, and that they will be adhered to and kept as low as reasonably achievable (ALARA).* ***Context:*** *Sections 15.2.2 and 3 of the Project Requirements, referenced in PSR 6.1.2, identify occupational dose limits and dose constraints in terms of 'effective' dose and the requirement that the DGR be designed, constructed, operated, and decommissioned in keeping with ALARA. Section 7.1.2.1 of the PSR and the Preliminary ALARA Assessment report present dose limits and targets in terms of effective dose.* *No acknowledgement or demonstration was made of the 'equivalent' dose limits as part of the radiation protection requirements for DGR design and of the adherence to these limits, or to keeping these doses ALARA.*

IR#	NSCA Regulations Section #	Information Request and Response
		OPG Response: The regulatory equivalent dose limits are contained within the Radiation Protection Regulations, and as noted in the Preliminary Safety Report (PSR) the DGR will be compliant with these regulations: • PSR, Section 1.4.1, Section 7.1.2.1 and Section 10.1, indicate that the Radiation Protection Regulations (SOR/2000-203) are applicable to the DGR. • PSR, Table 6-1 and Section 6.10.1, indicate that the DGR will be compliant with the OPG Radiation Protection Requirements. These OPG requirements include equivalent dose limits that are equal to the CNSC limits (Sections 4.1 to 4.3, OPG 2001). • Preliminary ALARA Assessment, Section 4.1 (SENES 2011) indicates that the Radiation Protection Regulations apply (SOR/2000-203), and Section 4.2.1 indicates that the regulations are implemented through the OPG Radiation Protection Requirements (OPG 2001). The regulatory dose limits specifically presented and discussed in the PSR and Preliminary ALARA report are the whole body effective dose limits. This is consistent with the nature of these wastes and waste handling, where the whole body effective dose is the practical limit. It is also consistent with other OPG waste management facility safety reports - in particular the WWMF Safety Report (OPG 2009a, Section 1.5). With respect to workers (i.e., NEWs), WWMF experience indicates that effective dose is generally more limiting, as documented in the quarterly reports. As an illustrative example, in the 2009 Fourth Quarter, the largest individual dose was 0.70 mSv external whole body, 0 mSv skin beta, and 2.06 mSv extremity (OPG 2009b). Although the extremity dose is higher than the external whole body dose (since the extremities are closer to the packages), the extremity dose limit (500 mSv/yr) is also much higher than the whole body dose limit (20 mSv/yr) and therefore the effective whole body dose is closer to its limit. In this example, the quarterly extremity dose is 2.06/500 =0.4% of dose limit, while the effective whole body dose is 0.70/20 = 4% of dose limit. Similar wastes and waste packages will be handled at the DGR, so the same conclusion is expected. That is as long as the worker whole body effective dose remains within its limit, practical experience at WWMF indicates that the worker doses will also remain within the equivalent dose limits. This expectation will be confirmed during operations. With respect to non-NEWs, their effective dose limit is proportionally more restrictive than their equivalent dose limits (i.e., 1 mSv/yr whole body, 50 mSv/yr skin and extremities). Also, since non-NEWs are not handling waste packages, their equivalent doses will be even smaller relative to whole body effective dose than for NEWs. Therefore, the PSR conclusion, that DGR operations will not exceed non-NEW effective dose limits,

IR#	NSCA Regulations Section #	Information Request and Response
		provides confidence that it will also not exceed non-NEW equivalent dose limits. With respect to the public, the DGR emissions will be much less than the preliminary DGR Derived Release Limits (DRLs). The preliminary DGR DRLs are set to the WWMF DRLs (OPG 2003). The latter were derived considering both effective and equivalent dose limits. Therefore, the DGR emissions will remain within public equivalent dose limits. With respect to postclosure performance, the assessment is based on effective whole body dose limits. This is consistent with the potential exposure situations, which would involve chronic dose due to released contaminants in the environment leading to a whole body dose through ingestion, inhalation and immersion. It is consistent with ICRP and CNSC recommendations that postclosure safety be assessed based on the effective dose. ICRP (1998) states that: "... the annual individual effective dose to a critical group for normal exposure and the annual individual risk to a critical group for potential exposure will together provide an adequate input to a comparison of the limiting detriment to future generations with that which is currently applied to the present generation." The same idea is again communicated in the CNSC G-320 regulatory guide (CNSC 2006), which states that: "Long term safety assessments of a facility or contaminated site should provide reasonable assurance that the regulatory radiological dose limit for public exposure (currently 1 mSv/yr) will not be exceeded." **References:** CNSC. 2006. Assessing the Long-term Safety of Radioactive Waste Management. Canadian Nuclear Safety Commission Regulatory Guide G-320. Ottawa, Canada. ICRP. 1998. Radiation Protection Recommendations as Applied to the Disposal of Long-lived Solid Radioactive Waste. International Commission on Radiological Protection. ICRP Publication 81. OPG. 2001. Radiation Protection Requirements - Nuclear Facilities. OPG Requirements N-RPP-03415.1-10001 R07. Toronto, Canada. OPG. 2003. Derived Release Limits for the Western Waste Management Facility. Ontario Power Generation report 0125-REP-03482-00002 R00. Toronto, Canada. OPG. 2009a. Western Waste Management Facility Safety Report. Ontario Power Generation report W-SR-01320-00001 R002. Toronto, Canada. OPG. 2009b. Nuclear Waste Management Division Western Waste Operations, Quarterly Operations Report, Fourth Quarter – 2009. Ontario Power Generation report W-REP-00531.1-00054-R00. Toronto, Canada. Radiation Protection Regulations. SOR/2000-203. Canada.

IR#	NSCA Regulations Section #	Information Request and Response
		SENES. 2011. Preliminary ALARA Assessment. SENES Consultants Ltd. report for the Nuclear Waste Management Organization NWMO DGR-TR-2011-36 R000. Toronto, Canada.
LPSC-01-08	▪ C1NFR 5(d) ▪ RPR 4(a) and 5	***Information Request:*** *For the Waste Package Receiving Building (WPRB) provide information clarifying:* ▪ *how ALARA is accounted for in the design of the WPRB (for NEWs and Non-NEWs);* ▪ *the maximum number of intermediate level waste packages that the intermediate level waste staging area is expected to support in an 8 hour shift;* ▪ *the maximum dose rate from the low and intermediate level waste packages in the staging areas;* ▪ *the location and general layout of adjacent control room and offices; and* ▪ *the application of ALARA in the design for those working in the office/control room.* ***Context:*** *PSR 6.2.1.2 Waste Package Receiving Building provides a general description of the number (24) of low level waste packages but not the number of intermediate level package that the staging area may support during an 8 hour shift.* *PSR 6.2.1.2 states that “localized shielding is incorporated into the WPRB wall design adjacent to the staging area, as required to protect workers … in accordance with OPG radiation protection requirements” and that the detailed engineering will ensure “the external dose rate outside the WPRB is below the OPG 25 µSv/hr building exterior radiation protection requirement and that dose rates in the office/control room are below the dose target of the 10 mSv/year.” (see PSR 7.7.1).* *Further, PSR 10.1.1 Keeping Doses ALARA, affirms that radiation exposure is, amongst other things, managed by “establishing facility design optimized on the basis of ALARA considerations”.* *CNSC staff expects that the structures are designed to ensure regulatory dose limits are respected and radiation exposures to individuals are ALARA. An examination of the Preliminary ALARA Assessment did not provide an account for workers in the office/control room area. Given the design targets, 25 µSv/hr at the building exterior and < 10 mSv/yr for the Zone 1 office/control room, it is not apparent whether the regulatory dose limits and ALARA have been taken into account for non-NEW workers in the design of the WPRB.* *No information is provided on the maximum dose rate from the low and intermediate level packages that will be used for the detailed engineering of the shielded wall, and figure 6-4 of the PSR does not clearly illustrate the location of the adjacent rooms and offices.*

IR#	NSCA Regulations Section #	Information Request and Response
		OPG Response: The Preliminary Safety Report (PSR), including the Preliminary ALARA Assessment (SENES 2011), considers the preliminary engineering design. At this design stage, shielding was not specified, but was assumed to be included as part of the detailed design, as appropriate to meet regulatory (NEWs and non-NEWs) and ALARA requirements. Specification of the shielding is part of the detailed design, and is not presently complete. The ALARA results will be provided with the Final ALARA Assessment report that will be prepared as part of the supporting documentation for the DGR Operating Licence application. Responses to the questions are provided below. <u>1. Accounting for ALARA in Design of the WPRB</u> The results of the detailed shielding assessment will specify the shielding requirements in the WPRB that will help ensure that dose rates remain below regulatory limits for NEWs (Zone 2) and non-NEWs (Zone 1), and are ALARA. Dose limits will be further managed through operational procedures including task dose planning, monitoring of individual worker doses and assignment of tasks, and scheduling of package deliveries. As an example of the latter point (which would benefit both NEWs and non-NEWs), it is planned to initially transfer mostly LLW from WWMF into the DGR, which will allow additional time for in-situ decay of ILW at WWMF before it is transferred. <u>2. Maximum Number of ILW Staged per Shift</u> ILW packages are normally present for a short period as they are transferred from the vehicle to the rail cart and then underground. The WPRB is planned to have a throughput of 2 ILW packages in an 8-hour shift. It will normally operate on a 5-day, 8-hr shift basis 2 ILW packages may be temporarily staged at the WPRB. <u>3. Maximum Dose Rate from L&ILW Packages in the Staging Area</u> The DGR Waste Acceptance Criteria include the following waste package dose rate limits (Table 5-5, PSR): - 2 mSv/hr on contact with external surface of waste package or shielding - 0.1 mSv/hr at 1 m from package to be transported - Exceptions may be approved by responsible health physicist. The design basis for WPRB shielding calculations is a minimum of a single waste package at 2 mSv/hr contact.

<table>
<tr><th>IR#</th><th>NSCA Regulations Section #</th><th>Information Request and Response</th></tr>
<tr><td></td><td></td><td>The maximum allowable dose rate for multiple packages will be assessed as part of the detailed shielding design.

<u>4. Location and Layout of Adjacent Control Room and Offices</u>

The locations of the Control Room and Offices within the Amenities Building will be reviewed as part of the detailed design, with detailed shielding assessments conducted in the occupied areas to ensure dose rates remain consistent with the specific location zoning (Zone 1 or Zone 2) and are ALARA.

<u>5. Application of ALARA in Amenities Building Design</u>

The Amenities Building contains Zone 2 and Zone 1 areas. The Zone 1 areas are being designed for a monthly dose rate average of less than 0.5 µSv/hr, consistent with OPG Radiation Protection Requirements (equivalent to a maximum dose of 1 mSv/yr for an assumed 2000 hr/yr occupancy). Detailed shielding calculations and review of locations of offices and control room mentioned above are part of ongoing ALARA considerations.

Reference:

SENES. 2011. Preliminary ALARA Assessment. SENES Consultants Ltd. report for the Nuclear Waste Management Organization NWMO DGR-TR-2011-36 R000. Toronto, Canada.</td></tr>
<tr><td>LPSC-01-09</td><td>▪ C1NFR 5(e)</td><td>Information Request:

Provide information clarifying both the need and availability of a back-up air supply in tanks or bottles to maintenance areas and refuge stations, and of the need for instrument air. Include supporting information when addressing need.

Context:

In the description provided in PSR 6.2.1.4 on the compressor building used to provide air to maintenance areas (surface and underground) and to refuge stations (underground). It was unclear whether back-up air in tanks or bottles is also being provided in case of a complete loss of compressed air. It is also unclear whether there is any requirement for instrument air.</td></tr>
<tr><td></td><td></td><td>OPG Response:

During DGR operations the surface-based compressors will deliver service air to the underground Maintenance Shop, Service Garage, Main Sump and Shaft Bottom Sump. There is no requirement for separate instrument air.</td></tr>
</table>

IR#	NSCA Regulations Section #	Information Request and Response
		The permanent Refuge Station has been sized and designed for 50 people. It has as its design basis 7.645 m^3 of breathing air per person which is sufficient for 8 hours of containment without additional air supply (MASHA 1998). There are breathing air lines to the refuge station supplied by the surface-based compressors as per the requirements of Ontario Reg. 854/90 for Mines and Mining Plants, Section 26. There will not be breathing air supply in tanks or bottles in or near the permanent refuge station. In addition to the permanent Refuge Station, there will be portable refuge stations positioned closer to the emplacement rooms as they are filled during operations. The compressed air delivery system has several levels of redundancy. Namely, two compressors, one operational and one spare and two supply lines (one in each shaft). The compressors are connected to emergency power that comprises two diesel powered generators providing 100% load redundancy. There is emergency power to the auxiliary hoists to bring underground workers out, with emergency egress routes available to staff. The portable refuge stations will be supplied with breathing air from the surface-based compressors, as well as contained in compressed air bottles. **Reference:** MASHA. 1998. Mine Rescue Refuge Stations Guidelines. Mines and Aggregate Safety and Health Association (now Workplace Safety North). Sudbury, Canada.
LPSC-01-10	▪ C1NFR 5(e)	***Information Request:*** *Provide additional information on the electrical systems, including the induction motor(s) that are its largest load, and the emergency power system. Include information on the basis for the identified emergency power loading and period of operation, and address NBCC emergency power requirements for the fire alarm system. Also address such things as: the kinds of analyses used to assess voltage and current at bus bars and to avoid common mode power failure; the use of batteries in the emergency generator, and in emergency lighting and communication; and the hazards that will be considered for the locations of distribution and control panels.* ***Context:*** *While general information is provided in PSR 6.2.4 on the induction motor, electrical supply and emergency power, information related to design and operational safety were missing such as:* ▪ *the standard for the induction motor(s) (National Electrical Manufacturers Association) (NEMA MG1);* ▪ *if the DGR will use the odd/even separation concept to avoid common mode power failure;* ▪ *if electrical transient assessment program analysis will be used to assess voltage and current at various bus bars;*

IR#	NSCA Regulations Section #	Information Request and Response
		▪ *if the fire alarm system is on the emergency power supply;* ▪ *the analysis for the basis of the 1750 kW emergency power presented in the PSR, taking into account the maximum capacity of individual loads;* ▪ *if batteries will also be used to support emergency lighting and communication, and the basis for their sizing;* ▪ *the basis for the 48 hour operation of the emergency diesel generator presented in the PSR, the standard for the generator, whether there is a need for provisions to hook-up a portable diesel generators, battery size for minimum five starts, the maximum black-out time for the facility; and the* ▪ *locations of electrical system distribution/control panels relative to natural event hazards (floods, etc); and of secondary controls to address access emergencies to the main control room.* *The additional information will enable a clearer understanding of the design of the electrical system and emergency power supply.*
		OPG Response: <u>Induction Motors</u> The following are the current reference heavy induction motor loads which will be fed from the power distribution system. These loads may vary based on the final equipment selection and vendor recommendations. 1. Main shaft hoist motors – 2 x 900 kW 2. Ventilation shaft hoist motors – 2 x 900 kW 3. Underground ventilation fans – 2 x 336 kW The induction motors will be designed and constructed as per NEMA Standard MG-1, Motors and Generators and CSA Standard C22.2, No. 100, Motors and Generators. <u>Class IV Power Distribution System</u> The electrical substation will have feed into each of two bus sections in the 13.8 kV switchgear. Electrical loads will be divided into two buses based on odd/even concept to avoid common mode power failures. In the event of a fault on one of the busses, the other bus will be unaffected. This main-tie-main arrangement provides redundancy from a utility supply perspective and provides the ability to fully transfer the electrical load to either bus section. The loads will be distributed between two buses in such a manner to have full redundancy. The surface and underground facilities will be fed at 13.8 kV via the electrical substation that will step down 13.8 kV to 600 V and re-distribute power at 600 V or 208/120 V as required. The design is to accommodate

IR#	NSCA Regulations Section #	Information Request and Response
		both the construction and operation needs. Based on the preliminary load calculations, two dry type transformers (13.8 kV-600 V) will be sized as 4.0 MVA each to provide N-1 redundancy for the aboveground loads. Power shall feed down through the main and ventilation shafts at 13.8 kV and terminate at the 13.8 kV switchgear in the underground substation. Each individual shaft cable will be rated based on the required supply load for underground providing full redundancy; i.e., if a shaft cable is lost or faulted, the remaining shaft cable will have sufficient capacity to distribute the required power without any scale back to operations. The Class III & IV power system analysis will be carried out using SKM Power Tool Version 6.5 for different possible scenarios to assess voltage and current at bus bars. Protection for the electrical substation will be coordinated with upstream and downstream protection devices. Power system analysis reports including the short circuits, transformer and line voltage drops, transient analyses as required, protection device coordination and arc flash hazard analysis reports will be prepared. Studies will be performed for all electrical power supplies to assure the stability under abnormal conditions. <u>Class III Emergency Power Distribution System</u> Class III Power shall be provided through emergency generators in compliance with CSA C282-09 (Emergency Electrical Power Supply for Buildings) to assure safety in the event of a Class IV power failure. It is not intended to maintain full facility operation in this scenario. Two diesel generator sets will be provided. In the event that one of the generators is not operable the second generator can supply the total emergency load requirements. Provisions for portable generator connection are being investigated for selected systems. The capacity of the generators will be sized to meet the requirement of Class III power capacity requirements of the facility. The generators will be sized taking in to account the maximum capacity of the individual loads. Based on preliminary calculations, two 1,750 kW, 13.8 kV diesel generator sets are required. Once all loads are identified as part of the detailed design, the size of the generator will be finalized. The emergency power system will feed equipment through the cables and electrical equipment used for Class IV distribution. All breakers in switchgears are motorized to allow remote operation by programmable logic control (PLC) for load shedding when a generator is running. The generators shall be connected to the system within 15 seconds as per CSA C282-09. The maximum black-out time will be less than 15 seconds. The emergency power generator system will ensure operation of all critical safety systems, including but not limited to, the following:

IR#	NSCA Regulations Section #	Information Request and Response
		1. Main and ventilation shaft auxiliary hoists and accessories; 2. Sump and dewatering pumps; 3. Two air compressors (any one of two will run under emergency power); 4. Fire alarm system; and 5. Emergency lighting and communications in the repository and on surface. The volume of each fuel tank will be sized to supply 24 hours diesel at its full load capacity or maintain more than 48 hours when the generator is running at around 35% rated load. Since each generator is equipped with its own diesel tank, and each generator is capable of supplying full emergency power loading, the Class III power system is capable to operate 48 hours under full loading during an emergency. Fuel storage capacity is conservative as it is not expected that full loading will be required in an emergency situation and there is minimal power requirements of the site once personnel are safely returned to the surface from the repository. Batteries for each of the emergency generators will have sufficient capacity for two complete cranking cycles which is 30 s of continuous cranking (i.e., a total of 60 s cranking time); or three 10 s crank attempts separated by 10 s rest periods based on the requirements of CSA C282-09. <u>Class II Power Distribution</u> An adequately sized local battery powered Uninterruptible Power Supply (UPS) with 20% spare capacity will be provided for Class II back up power supply requirements. Critical emergency shutdown devices or panels, local emergency lighting and communications will be UPS supported. Based on the maximum capacity of the loads, the battery banks will be sized to carry the emergency loads for a period of two hours with the charger off. This UPS will provide uninterrupted power for all critical loads during the black-out time before the emergency generator comes online and acts as a secondary source of emergency power in the event of an emergency generator system failure. <u>General Comments</u> All electrical equipment including distribution panels, control panels and all electrical terminations will be located at the shaft collar elevations or above (determined from the elevation requirements determined from the Maximum Flood Hazard Assessment, AMEC 2011) to limit the impact of postulated flooding events on the electrical systems. If access to the main control is not possible during an emergency, secondary hoist control in the main and ventilation headframes will be available. Beyond hoist control, the main purpose of the main control room is to monitor on-going facility operations.

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		Reference: AMEC NSS. 2011. Maximum Flood Hazard Assessment. AMEC NSS Ltd. report for the Nuclear Waste Management Organization NWMO DGR-TR-2011-35 R000. Toronto, Canada.
LPSC-01-11	▪ C1NFR 5(d)	***Information Request:*** *Provide information on the Human Factors (HF) design standard, criteria, and/or guidelines that has been and will be used in the detailed design. Identify the areas, both above and below ground, where Human Factors are being applied to the design. Provide additional information on the activities in the main control room and design features in other safety-significant areas.* ***Context:*** *PSR 6.2.1.4 and 6.2.1.4 provide descriptions of the design of the Waste Package Receiving Building (WPRB) and the Main Control Room. Project Requirements, section 19, does not identify the Human Factors design standard, criteria or guidelines that will apply to these areas and others, such as maintenance areas, refuge stations, where Human Factors considerations should be applied in design for safety.*
		OPG Response: The project has developed a Human Factors Engineering Program Plan and Human Factors Verification and Validation Plan. These detail the human factors (HF) standards, criteria and guidelines applicable to the design. Where HF requirements cannot be incorporated into DGR-specific design activities (e.g., Human Machine Interface (HMI), vendor supplied equipment) the requirements will be incorporated into procurement specifications for verification and validation prior to selection. The design of the Waste Package Receiving Building, offices, main control room, amenities building and all other buildings/structures is reviewed for human factors considerations using a checklist-based verification design review approach. The verification checklists used for design are based on human factors design standards, guidelines and best practices. The HF design evaluation includes review of facility layouts, process designs and equipment interface designs against the design review checklist. As a result of each evaluation, HF design recommendations are developed for consideration for design modifications. Examples of design standards, guidelines, and best practices that were used in the development of the checklist include: • CAN/CSA-ISO 9241-5-00. Workstation Layout and Postural Requirements (Adopted ISO 9241-4: 1998). • Chamberland, A., R. Carrier, F. Forest, and G. Hachez. (1997). Anthropometric Survey of the Land Forces. Department of National Defence.

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		• IEEE Std 1023-2004 (Revision of 1023-1998), IEEE Guide for the Application of Human Factors Engineering to Systems, Equipment, and Facilities of Nuclear Power Generating Stations. • Applicable requirements of the National and Ontario Building Codes. • MIL-STD-1472F. Department of Defense Criteria Standard. Human Engineering. August 1999. • MIL-HDBK-759C. Department of Defense Handbook for Human Engineering Design Guidelines. • Nuclear Regulatory Commission. (2002). Human-system interface design review guideline (NUREG-0700 Rev. 2). Washington, DC: United States Nuclear Regulatory Commission. • Nuclear Regulatory Commission. (2004). Human Factors Engineering Program Review Model (NUREG-0711 Rev. 2.). Washington, DC: United States Nuclear Regulatory Commission. • Ontario Occupational Health and Safety Act, Ontario Ministry of Labour. • Occupational Health and Safety Act Ontario Regulation 851, Industrial Establishments • Occupational Health and Safety Act Ontario Regulation 854 Mines and Mining Plants Part III, 46 (9) • Pheasant, S. & Stubbs, D. (1994). Manual Handling – An Ergonomic Approach. National Back Pain Association in collaboration with Thorn EMI. • Templer, J. (1992). The Staircase. Studies of Hazards, Falls and Safer Design. MIT Press. The checklist-based review evaluates the work tasks and work areas against the following human factors issues, where applicable: • Clearance and Accessibility; • Barriers and Protective Shielding; • Exits, Entrances and Doors; • Stairs, Ladders and Ramps; • Platforms, Catwalks and Walkways; • Floor Surfaces and Tripping Hazards; • Routes; • Lighting; • Temperature; • Humidity; • Noise; • Ventilation; • Vibration; • Radiological Exposure; • Personal Protective Equipment; • Working Postures;

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		• Manual Handling; • Stand-up Console (Fixed) Dimensions; • Sit-Down Console (Fixed) Dimensions; • Vertical Panels; • Safety and Interlocks; • Routine Procedures; and • Human Machine Interface Requirements (requirements will be tailored depending on interfaces provided).
LPSC-01-12	▪ C1NFR 5 (d)(e)	***Information Request:*** *Clarification is requested on the volumes of process water and underground seepage expected during the construction period and how it has been considered in the sizing of the stormwater management pond.* ***Context:*** *PSR 6.2.4.8 provides a description of the stormwater management system which is to serve during both DGR construction and operation. Information provided discusses the sizing of the stormwater management pond based on catchment size and rainfall events. This information does not indicate consideration in the sizing of excavation effluents during the period of underground construction (process water and underground seepage).*
		OPG Response: The flow rate of underground effluents during the construction phase is conservatively assumed to be a constant 21 L/s [Note that the estimated flow rate of underground effluents during the operational phase is much less at about 2 L/s]. The water will be pumped up the shaft from the main underground sump(s) and discharged into an oil/water separator at the surface for treatment of oils, grease and suspended solids, prior to discharge into the collection ditch system where it will flow to the stormwater management pond. A temporary water treatment plant will be available and used, as required, to remove excess amounts of oils, grease and/or suspended solids in the underground water (see response to IR-LPSC-01-27). The design of the stormwater management pond, including outlet structure, will: • Ensure post-development peak flows for various storm events do not exceed current peak flows in the existing site ditch leading to Lake Huron. ["Post-development peak flows" means peak flows after DGR project development for construction or subsequent operational phase activities.]; • Safely convey the peak outflow rate associated with 24-hour 100-year storm event;

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		• Provide 24 hours of sediment settling time from stormwater runoff associated with 25 mm of rainfall in 6 hours; and • Ensure that the average annual Total Suspended Solids (TSS) concentration in the effluent does not exceed 40 mg/L. The stormwater management pond will have a pond outlet structure that consists of a discharge pipe and an overflow weir. Water will normally leave the pond via the discharge pipe and in event of a major storm (say 100-year storm event) water would also discharge over the weir. All pond discharge water will flow into a set of culverts under the "interconnecting road" and then via an existing site ditch system to Lake Huron. The pond will be designed to attenuate post-development peak outflow rates such that they do not exceed pre-development values for 24-hour rainfall events with return periods ranging from 2 to 100 years (see table below). The underground water flow rate will be added to peak stormwater runoff rates where the later has been estimated using catchment size, run-off coefficients and varying rainfall events. Thus construction water volumes are being considered in the final design of the pond and its outlet structure.

Storm Event	Peak Run-off Flow Rate into Stormwater Management Pond (L/s)	Average Run-off Flow rate into Stormwater Management Pond over 24-hour Period (L/s)
24-hour rainfall event with return period of 2 years	530	6
24-hour rainfall event with return period of 100 years	3,700	14

Note: above estimates exclude inflow to pond due to underground construction dewatering, which is conservatively assumed to be 21 L/s.

The pond will have a maximum storage volume of about 10,000 m^3 which is the air volume between the permanent pool of water at base of pond and the crest of the weir. During the 6-hour, 25-mm storm event, rainfall run-off and construction water will flow into the pond. The rate of water inflow due to these two sources of water will exceed the discharge capacity of the discharge pipe. Thus most of water inflow during the storm event will be contained in the storage volume until discharged through the discharge pipe.

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LPSC-01-13	▪ C1NFR 5 (d)(e)	***Information Request:*** *Provide additional information on the stormwater management pond including the liner(s), point of influent and discharge control. The additional descriptions need to be supported with geotechnical information on the subsurface conditions at the site of the management pond.* ***Context:*** *PSR 6.2.4 and 9.3.2 describes the design (drawing H333000-WP404-10-042-0001) of the stormwater management pond as relying on natural or composite liner. No supporting geotechnical information has been provided on subsurface conditions at the site of the stormwater management pond. There is little description of the liner, point of influent, and discharge control.* *Additional information is needed for a complete a description of the design stormwater management pond.*
		OPG Response: The stormwater management pond will be located as shown on Drawing H333000-WP404-10-042-0001 (Preliminary Safety Report, Chapter 17 - Engineering Drawings). At the pond location there is between 0.7 to 1.5 m of surficial sand and gravel to clayey silt (fill materials) overlying at least 10 m of hard low-permeability glacial till (refer to response to IR-EIS-01-01). It is envisaged that the pond will be excavated into this thick glacial till unit and that the till will serve as a natural liner for the pond. The pond side walls will be lined, as required, to limit lateral seepage into any surrounding permeable overburden that overlies the till. Dewatering flows and stormwater runoff from the project site will be collected in ditches around the perimeter of the site and surface facilities and discharged into the pond's sediment forebay. The forebay inlet will be appropriately graded and lined with riprap for erosion protection. The pond outlet structure will be built into an embankment at the discharge-end of the pond and will consist of an overflow weir and a discharge pipe. The overflow weir, together with the available active storage in the pond, will control pond discharges during rainfall events with return periods of 2 to 100 years. The discharge pipe will control low flow discharges from the pond and ensure a minimum retention time for the settling out of suspended solids. In the event that Certificate of Approval criteria are exceeded in the discharge (e.g. increased total suspended solids – TSS), the valve on the discharge pipe can be closed discontinuing discharge. The pond outlet structure will be appropriately graded and lined with riprap for erosion protection.

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LPSC-01-14	▪ C1NFR 5(e)	***Information Request:*** *Provide additional information on the ventilation on the ventilation system and its operation in the area of the underground facility. This information should address things as: size of ventilation tunnels, exhaust filtration requirements; plenum description; control of contaminated condensation from ventilation; ventilation logic for normal operation; and location of underground fans.* ***Context:*** *As described in the PSR and stated in 4.4 of the Preliminary Conventional Safety Assessment “The repository’s underground ventilation system has been designed so that fresh air flows from the main shaft through the emplacement rooms to the return air drifts and then exhausts through the ventilation shaft to the surface … . Therefore, under normal conditions, workers are on the fresh air side of each workplace, with potentially contaminated air being exhausted from the workplace.” While a description of the ventilation system design and operation is provided, additional information is needed in areas such as the:* ▪ *size of the return air tunnels that are also used for egress;* ▪ *ventilation system exhaust filtration requirements;* ▪ *plenum description;* ▪ *control of contaminated water discharge from condensate associated with the ventilation shaft plenum;* ▪ *the ventilation logic for normal operations, including service areas and tunnels, in both the day and night time periods, and the* ▪ *general location of the underground fan(s)* *The additional information is needed for a clearer understanding of the ventilation system, including the logic for its operation.*
		OPG Response: The requested additional information is as follows: • The finished, or “neat”, dimensions of the return air tunnels are 4.5 m x 4.65 m (width by height) in the vicinity of the emplacement rooms and 5 m x 4.65 m elsewhere. • There is no requirement for air filtration at the exhaust for the underground ventilation system. During normal operation any evolving radioactive materials would be in gaseous form and would not be captured by filtration. Under postulated accident conditions no filtration is assumed and predicted consequence are small.

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		• The intake plenum is a reinforced concrete tunnel that extends into the main shaft headframe sub-collar. The two surface fans supply air to the main shaft via this nominal 4 m x 4 m cross-sectioned concrete air tunnel, into the main shaft and then to the underground facilities. • The exhaust plenum starts as a concrete horizontal conduit below grade from the ventilation shaft. The plenum than passes through two 45 degree bends to a surface conduit of round metal ducting before discharging through a stack to atmosphere. The cross-sectional area on the concrete and metal conduit is nominally 16 m^2. The above ground portion of the exhaust routing will be insulated to reduce the amount of condensation in this section during winter. • Any condensate water associated with cooling of ventilation air in exhaust plenum will be collected. The final exit velocity of the ventilation air will be low enough that water droplets will not be propelled to atmosphere. The plenum structure will have a sump and condensate will flow by gravity to the sump where it will be collected. Depending on the concentration of tritium or any other radioactive contaminants in the condensate, this water will be periodically removed from the sump and taken to a facility that is licensed to handle this type of material, if required. • The ventilation logic for normal operations is described in Section 6.3.8.1 of the Preliminary Safety Report (PSR). During day time normal operations, sufficient airflow will be delivered underground to ensure adequate ventilation in all areas occupied by workers and equipment. Ventilation air will be provided to all actively used rooms in the underground services area. Because it is currently envisaged that the DGR facility will only be active during weekdays during the operational phase, it is likely that the underground facility will be unoccupied during off-production hours. Thus the ventilation volume could be reduced during off operations hours. • As described in Section 6.3.8.5 of the PSR, the main exhaust fans are located in the return air tunnel at the location shown in Figure 6-14 of the PSR. (Note: An updated version of Figure 6-14 has been provided to the Joint Review Panel with OPG Letter, A. Sweetnam to S. Swanson, “Updated Information in Support of OPG’s Licence Application for a Deep Geologic Repository for Low and Intermediate Level Waste”, CD# 00216-CORR-00531-00101, February 10, 2012.)
LPSC-01-15	▪ C1NFR 5(e)	***Information Request:*** *Additional information is required concerning:* ▪ *the ventilation logic for fire events and its relation to the egress strategy and the fire suppression strategy;*

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		▪ *the use of fire doors and temporary walls, their construction, and their function in the underground fire suppression scheme; and* ▪ *the ventilation logic in the event of an incident involving the release from a non-fire event, of significant quantities of volatile radionuclides or volatile hazardous substances.* ***Context:*** *Further to underground ventilation: PSR 6.8.3.2 states “To fight a fire in a waste-filled emplacement room, fire doors or temporary barrier walls will be places across the entire cross-section of the access and return air drifts to isolate….”* *PSR 6.8.4 states “Ventilation fans and regulators underground are controlled remotely from surface … or manually … . For safety reasons, no alteration or disruption to the ventilation system will occur until all underground workers are accounted for and the mine rescue team has assessed the situation”; and the Preliminary Conventional Safety Assessment states “The underground layout of the DGR … . … provides secondary egress via the return air drifts.”* *It is unclear how the ventilation will be operated in the event of a fire given the use of the return air drifts as secondary egress and the identification of the use of fire doors (fixed structure location) and/or temporary barrier walls as a fire suppression scheme (construction, possible locations and timing of implementation).* *There was also no discussion of ventilation control in the event of an incident involving significant quantities of volatile radionuclides or volatile hazardous substances.* *The use of inflatable fire barriers to starve a fire of oxygen is not common, and may not be feasible from a pragmatic implementation perspective. CNSC staff has concerns with this method of fire suppression. The applicant will be required to demonstrate that the system is appropriately tested and qualified by an accredited testing laboratory (such as ULC), be shown to be feasible through testing and case studies and be supported by appropriate training and testing for the life of the facility.* *Additional information is needed for a clearer understanding of the ventilation system logic and its relation to the fire suppression scheme during abnormal events, such as fire. Information is also needed on how the ventilation will work in the event of a significant release of volatile radioactive or hazardous substance.*
		OPG Response: In the event of an underground fire or waste package drop, the ventilation flows will not be changed until all underground personnel are accounted for in the refuge stations. This is a common practice in mining operations as personnel know the ventilation flows in their work area and are counting on flow not to change while they are

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		retreating to a safe refuge. Also, continued ventilation flow provides notification of an event through the use of “stench gas” to indicate the need to report to the closest refuge station. Emergency response procedures will define the required response by personnel to a fire underground. In general terms, it is expected to be similar to the following. Upon notification of a fire, all underground personnel will report to the permanent refuge station where they will remain and await further instructions. If the fire is downstream of personnel, they will travel in fresh air back to the permanent refuge station. If the fire is upstream of personnel, they will travel downstream into a ventilated empty emplacement room and then through the return air tunnels to the permanent refuge station. The air speeds in the access tunnels and emplacement rooms will be slower than personnel can walk, and thus personnel will be ahead of the smoke/fumes. Once in the return air tunnels the air speed will increase to that where the smoke-filled air will be travelling faster than personnel can walk. However, fires are normally progressive in nature and it is anticipated that personnel would be able to advance along the return air tunnel to the underground services area before the smoke could reach these personnel. If the personnel are downstream of the fire and the room filling sequence is such that there is no empty room for exit to the return air tunnels, then the personnel will retreat to the portable refuge station at the end of the panel. In the event of an underground accident involving the release of volatile radionuclides or volatile hazardous substances personnel will follow the same general procedure as for a fire event. Once personnel are accounted for in the refuge stations, the authorized person in charge will direct operations to deal with the emergency event. There is currently no plan to use inflatable fire barriers to starve a fire. Once underground personnel are accounted for in refuge stations, plans for addressing the fire will be implemented. These plans may include: ventilation volume changes, fire door closures in the access tunnel to each of the panels, temporary barriers if practical, and/or mine rescue activity to control or extinguish the fire (refer to response to IR-LPSC-01-21). In addition to portable fire extinguishers underground as required by the Ontario mining regulations, a portable dry chemical fire suppression system will be available to the mine rescue team at a surface storage location and it could be taken underground by the team to suppress a fire. Mine rescue teams are required to periodically inspect all of their equipment to be sure that it is ready for use.
LPSC-01-16	▪ General Nuclear Safety and Control	***Information Request:*** *Additional information is requested justifying the statement made concerning the installation of fire suppression equipment in emplacement rooms.*

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	Regulations (GNSCR) 3(1)(i)	***Context:*** *It is stated that "Installing fire suppression equipment in the emplacement rooms would be ineffective due to the size of the rooms and the storage arrangement of packages."* *It is not clear why the installation of fire suppression systems would be ineffective where fire suppression systems are currently installed in the Low Level Storage Buildings of the Western Waste Management Facility (WWMF). Clarification is needed.*
		OPG Response: The arrangement and placement of waste packages is similar in the emplacement rooms as compared to the Western Waste Management Facility (WWMF) Low Level Storage Buildings (LLSBs). However, the available space around the packages is significantly less and accessibility constrained in the emplacement rooms. In order to maximize storage efficiency, while minimizing excavation requirements, the design optimizes the packing envelope and allows minimum distances or clearance between the packages and the emplacement walls and back (or ceiling) over the length of the emplacement room (refer to the Preliminary Safety Report, Section 6.5.3.1, Table 6-6: Summary of Clearances Used in the Emplacement Room Design). The clearances do not permit access within filled sections of the emplacement rooms by personnel or equipment to maintain fire suppression equipment. For this reason, there is no equipment or services installed in the emplacement rooms where waste is placed. Further discussion on the approach to fire protection in the emplacement rooms can be found in responses to responses to IR-LPSC-01-15 and IR-LPSC-01-21. There will be easily-accessible portable suppression equipment. In addition, unlike the WWMF, there are fire doors which can be closed and the ventilation cut off to starve the fire. The structure of the emplacement room is conducive to minimizing the potential for spread of the fire beyond that room. In the case of the LLSBs at the WWMF, the fire suppression system is based on CO_2 gas flooding. The use of an asphyxiating gas in this manner cannot be used underground based on personnel safety considerations.
LPSC-01-17	▪ C1NFR 5(d)	***Information Request:*** *Provide clarification on how the design of the shaft liners is expected to vary to address changeable rock conditions along the shaft length, and the method expected for the liner construction.* ***Context:*** *PSR 6.3.1.2 states "The main shaft contains a concrete liner designed for the varying conditions from the shaft collar to the shaft bottom. The liner is a key component to the support of the shafts, as well as, controlling water inflow into the shaft." PSR 6.3.2.2 indicates that the ventilation shaft liner performs the same functions. No*

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		information is provided on how the design is expected to change to address variability in ground conditions (e.g. seepage, rock strength) along the shaft length. *The design of the liners is not discussed. PSR 9.4.5.4, Final Liner Construction, does not describe the expected method for the liner construction. Additional information is needed to understand how the shaft liner design is expected to address variable rock conditions.*
		OPG Response: The two circular shaft liners will be unreinforced concrete structures where the concrete will be poured directly against supported rock (refer to response to IR-LPSC-01-32 for preliminary rock support requirements during shaft development). The liners will resist loadings in compression. It is expected the shaft liners will have a minimum thickness of 300 mm, with the thickness of the liners varying to resist varying hydrostatic and rock loading conditions. The liners will be constructed as a hydrostatic liner in the upper 200 m of the shafts where rock formations are relatively permeable. Below this upper water bearing zone the rock formations have very low permeability and thus the shaft liners can be designed as a "leaky liner". In this liner design, any groundwater inflow behind the liner is allowed to drain into and down the shaft in a controlled manner. This prevents build-up of water pressure behind the liners and avoids the need to construct a thick liner to withstand hydrostatic loading. Geomechanical modeling of the shaft excavations will be completed to estimate rock loading over the full depth of the shafts and to estimate how this loading will vary with time. The modeling will be iterative with liner detailed design and will be used to assess impact of dimensional requirements and construction assumptions for shaft development (e.g., excavated diameter, length of the development round, distance the shaft liner trails the shaft sinking face, etc.) on predicted rock loading. Construction of the shaft liners will be influenced by the contractor selected to sink the shafts. Typically, formwork is placed as part of the shaft sinking sequence from the working stage (Galloway) and the liner is poured in segments as the shaft advances. The segment length and distance the liner trails the sinking face will be determined by the shaft sinking sequence, and is likely to match the set steel spacing of 5 m.
LPSC-01-18	▪ C1NFR 5(d)	***Information Request:*** *Additional information on the dimensions and configuration of the underground facilities in the service area, the ramp to shaft bottom, ventilation tunnel, and loading pocket is requested. Also include information on the expected ground support needs in these areas.*

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		Context: *The opening sizes of some tunnels and the emplacement rooms are provided (see PSR 6.3.4 and 6.3.5 - figures 6-15, 6-16, 6-17, and 6-18). But similar information is not provided for the underground services area, the ramp to shaft bottom, the ventilation tunnel, and loading pocket. The text in 6.3.8.3, and subsequently 6.8.3.2, references ground support but does not provide a description of the methods expected to be used. This information will provide a better understanding of the facility design.*
		OPG Response: The excavated sizes of major openings in the Underground Services Area will generally be developed on the basis of the largest equipment that will need to access the tunnels and rooms either during construction or operations. The current bases for various opening sizes are as follows: 1. Service area access tunnel (tunnel leading to diesel fuel bay and maintenance shop on Figure 6-14 of the Preliminary Safety Report - PSR) is 8.6 m wide by 5.5 m high on the basis of having enough width during construction for a 3.5 m wide scooptram to pass a 3.0 m wide haul truck that is parked 0.3 m off of the wall of the tunnel and with a 1.5 m pedestrian clearance. During operations, the height allows a large forklift when empty to access the maintenance shop and diesel fuel bay. (Note: An updated version of Figure 6-14 has been provided to the Joint Review Panel with OPG Letter, A. Sweetnam to S. Swanson, "Updated Information in Support of OPG's Licence Application for a Deep Geologic Repository for Low and Intermediate Level Waste", CD# 00216-CORR-00531-00101, February 10, 2012.) 2. Ramp to shaft bottoms is 5.3 m wide by 5.0 m high on the basis of enough width during construction for a 3.0 m wide scooptram plus a 2.0 m pedestrian clearance. The height of the 450-m-long ramp is based upon developing with a 2.8 m high 2-boom drilling jumbo accessing the advancing face under a 1.4 m diameter ventilation pipe. This height allows for appropriate clearances between the vent pipe and tunnel roof, vent pipe and jumbo, and for roadbed material thickness. 3. Return air (ventilation) tunnel is sized on the same basis as the ramp with a 1.5 m pedestrian clearance used whenever there is an intersecting tunnel no less than 30 m apart and a 2.0 m pedestrian clearance in all other circumstances. 4. The loading pocket excavation accommodates the15m transfer conveyor and the chain feeder at the base of the waste pass. The transfer conveyor excavation has nominal dimensions of 3.0 m high x 6.1 m wide and 19.2 m deep with access for maintenance and housekeeping activities. The chain feeder excavation has nominal dimensions of 9.6 m high x 6.1 m wide and 4.0 m deep which

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<tr><td></td><td></td><td>accommodates the chain feeder, associated chute work and maintenance access.

As well, the excavated sizes for the rooms in the underground service area have been determined on the basis of construction requirements as follows:

1. The maintenance shop is 11.8 m wide by 11.0 m high by 53.0 m long on the basis of enough width for a 3.5 m wide scooptram alongside a 3.0 m wide haul truck with 1.0 m between the machines and another 2.0 m off each wall to accommodate working area and crane support columns. The height allows a 35 tonne overhead crane to lift the box off of a haulage truck. The length allows a 17.5 m long 3-boom drill jumbo to be in the Shop at the same time as a 10.5 m long truck and a 12.0 m long scooptram plus 2.0 m between the machines plus 2.0 m on each of the two opposite ends for work clearances plus 2.5m at each entrance for the walls with roll up fire doors.

2. The service bay (not shown on Figure 6-14; will be located adjacent and parallel to maintenance shop) complete with lube storage is for changing oil, lubricants and filters, hydraulic cylinders and equipment tires and is 9.8 m wide by 10.6 m high by 46.0 m long on the basis of enough width for a 3.5 m wide scooptram with 3.0 m off each wall to accommodate a tire change work area and crane support columns. The height allows cylinder replacement of the tallest reference forklift. The length allows the west end of the service bay to be used as a lube storage area.

3. The diesel fuel bay is 7.8 m wide by 7.5 m high by 39.8 m long on the basis of enough width for a 3.5 m wide scooptram and another 2.0 m off each wall to accommodate working area. The height allows a haulage truck to raise its box for access to the cylinders for greasing at the start of each shift. The length allows the west end of the diesel fuel bay to be used as a storage area for the steel diesel fuel totes.

4. Storage room is 7.4 m wide by 9.1 m high by 20.0 m long on the basis of the construction requirement for explosives storage. The construction application required sufficient clearance for the storage of explosives, as well as, sufficient space to load totes of explosives into the mobile explosives carrier.

The design of ground support is described in the response to IR-LPSC-01-34.</td></tr>
<tr><td>LPSC-01-19</td><td>▪ C1NFR 5(e)</td><td>Information Request:

Provide clarification of the dewatering system, including sump/pump locations, pump sizes, and effluent release description and location, with a simplified flow diagram(s).

Context:

PSR 6.3.19.4 provides the description and operation of a number of sumps and plans for the dewatering of the</td></tr>
</table>

IR#	NSCA Regulations Section #	Information Request and Response
		underground facility. Some of the sumps are interconnected and others are not, but this description is not clear. No diagram is provided indicating the location of the various sumps, nor is a diagram(s) provided illustrating their interconnections. There is no description of the point of release for effluent from the dewatering sump at the surface. This information is important understanding the facility design.
		OPG Response: The preliminary design of the operations' phase dewatering system is described in Section 6.3.10.4 of the Preliminary Safety Report (PSR). A simplified flow diagram for the underground dewatering system is shown in Figure 1 below.

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		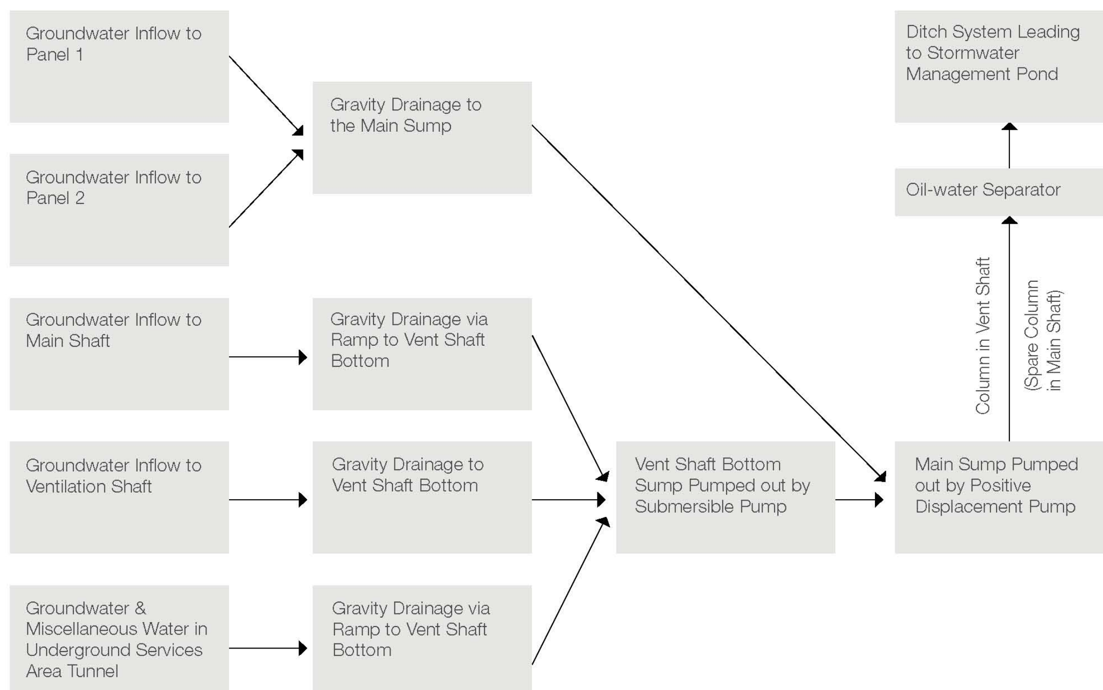 **Figure 1:** Simplified Flow Diagram for the Underground Dewatering System The following clarifies the sources of water that would be directed to the main underground sump and the estimated flow rates to this sump during normal and abnormal operating conditions. A clarification of the

IR#	NSCA Regulations Section #	Information Request and Response
		operations' phase dewatering system design is also provided below, including clarifications about sump/pump locations, pump sizes, and effluent release description and location. Groundwater Inflow Estimates: • Due to the extremely low hydraulic conductivity of the Cobourg Formation Lower Member, groundwater inflow over the entire underground repository (excluding the two shafts) is expected to be negligible. The rate of any groundwater inflow would likely be less than the rate at which the water would evaporate and thus this ground water would likely not flow to the main sump. • During normal operations, groundwater inflow through both shaft concrete liners is estimated at 2 L/s (see PSR, Section 6.3.10.4). This estimate is considered to be conservative. In the remote event that the concrete liner fails by cracking (say due to a seismic event) there could be an additional inflow of groundwater through the cracks in the upper hydrostatic portion of liner (see response to IR-LPSC-01-17). For purposes of preliminary sizing of the operations' phase dewatering system, it was assumed that up to 15 L/s of additional groundwater inflow could occur in the failed liner scenario (see PSR, Section 6.3.10.4). This estimate is considered to be conservative and will be updated as new information becomes available about hydrogeologic conditions in upper bedrock formations (to depth of about 180 m), ground treatment to be used in the upper permeable bedrock formations (see response to IR-LPSC-01-31) and how the shaft liners might behave during a postulated seismic event. Dewatering System Pumping Capacity: • The maximum pumping capacity of the dewatering system is currently set at 22 L/s (see PSR, Section 6.3.10.4). As new information about estimated rates of water flow to main sump become available under both normal and abnormal conditions, the design pumping capacity will be adjusted accordingly. Discharge Location at Surface: • See the response to IR-LPSC-01-12 for description of how water is discharged at surface. General Location of Sumps: • The main sump is located in the Underground Services Area. Water in all other repository sumps is pumped to the main sump and the collected water in this sump is then pumped to the surface. • As mentioned above, the main repository is expected to be dry. However, sumps are required in the access tunnels in each of the panels during the construction phase to collect service water used by drilling jumbo and for dust control. These sump locations will be available for use in the operations phase, if required.

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		• There will be a sump in the ramp by the bottom of the ventilation shaft. Groundwater flowing into the two shafts would flow to this sump. The bottom of the main shaft is connected to the sump at the bottom of the ventilation shaft via the ramp. The ramp provides downhill drainage path from the main shaft bottom to the ventilation shaft bottom.
LPSC-01-20	▪ C1NFR 5(e)	***Information Request:*** *Provide additional information on the fire water supply to the DGR site. The information needs to include an assessment of the sufficiency of the single point supply including the possibility and effect of a fire water impairment, the safety considerations and the planned response in such an event during the construction and operational periods.* ***Context:*** *PSR 6.8.3.1 states that "The fire water main is connected to the existing Bruce Power fire water system. Water for all water based fire suppression systems will be supplied by the fire water main".* *The fire water main as is understood to exist to the centre of the Bruce site is via a single point. A single point connection leads to a greater potential for an impairment of the system to the centre of site and therefore to the DGR. The applicant should consider the benefit of multiple supplies to the Bruce Power fire water system to minimize the potential for an impairment of the fire water system and the operational restrictions in such an event."* *Additional information is needed to establish the adequacy of the fire water supply.*
		OPG Response: The fire water supply to the DGR project site is from Bruce Power's existing fire water system and an assessment of the tie-in location(s) within the Bruce fire water system is being completed. Once the tie-in location(s) to the Bruce Power fire system are set, an assessment of supply disruption will be completed and actions taken to ensure a highly-reliable supply. The assessment will include the assessment of the supply, the DGR fire water system and any on-site and off-site support provided through Emergency Response. The DGR fire water main(s) will be buried and the fire water main loops will distribute fire water around the DGR surface facilities site. The fire water main(s) will meet the requirements of the latest National Building Code of Canada (NBCC), National Fire Code of Canada (NFCC), National Fire Protection Association (NFPA), NFPA 24, the Ontario Provincial Standard Drawings (OPSD) and Specification (OPSS). Post indicator valves will be provided to allow isolation of the fire water main if required for maintenance purposes. Hydrants will be

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		located throughout the DGR surface facilities site along roadways to provide access for emergency response crews. The fire main system will be installed below the frost line to prevent freezing. Metallic components of the fire main will be equipped with cathodic protection and freeze protection will be provided in specific locations where deemed necessary. The fire water main will be connected to the water-based fire suppression systems.
LPSC-01-21	▪ C1NFR 5(e)	***Information Request:*** *Provide clarification of the statement "if required" in respect to a dry standpipe at the main shaft is requested.* ***Context:*** *It is stated that "A dry standpipe and hose will be available at the main shaft station, if required." It is CNSC staff's opinion that at a minimum, a dry standpipe to supply water for fire fighting will be required in the underground portion of the facility.* *Clarification is required, given the opinion of CNSC staff concerning the need for the availability of fire water in the underground facility.*
		OPG Response: The response to IR-LPSC-01-22 describes the nature of planned underground fire suppression system at the DGR. These systems are predominantly non-water-based systems and provide a high level of protection against significant fire hazards underground. It is not proposed to use water-based fire suppression systems to fight potential fires involving radioactive waste underground. The use of water-based fire suppression systems could lead to large quantities of contaminated liquid that would need to be managed. It is primarily for this reason that it is not proposed to provide a fire standpipe, wet or dry, in the DGR. A dry standpipe also has the design challenge and safety concern of dissipating the energy that would be created by water falling ≈700 m in filling the dry standpipe.
LPSC-01-22	▪ C1NFR 5(e)	***Information Request:*** *Provide clarification of the fire suppression methods that will be used (fixed and portable), along with requirements for the systems.* ***Context:*** *The PSR and EIS Main Report identify a reliance on chemical-based fire suppression systems. The EIS Main Report states "handheld foam-based extinguishers located … in high traffic areas (i.e. diesel fuel bay,*

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		maintenance shop) as well as mobile equipments … and … a mobile foam generator … based underground for use in open emplacement rooms,". The PSR states "a foam based suppression system for the maintenance shop and diesel fuel bay … (single fixed pipe foam system) …installed to provide coverage to both rooms and a portable skid mounted dry chemical system is provided to aid mine rescue teams …" *It is unclear what will be used and where, if both a mobile foam generator and a mobile dry chemical system are to be used, and if a fixed foam system is being employed. There is little information indicating the intended size and type of fires the various systems are intended to address. It is also unclear what the water source for the foam units will be.*
		OPG Response: The fire suppression systems and provisions to be provided on the surface and in the underground are as provided below. Also refer to the responses provided in IR-LPSC-01-02 and IR-LPSC-01-36 for applicable codes and standards. • Fixed non-water fire suppression systems will be provided in areas of the DGR which contain storage of more than 500 L of oil, grease, or flammable liquids, service garages, and fueling stations in accordance with the OHSA Mines and Mining Plants Regulations (O.Reg. 854/90). This includes the Service Garage, Lube Bay, and Fuel Bay. One system will be provided for each area. The systems will be total-flooding style systems, with the protected space separated from the main tunnels via automated fire doors. The fixed system is planned to be a high-expansion foam fire suppression system. This system provides a proven low-water demand, fast initiation, option for fire suppression, which minimizes contaminated water run-off concerns. Water to support the foam system will be provided in totes. • The main and ventilation shaft hoisting equipment will be equipped with fixed fire suppression systems. These systems will be local application, protecting equipment deemed to be a potential fire hazard. These systems are intended to be dry-chemical fire suppression systems. • Each emplacement panel will be separated from the main tunnels via fire doors that span the entire cross-section of the access and return air drifts to starve any fire. In the event of a fire, the doors will close and the ventilation will manually be shut down after all workers are accounted for. The fire fighting team will have a portable dry chemical and foam system mounted on skids. It is not practical to maintain the fire suppression equipment inside the filled emplacement rooms and is ineffective due to the storage arrangement of packages (refer to response to IR-LPSC-01-16). The preclosure safety assessment as presented in the Preliminary Safety Report (Chapter 7) has analyzed releases from this

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		type of event. • Both fixed and mobile equipment (i.e., forklifts) located in the DGR will be provided with fixed local application fire suppression systems. These systems are intended to be dry-chemical fire suppression systems, installed to protect areas deemed to be fire hazards. • In addition to the fixed fire suppression systems, fire protection equipment stations will be located in all access and service drifts, as well as, specified locations as per the Ontario mining regulations (e.g., shaft stations, electrical rooms, etc.). These stations will be strategically located throughout the DGR. Each station will contain dry chemical fire extinguishers, self-contained breathing apparatus (SCBA), personal protective equipment, tools, etc. The equipment at each station will be determined based on the potential type and size fires in the vicinity of the station. DGR personnel will be trained in the use of fire extinguishers for manual fire fighting. • A Mine Rescue Team will be trained in mine fire fighting activities. The firefighting equipment and locations for this response team will be determined as part of detailed Mine Fire Procedures to be developed for the DGR.
LPSC-01-23	▪ C1NFR 5(e) ▪ RPR 4(a)(b), and 5(2)	***Information Request:*** *Provide clarification on radiation monitoring of air and water in the underground facility addressing such things as: the radionuclides monitored; sampling locations; types of monitoring equipment; measurement monitoring/control locations; emergency power; and notification/alarms.* ***Context:*** *PSR 6.11 provides a brief description of the radiation monitoring of air in underground areas (i.e. service area, active emplacement rooms) and water underground but does not identify what radionuclides will be monitored or the locations to be monitored.* *PSR 10.4.1 indicates that tritium, C-14 and gross-beta monitoring will be conducted at appropriate points as part of the environmental management system, but is not definitive “potentially including vent exhaust, surface water and groundwater”. An examination of the DGR EA Follow-up Monitoring Program, Table 5b, indicates monitoring of vent and WPRB exhaust for radon, tritium, particulate, and carbon-14 as part of the environmental management plan during operations, but it does not include any details of radiation monitored underground for worker health and safety.* *The description of the radiation monitoring was not sufficiently clear for CNSC staff to assess the adequacy of the radiation monitoring to protect workers and the environment.*

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		OPG Response: The Preliminary Safety Report (PSR) Sections 6.11 and 10.4.1 provide a general description of the radiation monitoring program. The elements of this radiation monitoring program are identified in more detail in Tables 5a and 5b of the DGR EA Follow-up Monitoring Program report (NWMO 2011), and discussed below. This program will be consistent with the OPG Radiation Protection Requirements - Nuclear Facilities (OPG 2001) and related procedures. The full monitoring program is identified in the DGR EA Follow-Up Monitoring Program report, including surface radiation monitoring (including waste package monitoring, Zone 2/Zone 1 interface monitoring and groundwater/ environmental monitoring). The underground non-radiological air quality monitoring is described further in the response to IR-LPSC-01-24. <u>Underground Radiation Monitoring</u> Tables 1 and 2 provide a summary of the underground radiation monitoring; these are adapted from Tables 5a and 5b in the DGR EA Follow-up Monitoring Program report (NWMO 2011). The underground facility radiation monitoring will include fixed monitors, portable monitors, and sampling locations. A fixed whole body monitor will be placed at the entrance to the refuge station, which also doubles as a lunch room. Portable monitors will be used to maintain appropriate controls around active areas, and for surveying (to ensure the Zone 2 underground facility remains free of loose contamination). The specific locations would depend on the work flow, and would be consistent with current WWMF practice. For example, portable tritium-in-air monitors or gamma monitors will be used at active emplacement rooms. There will be fixed continuous air sampling devices located at the surface exhaust from the ventilation shaft (stack monitor), which will collect air samples from a side stream. The air samples will be collected for the purpose of analyzing for tritium, C-14 and particulate (gross beta/gamma). (As with the WWMF incinerator, a separate stack monitor may be needed for C-14 from the other radionuclides.) The primary water sampling locations are the surface stormceptor for discharge from underground water to surface and the exhaust plenum condensate collection sump. <u>Notification Alarms</u> The underground radiation monitors would be hand-carried or cart based instruments with local readouts, similar to monitors currently in use at WWMF. The stack monitor (i.e., surface exhaust air sampling device) will have an alarm which sends a signal back to Control Room if the sampling device has failed (i.e., low air flow). No other information is sent back to Control

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		Room from this device. Electrical Power Supply The radiation monitors will be supplied with battery or line power, but not with emergency power. In the event of loss of power to the stack monitor, as with current operations at WWMF, radiological work ceases. In the event of electrical power system failure at the DGR facility, underground personnel will be directed, via underground communication system, to report to a refuge station. The permanent refuge station will have a clean breathing air supply that is connected to the emergency power supply. The underground communication system is also connected to the emergency power supply. Equipment The monitoring equipment will be similar to that used in WWMF, but the specific technology would be selected during the construction phase based on the best available technology at that time. Further information will be described as part of the Operating Licence application.

Table 1: Underground Air and Water Radiation Monitoring - Site Preparation and Construction (see NWMO 2011, Table 5a)

Reference	Nuclides	Type/Monitoring	Location
C-LIC-RAD1 Air	Radon	• 1 measurement /month/location. Radon is not expected to be an issue. It will be monitored for trends and the rate adjusted if appropriate. • Portable monitor, with local readout or off-site analysis	• Near working faces during excavation • Exhaust air flow near ventilation shaft
C-LIC-RAD5 Water	H-3 Gross beta /gamma	• 1 sample/week, averaged monthly, beginning 1 yr prior to operations. • Off-site analysis.	Sampled from surface stormceptor at underground sump discharge (for establishing baseline)
C-LIC-RAD5 Water	C-14	• 1 sample/quarter beginning 1 yr prior to operations. • Off-site analysis.	Sampled from surface stormceptor at underground sump discharge (for establishing baseline)

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Table 2: Underground Air and Water Radiation Monitoring - Operations (see NWMO 2011, Table 5b)

Reference	Nuclides	Type/Monitoring	Location
O-LIC-RAD1 Air	Radon	Portable monitor with local readout, as per C-LIC-RAD1.	Radon is not expected to be an issue. Location and frequency to be specified as part of the Operating Licence application based on results of C-LIC-RAD1.
O-LIC-RAD1 Air	H-3 C-14 Particulate (gross beta/ gamma)	Continuous airflow through sampling device, with samples analyzed weekly off-site. Equipment similar to WWMF incinerator stack sampler/monitor. Alarm on system failure (i.e., low air flow) to DGR control room, as with WWMF incinerator monitor. Class IV power, as with WWMF incinerator monitor.	Ventilation shaft exhaust
O-LIC-RAD5 Water	H-3 Gross beta/ gamma	1 sample/week, averaged monthly. Off-site analysis.	Sampled from surface stormceptor at underground sump discharge
O-LIC-RAD5 Water	C-14	1 sample/yr. Off-site analysis.	Sampled from surface stormceptor at underground sump discharge
O-LIC-RAD5 Water	H-3 Gross beta/ gamma C-14	1 sample/discharge (frequency may be reviewed based on trending analysis). Off-site analysis.	Sampled from exhaust plenum condensate sump
O-LIC-RAD6	H-3 Dose rate Others as required	Routine survey program Similar equipment to WWMF. Hand-carried battery powered monitors, or cart-	Frequency and location to be specified in the Operating Licence application. Will be consistent with OPG Radiation Protection Requirements and with

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<tr><td></td><td></td><td>based monitors connected to local 120 V Class IV power.</td><td>existing WWMF program.</td></tr>
<tr><td>O-LIC-RAD7</td><td>Whole body dose and skin beta dose</td><td>Worker dose monitors, similar to existing WWMF monitors.</td><td>Frequency and location to be specified in the Operating Licence application. Will be consistent with OPG Radiation Protection Requirements and with existing WWMF program.</td></tr>
</table>
References:
NWMO. 2011. DGR EA Follow-up Monitoring Program. Nuclear Waste Management Organization report NWMO DGR-TR-2011-10 R000. Toronto, Canada.
OPG. 2001. Radiation Protection Requirements - Nuclear Facilities. OPG Requirements N-RPP-03415.1-10001 R07. Toronto, Canada.
</td></tr>
<tr><td>LPSC-01-24</td><td>▪ C1NFR 5(e)</td><td>
Information Request:
Clarification is requested on the air quality monitoring system for the underground facility, addressing such things as sampling and air flow measurement/control locations, type of equipment, emergency power, and notification/alarms. Discussion of the need for future air quality monitoring of the closed panel should be included.
Context:
PSR 6.12 and 10.4.1.3 provides a general description of the monitoring of air quality and air flow underground, including the non-radioactive hazardous substances to be monitored. PSR 6.2.4.3, Control and Monitoring Systems, states that air quality is monitored but not controlled at surface in the main control room. The DGR EA Follow-Up Monitoring Program, Table 3b, 4b identifies air quality as controlled at surface.
The description of the air quality monitoring appears contradictory and not sufficient to assess the air quality monitoring system to protect workers in the DGR underground facility. It is also uncertain if there will be need in the future for air quality monitoring within the panel projected for closure within the first ten years of operation.
Clarification is needed for CNSC staff to assess the adequacy of air quality monitoring to protect workers and the environment during the operational period.
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IR#	NSCA Regulations Section #	Information Request and Response
		OPG Response: The Preliminary Safety Report (PSR) Sections 6.12 and 10.4.1 provide a general description of the air quality monitoring program. The elements of the underground non-radiological air quality monitoring program are identified in more detail in Table 4a-Atmospheric and Table 4b-Atmospheric of the DGR EA Follow-up Monitoring Program report (NWMO 2011), and discussed below. The underground radiological monitoring is described further in the response to IR-LPSC-01-23, Underground Radiation Monitoring. <u>Fixed Underground Air Quality Monitoring System</u> Air quality parameters will be monitored at various locations in the underground ventilation system with signals from fixed monitoring devices reporting to surface-based Control Room. At the following locations, the specified air quality parameters will be monitored: Surface Intake for ventilation system: • Airflow • Temperature • Humidity • NO_2 • Combustible gases. Louver-end of emplacement rooms: • Airflow • CO • Temperature. Upstream of main underground return air fans: • Airflow • Temperature • Humidity • NO_2 • CO • Combustible Gases.

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		Surface Exhaust for ventilation system: • Temperature • Humidity. Additional airflow monitoring devices will also be located at strategic locations in the system of tunnels with signals from monitoring devices reporting to Control Room. <u>Notification Alarms</u> The data from the fixed air quality monitoring system will be displayed in the Control Room and the flow of ventilation air will be adjusted, as required, to ensure safe working conditions for underground personnel. Air quality readings that are approaching predefined limits in the air stream will trigger alarms. Any high levels of air contaminates can be reduced by increasing the air volumes in that area. Air volumes in various parts of the underground facility will be controlled by adjusting the louvers at end of emplacement rooms and by adjusting the main underground fan. <u>Electrical Power Supply</u> The underground air quality monitoring system will not be supplied with emergency power. In the event of electrical power system failure at the DGR facility, underground personnel will be directed, via underground communication system, to report to a refuge station. The permanent refuge station will have a clean breathing air supply from the surface compressors that is connected to the emergency electrical power. The underground communication system is also connected to the emergency power supply. <u>Air Quality Monitoring in Closed Panel</u> Panels projected for closure will be ventilated and the air quality monitored as described above, until the time of closure. At closure, as stated in PSR 6.13, the underground space behind the closure walls will not be ventilated and all services will be terminated. Once closure walls are erected there would be no need to monitor air quality in the sealed underground space, as no re-entry is intended. <u>Equipment</u> The detailed design of air quality monitoring system and monitoring device specifications will be described as part of the Operating Licence application. **Reference:** NWMO. 2011. DGR EA Follow-up Monitoring Program. Nuclear Waste Management Organization report NWMO DGR-TR-2011-10 R000. Toronto, Canada.

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LPSC-01-25	▪ C1NFR 5(c)	***Information Request:*** *Provide clarification and additional information on the project schedule, including completion of engineering details and construction tasks.* ***Context:*** *PSR 9.1.2 provides a site preparation and construction schedule (Figure 9-1). The schedule of tasks in Figure 9-1 and the tasks as indicated by the text headings in PSR 9.1.2 do not align. Further, the schedule does not include information on the timeline for the completion of design details.* *Also not included is information identifying when construction plans (ground improvement, excavation plans and techniques, ground support, construction ventilation and dewatering) are expected to be complete.* *Additional information is needed on the schedule for completion of detailed engineering and construction plans so that CNSC compliance verification activities associated with the details and construction plans can be identified and integrated to assure regulatory oversight and licensee compliance.*
		OPG Response: The schedule provided in Figure 9-1 of the PSR assumes site preparation and construction tasks starting after receipt of the site preparation and construction licence (i.e., Year 1 of the project schedule). The exact timing for the start of construction tasks will depend on when the licence is awarded during the calendar year. The DGR design will be developed through Year 1 of the project schedule to substantial completion without the incorporation of detailed vendor information. Vendor information and contractor contributions to final design and construction scheduling will be incorporated following the receipt of the licence. However, the design required for site preparation activities will be to the level of "issued for construction - IFC" at the time of contract award as these activities are not constrained by equipment design requirements. There is sufficient time in the construction schedule to integrate vendor information in the design for IFC drawings and maintain planned construction activities. The sequence of construction activities in Figure 9-1 is consistent with the Level I schedule and the description of activities within Chapter 9. One area that may require clarification is with respect to the timing of ground treatment for the shafts. Chapter 9 describes two methods of treatment; freezing and grouting. In both cases, the ground treatment is required in advance of the shaft collar construction. However, in the case of grouting, these activities could be completed well in advance of the excavation of overburden for collar construction activities. It is likely that shaft grouting would be completed in conjunction with the site preparation activities. The schedule for activities referenced above (excavation plans and techniques, ground support, construction

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<tr><td></td><td></td><td>ventilation and dewatering) will be developed in conjunction with the approach selected by the successful contractor.</td></tr>
<tr><td>LPSC-01-26</td><td>▪ GNSCR 3(1)(b)</td><td>Information Request:
Additional information is requested describing the temporary concrete batch plant and the site services.
Context:
PSR 9.3.1 identifies the services that will be provided by the project for use by contractors on site and refers to figure 9-2 for the layout of the construction area. No description has been provided of the temporary concrete batch plant that will serve the construction of the DGR facility. Figure 9-2 does not identify the “service and fire water connection points” or the “communications connection point” which are common for all construction users.
Additional information is needed for a more complete description of temporary construction services.</td></tr>
<tr><td></td><td></td><td>OPG Response:
The concrete batch plant will be installed in the general area identified as “concrete batch plant area” on Figure 9-2 of the Preliminary Safety Report and will be installed as part of the site preparation activities. The batch plant and supply of concrete will be a contracted service to the project. The approved supplier will be required to demonstrate that the plant is capable of producing the required concrete volumes to the project specifications. They will also have to demonstrate how they will manage quality control of the product. Sufficient space has been allocated in the construction site plan for the batch plant, aggregate stockpiles, staging areas and wash-out facilities.
The electrical substation will be located in the general vicinity of area marked as “Construction Power Distribution Compound” on Figure 9-2. The substation will be supplied by a 13.8kV voltage transmission line from an existing transformer located at the Bruce nuclear site west of Interconnecting Road (existing road shown on Figure 9-2 that is located on west side of DGR project site) that serviced the former Heavy Water Plant facility.
Service water and fire water will be supplied through tie-ins to existing service water and fire water lines on the Bruce nuclear site. There are existing service water and fire water lines located immediately to the south and west of the DGR project site. Exact tie-in or connection locations are being discussed with Bruce Power who will be the provider of the service.</td></tr>
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IR#	NSCA Regulations Section #	Information Request and Response
		DGR project site communication system will likely connect to a fibre optics cable that is currently being installed in the abandoned railway bed located between DGR project site and Western Waste Management Facility. The connection point would be in the general vicinity of the crossing structure depicted on Figure 9-2. Construction laydown areas are also identified on Figure 9-2.
LPSC-01-27	▪ C1NFR 5(d)	***Information Request:*** *Provide additional information on the water treatment system and plant, such as location, the basis for the design, description of the point of release to the stormwater management system, and the expected operation.* ***Context:*** *PSR 9.3.2 states “Water pumped to the surface from the underground via the shafts during construction will be treated in a temporary water treatment plant prior to discharging in to the site stormwater management system. Contaminants such a nitrogen, ammonia and saline groundwater will be treated as necessary, in the stormwater management pond.”* *The EIS (4.4.1.5) indicates “The stormwater management pond is sized to provide a retention area for settling particles … . Additionally, water treatment will be employed in the drainage system upstream of the stormwater management pond for the duration of the site preparation and construction phase, and possibly the first two years of operation depending on monitoring results.” and (4.7.5.4) “the temporary treatment plant would be used, as required, to remove excess oil, grease and grit before discharge to the drainage network. It, however, will not be used to treat water in the stormwater management pond … .”* *The description of the water treatment system for surface and underground water is unclear from the descriptions provided in the PSR and EIS. The temporary plant location, the basis for the design, a description of the point of effluent control, and the general operation of the plant is not described. Further, as part of the water treatment during construction it is indicated that nitrogen, ammonia, and salinity will be treated (as necessary) in the stormwater management pond, but the process is not described.* *Additional information is needed to clearly understand the function and operation of the treatment system during the construction period which includes the plant and activities in the stormwater management pond.*
		OPG Response: The need for water treatment is expected to be limited to the water discharged from underground during the shaft sinking and lateral development phases. As stated in the Preliminary Safety Report, treatment will be primarily for oil, grease and sediment/grit removal prior to the discharge into the stormwater management ditch system. The project is not designing such a treatment system as the technology is readily available and will be

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		procured or supplied by the development contractor. The specifications of the system will be dependent on the excavation approach employed by the contractor and the expected volumes of effluent discharge. As with the specification of the treatment plant, the placement of the plant(s) will depend greatly on the contractor's approach. For example, it may be beneficial to provide a treatment plant for each of the shafts during sinking activities and transition to a single unit once the underground infrastructure is established for the lateral development phase. Also, the configuration of sumps and potential for re-circulating service water underground will influence the requirements of the treatment plant. In all cases, the water discharged from the treatment plants will be introduced into the stormwater management system at surface. It is not expected that additional treatment will be required at the stormwater management pond. Preliminary assessment of the expected waste rock management pile effluent characteristics indicates that there will not be elevated concentrations of nitrogen, ammonia or saline groundwater. Further confirmation of these findings will require the incorporation of the contractor's approach (e.g., type of explosives used) for the shaft sinking and lateral development activities. However, for example, should there be elevated ammonia levels measured at the stormwater management pond, aeration could be added at the forebay of the stormwater management pond to mitigate. Discharges from the stormwater management pond will meet the Certificate of Approval discharge criteria.
LPSC-01-28	▪ GNSCR 3(1)(b)	***Information Request:*** *Provide information describing the construction of the waste rock management area (WRMA).* ***Context:*** *While PSR 6.2.3 and drawing H333000-WP404-10-042-0003, provides some description of the WRMA, PSR 9.3.3 is very brief on the development of the area during the construction phase (stages, lifts, end-dump, etc).* *Additional information describing the construction of the waste rock management area is needed to assess construction activities.*
		OPG Response: The waste rock management area (WRMA) will be cleared, grubbed and stripped of topsoil which will be temporary stockpiled and re-used elsewhere on site. The site will be graded to ensure drainage to the perimeter storm water collection ditches. The ditches will be constructed as part of the site preparation activities prior to the deposition of waste rock. It is assumed that the waste rock (primarily argillaceous limestone) will be transported to the WRMA by off-highway trucks. The first step will be to construct an access ramp and working platform with the waste rock to

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		the elevation of the first lift (i.e., a vertical height of about 5 m). The access ramp will be constructed at a grade of not steeper than 10 (Horizontal): 1 (Vertical) and will be sufficiently wide to allow two directional traffic movement. The width of the access ramp will be dependent on the size of truck used by the contractor, but it is estimated to be 30 m wide. The first access ramp will be located in the south western corner of the WRMA (i.e., the closest point to the Ventilation Shaft). The trucks will dump the rock near the edge of the working platform. The rock will then be pushed over the edge with earth moving equipment (bulldozer would be typical). As the working face of the waste rock dump is advanced, the first lift is formed and the waste rock dump will be compacted by traffic loading. The working face of the waste rock dump will be at the angle of repose. The outer slopes will be profiled to the required slope of 2.5 (Horizontal): 1 (Vertical) with the earth moving equipment. Once the first lift has been completed, a 6 m step-in along the perimeter is required for the construction of the next lift. A second access ramp will then be constructed for the second lift with its base at the edge of the step-in. The same procedure as per the first lift is then followed for this lift and all subsequent lifts. There will be three lifts (based on a bulking factor 1.4) in total for a total pile height of about 15 m.
LPSC-01-29	▪ GNSCR 3(1)(j)	***Information Request:*** *Provide information on the estimated range of annual output of grey water and clarification on the range of waste rock produced per year.* ***Context:*** *PSR 9.3.4, states "during construction, sanitary services will be supplied and managed by the contractor, with disposal off-site. This will include sanitary and mine dry facilities … ." Table 9-1 identifies the sanitary waste volumes, but it is not clear on the volume of grey water. Further, the waste rock in the table is the total volume expected, and not a range per year during the period of excavation.* *Information on the quantity of grey water produced during construction is needed. Clarification is also needed on the approximate volume of waste rock expected to be produced annually during the period of excavation.*
		OPG Response: The projected ranges of sanitary waste presented in Table 9-1 of the Preliminary Safety Report (PSR) include both sewerage and grey water based on standard industry averages. Although it is assumed that the sanitary wastes are removed from site, the project is reviewing the opportunity to tie into Bruce Power's sanitary services for both the construction and operations phases. The estimated waste rock volume of 832,000 m^3 represents the repository lateral development excavation.

<table>
<tr><th>IR#</th><th>NSCA Regulations Section #</th><th>Information Request and Response</th></tr>
<tr><td></td><td></td><td>Based on the project schedule and assumptions of development productivities, the estimated annual volumes from lateral development from the 4th Quarter of Year 4 to the end of Year 7 of the project schedule are as follows:
<table>
<tr><th>Year</th><th>Volume (m³)</th></tr>
<tr><td>Year 4</td><td>105,750</td></tr>
<tr><td>Year 5</td><td>233,439</td></tr>
<tr><td>Year 6</td><td>311,251</td></tr>
<tr><td>Year 7</td><td>181,560</td></tr>
</table>
Note: Year 1 of the project schedule starts when the site preparation and construction licence is awarded.

The development schedule and annual production of waste rock will be further developed with the selected development contractor.</td></tr>
<tr><td>LPSC-01-30</td><td>▪ GNSCR 3(1)(b)</td><td>Information Request:
Provide information on the construction of the plenums as part of shaft pre-sinking activities.
Context:
While PSR 6.3.8.1 identifies the intake and exhaust plenums, the description of shaft pre-sinking activities does not include the construction of the main and ventilation shaft plenums.
To better assess construction plans, a description of the construction of the plenums is needed for a more complete description of shaft pre-sink activities.</td></tr>
<tr><td></td><td></td><td>OPG Response:
The details of the construction method for the plenums depend on the collar development approach selected by the shaft sinking contractor, and hence will not be known until that contract is let. With the reference approach to collar construction (i.e., excavation of overburden to bedrock and backfill to grade), the plenums will be formed and constructed to coincide with the backfilling of the excavation using standard construction techniques.

Should the shaft sinking contractor choose ground treatment of the overburden and excavate vertically to bedrock for the collar construction, excavation would be required to form and construct the plenums. In both</td></tr>
</table>

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		scenarios, the plenums are integrated in the collar design of both the main and ventilation shafts and would be constructed at the same time as the shaft collars. This enables proper backfilling of the shaft collars which are the foundations for the headframe structures.
LPSC-01-31	▪ GNSCR 3(1)(b)	***Information Request:*** *Provide additional information on the ground improvement planned for the upper 180 metres of bedrock, including the relative advantages of the proposed methods and estimates for the change in groundwater flow (before and after).* ***Context:*** *PSR 9.4.1 describes several ground improvement approaches for rock excavation that may be used for pre-sink (shaft collar) activities and shaft sinking activities. The description indicates ground water concerns primarily in the upper 180 metres of bedrock but is unclear what ground improvement approach will actually be used, and on the ground water flow estimates before and after ground improvement.* *Additional information on ground improvement plans and groundwater control will enable a better understanding of construction issues during shaft sinking.*
		OPG Response: At the DGR project site there are permeable bedrock strata to a depth of about 180 mBGS (metres below ground surface). Without ground treatment, there could be significant inflows of groundwater into the two shafts during shaft sinking. Ground treatment will likely be performed both from surface in advance shaft sinking at the two shaft locations and, as required, during shaft sinking (i.e., cover grouting from within the shaft). Further information on expected ground water inflows is presented in the response to IR-EIS-01-01. There are two surface-based options for ground treatment: ground freezing and grouting. There is high confidence based on experience in recent shaft sinking projects that ground freezing is viable to depths of 200 m and can reduce potential groundwater inflows to less than 3 L/s into the shaft excavations. However, shaft freezing is more expensive and can lengthen the project schedule in order to establish and maintain an effective freeze curtain. A surface-based grouting program, if technically feasible to depths of 200 m, would likely be less expensive to implement and could be executed in a shorter period of time. In addition, the grout curtain has the added long-term benefit of remaining in-place after the shaft sinking activities are completed and during DGR operations. It is expected that the grout curtain, in conjunction with the concrete shaft liner, will greatly reduce the potential amount of groundwater inflow into the two shafts from the permeable upper bedrock strata.

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		In 2011, an initial trial was conducted at the proposed location of ventilation shaft to determine the feasibility of a surface-based grouting to a depth of 200 m. The results of this trial were encouraging and demonstrated that surface-based grouting is likely feasible to depths of 200 m. The trial will be continued in 2012 for the purpose of confirming feasibility of surface-based grouting at the DGR project site.
LPSC-01-32	▪ GNSCR 3(1)(b)	***Information Request:*** *Provide information on the kinds of controlled drill and blast techniques that may be used to minimize the excavation damage zone (EDZ) associated with the shaft excavation. Also provide information discussing the kind of ground support expected for use during excavation of the shafts.* ***Context:*** *PSR 9.4.2 provides a brief description of rock excavation for the shaft collar in the upper 20 metres of bedrock with temporary equipment for drilling. PSR 9.4.5 briefly described the sinking of the main and ventilation shaft using “controlled drill and blast techniques”.* *No information is provided on what controlled drill and blast techniques may be used to minimize the EDZ. The EDZ is important to long term performance. Ground support is also not described.* *Additional information on the kinds of drill and blast and ground support techniques is needed for a more complete description of the construction of the DGR facility.*
		OPG Response: Controlled drill and blast techniques will be used to minimize the amount of overbreak and damage to the Ordovician shale and limestone formations. These formations will ultimately host the low-permeability shaft sealing materials to be placed in the two shafts at the time of decommissioning (see Chapter 13 in the Preliminary Safety Report - PSR). This zone of damaged rock immediately at the perimeter of the shaft excavation is referred to as the highly damaged zone (HDZ) (see Figure 4-80 in PSR for definition of HDZ, EDZ and EdZ). The contractor will be responsible, in consultation with the NWMO, for selecting the drill and blast method that will best minimize damage. These could include increasing blast hole density and reducing the powder factor per hole, use of high density perimeter holes close to the excavation limit, varying the types of explosives used for each round, etc. The contractor will explore various approaches to controlled drill and blast in the upper 200 m of the shafts and then select the preferred method before reaching the Ordovician shales. Ground support for the shafts, as well as underground excavations, will be selected based on actual conditions encountered during excavation (i.e., the observational approach). The ground support will be adapted to the observed conditions (e.g., no overstressed conditions, overstressed conditions, potential slaking, etc.). There

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		will be a series of ground control measures applied over the length of the shaft. Rock bolt types, lengths and sizes will vary, as will the method of anchoring to the rock (resin versus mechanical). There may be the need for additional initial support in the form of shotcrete. In general, the typical initial rock support installed immediately after excavation will consist of nominally 3-m-long, 25-mm-diameter resin grouted rock bolts and welded wire mesh with supporting anchorages. The rock bolts will have varying spacing depending on ground conditions and will be used with fast-setting resin cartridges to provide end-anchoring (300 mm anchor length) and slow setting resins to bond the remaining length of the bolt with a free length of approximately 0.5 m in the hole at the bolt head. The free length will facilitate rock bolt removal in conjunction with over-excavation in the HDZ. The design of the rock bolts takes into account the residual elastic movements of the rock due to subsequent advance of the shaft, and the long term displacement of the rock due to swelling, if the rock formations exhibit swelling characteristics.
LPSC-01-33	▪ GNSCR 3(1)(b)	***Information Request:*** *Provide additional information on the waste rock dumping facility and the muck bay (with sump description, dust control, etc) associated with the main and ventilation shafts.* ***Context:*** *PSR 9.4.3 briefly describes a temporary waste rock dumping facility and muck bay beside the main headframe for shaft sinking, and similar facilities for waste rock from underground development associated with the ventilation shaft (PSR 6.2.2.1).* *Additional information on the temporary and permanent muck bays and dumping areas (nominal size, dust control, etc.) provides a more complete understanding of waste rock handling.*
		OPG Response: During shaft sinking, the excavated rock (waste rock) will be hoisted to surface by shaft sinking buckets and dumped into muck bays adjacent to the headframes via dump chutes. Muck bays will be of reinforced concrete construction lined with steel. Muck bay floors will slope toward the entrances where grating covered trenches are located to direct run-off to the site drainage system. The main shaft headframe will have a single muck bay for shaft sinking located adjacent to the headframe on the south side. This muck bay will be removed once the shaft sinking activities are complete at the main shaft. The ventilation shaft headframe will have two muck bays during sinking and development located adjacent to the headframe on the north side. During development, the waste rock will be hoisted in the skip and dumped into the ventilation shaft headframe muck bays via a dump chute with diverter gate. Muck bays will be sized to

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		provide a nominal 100 m^3 storage capacity. As is typical in mining operations, the excavated rock is sprayed or misted with water to reduce fugitive dust where the material is loaded and hauled underground. As such, fugitive dust at the muck bays is not expected to be an issue. In addition, the waste rock to be hoisted will not be crushed after blasting but sized to 305 mm minus through a grizzly with hydraulic rock hammer which reduces the amount of fines in the waste rock. The waste rock hoisted to surface is estimated to have a moisture content of 5-8% at the point of discharge and will be dumped into muck bays that are enclosed on three sides.
LPSC-01-34	▪ GNSCR 3(1)(b)	***Information Request:*** *For underground development provide additional information on the excavation cycle, the use of partial-face excavation, and the ground support methods and their expected locations for installation.* ***Context:*** *PSR 9.4.7.1 provides a brief, but incomplete, description of the drill and blast excavation cycle. It is not clear what support is expected for the typical profiles of the excavated openings, and whether steel mesh is part of the initial ground support. It is also unclear what partial-face excavation may be conducted to reduce risk of rock falls and where it may be expected to be used.* *Additional information is needed to complete the excavation plans for the underground development.*
		OPG Response: Excavation of underground openings will be carried out by drill and blast methods. The excavation cycle is described in Section 9.4.7.1 in the Preliminary Safety Report (PSR). Current concepts include planned round lengths (lateral length of the blast) that do not exceed the width or the height of the rooms, which means that the excavation benefits from some support provided by the face while rock bolts are being installed. It is anticipated that full-face excavation will be adopted in all access tunnels beyond the shaft stations and all of the emplacement rooms. It is further anticipated that excavation at the shaft stations and several of the shaft area excavations will be by partial-face or benching sequence. At the repository level (access tunnels and emplacement rooms), the ground support consists of both plain (or un-reinforced) and fibre reinforced shotcrete, welded wire mesh, 25 mm diameter hollow core mechanical rock bolts and 12 mm diameter cable bolts. To prevent any potential propagation of fractures or spalling as well as to "stitch" the bedding layers and to provide a thicker beam above the roof, rock bolts will be installed in all workings. Supplementary cable bolts will be installed in selected areas such as shaft stations, maintenance areas and other wide intersections. The tentative bolting pattern is 2.05 m × 2.05 m spacing, 3 metre long bolts

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		for the emplacement rooms. A pattern of 1.68 m × 1.68 m, 2.4 metre long bolts will likely be used in the access tunnels. All bolts will be galvanized, hollow, initially end anchored and pre-stressed to maintain the tight bedding. As the rooms and tunnels are advanced, secondary cement grouting of the bolts will be carried out for long term support and corrosion protection. In additional to bolting, mesh or fibre reinforced shotcrete will be applied after each round to prevent small "loose" from falling and jeopardizing the safety of the workers. If mesh is used, plain shotcrete can be applied at a later time, when it is most convenient in the construction cycle.
LPSC-01-35	▪ GNSCR 3(1)(b)	***Information Request:*** *Provide additional information on the lateral development and the ventilation schemes for the development sequences to allow confirmation of the ventilation system capacity. Provide description of the ventilation system during underground development (e.g. temporary or permanent rigid metal ducting?).* ***Context:*** *PSR 9.4.7.2, 9.4.7.3 and Figures 9-4 to 9-8 provides only a brief description on the development sequence and the associated ventilation.* *No information is provided about the development and ventilation of the shaft bottom ramp, and information is lacking on the other lateral development sequences. This limits determining the adequacy of the capacity of ventilation system. The lateral development schedule suggests a minimum of 6 development headings indicating, based on Figure 2.3, Radon Assessment, a requirement for 180 m^3/sec maximum air flow. This is different from PSR 6.3.8.2, which indicates 130 m/sec maximum air flow during construction. Figure 9-12 shows a push (40 kw) - pull (80 kw) system for a single heading, but this is uncertain.* *Additional information is needed so that ventilation requirements for the construction period can be confirmed by CNSC staff.*
		OPG Response: The construction of the underground repository will likely be performed in four major stages with each stage employing a ventilation scheme unique to that stage. 1. *Shaft Sinking:* the two shafts will be ventilated separately in the shaft sinking stage. Fans and heaters will be set up on the concrete intake and exhaust plenum structures. Air will be delivered to the shaft bottom via temporary ventilation ducts connected to plenum structures.

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		2. *Development Out of Shafts:* until the two shafts are connected, air will be supplied to the level via temporary ducts in each shaft. 3. *Development After Shafts Are Connected*: when the shafts are connected by a tunnel at the repository level, a temporary bulkhead will be established in the tunnel between the two shafts. Fans will be installed in this underground bulkhead to pull air down the main shaft and send the air back to surface via the ventilation shaft. At this time, the temporary shaft sinking ducting and aforementioned temporary fans and heaters will be removed. The first of the two permanent fresh air fans and heating system at the intake plenum structure will also be established at this time where the primary function of the surface fan(s) is to push air through the heaters to the main shaft where it is drawn underground by the bulkhead fans. 4. *Development Using Permanent Return Air Fans*: once the underground services area is developed and electrical power is available, the two permanent main underground fans will be installed and operated. The temporary bulkhead between the two shafts will be removed. The main underground fans draw air down the main shaft into the underground services area. Walls, doors and louvers control air flow through underground services area. Air to the ramp to shaft bottom is fan assisted and draws fresh air from the repository level through an established ventilation bulkhead at the top of the ramp. 5. Once underground development expands out into the two panels of emplacement rooms, there will be increased construction activity and thus a need for larger volumes of air. Temporary metal and fabric ducting with auxiliary fans will be used in headings until flow-through ventilation is established as described in Section 6.3.8 of the Preliminary Safety Report. Regarding the minimum number of development headings at any given time, this refers to the available faces for development. However, only 4 faces will be active at any given time in order to maintain an average of 4 development rounds per day. Further, the air flow requirements of the rooms vary with the type of equipment active in the room. The estimated airflow requirements detailed in Section 6.3.8.2 of the Preliminary Safety Report of 102 m^3/s reflects the activities required in each of the rooms to meet development objectives and the airflow requirements. The airflow requirements of 30 m^3/s shown in Figure 2.3 of the Radon Assessment show the peak flow requirement of an emplacement room during construction, not the average. The ultimate ventilation requirements will depend on the development approach and equipment selection of the contractor. The proposed ventilation system is flexible to accommodate changes in the total airflow requirements if required.

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LPSC-01-36	▪ GNSCR 3(1)(b)	***Information Request:*** *Clarification is needed on the application of fire safety/protection requirements of Part 8 of the National Building Code and Ontario Regulation 213/91 Construction Projects during the site preparation and construction phase.* *Additional information is needed addressing fire and fire protection during construction, including a fire hazard analysis and the development of a fire protection program for the site preparation and construction phase of the DGR project.* ***Context:*** *There is no apparent discussion in PSR 9.4.9, Occupational Safety, on fire protection during the site preparation and construction phase.* *PSR 9.4.9 does refer to the Ontario Occupational Health and Safety Act and the Preliminary Conventional Safety Assessment Report which identifies the Mines and Mining Plants Regulations, RRO 1990 Reg.854. This regulation includes fire protection. But no references are made to the application of Part 8 of the National Building Code of Canada (NBCC), "Safety Measures at Construction and Demolition Sites" (and by citation the National Fire Code of Canada) for the construction phase of the DGR project. Nor is reference made directly to Ontario Regulation 213/91 Construction Projects. Both Part 8 of NBCC and Ontario Regulation 213/91 are applicable during the development of the DGR facility, and through Part 8 of the NBCC there is an expectation for a fire protection program during this period.* *Table 5.3, Summary of Construction Conventional Safety Assessment, in the Preliminary Safety Assessment Report did not identify 'fire' as a hazardous condition and did not, therefore, indicate control and mitigation measures. Fire was addressed as a hazardous condition in Table 5.2 for site preparation. CNSC staff requires the development of the Fire Protection Program and a Fire Hazard Analysis (FHA) based on the consideration of National Fire Protection Association (NFPA) 122 and NFPA 801.* *Clarification and additional information is required to understand how fire and fire protection will be addressed during site preparation and construction of the DGR.*
		OPG Response: A detailed Fire Protection Program for site preparation and construction will be prepared in accordance with the National Building Code of Canada-Part 8, the National Fire Code of Canada, the Ontario Health and Safety Act, and guidance from National Fire Protection Association (NFPA) standards 122 and 801, and Ontario Regulation 213/81, which have all been reviewed for their relevance to this project. A fire protection plan will be prepared which will be based on a fire hazard analysis based on guidance from NFPA 122 and 801. The plan will be

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		finalized once the construction contractors have been hired and details of their construction equipment and on-site infrastructure are fully known. However, the plan will outline the fire protection measures to be implemented during the construction of the DGR, both for the construction of the buildings and facilities, as well as for underground development. There will be provisions in the plan to segregate hazardous material, limit combustible material, have available numerous fire extinguishers, and have a site emergency response plan. The plan will be specific to the availability of services and the activities/hazards associated with the activities to be completed.
LPSC-01-37	▪ GNSCR 3(1)(b)	***Information Request:*** *Provide additional information clarifying, for the site preparation and construction phase, the conventional safety requirements. The information should include any additional controls and measures for conventional safety required by the applicable regulations under Ontario’s Occupational Health and Safety Act and not currently identified in the Conventional Health Assessment, and how the controls and mitigations are to be provided.* ***Context:*** *PSR 9.4.9 discusses occupational safety and contingency planning, primarily referencing Ontario’s Occupational Health and Safety Act, the NWMO’s Health and Safety Management Plan, the Design and Construction Phase Management System (provided), and the Conventional Safety Assessment (provided). Tables 5-2 and 5-4 in the Conventional Safety Assessment, provides a summary of the hazards during site preparation and construction, and lists the controls and mitigation measures needed to address them. It is not apparent in the PSR and Construction Phase Management System document how the controls and mitigation are to be provided and what, if any, additional controls and measures may be required by the applicable regulations made under Ontario’s Occupational Health and Safety Act.* *Additional information is needed on the controls and measures and their application in the period of site preparation and construction to assure CNSC staff of worker safety.*
		OPG Response: The site preparation and construction activities will be carried out in compliance with Ontario’s Occupational Health and Safety Act and its associated regulations. In its capacity as Constructor, the NWMO will ensure that: the measures and procedures prescribed by the Act and the associated Regulations are implemented on the project, every employer and every worker performing work on the project complies with the Act and Regulations and the health and safety of workers on the project are protected.

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		The NWMO has developed a project Health, Safety and Environmental Management Plan (HSEMP) and a set of procedures that govern the planned work activities. The procedures will be reviewed and updated, as required, to reflect the specific work being performed. This includes incorporating best work practices and task-specific procedures provided by the various contractors. The project organization will include a health, safety and environment manager who is responsible for facilitating safe work planning as well as performing field monitoring and coaching on safe work practices. As required by the HSEMP, risk assessments are conducted for all work to be performed, with criteria established to identify tasks as having a high potential for harm should they not be performed properly. Such tasks are subjected to a job safety analysis by the contractor, the supervisor and the owners’ safety supervisor. The job safety analysis provides the basis for a safe work plan which describes how the work is to be done, how the risks are to be mitigated and which procedures will be followed during the execution of the work. Workers are involved with the work review and acknowledge the safe work plan with their supervisor prior to starting any work. If the nature of the work changes, or new workers are introduced, the safe work plan will be reviewed, and any and all new risks associated with the revised work will be mitigated. With respect to Tables 5.2 and 5.4 of the Preliminary Conventional Safety Assessment, the current HSEMP and procedures adequately address all items with respect to the site preparation and construction activities that are to be undertaken at surface. Nevertheless, these will be reviewed prior to the commencement of work as part of the job safety analysis that must be carried out to develop the required safe work plan for each phase of that work. Further development of procedures is required for the shaft sinking and lateral development activities. These procedures are planned to be developed in conjunction with the contractor(s) that will be retained for this work and these procedures will be in place prior to the start of that work. In addition, the project plans and procedures are reviewed annually and are updated at any time that there is a revision to the governing Acts or Regulations. All workers are required to be trained on the site emergency response procedures as part of their orientation. Emergency drills are carried out on a routine basis to ensure that all workers understand how to react and what to do during an emergency. This includes emergencies that may occur off of the project island, e.g., a Bruce site nuclear emergency. Currently, the HSEMP is being divided into two plans, namely, the Health and Safety Management Plan (HSMP) and the Environmental Management Plan (EMP). The HSMP will comply with the requirements of CSA Z1000:2009 and the EMP with the requirements of ISO 14001.

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LPSC-01-38	▪ GNSCR 3(1)(b)	***Information Request:*** *Provide additional information clarifying the commissioning of temporary installations, such as the water treatment plant, used during the site preparation and construction phase and permanent installations, such as the hoists, that are used in a construction configuration during the same period.* ***Context:*** *PSR 9.4.11 states “Commissioning plans for the DGR project will be developed in accordance with the commissioning program referred to in the Design and Construction Phase Management system document. … Commissioning … will be staged, with initial commissioning of key equipment and facilities occurring early the construction program to support development of the repository.”* *PSR 9.4.11.1-2, describes commissioning for subsequent operation of the DGR facility but provides no details on the commissioning of temporary installations (such as the galloway, water treatment plant and the batch concrete plant) that support construction. The commissioning of permanent installations for use in during the construction phase (such as the hoists in the main and ventilation shafts, the stormwater management pond) also does not appear to be discussed. CNSC staff was unable to confirm if the commissioning as discussed in the Design and Construction Phase Management System document included the period of site preparation and construction.* *Additional information on the commissioning of temporary and permanent installations used in a construction configuration is needed to fully understand this activity during the construction phase.*
		OPG Response: The commissioning plan as referenced in the Design and Construction Phase Management System document (NWMO 2011) will be inclusive for temporary equipment required for construction, as well as the end-use commissioning requirements to meet Ontario Power Generation’s operational acceptance requirements. The major systems, structures and equipment that will need to be commissioned to support construction include: • Electrical supply onto the DGR site including electrical substation; • Service water and fire water connections into the existing Bruce nuclear site systems; • Main shaft and ventilation shaft headframes; • Temporary shaft sinking hoisting equipment followed by permanent hoisting equipment for the main shaft and ventilation shaft (latter installed and commissioned after shaft sinking is complete); • Underground ventilation systems – temporary systems used during shaft sinking and initial off-shaft development at both shafts followed by permanent ventilation system used during lateral development;

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		• Waste rock handling system including underground waste rock handling equipment, loading pocket , shaft conveyance (i.e., skip) and surface-based waste rock handling equipment; and • Stormwater management system. **Reference:** NWMO. 2011. Design and Construction Phase Management System (OPG’s L&ILW DGR). NWMO document DGR-PD-EN-0001 R000. Toronto, Canada.
LPSC-01-39	▪ C1NFR 5(f) ▪ RPR 4, and 5	***Information Request:*** *Provide information clarifying the purpose and use of the collective dose benchmark for the DGR. Also include information on the disposition of the recommendations put forth in the Preliminary ALARA Assessment.* ***Context:*** *PSR 7.1.1 states “The WWMF operating experience over the past 40 years is also an important context for this DGR operational safety assessment. Many of the waste packages to be emplaced within the DGR are currently handled, transferred and stored in the WWMF.” The Preliminary ALARA Assessment identifies the collective dose benchmark for DGR workers as 55 person - mSv/year (based on the WWMF experience). However, the actual collective dose estimate for DGR workers (i.e. waste handling, maintenance and support workers) is 137 person – mSv/year, which is significantly higher that the collective dose benchmark.* *Given the differences between the collective dose estimate and the benchmark, the intent of the collective dose benchmark and the purpose it serves in the design and operations is unclear. As well, the suggested efforts presented in the Preliminary ALARA Assessment to reduce the collective and individual doses are recommendations, and it is not clear whether any will be accepted and implemented in the design and operation of the DGR.*
		OPG Response: <u>1. Collective Dose Benchmark</u> The purpose of the preliminary ALARA assessment (SENES 2011) is to provide a baseline to direct the subsequent detailed design and ALARA optimization. It does this by deriving a DGR worker collective dose estimate, and thereby identifying the principal contributors to this collective dose. This information provides an indication of where optimization will be most useful. The collective dose was estimated using a bottoms-up task-analysis approach based on estimates for activities, number of workers, distance from packages, and task durations. This estimate represented the wide variety of

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		packages by 8 specific packages. This resulted in a preliminary dose estimate of 137 person-mSv per year during the initial higher package handling period. Since this was derived from a task analysis basis, this estimate provides specific information on the higher dose tasks. As an independent check, the collective dose was also estimated by using a simple analogy from actual Western Waste Management Facility (WWMF) worker dose experience, where similar waste packages are handled. WWMF worker doses were simply scaled up by the larger waste volume to be handled during the initial DGR operations. This scaling led to the 55 person-mSv per year estimate. This value is much smaller than the task-based estimate noted above. As it is just scaled by a waste-volume-analogy, the scaled estimate is not useable to provide specific direction on optimization. However, it does provide an indication that the 137 person-mSv/yr value may be significantly reduced as more realistic information and practices are taken into account. 2. Preliminary ALARA Report Recommendations The Preliminary ALARA Assessment, Section 7.3, identifies initial recommendations for dose reduction based on their potential to significantly reduce the estimated total worker dose. The recommendations and status are summarized in the table below.

Recommendation	Status
Optimize the design of the ILW Shield waste containers	The detailed design of these waste packages is not currently available, as they are not intended for use until 2019. For the Preliminary ALARA assessment, the package dose rates were therefore assumed conservatively high. The design will be prepared incorporating the ALARA principle, before such packages are put into service.
Consider options to reduce dose to the light-duty forklift operator, in particular adding shielding or increasing the driver-load distance.	Detailed specifications for the mobile equipment have not yet been prepared as they are not intended for use until 2019. The Final ALARA assessment will lead to additional dose reduction measures as required.
Consider adding shielding around package staging area in the WPRB, and moving this area away from the control room location.	The amount of shielding required is currently being assessed as part of the detailed design.
Place waste packages with relatively high dose rates within emplacement room and staging areas such that	Administrative procedures will be developed for the operations phase, and will take into account the necessary placement of waste to ensure ALARA dose to workers.

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		other lower dose rate packages provide self-shielding to worker location. **Reference:** SENES. 2011. Preliminary ALARA Assessment. SENES Consultants Ltd. report for the Nuclear Waste Management Organization NWMO DGR-TR-2011-36 R000. Toronto, Canada.
LPSC-01-40	▪ C1NFR 5(f)	***Information Request:*** *Provide additional information to support statements on the applicability of the Derived Release Limits (DRLs) for the WWMF to the DGR site on preliminary basis. Include information on plans for the development of final DRLs for DGR operation.* ***Context:*** *The PSR refers to the use, on a preliminary basis, of DRLs prepared for the WWMF because of similar wastes, and location of release sources. These DRL calculations include air dilution factors developed for the WWMF. The PSR indicates that the estimated doses, which are based on the estimated release rate for the DGR compared to the DRLs, are considered conservative. While the similarity of waste is understood, there is no discussion of the similarities of location and release height to support the statements on applicability.* *Additional information is needed to confirm the general applicability of the WWMF DRLs to the DGR.*
		OPG Response: For the preclosure safety assessment in support of the application for Site Preparation and Construction Licence, it was assumed that the DRLs for the DGR were the same as the approved DRLs for the Western Waste Management Facility (WWMF) (OPG 2003). Table 1 provides the key factors included in the 2003 WWMF DRL assessment and the relevance of these factors to the DGR. The table shows that the WWMF DRLs provide a reasonable basis for the DGR preliminary safety assessment. Figure 1 (provided at the end of the responses to LPSC IRs) shows the air and water release points for the WWMF and DGR, and the nearest receptor locations around the Bruce nuclear site. The figure shows that the air release points are very close. The water release points are different, but as noted in Table 1, the assumed extent of dilution to nearest receptor for the WWMF DRL is readily met for the DGR water release point.

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Table 1: Comparison of Factors Applicable to WWMF DRL and DGR

Factors Included in the 2003 WWMF DRLs	Relevance of Factor to DGR
Releases to both air and water are considered	Same
Releases are reasonably continuous	Same
No significant release of ^{83m}Kr (potential dose to lens of eye)	Same
No significant release of particulate to environment (potential dose to hands and feet)	Same
Air releases were modelled from a single ground source release point as this was most conservative of the three actual release points: incinerator stack at 21 m, buoyant plume; Waste Volume Reduction Building (WVRB) vent at 20 m, no plume buoyancy; and Low Level Storage Buildings (LLSBs) at ground level, ambient temperature.	There are two main air release points from the DGR - the Waste Package Receiving Building (WPRB) exhaust vent at around 20 m above ground level, and the ventilation shaft exhaust at several metres above ground level. Treating these as a similar ground level release would be conservative.
Air releases were evaluated based on the WVRB location, with nearest critical group location ~3 km SSE of the site (OPG 2003, Table 2). This was the limiting group for air release of H-3 and C-14 (F14, OPG 2003, Table 30).	The main air release location is the ventilation shaft exhaust, which is ~0.4 km N of the WWMF air release point. As illustrated in Figure 1 (provided at the end of the responses to LPSC IRs), this release point is close to the WWMF reference air release point, and a similar distance to the same critical group as in WWMF.
Water releases from the site go through the railway ditch to Stream C and then to Baie du Dore. This water is then used by receptors from Scott Point, which is the waterborne critical group (R1, OPG 2003, Table 30). The total dilution to receptor at Scott Point is 50 L/s (minimum Stream C flow) x 20 (Baie du Dore dilution factor) = 1000 L/s = 1 m^3/s.	Water releases from the site go through the DGR stormwater management pond and into Macpherson Bay. This is different from WWMF. Contaminants would then be mixed with the near-shore current flow and carried to the nearest receptor, also Scott Point. The total dilution to receptor at Scott Point can be shown to be in similar range as per WWMF release as follows. The DGR releases would be mixed by the current along

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That is, 1 Bq/s of release corresponds to a concentration of 1 Bq/m^3 at the nearest point of use.	the lake shore. The lake depth is a few metres close to shore, and the water is mixed by wave action and currents. The actual dilution will be assessed explicitly as part of preparing the DGR-specific DRLs. But as a simple estimate, assuming cautiously that the releases mix just to an effective depth of 1 m and width of 10 m by the receptor location at ~ 3 km distance, and with an annual average current flow of 0.1 m/s in Lake Huron off-shore (CSA N288.1, Table F.4), then the diluting water amount would be 1 x 10 x 0.1 = 1 m^3/s. As with the WWMF, this means that 1 Bq/s water release from the DGR would also correspond to a concentration of 1 Bq/m^3 at the nearest point of use. This the same as assumed for the WWMF DRLs.
Transfer pathways and factors from OPG DRL Guidance report (OPG 2002)	The transfer pathways remain relevant, but the reference transfer factors have since been superseded by CSA N288.1-08 (2008). See further discussion of this below.
Actual receptor locations around the Bruce site, representing residential, non-dairy farm, farm and industrial.	Same. These receptors cover the range of receptors around the Bruce nuclear site. As shown in Figure 1 (provided at the end of the responses to LPSC IRs), these receptors are also the closest to the DGR.
Six age groups evaluated	Current guidance indicates that three age groups are sufficient for DRL calculations.
Effective and equivalent dose limits from Radiation Protection Regulations	Same. These dose limits are still applicable.

Recently, OPG has updated its WWMF DRLs to reflect current information, and in particular implementation of CSA N288.1-08 (CSA 2008), 2007 site-specific survey data, and current meteorological data. These updated DRLs have been submitted for CNSC acceptance (OPG 2011). The updated DRLs are generally larger than the 2003 DRLs for key DGR nuclides. The exception is airborne C-14, for which the updated WWMF DRL is 4 times smaller. However as shown in the DGR Preliminary Safety Report, the DGR will operate well below its preliminary DRL for airborne C-14 (< 0.1% of DRL, Table 7-10, PSR), so a reduction in DRL by a factor of 4 will have no effect on the DGR safety conclusions. Therefore this indicates the present (2003) WWMF DRLs are still useful guidance for the preliminary safety assessment of the DGR.

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		OPG will develop and propose DGR-specific DRLs for CNSC approval prior to submitting its application for an Operating Licence for the DGR. These DRLs will be calculated as per applicable CSA and CNSC guidance in effect at that time. **References:** CSA. 2008. Guidelines for Calculating Derived Release Limits for Radioactive Material in Airborne and Liquid Effluents for Normal Operation of Nuclear Facilities. Canadian Standards Association, CSA N288.1-08. Toronto, Canada. OPG. 2003. Derived Release Limits for the Western Waste Management Facility. Ontario Power Generation report 0125-REP-03482-00002-R00. Toronto, Canada. OPG. 2011. Letter to CNSC, T. Doran to R. Barker, “Derived Released Limits and Action Levels for the Western Waste Management Facility”, November 29, 2011. Radiation Protection Regulations. SOR/2000-203. Canada.
LPSC-01-41	▪ C1NFR 5(f)	***Information Request:*** *Identify events on the Bruce site that could affect the DGR. Provide an assessment of how the DGR may be affected, including possible simultaneous events at both the Bruce Power facilities and the DGR. Information needs to include how these events influence the DGR facility design (if they do) and if, and how, such events need to be addressed in contingency plans (e.g. changes to the status of DGR and Bruce Power operations) and emergency planning (e.g. changes to emergency response assistance) for the construction and operational phases.* ***Context:*** *PSR 7.5.1.2 and Table 7-25, Initiating Events, identifies many external events that are assessed as to their potential to affect operations at the DGR facility. However, the list of potential external events does not include radiological and nuclear events and/or other events originating from other areas of the Bruce site. These events may have effects that might necessitate changes to the DGR design, to contingency planning and to emergency response plans for the construction and operational phases.* *The assessment of the effects of initiating events occurring elsewhere on Bruce site, including simultaneous events, needs to be included to demonstrate adequate consideration of all potential events affecting the DGR.*
		OPG Response: The Bruce A and B reactors are about 1.5 km distance from the DGR on the Bruce nuclear site, and their

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		associated transformer stations and high voltage transmission lines are about 1 km. There are also steam lines and an oil-fired heating plant at about 0.5 km. There are two 3500 US gallon propane tanks at the WWMF incinerator at about 0.3 km. These facilities are too far from the DGR to have any significant direct effect (e.g., explosion impact). There are no active rail lines, natural gas pipelines, or large flammable gas storage facilities within a kilometre of the DGR. (Propane heating of the DGR may be used during construction, but not during operation.) Consequences of accidents or events at these other site facilities that could potentially affect the DGR site are those involving radiation release, fires, loss of power, or loss of site emergency services. The implications of these are discussed below. *Radiation Release* Radioactive materials could be released from the Bruce reactors under accident conditions. The main effect of this on the DGR is that workers would stop construction or waste emplacement operations and go to their predetermined site emergency locations (e.g., refuge stations underground) and later, potentially evacuate the DGR area. The DGR would have to go into shutdown mode. Since the safety of the stored packages at the DGR is not dependent on active cooling systems, there would be no associated impact on the stored waste. As part of the radiation emergency response, building ventilation would be stopped within the surface facilities. Underground ventilation and compressed air supply from surface would also be stopped in the case of a radiation emergency. Although this would be inconsistent with conventional emergency response where mine ventilation would continue until all workers have reached the nearest refuge station, there will be sufficient air supply at the repository level for breathing air for a prolonged period, even with the ventilation fans shut-down. Notification of the emergency event would be through the repository "leaky feeder" communication system and emergency procedures would be developed to ensure personnel are accounted for. *Fires* Fires could occur in the other facilities. The smoke from these could impact surface and underground operations, requiring workers to stop construction or waste emplacement operations at the DGR and go to emergency locations (e.g., refuge stations underground) and later, to evacuate the DGR area if the fire is not put out quickly or results in radioactive contamination of the area. The DGR will have to go into shutdown mode. As with *Radiation Release* above, the passive nature of the DGR means that there will be no safety impact. *Loss of Power* In the event of accidents at other on-site facilities, or due to natural events, there may be loss of site power impacting the DGR. The DGR will then rely on its own emergency backup generators to provide power for

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		emergency services. Waste emplacement operations at the DGR will be put on hold, workers will be removed from underground, and only key systems will be operated. The DGR backup generators will have sufficient fuel for 48 hours at full emergency power, which would provide for longer power in practice as systems are progressively shut off (e.g., hoist system after workers are removed from underground). See response in IR-LPSC-01-10. *Loss of Site Emergency Services* If other major accidents occur at the Bruce nuclear site, an effect could be the unavailability of site emergency services. This could mean, in particular, that the Bruce Emergency Response Team would be fully occupied with the other event, and not able to assist the DGR if a subsequent accident were to occur at the DGR. If this service was confirmed to be unavailable or limited in ability to respond, the DGR construction or waste emplacement operations would be put on hold. *Simultaneous Events* In the event of an unlikely event affecting the whole Bruce site, such as a large earthquake or tornado, the key impact on the DGR could be the prolonged loss of power and emergency services to the DGR site. However, the DGR itself is largely passively safe - it does not require cooling, and any buildup of radioactive gases or other gases is a slow process. The key issue would be to restore the sump pumps to remove water infiltrating into the repository. Without power, water will accumulate in the DGR sumps. However, there is a significant volume available within the shaft bottoms, the ramp to shaft bottoms, and areas around the shafts. The repository layout also has the emplacement rooms updip from the shafts, following the slope of the host rock formations, which puts the wastes above where water would initially accumulate. Without any power it would take several weeks under design-basis inflow assumption of 2 L/s before water could reach the emplacement rooms, allowing considerable time for the re-establihment of electrical power. Water inflow rate would normally be very low due to the low permeability of most of the rock and the grouting of permeable layers. If the inflow rate were higher than the design basis inflow, the time to reach the emplacement rooms would be shorter. If this continued, the water would eventually flood the containers and there would be release of radioactivity into the water. However, this water would essentially be stagnant and releases of radioactivity from the site would be slow. *In summary*, the most likely consequence of various accidents at other facilities on the Bruce site is that they would result in the DGR stopping its construction or operation activities, and going into a shutdown mode.

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LPSC-01-42	▪ C1NFR 5(f)	***Information Request:*** *Provide information on the process by which information from the analysis of initiating events and accidents is being carried into the detailed design process, training, and procedural development.* ***Context:*** *PSR 7.5 discusses initiating events involving human error in design, training, and procedures and assesses potential effects. These events can be minimized through appropriate mechanisms that ensuring information is provided to the correct processes.* *It is unclear what mechanisms will be used to ensure the minimization of human error in initiating events. This information will facilitate CNSC staff's assessment of the integration of human factors considerations in the project.*
		OPG Response: The initiating events identified as part of the Preliminary Safety Report (PSR) were assessed during the Human Factors (HF) Operating Experience (OPEX) and Lessons Learned Review, and the HF Task Analysis and Design Reviews (through the use of a Human Factors Verification Checklist) to evaluate the impact of human error. As a result of these reviews, human factors recommendations were provided for consideration in future design activities as per the Human Factors Engineering Program Plan. There will be detailed procedures and training developed for operations staff which will include standard human performance error prevention tools and standards. In addition there will be emergency procedures developed for accidents. These procedures and training will be developed as part of hand-over preparation and more detail will be provided as part of the Operating Licence application.
LPSC-01-43	▪ GNSCR 3(1)(i)	***Information Request:*** *For the operational period, provide additional information supporting either the application of the Nuclear Waste Management Division's existing fire protection program and hazard assessment or the development of a DGR specific fire protection program and fire hazard assessment.* ***Context:*** *It is stated in PSR 6.8.1 that "The design and operation of the DGR Facility is such that the risk of a fire occurring is minimized. Features of the DGR that lower the risk of fires include:* *Independent third party review of the fire protection design;*

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		Implementation of the Nuclear Waste Management Division (NWMD) Fire Protection Program (refer to Chapter 10) and fire hazard analysis;" *CNSC staff requires the development of the Fire Protection Program and a Fire Hazard Analysis (FHA) based on the consideration of National Fire Protection Association (NFPA) 122 and NFPA 801. There is no information provided to indicate why the NWMD fire protection program developed for OPG's operating, surface based, waste management facilities would be applicable to an operating DGR facility as the DGR has both a surface and deep underground component.* *Therefore, additional information is required supporting the application of the existing program and hazard assessment or identifying the development of a DGR specific FHA and fire protection program for the operational period.*
		OPG Response: The Fire Protection (FP) Program for the operational phase of the DGR will be developed similarly to the FP Program for the site preparation and construction, as described in the response to IR-LPSC-01-36. To reiterate, the operational FP Program will be specific to the DGR, due to the unique fire protection requirements associated with the facility, and will include a Fire Hazard Analysis based on the guidance of NFPA 122 and 801.
LPSC-01-44	▪ GNSCR 3(1)(e) ▪ RPR 4	***Information Request:*** *With respect to the Radiation Protection Program, the proponent is requested to clarify how individual doses are also kept ALARA.* ***Context:*** *PSR section 10.1 states "The Radiation Protection Program will achieve and maintain high standards of radiation protection including the achievement of the objectives listed below.* *a) Control occupational and public exposure by:* ▪ *Keeping individual doses below regulatory limits;* ▪ *Avoiding unplanned exposures;* ▪ *Keeping individual risk from lifetime radiation exposure to an acceptable level; and* ▪ *Keeping collective doses ALARA, social and economic factors taken into account."* *There was no indication that individual doses will be kept ALARA once the DGR facility begins operation. Clarification is required to understand how this will be achieved.*

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		OPG Response: The Preliminary Safety Report, including the Preliminary ALARA Assessment (SENES 2011), provides information on worker doses. The results show the general feasibility of the DGR design with respect to meeting CNSC individual worker dose limits. The detailed design will include ALARA considerations with respect to the shielding design, monitoring and package handling. During DGR operations, OPG’s ALARA practice at the Western Waste Management Facility (WWMF) will be followed. At WWMF, senior management is committed to the effective management of occupational dose, including the establishment of processes to estimate collective dose for general operations and maintenance, effective ongoing monitoring, and dose targets Individual worker dose is further controlled through establishment of an adherence to dose limits for workers and jobs based on industry best practice: • No dose shall be received unless there is a benefit; • All modifications and processes are assessed for dose impact on workers; • Hazards are identified, risk is evaluated, and control measures are established; • Work is planned, and execution is overseen; and • Worker dose is monitored and controlled. Part of ensuring ALARA is the setting of Exposure Control Levels (ECLs) and Administrative Dose Limits (ADLs) below the regulatory dose limits, according to OPG procedure N-PROC-RA-0019 (Dose Limits and Exposure Control). ECLs are set lower than ADLs; this ensures that if ECLs are exceeded, employees and supervisors can use dose control measures to ensure the ADLs are not exceeded. Workers will have personal alarming dosimeters as well as thermoluminescent dosimeter (TLD) badges when performing radioactive work. Further information will be provided in the Final ALARA Assessment that will be prepared as part of the DGR Operating Licence application. **References:** OPG Procedure. Dose Limits and Exposure Control, N-PROC-RA-0019. SENES. 2011. Preliminary ALARA Assessment. SENES Consultants Ltd. report for the Nuclear Waste Management Organization NWMO DGR-TR-2011-36 R000. Toronto, Canada.

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<tr><td rowspan="2">LPSC-01-45</td><td rowspan="2">▪ GNSCR 3(1)(b)</td><td>Information Request:
Clarification is required on emergency response and preparedness arrangements for the construction phase. Information on the arrangement(s) should address:
▪ the scope of the services;
▪ the roles and responsibilities of each of the parties as it pertains to the planning, preparedness and response capabilities, including the use of drills and exercises to demonstrate how the response teams will work together under emergency conditions;
▪ the provision and maintenance of emergency response equipment at the DGR, emergency communications systems/equipment;
▪ how command and control will be maintained between organizations during emergencies.; and
▪ in the event of an emergency or simultaneous emergencies involving the DGR and Bruce facilities, the contingency plans, including the need to curtail activities at either the DGR and Bruce facilities.
Information on any mutual aid arrangement with a back-up off-site mine rescue team(s) during the construction phase should also be provided.
Context:
The PSR (9.3.1) states, for the construction phase, that "services provided by the project will include … emergency response and mine rescue (mine rescue supported by the contractor)." Text elsewhere in the PSR, for example PSR 6.8, refers to arrangements with Bruce Power for emergency response during the operational period, but is silent on the construction phase. PSR 9.4.9.1 references the Health and Safety Management Plan which is described in the Design and Construction Phase Management System as including the site emergency plan but no detail is provided.
It is unclear what emergency response services will be provided by Bruce Power in the construction phase and what will be provided by OPG/NWMO and other contractors. Mine rescue plans and the arrangement for additional response teams are not described in detail. Fire response plans refer to existing response arrangements with the Western Waste Management Facility but provides no description of that service.
Additional information is needed to assess emergency response and preparedness planning emergency events during the period of site preparation and construction.</td></tr>
<tr><td>OPG Response:
The DGR project's emergency response and preparedness arrangements for the construction phase will have several contributors, each with specific roles and responsibilities. As NWMO will be in the role of Constructor</td></tr>
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		(under Ontario's Occupational Health and Safety Act), it will be their responsibility to ensure these requirements are in-place and adequate for the work. There will be contributions to this effort from OPG, Bruce Power and the various contractors supporting the construction activities. The project emergency response plan describes how the project will deal with emergencies during the construction phase. It addresses surface, underground and off-site emergencies. All staff, contractors and visitors are required to review and acknowledge the emergency response plan and associated procedures as is required of NWMO's DGR site orientation process. This process was in force when the NWMO acted as Constructor for recent site investigation activities conducted at the DGR project site. The plan details the processes to follow in the event of an emergency. The emergency may be related to Health and Safety, equipment or material damage, environmental incidents or off–site influences. Off-site emergencies include radiation emergencies, weather, road closures, fire etc. Emergency preparedness planning is conducted in conjunction with contractors, OPG and Bruce Power. The project will have trained first aid responders, both staff and contractors, for front-line medical incidents. Depending on the severity of the incident, Bruce Power's emergency response team (ERT) will be contacted to respond. As per the OPG-Bruce Power site services agreement, Bruce Power's ERT services are extended to the DGR project site to provide medical and fire response support. Bruce Power's ERT group is integrated into the site's communication protocols for notifications of incidents from the site, as well as, potential influences of Bruce Power on the site (e.g., radiation emergency). The project health and safety organization will be responsible to maintain the emergency response and communication equipment specified for the site, including contractor supplied equipment. This will include routine inspections and testing of equipment and maintaining records of such inspection. The site emergency response requirements will be modified through the project phases to reflect the nature of the work being performed and the parties involved. The emergency response system will be tested annually. Ontario Mine Rescue response practices will be used for the underground emergency response at the DGR project. The configuration of the mine rescue teams will be further defined for the project as the contractors are engaged to provide services. As is the practice in Ontario, mutual aid agreements with local mining operations supporting Ontario Mine Rescue will be established closer to the start of construction. Contingency plans have yet to be developed for the project to reflect the potential for simultaneous emergencies and expected response. Selected contractor capabilities could have an effect on the requirements of external support. This area will require future consideration and will be reflected in the DGR Emergency Response Plan as appropriate.

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LPSC-01-46	▪ C1NFR 3(k)	***Information Request:*** *Clarify whether table 8.1 of the preliminary decommissioning plan includes the hazardous materials that may be present in the DGR at the end of operations. If not, provide information on the type, quantity/volume and form of these other hazardous materials. Also clarify the application of the information in tables 8.1 and 8.2 to the decommissioning of the DGR after construction.* ***Context:*** *PSR 13.11 describes general differences in the decommissioning planning at the end of construction from the planning at the end of operation for the DGR. Appendix B in the Preliminary Decommissioning Plan (PDP), provides some additional detail and identifies waste sections 8.2 and 8.3 of the facility plan as describing the avenues for the disposal of decommissioning waste should decommissioning occur at the end of construction. Section 8.2 of the PDP states “at the time of shut down any surplus hazardous materials will be removed from the facility for disposal at a licensed hazardous waste management facility.”* *It is not clear if the hazardous materials identified in table 8.1 of section 8.2 as “arising for the decommissioning” includes the surplus hazardous materials noted in the quote above (i.e. present in the DGR but not generated by decommissioning activities). The text in B.5 of Appendix B is also silent on whether tables 8.1 and 8.2 apply for decommissioning the DGR at the end of construction.*
		OPG Response: Tables 8.1 and 8.2 in the Preliminary Decommissioning Plan (PDP) include the waste materials arising from decommissioning the DGR as described below. Table 8.1 estimates waste materials that would be generated on a yearly basis as a result of using large equipment to remove facility materials, equipment and systems, as well as to demolish surface facilities. Therefore, this information is not intended to represent an “after construction or operation” estimate since this waste would only be generated as a result of the decommissioning. The decommissioning schedule in Appendix B of the PDP is much shorter than the operations schedule presented in Figure 5.1 of the PDP. Therefore, the total amount of waste generated during the 1½ years of decommissioning in this instance would be significantly lower. To clarify “hazardous materials that may be present in the DGR at the end of operations”, the PDP further describes this in Section 8.3 as fluids (e.g., fuel, lubricants, hydraulic fluids, etc.) and batteries needed for the underground mobile equipment. This equipment will only be needed to support waste placement activities and the materials needed to operate this equipment would only be present in small quantities in the repository. It was highlighted in the discussion since there is a possibility that this equipment could be contaminated at the

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		end of operations. However, the range estimated for materials presented in Table 8.1 are sufficient to cover the materials needed to operate this equipment and to acknowledge that small quantities could be in the repository at the end of operations. It should be noted that Section 8.2 of the PDP also states that "At the time of shutdown any surplus hazardous materials will be removed from the facility for disposal at a licensed hazardous waste management facility". This is reference assumption. The volumes and types of hazardous wastes anticipated to be generated during operations are given in Section 4.8.5.2 of the Environmental Impact Statement. At the end of construction, the mobile equipment and other materials noted above will not be in the facility. Therefore, this statement does not apply to decommissioning following construction. It is also worth noting that the PDP assumes that the waste management program to support construction activities is adequate to manage all the wastes, such as those identified in Table 8.1, arising from this licensed activity. In contrast, Table 8.2 includes estimates for DGR Facility materials that will be removed as part of the decommissioning, the bulk of which will be generated from decommissioning the ventilation and main shaft headframes. These materials would more closely represent "after construction" details. However, the current plan does not anticipate the need to remove shaft internals, concrete liners or the surrounding rock (HDZ) for decommissioning "after construction". To clarify, the "after construction" version of PDP Table 8.2 includes the information in Table 1.

Table 1: Waste Materials Arising from Decommissioning following Construction

Structure	Material Type	Quantity
Ventilation shaft headframe	Steel	520 tonnes
	Concrete	260 m^3
Main shaft headframe and WPRB	Steel	380 tonnes
	Concrete	8,700 m^3
Other items such as miscellaneous cabling, panels, and other equipment		

Note: Volumes (in m^3) of material are bulked volumes.

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LPSC-01-47	▪ C1NFR 3(k)	***Information Request:*** *Provide clarification on the decommissioning activities associated with the decommissioning of the DGR following construction. Provide information on the conditions that may require mitigation if decommissioned after construction. Information should also be provided on what effect the possible mitigation (worst case scenarios) would have on the cost of decommissioning provided in the Preliminary Decommissioning Plan for the end of construction.*

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		Context: *The PSR and Appendix B of the Preliminary Decommissioning Plan indicates that the decommissioning process will be similar to that proposed for the DGR at the end of operation, with the exception of the installation of the concrete monolith and shaft seal system. It is not clear from the information presented if the shaft liners will be left in the shafts or what mitigation is needed to address issues of surface subsidence associated with the collapse of the open shafts and the possibility of saline groundwater from the Salina A1 and Guelph formations impacting the potable groundwater.* *Worst case scenarios need to be identified as they require consideration when developing cost estimates for a reasonably conservative financial guarantee. It is uncertain whether the costs identified for decommissioning at the end of construction (Appendix B) reflect consideration of the worst case scenarios.*
		OPG Response: Decommissioning following construction is a simplified version of decommissioning following operations. Some of the notable differences are the following exclusions, which are not performed for decommissioning "following construction": • Construction of the concrete monolith; • Removal of shaft internals, shaft liners and surrounding rock (HDZ); and • Installation of the shaft seal system. It is expected that decommissioning activities will be completed as follows: <u>Preparing for Decommissioning</u> Similar to the Preliminary Decommissioning Plan (PDP), Section 5.3, the site and facility will be prepared for decommissioning by removing materials from the underground repository, if required. <u>Decommissioning of the Ventilation and Main Shafts</u> Decommissioning of the ventilation and main shafts includes the removal of the shaft hoists (and replacement with a temporary stage hoist). As noted above, decommissioning of the shafts following construction excludes the removal of the shaft internals, shaft concrete liners and the installation of the shaft seal system. As indicated in the PDP, Section B1, the basis for decommissioning the shafts following construction is Ontario Regulation 240, Mine Development and Closure. The PDP, Section 5.4.3.6 indicates that a concrete cap will be constructed through staged pours to meet the requirements of this regulation. Because the shaft liners are not planned to be removed, and because the upper 180 metres, as well as permeable units such as the Salina

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		A1 and Guelph formations, will be grouted prior to (or during) shaft construction, any impact on the upper ground water from the lower permeable saline formations will be minimized. <u>Decommissioning Surface Facilities</u> Similar to the PDP, Section 5.4.6, the surface facilities will be decommissioned as outlined in this section. <u>Waste Rock Management Area and Site Restoration</u> Similar to the PDP, Sections 5.4.7 and 5.5, the waste rock management area will be covered and the site will be restored. <u>Cost Estimate for Decommissioning following Construction</u> The activities described above form the basis for the cost estimate presented in the PDP, Appendix B for decommissioning following construction. A conservative cost estimate was developed consistent with G-219 on Decommissioning Planning for Licensed Activities and CSA N294 on Decommissioning of Facilities Containing Nuclear Substances, including a contingency allowance.

FIGURE ASSOCIATED WITH RESPONSES TO LPSC IRs

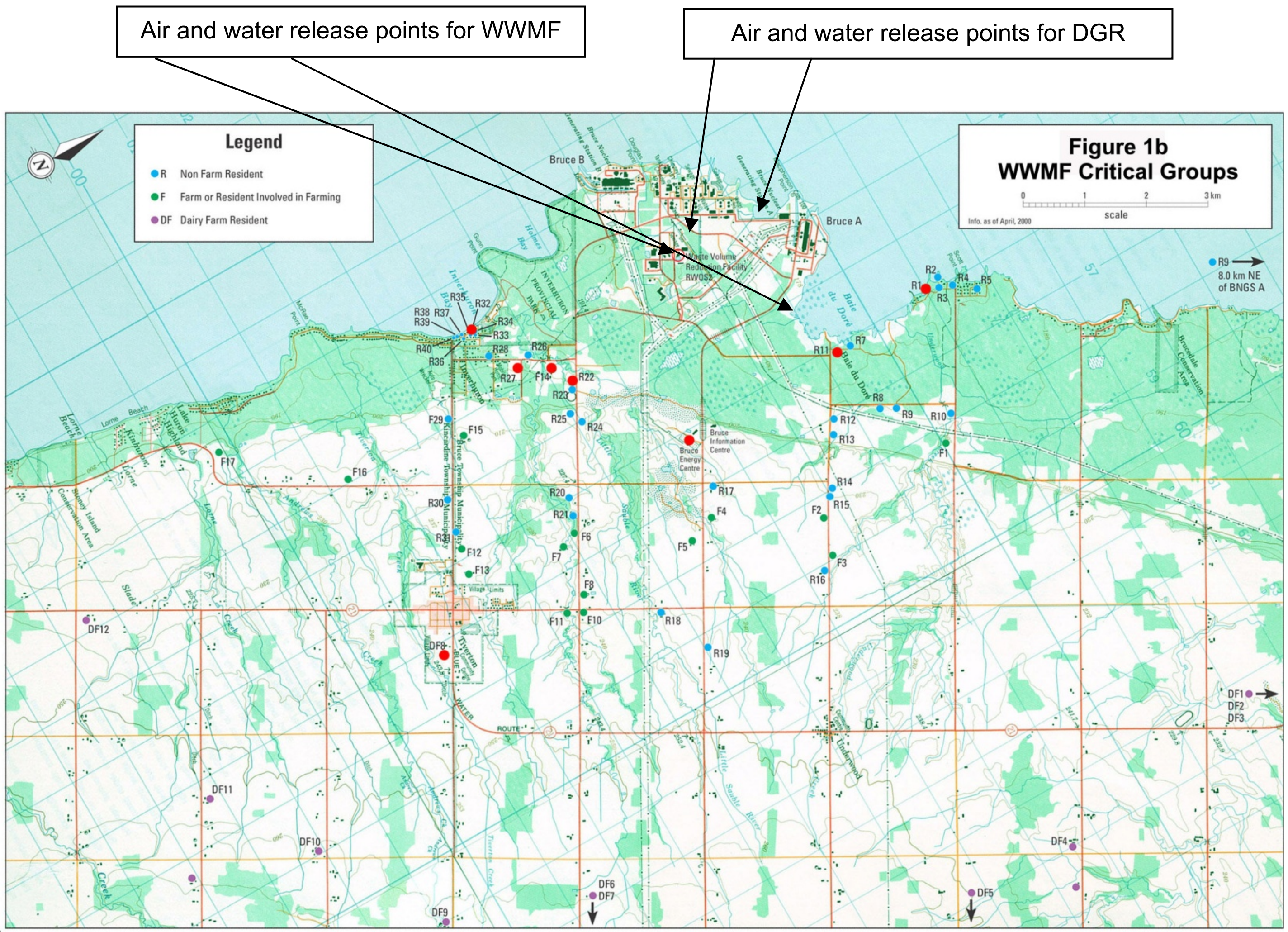

Figure 1 (associated with IR-LPSC-01-40). This figure from the 2003 WWMF DRL report shows the locations of various receptors around the Bruce nuclear site, and the receptors specifically evaluated as part of the 2003 WWMF DRL. The location of the release points used for the WWMF calculations are shown, as well as the locations of the DGR release points.