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March 6, 2017

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Canadian Environmental Assessment Agency

Sent via email: CEAA.DGR.Project-Projet.DGR.ACEE@ceaa-acee.gc.ca

Subject: Technical Review of Ontario Power Generation's Response to the Request for Additional Information for the Deep Geologic Repository for Low and Intermediate Level Radioactive Waste Project

On January 18, 2017, Natural Resources Canada (NRCan) received a request from the Canadian Environmental Assessment Agency (CEA Agency) to make available the department's specialist or expert knowledge to enable the technical review of Ontario Power Generation's (OPG) response to the Minister of Environment and Climate Change for additional information relating to the Deep Geologic Repository for Low and Intermediate Level Radioactive Waste.

NRCan's has reviewed of this project as it relates to technical information that falls within our departmental mandate, including

- Groundwater and hydrogeology; and
- Seismicity and seismic hazards.

Our review did not consider OPG's assessment of the economic feasibility of alternate locations, as the department does not possess such expertise.

Within the scope of NRCan's review, NRCan agrees with OPG's analysis and conclusions related to the significance of environmental effects, and believes that OPG has used a rational and transparent approach to justify its preference for a DGR at the Bruce site. At this time, NRCan has no Information Requests for the Agency's consideration, however full technical comments with some additional considerations from NRCan's reviewers are attached.

In addition, NRCan notes that should additional information related to the acid generating potential for the sedimentary and crystalline alternate geologic formations become available during the review of OPG's submission, NRCan possess expert knowledge that could inform the review.

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If you have any questions or require clarification on our comments please feel free to contact me at <contact information removed>

Sincerely,

<Original signed by>

John Clarke
Director for Environmental Assessment
Office of the Chief Scientist

Attachments (1): Natural Resources Canada (NRCan) Comments on the Ontario Power Generation Proposed Deep Geological Repository for Low- and Intermediate Level Radioactive Waste: OPG Response to Information Requests from the Minister of Environment and Climate Change

Natural Resources Canada (NRCan) Comments on the Ontario Power Generation Proposed Deep Geological Repository for Low- and Intermediate Level Radioactive Waste: OPG Response to Information Requests from the Minister of Environment and Climate Change

March 6, 2016

Groundwater Review

Scope of Review

The purpose of this review is to assess the extent to which OPG's response of December 2016 addresses requests from the Minister of Environment and Climate Change in her letter of February 2016 for supplementary studies on alternate locations for the DGR project, cumulative effects assessment, and mitigation commitments. The scope of this review is limited to issues concerning groundwater flow and radionuclide transport discussed in the supporting technical documents attached to the OPG response letter of December 28th, 2016.Within the scope of this review, the following documents have been considered:

- Letter from The Honourable Catherine McKenna, Minister of Environment and Climate Change, to Laurie Swami, Vice-President of Nuclear Services, Ontario Power Generation, dated February 18th, 2016.
- Letter from Lise Morton, Vice-President of Nuclear Waste Management, Ontario Power Generation, to Heather Smith, Vice-President of Operations, Canadian Environmental Assessment Agency, dated December 28th, 2016, with reports in attachment.
- Letter from Lise Morton, Vice-President of Nuclear Waste Management, Ontario Power Generation, to Heather Smith, Vice-President of Operations, Canadian Environmental Assessment Agency, dated January 13th, 2017, with mitigation cross-reference table and errata.
- OPG's Deep Geological Repository Project – Study of Alternate Locations – Main Submission, December 2016. 00216-REP-07701-00013.
- OPG's Deep Geological Repository Project – Description of Alternate Locations, December 2016. 00216-REP-07701-00014.
- OPG's Deep Geological Repository Project – Environmental Effects of Alternate Locations, Golder, December 2016. 00216-REP-07701-00015.
- OPG's Deep Geological Repository Project – Updated Analysis of Cumulative Environmental Effects, Golder, December 2016. 00216-REP-07701-00018.
- OPG's Deep Geological Repository Project – Adaptive Phased Management Deep Geological Repository Preliminary Description, NWMO, December 2016. 00216-REP-07701-00017
- OPG's Deep Geological Repository Project – Mitigations Measures Report, December 2016. 00216-REP-07701-00019

Alternate Locations for the Project

The first request from the Minister concerns the need for a study of alternate "means" or, in this case, alternate locations for carrying out the DGR project:

a) *"A study that details the environmental effects of technically and economically feasible alternate locations for the Project, with specific reference to actual locations that would meet Ontario Power Generation's criteria for technical and economic feasibility. In conducting this study, Ontario Power Generation is to detail the thresholds for what is considered to be technically and economically feasible. In addition, Ontario Power Generation is to indicate what the incremental costs and risks would be for additional off-site transportation of the nuclear waste."*

OPG's response to this request consists of four documents including a main submission and three supporting technical reports. NRCan's groundwater expert has reviewed the main submission and technical reports containing descriptions of the alternate sites and analyses of environmental effects at the alternate sites. The fourth report is concerned with cost and risk estimates related to transportation of waste to alternate locations, and is not within the scope of this review.

The "Description of Alternate Locations" report sets out OPG's criteria for technical and economic feasibility of alternate DGR locations along with their respective thresholds. The two technical feasibility criteria identified by OPG are:

1. Is the host rock geologically stable and resistant to expected geological and climate change processes? Host rocks that have been stable for much more than a million years (life span of intermediate level waste) meet this criterion.
2. Is the depth and thickness of competent rock sufficient to host and enclose a DGR? A minimum depth of 200 m is required so that the DGR is below any potable aquifer system, and a minimum thickness of 300 m is required in order to ensure at least a 100 m layer of rock above and below the repository horizon.

While not very restrictive, these criteria and thresholds are appropriate for the requested screening-level analysis of alternate means for an alternate DGR location. Based on these criteria and thresholds, OPG has identified two suitable alternate locations to the proposed Bruce DGR site. The first location would be in crystalline bedrock of the Canadian Shield while the second would be in sedimentary rocks of the Michigan or Appalachian Basins of Southern Ontario.

From a hydrogeological perspective, the most important feature of a crystalline bedrock DGR location is the likely presence of permeable fractures which decrease in frequency with depth. This requires a greater level of site characterization compared to a location in sedimentary rocks such as the proposed Bruce DGR. Also, because of the mobility of radioactive carbon-14 (from CANDU intermediate level waste) in groundwater and in methane, there would be a greater need for engineered barriers to radionuclide migration. According to OPG, a DGR design for a crystalline rock location could be developed to meet regulatory standards; however, the safety margin would be lower than at the proposed Bruce site. In NRCan's opinion, OPG has given a fair description of expected hydrogeological characteristics at a crystalline rock DGR location and their implications for design development.

From a hydrogeological perspective, the characteristics of an alternate sedimentary rock location in southern Ontario would be very similar to those of the proposed Bruce DGR. Although not mentioned in the report, a concern with a sedimentary location further south of the Bruce site would be the greater resource potential (e.g. rock salt, hydrocarbons) and the corresponding increased risk of human intrusion. A related concern is the possible presence of large numbers of historic uncharted and abandoned oil and gas wells in the region which could adversely affect radionuclide containment. These considerations also tend to favour the proposed Bruce DGR location over another sedimentary location in southern Ontario.

The "Environmental Effects" report assesses the environmental effects of the sedimentary and crystalline alternate locations to the Bruce DGR site. This assessment is achieved by first identifying potential interactions between each alternate location and the Valued Ecosystem Components (VECs) representing its environment, and then describing the potential effects where an interaction is identified. For each VEC, OPG provides the following information:

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

Finally, for each VEC, the potential effects on the environment for the alternate DGR locations are compared to those predicted for the Bruce DGR project. Within the scope of this review, the Geology and Hydrogeology VECs (soil quality, groundwater quality, and groundwater flow) are the most relevant although, for the crystalline location, the Radiation and Radioactivity VECs are also relevant.

For a sedimentary rock alternate location, potential interactions between the DGR and Geology and Hydrogeology VECs are identified in Table 4.5-1 and potential effects are discussed. A comparison between potential effects and mitigation measures for the sedimentary alternate location and the Bruce DGR site is presented in Table 4.5-2. OPG concludes that effects of the alternate location on the Geology and Hydrogeology VECs would be very similar to those for the Bruce site and would not result in any residual adverse environmental effects.

For a crystalline rock alternate location, potential interactions between the DGR and Geology and Hydrogeology VECs are the same as those identified for a sedimentary alternate location. However, environmental effects for these VECs derive mainly from the fractured nature of the bedrock and the existence of active groundwater flow in localized fractures, mainly in the shallow subsurface. According to OPG, despite their obvious geological differences, the crystalline location and the Bruce site are similar in that the shallow and intermediate bedrock zones are expected to be the most permeable while the deep bedrock zones are expected to have very low permeability and diffusion dominated radionuclide transport. A comparison between potential effects and mitigation measures for the crystalline alternate location and the Bruce DGR site is presented in Table 5.5-1. OPG concludes that effects of the alternate location on the Geology and Hydrogeology VECs would be very similar to those at the Bruce site and would not result in any residual adverse environmental effects. However, additional groundwater flow mitigation measures in the form of engineered barriers may be required for the crystalline location, particularly during the shaft construction phase.

Potential interactions between the DGR and the Radiation and Radioactivity VECs are believed to be similar to those identified at the sedimentary alternate location. Potential environmental effects are somewhat different, however, due to the fractured, and possibly more permeable, nature of crystalline bedrock. OPG considers that additional engineered barriers may be required to contain radioactive carbon-14 released from intermediate level waste. Because of higher uranium concentrations in granitic rocks, natural background levels of radon may be higher as well and this may require mitigation to ensure worker protection. OPG concludes that overall residual effects of the project on the Radiation and Radioactivity VECs for a crystalline rock DGR would be similar to those at the Bruce DGR (Table 5.6-1). However, more extensive mitigation measures may be required to prevent radionuclide migration as a result of the more fractured nature of bedrock at a crystalline location. In OPG's opinion, the margin of safety for a crystalline alternate location would be inherently lower than that of a DGR at the Bruce site if the crystalline rock is indeed more permeable.

The main submission document provides background on the Bruce DGR project, the Federal Review process, Panel conclusions, and context related to the Minister's request for a study of alternate locations. The document summarizes study methodologies and findings detailed in the supporting technical reports. This includes a description of the criteria used to determine technically and economically feasible alternative locations, a description for an "alternate location" DGR project highlighting differences and similarities with the Bruce project, and descriptions of the alternate locations themselves. The environmental effects of the alternate DGR locations are summarized in Section 5.5 (Table 5-2). OPG concludes that a DGR could be constructed at either of the alternate locations without any likely significant adverse environmental effects. OPG also concludes that some environmental effects are likely to be greater at both the sedimentary and crystalline locations as compared to those at the Bruce site. OPG lists a number of VECs for which environmental effects would be greater. However, none of these VECs fall within the scope of this review. From a strictly geoscience perspective, OPG considers that both alternate DGR locations would be as good as the Bruce site in terms of environmental effects but that the crystalline location would require more mitigation measures related to controlling groundwater flow and radionuclide transport in fractures. OPG's overall conclusion is that there would be more environmental effects related to a DGR at either alternate location and that the Bruce site remains the preferred location for a DGR for these and other reasons related to costs and waste transportation risks (p.86).

Within the scope of this groundwater review, it is NRCan's opinion that OPG has satisfactorily addressed the Minister's request for an analysis of alternate DGR locations. The methodology adopted by OPG for determining alternate locations is reasonable for such a high-level exercise. The characterizations of the environment at the two locations were adequate. The methodology for identifying and assessing environmental effects for different VECs at the two alternate locations is appropriate for this type of study. NRCan agrees with OPG's analysis and conclusions related to significance of environmental effects within the scope of this review, and believe that OPG has used a rational and transparent approach to justify its preference for a DGR at the Bruce site. NRcan has no requests for information related to this response to the Minister.

Updated Analysis of Cumulative Effects

Phase 1 Preliminary Assessments of NWMO's Adaptive Phased Management program for a used nuclear fuel DGR identified potential host communities in the Township of Huron-Kinloss, the municipality of South Bruce, and the municipality of Central Huron. Given that these sites are in proximity of the proposed Bruce DGR and within the territory of the Saugeen Ojibway Nation, the Minister's second request concerns the need for an updated cumulative effects analysis for the Bruce DGR:

b) "An updated analysis of the cumulative environmental effects of the Project in light of the results from Phase 1 Preliminary Assessments undertaken by the Nuclear Waste Management Organization, which identified three potential host communities that fall within the traditional territory of the Saugeen Ojibway Nation."

OPG's response to this request consists of two technical documents. The Adaptive Phased Management (APM) Deep Geological Repository (DGR) Preliminary Description report presents a conceptual-level hypothetical DGR for spent nuclear fuel located at one of the three potential host communities near the Bruce site and hosted in sedimentary bedrock. The report describes the physical components of the DGR, project phases and activities, emissions, discharges and wastes, the physical and biological setting, potential mitigation measures at different phases of the project, and the effects on Aboriginal Peoples. In NRCan's opinion, the level of detail provided is adequate for the purpose of assessing potential interactions between the project and the groundwater environment.

The second technical document presents the updated cumulative effects assessment for the Bruce DGR. The assessment considers residual effects identified for each VEC and the potential for effects of past, present, and reasonably foreseeable projects to affect the same VECs. The report first describes residual effects of the DGR Project at the Bruce Nuclear Site for the different VECs. Residual adverse effects from the Bruce DGR project are summarized in Table 3-1. They concern the following VECs: Surface water quantity and flow; Eastern white cedar; Aquatic environment components including fish; Air quality; Noise levels; Social assets; Human health; Radiation and radioactivity. Table 3-2 lists the VECs for which no adverse residual effects of the Bruce DGR project are identified. The updated assessment of potential cumulative effects is, however, limited to only those VECs having adverse residual effects from the Bruce DGR project. The VECs not considered further include all those directly related to geology and hydrogeology. The report then describes potential adverse effects stemming from the APM DGR in one of nearby host communities. When effects of the two projects overlap in time or in space, there is potential for cumulative effects. These effects are identified and assessed along with mitigation measures.

The report identifies potential for cumulative adverse effects for Radiation and Radioactivity VECs related to deep groundwater systems (section 5.8.3, p.34): Radionuclide diffusion from the two repositories could eventually reach more active groundwater systems in the Cambrian sandstone and Guelph Formation which are connected across the entire region. However, the report concludes that any cumulative adverse effect related to post-closure migration of radionuclides in deep groundwater systems would be very unlikely. This conclusion is based on analyses conducted previously by the Proponent in response to NRCan information request IR-EIS-08-397.

Within the scope of this review, NRCan agrees with OPG that there is no potential for likely cumulative adverse effects stemming from the Bruce DGR and an APM DGR for used nuclear fuel sited in one of the nearby possible host communities. Nonetheless, NRCan recommends monitoring of groundwater quality and radionuclide transport in the Cambrian sandstone and Guelph Formation as a prudent follow-up measure (See below).

Mitigation and Monitoring Commitments

The third request from the Minister concerns the need for an updated and consolidated list of mitigation and monitoring commitments made by OPG:

c) "An updated list of mitigation commitments for each identified adverse effect under CEAA 2012. Ontario Power Generation shall identify out-dated or redundant commitments that were previously brought forward to the Panel."

The report prepared in response to this request provides an updated list of mitigation and monitoring commitments for each identified adverse effect for the DGR project at the Bruce Nuclear site. The lists are grouped according to Environmental Component and sub-divided according to Valued Component (VC).

Mitigation and monitoring commitments within the scope of this review are associated with the "Geology" Environmental Component. They are summarized in Table 3-1 and described in detail in Table A-1 of Appendix A. Valued Components under "Geology" are overburden groundwater quality and groundwater transport, shallow bedrock groundwater quality and shallow bedrock solute transport, intermediate bedrock water quality and solute transport, and deep bedrock water quality and solute transport. In NRCan's opinion, the proposed mitigation measures related to these VCs are appropriate and comprehensive. Proposed monitoring programs to confirm predictions of the DGR Geosynthesis Program (MON-G-04; MON-G-05; MON-G-08) are appropriate and complete. Monitoring to be conducted as part of the proposed Geoscientific Verification Plan is captured under commitments MON-G-09 and MON-G-10. Monitoring and follow-up investigations related to the groundwater tritium plume emanating from the Western Waste Management Facility are captured under commitments MON-R-04 and MON-R-05. These two commitments are also captured under the "Radiation and Radioactivity" Environmental Component in Tables 3-5 and A-5.

Based on the concordance between OPG commitments and the Agency's (CEAA) draft conditions (OPG letter of January 13th, 2017), in the report, NRCan suggests that:

- Mitigation commitment MIT-H-08 should be cross-referenced with CEAA 11.5
- Monitoring commitment MON-G-02 should be cross-referenced with CEAA 9.6, 11.4, and 11.5
- Monitoring commitment MON-G-03 should be cross-referenced with CEAA 9.6
- Monitoring commitment MON-G-04 should be cross-referenced with CEAA 11.4
- Monitoring commitment MON-G-05 should be cross-referenced with CEAA 11.5
- Monitoring commitment MON-G-07 should be cross-referenced with CEAA 11.4 and 11.5

NRCan recommends that commitment MON-G-08 concerning the monitoring of groundwater quality and solute transport in the intermediate and deep bedrock zones be included in the Canadian Environmental Assessment Agency's conditions for recommendation to the Minister of Environment and Climate Change for inclusion in a Decision Statement. A condition should specifically stipulate that monitoring of groundwater quality and solute transport should include the deeper permeable units at the DGR site: Salina A1 carbonate, Guelph Formation, and Cambrian sandstone. This monitoring is important, particularly for assessing cumulative effects should an APM DGR ever be constructed in the region.

Seismic Review

Scope of Review

The purpose of this review is to assess the extent to which OPG's response of December 2016 addresses requests from the Minister in her letter of February 2016 for supplementary studies on alternate locations for the DGR project, cumulative effects assessment, and mitigation commitments. The scope of this review is limited to seismic issues discussed in the supporting technical documents attached to the OPG response letter of December 28th, 2016.Within the scope of this review, the following documents have been considered:

- Letter from The Honourable Catherine McKenna, Minister of Environment and Climate Change, to Laurie Swami, Vice-President of Nuclear Services, Ontario Power Generation, dated February 18th, 2016.
- Letter from Lise Morton, Vice-President of Nuclear Waste Management, Ontario Power Generation, to Heather Smith, Vice-President of Operations, Canadian Environmental Assessment Agency, dated December 28th, 2016, with reports in attachment.
- Letter from Lise Morton, Vice-President of Nuclear Waste Management, Ontario Power Generation, to Heather Smith, Vice-President of Operations, Canadian Environmental Assessment Agency, dated January 13th, 2017, with mitigation cross-reference table and errata.
- OPG's Deep Geological Repository Project – Study of Alternate Locations – Main Submission, December 2016. 00216-REP-07701-00013.
- OPG's Deep Geological Repository Project – Description of Alternate Locations, December 2016. 00216-REP-07701-00014.
- OPG's Deep Geological Repository Project – Environmental Effects of Alternate Locations, Golder, December 2016. 00216-REP-07701-00015.
- OPG's Deep Geological Repository Project – Updated Analysis of Cumulative Environmental Effects, Golder, December 2016. 00216-REP-07701-00018.
- OPG's Deep Geological Repository Project – Adaptive Phased Management Deep Geological Repository Preliminary Description, NWMO, December 2016. 00216-REP-07701-00017
- OPG's Deep Geological Repository Project – Mitigations Measures Report, December 2016. 00216-REP-07701-00019

OPG's Deep Geological Repository Project Study of Alternate Locations Main Submission

Technical and Economic Feasibility Criteria and Thresholds are presented in Table 2-1 of the Study of Alternate Locations Main Submission. NRCan advises that the proposed technical threshold would better read : *The rock has been stable for times that are long compared to the main hazard in the L&ILW, and has been resilient to past glacial and seismic events <u>for the past</u> 1 million years.*

Following on, it is insufficient for the Column specifying How the Alternate Locations satisfy the Criteria and Threshold to say only that the rock is older than 1 million years. It would be more appropriate to show that the rock has remained "substantially undisturbed" for at least 1 million years.

This criterion is certainly likely to be possible for a generic alternate site in either crystalline or sedimentary rock, including in the alternate locations presented in Figure 2-1, though the chances of doing so are higher in some parts of the shaded areas than in other parts. Specifically, the rate of earthquakes suggests that crystalline sites near the Quebec border and sedimentary sites near lakes Erie and Ontario might fail the criterion.

Section 4.1.1 presents the key environmental features of the Crystalline Alternate Location and states "The location has a low seismic hazard." Although correct for some parts, not all the shaded area of crystalline bedrock area in Figure 2-1 has equally low hazard. In particular the eastern part of the shaded area has high to moderate seismic hazard, and on those grounds the western part of Northern Ontario would be preferable.

Likewise, Section 4.2.1 outlines the key environmental features of the sedimentary alternate location and it is noted that "The alternate location is within an area of low seismic hazard." Although correct for some parts, not all the shaded area of sedimentary rock in Figure 2-1 has equally low hazard. In particular the southern and eastern part of the shaded area has moderate seismic hazard, and on those grounds the northern part of the shaded area would be preferable.

From a stability perspective, the most important way to satisfy the technical criterion is not the age of the rocks (which does impose a necessary minimum condition), but demonstrating their past stability. This is certainly likely to be possible for a generic alternate site in either crystalline or sedimentary rock, though the chances of doing so are higher in some parts of the shaded areas on Figure 2-1 than in other parts. Specifically, the rate of earthquakes suggests that it might be hard to qualify crystalline sites near the Quebec border, and sedimentary sites near lakes Erie and Ontario. These considerations also tend to favour the proposed Bruce DGR location over an alternative sedimentary location farther south in southern Ontario. Although the stability considerations would reduce the likely area available for locating a successful site, they do not preclude finding a technically feasible alternative site in either crystalline or sedimentary rock.

OPG's Deep Geological Repository Project: Description of Alternate Locations

As noted above, the approach that as long as the bedrock is older than 1 million years, the region is stable and therefore technically suitable as presented in Section 2.1 of Description of Alternate Locations should be reconsidered (see additional comments above).

Section 3.3 discusses the stability for the crystalline alternate location and notes, "This is within the North America interior cratonic region; which in general has a low seismic hazard." Although generally correct, not all the shaded area of crystalline bedrock in Figure 2-1 has equally low hazard. In particular the eastern part of the shaded area has high to moderate seismic hazard, and on those grounds the western part of Northern Ontario would be preferable.

Similarly, Section 4.3 discusses the stability for the sedimentary alternate location and states, "The sedimentary alternate location is in southwestern Ontario, and is within an area of low seismic hazard." Although generally correct, not all the shaded area of sedimentary rock in Figure 2-3 has equally low seismic hazard. In particular the southern and eastern part of the shaded area has moderate seismic hazard, and on those grounds the northern part of the shaded area would be preferable.

OPG's Deep Geological Repository Project – Mitigations Measures Report

MIT-P-02 indicates "All underground facilities (office, tunnel, emplacement room) will be constructed in accordance with the seismic requirements of the latest edition of the National Building Code at the time of the construction. [EA-142, IRC-LPSC-01.01, IRC-LPSC-01.02, IRC-LPSC-04.09] "

It should be noted that there are no specific seismic requirements in the National Building Code for underground facilities; however, the design levels contained in NBCC may be applied to the design of those facilities.

Within the scope of the seismic review, it is NRCan's opinion that OPG has satisfactorily addressed the Minister's request for an analysis of alternate DGR locations. The methodology adopted by OPG for determining alternate locations is reasonable for such a high-level exercise. The characterizations of the environment at the two locations were adequate. The methodology for identifying and assessing environmental effects for different VECs at the two alternate locations is appropriate for this type of study. NRCan agrees with OPG's analysis and conclusions related to the significance of environmental effects within the scope of its review, and believes that OPG has used a rational and transparent approach to justify its preference for a DGR at the Bruce site.