DGR JOINT REVIEW PANEL HEARING WRITTEN SUBMISSION IN SUPPORT OF AN ORAL INTERVENTION

Independent Review of Hydrogeological Issues Pertaining to the OPG Environmental Impact Statement for the Proposed Deep Geologic Repository Project

Prepared for:

The Canadian Environmental Law Association

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1) Introduction

I am a hydrogeologist and Professional Geoscientist, and I have worked as an environmental consultant for over 25 years (2 years for a major consulting firm in Germany, and 25+ years independently in Canada). I am a specialist in groundwater and surface water contamination issues, and have investigated many such issues over the course of my consulting career.

I have given testimony as an expert witness on hydrogeological issues before various boards, including the Canadian Nuclear Safety Commission, the Environmental Assessment Board, the Joint Board, the Ontario Municipal Board, the Ontario Environmental Review Tribunal, and the Niagara Escarpment Commission. A copy of my Curriculum Vitae is included in **Appendix 1** of this review.

I have been retained as an expert by the Canadian Environmental Law Association (CELA) to provide an independent review of the Environmental Impact Statement (EIS) for the proposed Deep Geologic Repository (DGR) Project. The DGR Project has been put forward by Ontario Power Generation (OPG), "the proponent" under the environment assessment process.

The focus of my review of the DGR proposal are the following:

- the overall merits of the proposal;
- the adequacy of the site investigation;
- potential groundwater quality impacts related to inorganic, organic, and radiological contaminants which may be associated with any aspect of the proposal; and
- potential surface water quality impacts related to inorganic, organic, and radiological contaminants which may be associated with any aspect of the proposal.

The adequacy of the EIS (from a hydrogeology perspective) can be measured by the degree to which the EIS provides:

- a comprehensive description of the local geology, hydrology and hydrogeology;
- a comprehensive assessment of potential water quality impacts at all stages of the project including site preparation and construction, DGR operation, closure, and the very long post-closure period;
- detailed proposals for mitigation of any foreseeable impacts;
- appropriate monitoring plans and realistic contingency plans.

In order to carry out this work, I have reviewed a series of documents and the most important of these are listed as references in **Appendix 2** of this review. I also toured the area of the proposed DGR Project on June 13, 2013, and discussed various aspects of the proposal with the proponent's representatives who were present on the day of the tour.

I was strongly assisted and advised during my work on the review of documents in relation to the DGR project and the preparation of this report by Dr. Chris Smart of the University of Western Ontario. Dr. Smart is an expert in the fields of karst hydrogeology and glacial erosion. I have experience and expertise in the field of karst hydrogeology (and have co-authored several papers with Dr. Smart on this topic), and those aspects of this report pertaining to karst and evaporite dissolution issues are based on a collaborative effort by Dr. Smart and myself.

We submitted (through CELA) a series of Information Requests (IRs) which were forwarded to the proponent. Due to problems with the IR process it was challenging to determine if many of our IRs were ever answered. The problems we encountered with the IR process and more generally with the environment assessment process are discussed in more detail in **Section 3** of this report.

This review outlines my findings, conclusions and recommendations regarding the EIS and the potential impacts of the proposed Deep Geologic Repository (DGR) Project.

2) Overview of the DGR Proposal

The DGR proposal consists of the following key aspects:

- the planned excavation (at 680 meters below the ground surface on the grounds of the Bruce Nuclear Plant) of a permanent, deep repository for Ontario's low- and intermediate-level radioactive wastes (L&ILW) in a DGR construction period of 5-7 years;
- the deposition of those radioactive wastes in the DGR, over an operational period which will last for decades;
- once the main and ventilation shaft are sealed, the entombment of the DGR beneath about 200 meters of thick and impermeable overlying shale bedrock;
- about 450 meters more of mainly carbonate and evaporite sedimentary rocks overlie the thick shales, and are in turn covered by a relatively thin layer of overburden;
- the proponent's proposed monitoring of the DGR facility is for about 300 years after closure, after which there is no intention to further monitor the facility; and
- the containment of radioactive wastes for hundreds of thousands of years.

I have carefully reviewed a number of Technical Support Documents (hereafter referred to as "TSDs") which describe various aspects of the investigation and impact assessment for the DGR site from the perspective of its impacts on the local groundwater and surface water flow systems.

Characterization of the proposed DGR site has been done through drilling of a total of 8 deep boreholes, with numerous tests done on the quality of the geological materials and the groundwater which were encountered in the boreholes. It should be noted that the possible benefits (in terms of improved site characterization) of further drilling are outweighed by the risks of overdrilling the site and potentially creating hydraulic connections from the surface to the DGR host formation.

The proposed DGR will be situated in low permeability and structurally sound shaley limestone formations, which will provide a suitable host formation for the DGR excavations. These shaley limestone host formations are overlain by very thick (200 meters) and even lower permeability shales, which provide the hydraulic containment of the site.

Overlying the 200 meters of shale bedrock are an additional 450 meters of various kinds of sedimentary rocks, which will provide the deep shales with protection from surface erosion over the million year timeframe in which the DGR will be required to contain the radioactive wastes.

The upper 170 meters of carbonate bedrock at the DGR site are considered a zone of active karst development. There is little evidence of karst activity or potential below this depth. However over the long term karstic enhancement and/or evaporite dissolution-related enhancement of formation permeabilities is a potential issue in the entire upper 450 meter thick sequence of mainly carbonate and evaporite bedrock, which could under various glaciation scenarios be vulnerable to significant permability increases.

The deep 200 meter thick and effectively impermeable shale bedrock layers which immediately overlie the DGR host horizon are not considered to be vulnerable to erosion or significant permeability increases over a million year timeframe.

The proposed disposal in the DGR of Ontario's low- and intermediate-level radioactive wastes (L&ILW) would replace the current temporary storage of these wastes at the nearby Western Waste Management Facility (WWMF) on the Bruce Nuclear Property.

This report identifies problems with the environmental assessment process, the site characterization, the impact assessment, the proposed monitoring programs, and with various aspects of DGR proposal itself. These problems are discussed in detail in the following sections of this review.

3) Problems with the Environmental Assessment Process

There were two significant environmental assessment process related problems which impacted our review of the EIS and related documentation:

a. The Information Request (IR) process has been dysfunctional, and was a major impediment to obtaining the necessary information to properly review and understand the DGR proposal.

b. New documents were still being submitted on behalf of the proponent a couple of weeks before the August 13, 2013 deadline by which intervenors were required to submit their final reports. There was not adequate time to thoroughly review and understand these new documents.

These issues are discussed in more detail below.

a) Dysfunctional Information Request (IR) Process and Organization

i) A significant problem with the IR process was that carefully formulated questions which we submitted were modified by the Panel before being submitted to the proponent. In some cases this meant that our questions were so altered that the proponent's responses were of no benefit in addressing our original questions. In other cases it also meant that it was difficult or impossible for us to determine if our questions were ever submitted or responded to by the proponent.

This concern was communicated to the Panel in letters from CELA dated April 19, 2013 and May 24, 2013. The letter on May 24, 2013 includes the following expression of our concern about this matter:

> *"In addition, CELA submitted a letter dated April 19, 2013 to the Panel expressing concern about the difficulty in determining whether the IRs had been responded to by OPG.*
> *Notwithstanding the responses from the Panel Secretariat to our letter, our hydrogeological experts have found it to be effectively impossible to track their IRs through the process to see if they have been adequately responded to – or even to see if they've been responded to at all. For this reason alone, we submit that the EIS should be found to be insufficient at this time. This is a matter of grave concern to us, and we request that the Panel respond to this concern."*

While we appreciate that there were responses from the Panel Secretariat to these letters, the responses were unsatisfactory in terms of actually addressing and fixing this problem.

ii) A second signifcant problem with the IR process pertained to the organization and presentation of the IRs. The IRs were ordered by date of receipt rather than by topic, and had only limited searchability. Our experience was that the IR information base was not managed effectively, to the detriment of critical reviewers of the DGR proposal.

b) Last-Minute Submission of Proponent's Documents

The Panel has set an August 13, 2013 deadline for submissions. This deadline falls in the middle of summer holidays for CELA experts and staff, making the writing, review, and coordination of the CELA submission extremely difficult in terms of scheduling. We have nonetheless done our best to work around these constraints, and plan and schedule our work to meet the August 13, 2013 deadline.

Our efforts were however undermined by the last-minute submissions of documents by the proponent. Last-minute document submissions include the following:

- Posted at http://www.ceaa.gc.ca/050/documents/p17520/91944E.pdf is CEAR # 1245, which is Panel Member Document (PMD) 13-P1.1, Ontario Power Generation's summary of their Request for a Decision Regarding their "Application for a Site Preparation and Construction Licence for a Deep Geologic Repository for Low and Intermediate Level Waste" (34 pages).

- Posted at http://www.ceaa.gc.ca/050/documents/p17520/91945E.pdf is CEAR #1246, which is PMD) 13-P1.1A, Ontario Power Generation's summary of their Request for a Decision Regarding their "Environmental Assessment for Ontario Power Generation's Application to Prepare a Site and Construct a Deep Geologic Repository for Low and Intermediate Level Waste" (56 pages).

- Posted at http://www.ceaa.gc.ca/050/documents/p17520/91309E.pdf is Ontario Power Generation's " Commitments Report" to the Joint Review Panel (over 170 pages).

This is simply poor process. The documents themselves are helpful in that they provide good overviews of the proponent's position and commitments in support of the project, but they have been completed and made public so late in the process that they are of only limited assistance because it was simply not possible to make proper use of them in the time available.

Recommendation 1

The Joint Review Panel should take the deficiencies in the environmental assessment process into account in its review and assessment of the viability of the DGR project. Furthermore, future Panels should take the deficiencies in the environmental assessment process into account and take all necessary steps to ensure that these do not occur in any new environmental assessment process under the Canadian Environmental Assessment Act.

4) Concerns about the Site Characterization

Although a site which is potentially suitable from a hydrogeological perspective has been found, there are a number of issues which could and should have been investigated or explained more thoroughly in the EIS documentation in order to provide further assurance about its viability.

The issues requiring further investigation/explanation include the following:

a. the high hydraulic heads in the Cambrian sandstone, and the lack of information about hydraulic heads in underlying Precambrian basement;
b. information on deep oil/gas exploration boreholes;
c. permeability of the Silurian "barrier" formations;
d. the existing groundwater and surface water quality in the vicinity of the DGR site (in particular the elevated tritium levels and the reasons for these).

These issues are discussed in more detail below.

a) Hydraulic Conditions in the Cambrian Sandstone and the Underlying Precambrian Basement

Section 5.6.1.3 of the Geology TSD provides a discussion of hydraulic conditions in the deep groundwater flow system. It is clear from a review of this section that the Cambrian sandstone formation (found at about 840 to 860 meters below ground surface (mbgs) is a significant aquifer, which is characterized by relatively high average hydraulic conductivities of about $3x10^{-6}$ m/s.

Rather unexpectedly - the Cambrian sandstone is overpressured (11,000 kPa) and has very high hydraulic heads of 165 meters above the ground surface. This is an unusual and difficult to understand condition, and I was not able to find any explanation for it in the EIS documentation. This condition may extend downward to the Precambrian unconformity (which may be a zone of higher permeability), or even into the underlying Precambrian bedrock.

The excavation of the DGR will result in a huge pressure gradient and hydraulic gradient being established between the Cambrian sandstone and the overlying DGR.

The implications for the DGR project are that if any hydraulic connection from the DGR down to the Cambrian sandstone exists or is established, then more - perhaps much more - water will need to be pumped from the DGR than has been planned for in the site design.

In addition, the overpressures and formation heads may be sufficient to push groundwater and DGR-related contaminants up to the ground surface - note that this could only occur in the event of both a hydraulic connection from the DGR to the ground surface (eg. via a failed shaft seal) <u>and</u> a hydraulic connection from the DGR to the underlying Cambrian sandstone (eg. via a fault).

In this context the plans to excavate the ventilation shaft to a depth of 746 mbgs (ie. to within about 100 meters above the Cambrian sandstone) are worth reexamining.

<u>Recommendation 2</u>

a) The proponent should provide information on the shut-in pressure and the water quality at the Precambrian unconformity.

b) The proponent should provide a discussion of whether the proposed excavation depth of 746 mbgs is needed for the ventilation shaft, given the overpressured high hydraulic conductivity and high hydraulic head Cambrian sandstones which underlie the DGR site.

<u>b) Information on Deep Oil/Gas Exploration Boreholes</u>

Page 27 of the Geology TSD states that:

> *"Of more than 21,000 documented wells drilled in Ontario, only 27 petroleum exploration wells have been drilled within a radius of 40 km of the proposed DGR.."*

We requested more information about the depths and locations of the 27 known wells within 40 km of the DGR site, and after a long search found the proponent's answer in IR response EIS-05-178. Review of the information in the IR response reveals that 11 of the boreholes were drilled from the ground surface through to beyond the depth of the proposed DGR host horizon, and the closest of these wells was drilled within 3.5 km of the DGR site. The 11 wells are listed as "abandoned", which is said to mean "officially plugged and abandoned" with no further information provided.

There is also a not-to-be-discounted possibility of undocumented oil exploration wells having been drilled in the vicinity of the DGR. Such boreholes (if they were not properly sealed) could provide very effective pathways for vertical groundwater flow and contaminant transport.

<u>Recommendation 3</u>

a) The proponent should provide a full description of the measures taken to secure each of the 11 deep "abandoned" wells within 40 km of the DGR site.

b) The worst-case scenario of undocumented oil exploration wells being present in the area of the proposed DGR should be considered and explicitly addressed by the proponent.

c) Permeability of the Silurian "Barrier" Formations

The proposed DGR facility will be overlain by about 650 meters of bedrock. The EIS has confirmed that the upper 170 meters of the bedrock is a zone of active groundwater flow and karst dissolution with enhanced bedrock permeabilities. Below that there is little evidence of active groundwater flow, and no evidence of karst development.

I have found that the EIS documents assume that below 170 meters, all of the bedrock formations are effectively impermeable and can be relied upon to prevent groundwater carrying contaminants from the radioactive wastes in the DGR from ever coming into contact with the active shallow groundwater flow system in the upper 170 meters of the bedrock.

For example, page 34 of the Geology TSD (in discussing the "Intermediate" bedrock formations between 170 meters below ground surface (mbgs) and 450 mbgs), states that:

> *"The intermediate bedrock grouping includes dominantly shale rock formations which can potentially provide a significant water and/or contaminant transport barrier between the DGR repository levels in the deep bedrock, and the shallow bedrock formations above."*

This is an inaccurate statement - the Silurian bedrock formations at the "Intermediate" depths between 170 and 450 mbgs are not shales, they are predominantly carbonates (limestones and dolostones) and evaporites. There is little in the way of shales in the Intermediate bedrock formations. Yet only shale can be considered an effective long-term barrier to groundwater movement.

Both carbonates and especially evaporites are vulnerable to dissolution in the presence of flowing groundwater, so their effectiveness as a barrier is at risk as soon as they are disturbed and exposed to flowing groundwater. In my opinion it is a mistake to be considering the Intermediate carbonate and evaporite bedrock formations as a hydraulic barrier, because they are vulnerable to significant increases in permeability due to dissolution. All that is needed for this to occur is a disturbance which facilitates groundwater flow, and the passage of sufficient time.

The excavation of the vertical tunnels for the main shaft and the ventilation shaft for the DGR represents a massive disturbance. Large tunnels will be blasted into the bedrock, and it is quite conceivable that there will be significant movement of groundwater from the shallow active flow system downward into the Intermediate bedrock formations via the area of disturbed bedrock around the shaft tunnels.

Another disturbance is present in the form of boreholes which were drilled for the DGR investigations. The proponent undertakes to seal these boreholes properly and effectively, but there is no way of ascertaining whether these efforts will prove effective for a period of hundreds of thousands of years.

Finally, there are signs that there is already a zone of vulnerability in the Intermediate depth Silurian bedrock formations. The Silurian Salina formation comprises a suite of evaporite and precipitate subformations that currently serve as a significant hydrogeological and physical barrier, but there is no assurance that it can continue to serve this function in the long term.

The remarkable hydraulic isolation of the proposed DGR is ensured by the presence of soluble minerals such as halite and anhydrite. Hydration locks water into the mineral lattice preventing migration directly and attendant swelling further restricts hydraulic conductivity. However, significant flows of water will dissolve and remove these mineral barriers resulting in much higher permeability. The effect of such flushing particularly on hydraulic conductivity, effective porosity and barrier performance has not been assessed. It should be noted that solutional erosion and collapse are characteristic features of much of the Salina with complete removal of the major Salina B halite (salt) facies having occurred regionally and locally.

Moreover the "Salina A1 Carbonate" exhibits high permeability and anomalous hydraulic head. High hydraulic conductivities are reported from this zone (please see Geosynthesis TSD, Figure 51 on page 194). The Geosynthesis TSD also has a series of figures which show anomalously dilute water quality indicating active groundwater movement, including the following:

- Figure 4.6 on page 161, showing a TDS anomaly;
- Figure 4.7 on page 163, showing a stable isotope anomaly;
- Figure 4.8 on page 164, showing a halide anomaly;
- Figure 4.9 on page 169, showing a halide ratio anomaly.

The relatively fresh water found in this zone is inferred to be a mix of modern and glacial water, which indicates relatively fast penetration of near-surface groundwater to considerable depth. Complementary flushing of deep water to the surface is implied. The mechanism for transport of this groundwater is unknown, but it substantially varies from the EIS site conceptual model and modelling results reported. There is a groundwater flow condition in the DGR subsurface that is much faster than has been estimated, and which computer simulations have failed to account for.

For the above reasons, it would be prudent to assume that the potential barrier function of the Intermediate bedrock formations will be compromised to some degree. Fortunately the underlying 200 meters of Ordovician shales will comprise a very effective hydraulic barrier.

Recommendation 4

a) Further work on the DGR project should be premised on a prudent assumption that the Silurian bedrock formations will not provide an effective hydraulic barrier over the long term.

b) The proponent should model DGR performance using worst-case permeabilities, based on leach testing of all "barrier" formations.

d) Existing Groundwater and Surface Water Quality near the DGR Site (and Tritium Levels)

The Bruce Nuclear facility has known areas of groundwater contamination. A superficial discussion of contamination in these areas is provided in Section 5.7.2.1 of the Geology TSD.

Radioactive tritium is present at high levels in groundwater throughout the vicinity of the Western Waste Management Facility (WWMF), which is where the radioactive wastes going into the DGR will be coming from. Our attempts to determine the extent and distribution and reasons for the tritium contamination through IRs and review of the EIS documentation were not successful. The extensive borehole and water quality monitoring information available to the proponent has not been compiled to provide a comprehensible overview of the distribution and migration of tritium on site.

It is of concern that whatever workplace management and operating conditions allowed the spread of tritiated water through the area of the WWMF may also prevail at the DGR site and allow significant contamination of groundwater and/or surface water in the DGR area.

If a decision is made to move the wastes to the DGR based on a review of all the evidence at the hearing, then this site from a hydrogeological perspective would provide a considerably more secure location for these wastes than their current situation can provide. However, I take no position on whether the proponent's EA work to date satisfies CEAA provisions, the JRP Agreement, or EIS Guidelines respecting the analysis of alternatives to and alternative sites.

Modeling by Sykes (2012) suggests that the DGR excavation and stormwater management pond (SWMP) are at minimal risk of potential tritium contamination. However, the primary aquifers at the DGR site are highly karstic shallow carbonate formations and highly heterogeneous quaternary glacial sediments. Both these media exhibit substantial preferential flow, making the model's porous medium based characterization of contaminant distribution and migration problematic.

More accurate monitoring and modelling reports are needed to explore the likely heterogeneities in tritium distribution.

It is possible that construction activities will encounter high levels of tritium well outside the boundaries of the predicted plume. It should be noted that groundwater levels of tritium are observed to be either rising or falling less rapidly than might be expected from radioactive decay, indicating substantial contaminant mass in the subsurface.

The radioactive characterization of the DGR area's subsurface unexpectedly revealed tritium at considerable depth. This alarming result was attributed to accidental borehole contamination by tritiated local drilling fluid. It is of particular concern that the DGR Study Team were apparently not aware of the presence of radioactive tritium in the groundwater. Workers can not sense their exposure to tritium contamination, so due diligence requires appropriate information sharing and monitoring protocols.

Recommendation 5

a) The proponent should provide full disclosure on what combination of workplace practices and incidents led to the tritium contamination which is observed in groundwater throughout the area of the Western Waste Management Facility.

b) The distribution of tritium in the subsurface should be determined by integration of all monitoring data and communicated to site operators, regulators, and the public.

c) The migration of tritium in the subsurface should be modelled using values of effective porosity appropriate to the karstic host formations.

d) The proponent should provide a full description of what measures will be undertaken to ensure that the surface water management pond (SWMP) does not become contaminated by tritium (or other radiological contaminants) during construction and operation of the DGR.

e) The proponent's radiological surface water monitoring parameter list includes tritium, gross beta, and carbon 14. Proposed maximum target levels for each parameter should be proposed for the SWMP by the proponent, with a rationale provided for each parameter.

f) Field workers exposed to local groundwater should have appropriate briefings, operational protocols and monitoring appropriate to the potential tritium hazard.

5) Hydrogeological Impact Assessment

a) Introduction

Impacts on groundwater and/or surface water quality may arise during the construction and operation period, or after the DGR is closed and sealed off.

Considerable impact assessment work has been carried out, and is documented in various TSDs, reports and technical memoranda prepared by the proponent and the consultants retained by the proponent. Further improvements have been made to the impact assessment as a result of the IR process, such that some of the issues which we originally identified have now been addressed.

b) Groundwater Impacts during Construction and Operations

The proposed groundwater monitoring program is adequate for the construction and operation period. The DGR site is about 1 km from Lake Huron, and all groundwater from the area of the DGR project site is flowing towards Lake Huron.

The DGR construction and operation period should not be problematic from a groundwater quality perspective, assuming the site is reasonably well run and any spills are promptly reported and thoroughly addressed. The overburden deposits are lower permeability glacial tills, which will provide initial containment of any spills. But there is a need to respond quickly to any surface contamination issues, because the underlying shallow bedrock formations are high-permeability karstic carbonates which will rapidly transport any contaminants reaching them to the lake.

Any DGR construction and operations related impacts on groundwater quality will be significantly attenuated (mainly by dilution) once they reach the lake, and as a result I have no particular concerns about potential groundwater quality impacts during the DGR construction and operations period.

c) Post-Closure Impacts, and Implications for Groundwater Monitoring

The impact assessment concludes that there should not be any long-term groundwater impacts from the wastes being disposed of in the DGR - assuming the DGR facility and the bedrock strata in which it is entombed remain intact, and that the shaft seals and backfill are effective in eliminating vertical hydraulic connections along the vertical shaft tunnels.

The proponent's impact assessment is based on the above assumptions, however these assumptions do not, in my professional opinion, adequately consider a conceivable worst case scenario relating to the effectiveness of the shaft seals and backfill in preventing vertical groundwater movement.

The hydrogeological investigations carried out as part of the DGR site assessment have established that the proposed DGR facility will be situated within and below hundreds of meters of bedrock formations of extraordinarily low permeabilities.

The permeabilities of these formations are so low, that it is highly unlikely that the various seal and backfill materials proposed to be used to close off the main access shaft and ventilation shaft will achieve anywhere close to such low permeabilities. As a result, the sealed and backfilled shaft tunnels will represent permanent weaknesses in the long-term entombment of the radioactive wastes in the DGR. They will in fact be the weakest points in the proposed containment of the completed DGR facility.

At best it will be extremely difficult to effectively seal off these vertical shaft tunnels to the point where they - and the surrounding bedrock - form impermeable barriers to vertical groundwater movement. The excavation of the vertical tunnels for the main shaft and the ventilation shaft for the DGR represents a massive disturbance. Large tunnels are to be blasted into the bedrock. The walls of the tunnels will not be smooth - they will be rough, jagged and uneven and there will be a zone of disturbed bedrock extending outward from the bedrock openings which form the tunnel walls.

The shafts themselves are to be sealed off to prevent groundwater from flowing into them in a horizontal direction from any surrounding permeable bedrock formations during the construction and operations period. This sealing will likely be quite effective. It will be a much more significant challenge to try to also seal the disturbed areas external to the shaft tunnel openings to eliminate groundwater flow in a vertical direction. This is partly because unlike the horizontal seals (whose effectiveness is readily apparent by the intrusion of water into the shafts), there is no way of easily determining if there is vertical groundwater movement occurring in the disturbed areas around the tunnels or if efforts to seal the rock are effective.

There will very likely be vertical groundwater movement in the disturbed bedrock areas around the shaft tunnels from the time that the tunnels are excavated through to the closure of the DGR. During the closure period when the shaft tunnels are being backfilled and sealed will provide the best opportunity to try to also ensure that the surrounding disturbed bedrock areas around the tunnels are made effectively impermeable to vertical groundwater movement. But it will be tremendously challenging to create an effective seal that will last for hundreds of thousands of years.

Consideration of this critical issue is provided in various EIS reports (in particular the Excavation Damaged Zones Assessment) and in many IRs (including IR LPSC-03-62, which was particularly helpful). There is discussion of a Highly Damaged Zone (HDZ) which may be present at the tunnel excavation face, and the Excavation Damaged Zone (EDZ) which pertains to the broken rock at and behind behind the tunnel face where there have been significant changes in flow and contaminant transport properties.

It is fair to say that the study of Excavation Damaged Zone (EDZ) assessment and remediation is an emerging science. While I appreciate that the proponent is committed to minimizing the EDZ around the shaft tunnels and to effectively sealing these features, I see no sign that there is currently any capability to actually do so with confidence that the end result has recreated the permeability of the undisturbed bedrock.

Vertical permeabilities in the sealed and backfilled shafts are, in my opinion, likely to be a factor of 1000 or more higher than in the surrounding low-permeability bedrock formations. By implication it is a near certainty that if any contamination from the DGR facility migrates vertically then it will be coming up via the areas of disturbed bedrock around one or both of the former shafts.

Despite the proponent's acknowledgement that there is a risk of increased permeability adjacent to the backfilled and sealed shafts, there is no sign that this has been recognized in the development of proposals for long-term groundwater monitoring of the site. The locations for proposed monitoring wells do not appear to include the actual vertical tunnels of the sealed and backfilled shafts, even though these are almost certainly the pathways which any upward moving groundwater contamination will be following.

Recommendation 6

a) The proposed groundwater monitoring plans for the DGR facility should be amended to include monitoring well nests atop each of the vertical tunnels of the main access shaft and the ventilation shaft.

b) These wells should be installed after the shafts have been sealed and backfilled to ground surface.

c) The bottom well in each nest should be installed at the top of the low-permeability shaft seal/backfill materials, and wells should be installed in higher permeability units above that depth with a maximum spacing of 40 meters vertically.

6) Hydrogeological Concerns with respect to Site Design and Operations

a) General Comment

Detailed work has been carried out in terms of describing the proposed DGR site design and operations, and this work is documented in various reports and technical memoranda prepared by the proponent and the consultants retained by the proponent.

For the most part, the design and operations are well thought out and presented at an adequate level of detail for an environmental assessment. As with the impact assessment, the proposals for site design and operations have evolved and been clarified through the IR process. Earlier issues which we had identified have been resolved or explained to our satisfaction - with one notable exception.

b) The Stormwater Management Pond (SWMP)

At this point there is only one water quality related issue which I have identified as requiring some further work and consideration - the design and management of the stormwater management pond (SWMP).

All surface water run off from the DGR construction project, all groundwater from the DGR excavation, and all sump water pumped from the constructed DGR facility during the decades-long operational period will be feeding into the pond. **The SWMP is therefore the critical feature when it comes to water protection for the proposed DGR project.**

There are however several design and operational issues pertaining to the stormwater management pond (SWMP) which require further attention:

i. targets for discharge water quality;
ii. in-design mitigation and SWMP treatment proposals;
iii. pond capacity;
iv. proposal to hold back pond contents.

These issues are discussed in more detail below.

i) Targets for Discharge Water Quality

The SWMP will contain all runoff from the DGR construction site, the waste rock pile leachate, as well as all sump water from the DGR facility. The projected water quality of the SWMP is outlined in a report entitled "Water Quality Modelling Results for the Stormwater Management Pond" which is dated December 2012 and is hereafter referred to as the "Water Quality Modelling Report".

The Water Quality Modelling Report compares water quality in the SWMP to the Provincial Water Objectives (PWQO), which, in my opinion, establish the appropriate criteria for setting discharge water quality limits.

However it is clear from that Water Quality Modelling Report that there is a real possibility that water quality in the SWMP will not meet the PWQO for many of the parameters considered in the report. In addition other parameters which are likely to find their way into the SWMP (including various organic chemicals such as toluene) were not considered in the report.

Target discharge water quality limits for inorganic chemicals have been established for the SWMP, and are outlined in the DGR Follow Up Monitoring TSD. The limits which have been set are appropriate.

Target discharge water quality limits for organic chemicals have not been established for the SWMP. Given the scale of the DGR project, this is not a reasonable omission. BTEX parameters (benzene, toluene, ethylbenzene, and xylenes) and PAHs (polynuclear aromatic hydrocarbons) are contaminants which are likely to be present on the DGR site and which pose significant threats to downstream water quality if they are present in discharges from the pond.

Recommendation 7

a) The proponent should commit to using the PWQO as the basis for setting SWMP discharge water quality limits for selected organic chemicals, including BTEX parameters (benzene, toluene, ethylbenzene, and xylenes) and PAHs (polynuclear aromatic hydrocarbons).

b)Water in the SWMP which does not meet the PWQO for the selected organic chemicals should be held back for further treatment and testing.

ii) In-Design Mitigation and SWMP Treatment Proposals

A project of the magnitude of the proposed DGR brings with it the potential for significant water quality impacts. Testing is proposed to assess the degree of such impacts in the SWMP, and if such impacts are detected then they will need to be addressed by the proponent.

Several in-design mitigation and water treatment possibilities for the SWMP are mentioned in various documents (such as the Water Quality Modelling Report and the DGR Follow Up Monitoring TSD), including the following:
• grouting high-TDS bedrock formations to reduce groundwater inflow into the shafts;
• modification of normal blasting practices;
• separating out waste rock pile water and treating to reduce unionized ammonia levels;
• using an evaporator to concentrate high-TDS water (which would have to be collected and treated separately).

The proponent has not made a firm commitment to actually implement any of these in-design mitigation or treatment methods.

A firm commitment to implementing in-design mitigation would involve the proponent stating that in-design best management practices will be followed to reduce the concentrations of various parameters in the SWMP (such as ammonia, BTEX parameters, PAHs, metals, and salts) as much as possible. A firm commitment to providing necessary treatment would involve setting discharge criteria for such parameters, establishing a program of regular testing for those same parameters, and firmly committing to providing whatever treatment is necessary to keep SWMP water quality below the discharge criteria.

In my professional opinion the proponent should commit to in-design best management practices and to treating the pond water unless rigorous testing has confirmed that it meets the PWQO for all parameters of concern.

Recommendation 8

The proponent should commit to in-design best management practices, and to treating the SWMP discharge water unless a program of rigorous testing has confirmed that it meets the PWQO for all parameters of concern (including ammonia, BTEX parameters, PAHs, metals, and salts).

iii) Pond Capacity

Another issue of concern pertaining to the SWMP is the need for adequate capacity. Various TSDs indicate that the SWMP through which all surface water from the DGR facility and construction site will flow will have the design capacity to handle a 100 year storm event. Given the predicted and already-observed effects of global climate change on precipitation intensities, this may not be a conservative design.

Recent events from across Canada confirm that our climate is in the process of changing, and that in particular precipitation intensities are increasing during rain events. Severe flooding events are becoming more commonplace, and the conventional standard for engineering design (the “100-year storm”, statistically estimated based on historic data) is being exceeded with unsettling regularity in locations across the country.

Under these circumstances and in a time of global climate change, it would be prudent and proactive for the proponent to commit up front to designing and constructing the SWMP so that it can contain the “Regional Storm” event (ie. the equivalent of Hurricane Hazel).

Recommendation 9

> **The SWMP should be designed and constructed with sufficient capacity to contain the Regional Storm (ie. Hurricane Hazel).**

iv) Proposal to Hold Back Pond Contents

Increasing the design capacity of the SWMP is particularly important given the proponent's commitment to “close the gate” and hold back the pond water if it doesn’t meet discharge criteria. SWMP discharge water quality is proposed by the proponent to be tested on a regular basis, with the pond water being “held back” if it fails this testing.

The details of how this is to work in practice have not been provided to date by the proponent. It is clear that this proposal will only be workable if the SWMP has been designed with ample capacity, such that its contents can be held back in the event of adverse test results. (This would support the need for the increased SWMP capacity recommended in **Recommendation 9**.)

The optimal way for such a system to work would be to have two triggers for the pond contents to be held back:

- if the SWMP water discharge quality fails to meet detailed PWQO-based discharge criteria during a scheduled regular testing event (as discussed in **Section 6)b)i)** above);
- if the SWMP discharge water quality fails to meet a specified level of conductivity during ongoing, continuous monitoring.

Continuous monitoring of conductivity at the pond outlet is also recommended, and can be used to trigger a “closing of the gate” if a precautionary limit is exceeded. Electrical conductivity is an excellent surrogate parameter to use as a broad measure of water quality impairment - in essence, the higher the levels of contamination in the SWMP, the higher the conductivity will be. If conductivity exceeds a certain level, then this provides a broad indication that something has happened to affect the water quality in the SWMP. Closing the gate will then allow more detailed testing to be done to ascertain the reason(s) for the change in water quality.

It should be noted that what happens next if the SWMP contents have been held back (because of adverse water quality test results) has not been specified by the proponent. In some cases, further treatment could improve pond water quality such that it meets PWQO and can be discharged. In other cases, it may not be possible to effectively treat the water in the SWMP with the facilities on hand.

It would be advisable to have arrangements in place with a local wastewater treatment plant, so that the SWMP contents can be removed and trucked to the wastewater treatment plant if poor water quality in the SWMP can not be quickly improved following adverse test results.

Recommendation 10

a) There should be continuous measurement of SWMP discharge water quality (by measuring electrical conductivity), coupled with a program of regular more detailed testing for various discharge criteria.

b) If there are adverse water quality results exceeding the PWQO, then the SWMP contents should be held back to allow for more detailed testing and investigation to determine the reason(s) for the adverse test results.

c) Arrangements should be made with a local wastewater treatment plant to take the SWMP contents in the event that on-site treatment is not able to reduce pond contaminant levels to below discharge criteria.

7) Monitoring and Contingency Plans

The work which has been carried out to date on the DGR monitoring and contingency plans has in a number of areas not been consistent with what would be expected given the importance and scale of the DGR project and the potential it brings with it for unacceptable water contamination.

Some monitoring and contingency issues require further work by the proponent. A number of monitoring/contingency issues have already been addressed in previous sections of this report, with the recommendations being provided for improvement.

The additional monitoring issues requiring further consideration/description by the proponent include the following:

a. the duration of the proposed post-closure monitoring period (300 years) seems arbitrary and too short given the long-lived contaminants being disposed of in the DGR;
b. provision needs to be made for development of robust monitoring programs;
c. there is no provision in the EIS outlining how the proponent will respond in the event of adverse monitoring results, or what monitoring results might trigger a response from the proponent;
d. independent review (including adequate funding and public access to information) is needed for the DGR monitoring programs.

These issues are discussed in more detail below.

a) Arbitrary 300 Year Post Closure Monitoring Period

The proposed 300-year post-closure monitoring period is arbitrary, and seems far too short given the very long timeframe over which the DGR will be required to provide containment of the radioactive wastes in the repository.

If one assumes a target of one million years containment to be provided by the DGR, then 300 years marks 0.03% of the overall containment period. It is not clear why the commitment by the proponent to monitor the facility is not open-ended, or at least of a longer duration.

The proponent's proposed 300-year monitoring duration is inadequate. There is no reason to assume that a plausible DGR containment failure scenario would be detectable by the relatively shallow proposed groundwater monitoring program within 300 years. In fact, many if not most of the most plausible failure scenarios would require a considerably longer period of time for contaminants to make their way up to the shallow groundwater flow system.

Ontario's landfill operators are required to calculate the contaminating lifespan of their facility, and to make provision for continued monitoring throughout that contaminating lifespan. The contaminating lifespans of landfills are measured in centuries, and so are the monitoring commitments for these facilities.

To date the proponent has not provided a compelling argument in favour of their proposal to terminate their obligations for monitoring the DGR facility after only 300 years. It would appear prudent for the proponent to commit to monitoring as long as possible, and at a minimum for a period of at least 1000 years.

Recommendation 11

a) The proponent should commit to sustaining a longer-term monitoring effort for the DGR facility following closure.

b) The commitment should be open ended (ie. to monitor "as long as possible") with a minimum monitoring period of 1000 years.

b) Development of Robust Monitoring Programs

The DGR Follow Up Monitoring TSD provides conceptual outlines of proposed monitoring programs, but provides few of the details which are an integral part of a robust and effective monitoring program.

Components of monitoring programs which are generally missing from the TSD include the following:

- a list of monitoring locations, and a map showing those locations;
- a list of indicator parameters which will be used to determine if contamination is occurring;
- trigger levels for each of the monitoring parameters, which if exceeded will trigger action by the proponent;
- conceptual outlines of contingency plans which will be triggered if confirmed adverse monitoring results are obtained.

A major concern with the proponent's failure to develop these components is the fact that if they are developed after the EA process has concluded, then the proponent will effectively have avoided subjecting these details to independent and public scrutiny. It is recommended that the details of the necessary DGR monitoring programs be subject to the same level of scrutiny that the EA and EIS have been subject to.

Monitoring programs can provide insight into environmental conditions and processes, provided that a suitable critical analysis which facilitates understanding of the data that have been collected is undertaken. It is this *understanding* rather than the data itself that provides a baseline against which changes and stability can be assessed and interpreted.

Furthermore, critical data analysis also provides an ongoing review of the efficacy of the monitoring protocol. For example, it can reveal gaps in spatial monitoring locations, or critical sampling times that might be missed There is no evidence in the Follow Up Monitoring TSD that OPG is committed to ongoing analysis and critical review of its monitoring results and protocol. Instead, the impression is that the commitment is to simply collect the data as directed.

The ongoing development of environmental monitoring technologies over the long term needs to be planned and accounted for. Sampling a series of boreholes may well be considered quaintly antiquated within the monitoring period of this proposed facility. A commitment from the proponent to adaptively updating the monitoring programs in concert with technological advances is essential.

Recommendation 12

a) The full details of the necessary DGR monitoring programs should be developed by OPG, and made available to all EA stakeholders for review and comment.

b) An arm's length process for critical analysis and review of the data and the effectiveness of the DGR monitoring programs should be established by the proponent.

c) The DGR monitoring programs should undergo periodic review to consider adoption of contemporary best practices and technologies as these evolve.

c) The Proponent's Contingency Responses to Adverse Monitoring Results

The EIS and its supporting documentation (in particular the Follow-Up Monitoring TSD) provide conceptual descriptions of monitoring proposed for the DGR project. However, these documents in most instances fail to provide descriptions of what kind(s) of adverse results will trigger a contingency response from the proponent, and what sort of contingency response might be triggered.

Following are some examples of conceivable adverse monitoring scenarios:

- Excavation sump monitoring during the construction phase of the project which detects high levels of radioactive tritium contamination in groundwater flowing into the shaft excavation(s).

- Facility sump monitoring during the operations period which detects unexpectedly high amounts of groundwater flowing into the DGR facility through the floor of the facility.

- SWMP monitoring which detects adverse water quality during the construction or operations period which does not respond adequately to treatment, such that the pond remains contaminated. This situation becomes acute if the pond is close to being full with heavy rains pending.

- Post-closure groundwater monitoring which detects signs of upwelling contamination whose most likely source is the DGR facility.

Conceptual descriptions of contingency responses to these and other conceivable monitoring results should be provided by the proponent. Moreover, as with the monitoring programs, these contingency responses should be subject to broad public scrutiny.

Recommendation 13

The conceptual details of the necessary DGR contingency plans should be developed by the proponent, and made available to all EA stakeholders for review and comment.

d) Independent Review and Public Dissemination of DGR Monitoring Results

The proponent has committed to a decades-long monitoring period during the active site preparation, construction and operations phases of the proposed DGR facility and to a 300-year post-closure monitoring period.

While I firmly believe that the 300-year monitoring period is inadequate (as outlined above), the fact that the proponent has committed to a centuries-long monitoring period for the proposed DGR facility means that careful thought needs to be given to facilitation of independent review of that monitoring program.

Independent review of monitoring results is the surest way to ensure that the program remains focussed, effective, and up to date. It is in the public interest for the proponent to facilitate independent review of the monitoring for the proposed DGR facility.

Our experience in accessing results from existing monitoring programs proved instructive in this regard. Despite our diligent efforts it proved impossible to obtain an integrated, clear and explicit overview of current groundwater contamination at the Bruce Nuclear site, even though such an overview was important to improving our understanding of the site hydrogeology. Information requests to the proponent did not elicit much greater clarity. This sort of opacity is unacceptable, and feeds public distrust of the proponent and the proposal.

Missing from the EIS and its supporting documentation is a meaningful commitment by the proponent to subject its DGR monitoring program results to independent and proponent-funded review, and to make the full results of its monitoring programs readily available to the public for review.

Recommendation 14

a) The proponent should subject its DGR monitoring program results to independent non-governmental review, and should provide funding to facilitate this review process.

b) The proponent should make the full results of its monitoring programs readily available to the public for review.

8) Conclusions

1) The proposed DGR site is potentially suitable from a hydrogeological perspective. The proposed DGR is to be situated in low permeability and structurally sound shaley limestone formations, which will provide a suitable host formation for the DGR excavations. These shaley limestone host formation are overlain by very thick (200 meters) and even lower permeability shales, which provide the hydrauli containment of the site.

Overlying the 200 meters of shale bedrock are a further 450 meters of various kinds of sedimentary rocks, which will provide the deep shales with protection from surface erosion over the million year timeframe in which the DGR will be required to contain its radioactive wastes.

2) The upper 170 meters of carbonate bedrock at the DGR site are considered a zone of active karst development. There is little evidence of karst activity or potential below this depth. However over the long term karstic enhancement and/or evaporite dissolution-related enhancement of formation permeabilities is a potential issue in the upper 450 meters of sedimentary bedrock, which could under various glaciation scenarios could be vulnerable to significant permeability increases.

3) The deep 200 meter thick shale bedrock layers which immediately overlie the DGR host horizon are not considered to be vulnerable to erosion or significant permeability increases over a million year timeframe.

8) Conclusions - continued

4) The proposed disposal in the DGR of Ontario's low- and intermediate-level radioactive wastes (L&ILW) would replace the current temporary storage of these wastes at the nearby Western Waste Management Facility (WWMF) on the Bruce Nuclear Property. There is extensive tritium contamination in the area of the WWMF, but it has not been possible to determine the extent and distribution and reasons for this.

If a decision is made to move the wastes to the DGR based on a review of all the evidence at the hearing, then this site from a hydrogeological perspective would provide a considerably more secure location for these wastes than their current situation can provide. However, I take no position on whether the proponent's EA work to date satisfies CEAA provisions, the JRP Agreement, or EIS Guidelines respecting the analysis of alternatives to and alternative sites.

5) There were a significant number of problems with the environmental assessment process being administered by the Canadian Nuclear Safety Commission (CNSC) and the Canadian Environmental Assessment Agency (CEAA). These include problems with the IR process and the late production and disclosure of the documents by the proponent. These problems are described in detail in **Section 3** of this report.

6) There were a number of shortcomings in the characterization of the DGR site, and 4 major issues requiring further investigation/explanation were identified:

a. the high hydraulic heads in the Cambrian sandstone, and the lack of information about hydraulic heads in underlying Precambrian basement;
b. the inadequate information on deep oil/gas exploration boreholes;
c. the permeability of the Silurian "barrier" formations;
d. the existing groundwater and surface water quality in the vicinity of the DGR site (in particular the elevated groundwater tritium contamination levels and the reasons for these).

These issues are described in detail in **Section 4** of this report.

7) The DGR construction and operation period should not be problematic from a groundwater quality perspective, assuming the site is reasonably well run and any spills are reported and addressed promptly and thoroughly.

8) For the most part, the design and operations are well thought out and presented at an adequate level of detail for an environmental assessment. There are however several design and operational issues pertaining to the stormwater management pond (SWMP) which require further attention:

a. targets for discharge water quality;
b. lack of proponent commitments on in-design mitigation and SWMP treatment proposals;
c. inadequate pond capacity;
d. the proposal to hold back SWMP contents following adverse test results.

These issues are described in detail in **Section 6** of this report.

9) The weakest aspects of the DGR proposal are the monitoring and contingency plans, which are currently only developed at a conceptual level. Critical details are missing from the plans which have been presented, and there is a concern that these critical details will avoid public scrutiny if their development is put off until after the conclusion of the EA process. The proposed 300-year post closure monitoring period is not adequate. My concerns about the proposed monitoring and contingency plans are described in detail in **Section 7** of this report.

9) Recommendations

The EIS (with its supporting documentation) should not be approved in its current form. The proponent should be required to address and implement the recommendations provided in this report.

Recommendation 1)

The Joint Review Panel should take the deficiencies in the environmental assessment process into account in its review and assessment of the viability of the DGR project. Furthermore, future Panels should take the deficiencies in the environmental assessment process into account and take all necessary steps to ensure that these do not occur in any new environmental assessment process under the Canadian Environmental Assessment Act.

Recommendation 2)

a) The proponent should provide information on the shut-in pressure and the water quality at the Precambrian unconformity.

b) The proponent should provide a discussion of whether the proposed excavation depth of 746 mbgs is needed for the ventilation shaft, given the overpressured high hydraulic conductivity and high hydraulic head Cambrian sandstones which underlie the DGR site.

Recommendation 3)

a) The proponent should provide a full description of the measures taken to secure each of the 11 deep "abandoned" wells within 40 km of the DGR site.

b) The worst-case scenario of undocumented oil exploration wells being present in the area of the proposed DGR should be considered and explicitly addressed by the proponent.

Recommendation 4)

a) Further work on the DGR project should be premised on a prudent assumption that the Silurian bedrock formations will not provide an effective hydraulic barrier over the long term.

b) The proponent should model DGR performance using worst-case permeabilities, based on leach testing of all "barrier" formations.

Recommendation 5)

a) The proponent should provide full disclosure on what combination of workplace practices and incidents led to the tritium contamination which is observed in groundwater throughout the area of the Western Waste Management Facility.

b) The distribution of tritium in the subsurface should be determined by integration of all monitoring data and communicated to site operators, regulators, and the public.

c) The migration of tritium in the subsurface should be modelled using values of effective porosity appropriate to the karstic host formations.

d) The proponent should provide a full description of what measures will be undertaken to ensure that the surface water management pond (SWMP) does not become contaminated by tritium (or other radiological contaminants) during construction and operation of the DGR.

e) The proponent's radiological surface water monitoring parameter list includes tritium, gross beta, and carbon 14. Proposed maximum target levels for each parameter should be proposed for the SWMP by the proponent, with a rationale provided for each parameter.

f) Field workers exposed to local groundwater should have appropriate briefings, operational protocols and monitoring appropriate to the potential tritium hazard.

Recommendation 6)

a) The proposed groundwater monitoring plans for the DGR facility should be amended to include monitoring well nests atop each of the vertical tunnels of the main access shaft and the ventilation shaft.

b) These wells should be installed after the shafts have been sealed and backfilled to ground surface.

c) The bottom well in each nest should be installed at the top of the low-permeability shaft seal/backfill materials, and wells should be installed in higher permeability units above that depth with a maximum spacing of 40 meters vertically.

Recommendation 7)

a) The proponent should commit to using the PWQO as the basis for setting SWMP discharge water quality limits for selected organic chemicals, including BTEX parameters (benzene, toluene, ethylbenzene, and xylenes) and PAHs (polynuclear aromatic hydrocarbons).

b) Water in the SWMP which does not meet the PWQO for the selected organic chemicals should be held back for further treatment and testing.

Recommendation 8)

The proponent should commit to in-design best management practices, and to treating the SWMP discharge water unless a program of rigorous testing has confirmed that it meets the PWQO for all parameters of concern (including ammonia, BTEX parameters, PAHs, metals, and salts).

Recommendation 9)

The SWMP should be designed and constructed with sufficient capacity to contain the Regional Storm (ie. Hurricane Hazel).

Recommendation 10)

a) There should be continuous measurement of SWMP water quality (by measuring electrical conductivity), coupled with a program of regular more detailed testing for various discharge criteria.

b) If there are adverse water quality results exceeding the PWQO, then the SWMP contents should be held back to allow for more detailed testing and investigation to determine the reason(s) for the adverse test results.

c) Arrangements should be made with a local wastewater treatment plant to take the SWMP contents in the event that on-site treatment is not able to reduce pond contaminant levels to below discharge criteria.

Recommendation 11)

a) The proponent should commit to sustaining a longer-term monitoring effort for the DGR facility following closure.

b) The commitment should be open ended (ie. to monitor "as long as possible") with a minimum monitoring period of 1000 years.

Recommendation 12)

a) The full details of the necessary DGR monitoring programs should be developed by OPG, and made available to all EA stakeholders for review and comment.

b) An arm's length process for critical analysis and review of the data and the effectiveness of the DGR monitoring programs should be established by the proponent.

c) The DGR monitoring programs should undergo periodic review to consider adoption of contemporary best practices and technologies as these evolve.

Recommendation 13)

The conceptual details of the necessary DGR contingency plans should be developed by the proponent, and made available to all EA stakeholders for review and comment.

Recommendation 14)

a) The proponent should subject its DGR monitoring program results to independent non-governmental review, and should provide funding to facilitate this review process.

b) The proponent should make the full results of its monitoring programs readily available to the public for review.

Appendix 1

Curriculum Vitae

of

Wilf Ruland (P. Geo.)

Curriculum Vitae of Wilf Ruland

(Professional Geoscientist)

Address: Wilf Ruland (P. Geo.)
766 Sulphur Springs Road
Dundas, Ontario
L9H 5E3
Tel: (905) 648-1296
E-mail: deerspring1@gmail.com

Education:

1988 Master of Sciences in Earth Sciences,
University of Waterloo.
Supervisor: Dr. John Cherry

Master's project focussed on the hydrogeological properties of fractured clay deposits in Lambton County. 15 courses provided a broad background in hydrogeology.

1982 Honours Bachelor of Science in Geography and Geology,
McMaster University.

30 courses provided a broad background in natural science, geography and geology.

Experience:

since 1988 Environmental Consultant, as head of own consulting firm
(Citizens' Environmental Consulting).

Active as advisor and consultant on issues related to groundwater or surface water contamination or depletion for private citizens, citizens' groups, environmental groups, First Nations, companies and public agencies from across Ontario.

Specialization in addressing landfill-related groundwater and surface water contamination problems through review of hydrogeological impact studies, field investigations, and participation in public meetings and hearings.
Ongoing contracts include investigations of water contamination at landfills near St. Catharines, Brockville, Kingston, Waterloo, and Windsor.

Other significant areas of work include review of pit and quarry proposals and applications for Permits to Take Water, investigations of well interference resulting from quarries, and groundwater contamination emanating from major industrial properties and gas stations.

Experience: continued

1988-1993 Research Associate, Waterloo Centre for Groundwater Research, University of Waterloo

Work included research into the hydrogeology of fractured clays and into the impacts of landfills on groundwater.

1983-1985 Hydrogeologist, Ingenieur-Geologisches Institut, Westheim, Germany.

Work included hydrogeological field work, supervision and evaluation of drilling programs, supervision and evaluation of pumping tests, research and preparation of hydrogeologic reports, and supervision of environmental monitoring for a major railway construction project.

Publications, Papers and Research Reports:

Worthington, S.R.H., Smart, C.C., and Ruland, W.W. 2012. Effective Porosity of a Carbonate Aquifer with Bacterial Contamination: Walkerton, Ontario, Canada. Published in the Journal of Hydrology, Vol. 464-465 (2012), p. 517-527.

Ruland, W.W. 2005. Presentation on Source Water Considerations and the Walkerton Setting. Presented at the Canadian Water Network's Walkerton Water and Public Health Training Workshop, May 28 - June 2, 2005.

Worthington, S.R.H., Smart, C.C., and Ruland, W.W. 2002. Assessment of Groundwater Velocities to the Municipal Wells at Walkerton. Paper presented at the 3rd Joint IAH-CNC/CGS Conference, October 20 - 23, 2002 in Niagara Falls, Ontario.

Worthington, S.R.H., Smart, C.C., and Ruland, W. 2001. Karst Hydrogeological Investigations at Walkerton. Report prepared for and submitted as evidence at the Walkerton Inquiry.

Ruland, W.W., Schellenberg, S.S., and Farquhar, G. 1993. The Fate of Landfill Leachate in Waste Water Treatment Plants and in Groundwater at Attenuation Landfills. Report prepared for the Ontario Ministry of Environment and Energy.

Ruland, W.W., Cherry, J.A., and Feenstra, S. 1991. The Depth of Fractures and Active Ground Water Flow in a Clayey Till Plain in Southwestern Ontario. Published in the Journal of Ground Water, Vol. 29, No. 3, p. 405-417.

D'Astous, A.Y., Ruland, W.W., Bruce, R.J., Cherry, J.A., and Gillham, R.W. 1989. Fracture Effects in the Shallow Groundwater Zone in Weathered Sarnia Area Clay. Published in the Canadian Geotechnical Journal, Vol. 26, No. 1, p. 43-56.

Fracture Depths and Active Groundwater Flow in a Clayey Till in Lambton County, Ontario. 1988. Unpublished M.Sc.Project, University of Waterloo.

Cherry, J.A., MacQuarrie, K.T.B., and Ruland, W.W. 1987. Hydrogeologic Aspects of Landfill Impacts on Groundwater and Some Regulatory Implications. Paper presented at the PCAO/MOE Seminar on Landfill Regulations May 13, 1987.

Wilf Ruland (P. Geo.) - Partial List of Consulting Experience:

1) Investigations/Reviews of Landfill-Related Water Contamination:

Niagara Road 12 Landfill, near Grimsby, Ontario.
- Peer Review for the Niagara Road 12 Litizen Liaison Committee (2008-2010).

Humberstone Landfill in Welland, Ontario.
- Peer Review for the Humberstone Public Liaison Committee (since 2007).

City of Owen Sound's Derby Landfill site, near Owen Sound, Ontario.
- investigation and review for the Ledingham family (2004-2006)

Town of Northeastern Manitoulin and the Islands Landfill, near Little Current, Ontario;
- investigation and review for Mr. Raeburn Smith and Mrs. Virginia Smith (since 2004).

Rennie and Brampton Street Landfill Sites, Hamilton, Ontario;
- Peer Review for the Rennie/Brampton Citizens' Liaison Committee (2001-2005).

Town of Thessalon Landfill Site, near Thessalon, Ontario;
- investigation for Mr. Mark Petingalo and Mrs. Wendy Petingalo (in 2000).

City of Brockville Landfill Site, Brockville, Ontario;
- review for Brockville Public Liaison and Monitoring Group (since 1997).

Fletcher Tile Landfill Site, near Chatham, Ontario;
- investigation for Citizens Opposed to Landfill Development (1996-1997).

Bracebridge Landfill Site, Bracebridge, Ontario;
- investigation for Dr. David Kent (1995-1996).

Waterloo Sanitary Landfill Site, Waterloo, Ontario;
- review for Waterloo Waste and Water Watchers (since 1995).

Innisfil Landfill Site, Innisville, Ontario; investigation for Mrs. Helen Hodgson (1995 - 1999).

Tom Howe Landfill Site, near Hagersville, Ontario;
- review for the Mississaugas of the New Credit First Nation (since 1994).

Wolfe Island Waste Disposal Site, Wolfe Island, Ontario;
- investigation for Ms. Theresa James (since 1994).

Bensfort Road Landfill, near Peterborough, Ontario;
- investigation for Mr. Gary McCarrell and Mrs. Lori McCarrell (1991-1993).

Orillia Landfill Site, in Orillia, Ontario; investigation for Citizens Acting Now (1991).

Storrington Landfill near Kingston, Ontario;
- investigation for Storrington Committee Against Trash (1990-1997).

Glenridge Quarry Landfill in St. Catharines, Ontario;
- review for Glenridge Landfill Citizens' Committee (since 1989).

Warwick Landfill near Watford, Ontario;
- investigation for Watford Warwick Landfill Committee (1989-1996).

Brow Quarry Landfill near Dundas, Ontario;
- investigation for Greensville Against Serious Pollution (1988-1989).

Essex County Landfill No. 3 in Maidstone Township, Ontario;
- reviews for Maidstone Against Dumping and Maidstone Township (1988-2008).

Town of Cobourg Landfill, in Haldimand Township, Ontario;
- investigation for Mr. Joe Sherman (1988-1991).

2) Reviews of Proposals to Site New or Expand Existing Landfills

Proposal to massively expand the Richmond Landfill near Napanee, Ontario;
- review for the Concerned Citizens Committee of Tyendinaga Twp. (2004 - 2006, and since 2010).

Proposal to expand and significantly alter the Edwards Landfill
(including excavation of hazardous wastes, and relocation of other wastes) near Cayuga, Ontario;
- review for Haldimand Against Landfill Transfers (2004 - 2006)

Proposal to massively expand the Warwick Landfill near Watford, Ontario;
- Peer Review for the Township of Warwick (1998-2008).

Proposal to site a landfill near Cochrane, Ontario;
- review for the Fournier Action Committee (1997 -1999).

Proposal to site a landfill in the abandoned Adams Mine Site near Kirkland Lake;
- review for the Coalition of Temiskaming Concerned Citizens (in 1995).

Proposal to site a landfill in the Taro East Quarry near the Niagara Escarpment
in Stoney Creek, Ontario;
- review for Stoney Creek Residents Against Pollution (in 1995).

Proposal to develop a perimeter-berm landfill around the Lake Ontario Steel Company Limited property in Whitby, Ontario; Peer Review for the Lasco Berm Liason Committee (1991-1995).

Proposal to build a landfill in a Class 2 Wetland near Cayuga, Ontario;
- review for Haldimand-Norfolk Organization for a Pure Environment (1989-1990).

Proposal to site a landfill in the Acton Quarry near Milton, Ontario;
- review for Protect Our Water and Environmental Resources (in 1989).

3) Review of Landfill Closure and End Use Plans

Closure Plan for the Tom Howe Landfill Site, for the Mississaugas of the New Credit First Nation (2005, and 2009/2010).

Closure Plan for the Richmond Landfill near Napanee, Ontario;
for the Concerned Citizens Committee of Tyendinaga Twp. (2007).

End Use Plan for the Glenridge Quarry Naturalization Site (formerly the Glenridge Laandfill), for the Glenridge Landfill Liaison Committee (2002).

Closure and post-Closure Care Plan for the Brockville Landfill Site, for the Brockville Public Liaison and Monitoring Group (2000-2001).

Closure and End Use Plan for Essex County Landfill No. 3, for Maidstone Against Dumping (1996).

4) Other Landfill-Related Projects

Peer Review of proposal to expand the Clean Harbors Hazardous Waste Landfill Facility near Sarnia, Ontario (since 2010); for the Township of St. Clair.

Investigation and review of groundwater and surface water contamination being caused by a cement kiln dust landfill near Bath, Ontario. Negotiated an agreement with Lafarge Cement to remediate the existing landfill and use an industry-standard design on a go-forward basis. For Lake Ontario Waterkeeper (2007-2010).

Member of the Expert Panel (appointed by the Minister of the Environment) to look into potential health and environmental impacts from the Taro East Landfill in Stoney Creek, Ontario (in 2000). The final report of the Expert Panel was released in October 2000, and the Addendum Report was released in December 2000.

Technical advisor to private citizens who successfully prosecuted the City of Hamilton (which pleaded guilty) for contamination by PCB-laden leachate of Redhill Creek (in 2000).
The resulting $450,000 fine was a record for fines paid under such prosecutions.

5) Reviews of Waste Management Master Plan (WMMP) Studies

Region of Haldimand-Norfolk Waste Management Master Plan (WMMP);
- review for the Mississaugas of the New Credit First Nation (1995-1996).

South Simcoe County Waste Management Master Plan;
- review for the South Simcoe Waste Action Network (since 1994).

Leeds and Grenville Waste Management Master Plan;
- review for Sabourins Crossing Residents Against Megadumps (in 1994).

Pembroke and Area Waste Management Master Plan;
- review for the Snake River/Micksburg Anti-Dump Association (1991-1992).

Northumberland County Waste Management Master Plan;
- review for Mr. and Mrs. J. Sherman (1989-1991).

Wellington County Waste Management Master Plan;
- review for the Concerned Alma Citizens (1988-1991).

6) Nuclear-Related Peer Review Work

Review of the Draft Environmental Impact Statement for the proposed Darlington 'B' New Nuclear Power Plant Project;
- review for Lake Ontario Waterkeeper (2010-2012).

Review of the proposed remediation of the Cameco Nuclear Waste Processing Facility in Port Hope, Ontario;
- review for Lake Ontario Waterkeeper (starting in 2010).

Review of the Draft Guidelines for the Environmental Impact Statement for the proposed Darlington 'B' New Nuclear Power Plant Project;
- review for Lake Ontario Waterkeeper (2008).

7) Other Investigations of Groundwater Contamination

Contamination by petroleum hydrocarbons of a greenhouse property from an adjacent Hydro One maintenance center in Kenora, Ontarioo; investigation for the Schmidt Family (2008)

Impacts of residual contamination on a former industrial property, which is now the site of St. Mary's High School; investigation for Environment Hamilton (2002 - 2004).

Contamination by petroleum hydrocarbons and volatile organic chemicals (VOCs) from a former service center near High Park, Toronto; investigation for Mr. Gerard Kennedy, MPP (in 2002).

Contamination of municipal water supply wells by E-coli bacteria in Walkerton, Ontario;
- investigation for Concerned Walkerton Citizens (2000 - 2002).

Contamination by petroleum hydrocarbons and volatile organic chemicals (VOCs) from an Imperial Oil fuel and liquid transfer facility in Kapuskasing, Ontario; investigation for the Schlechter family (in 2000).

Contamination by petroleum hydrocarbons from a Gulf Canada gas station in Port Loring, Ontario;
- investigation for People Against Contaminated Water (PACW); (1999 - 2001).

Contamination by petroleum hydrocarbons from a gas station in Bamberg, Ontario;
- investigation for the Bush and Fink families (1997 - 1998).

Groundwater contamination in Cambridge, Ontario caused by Ciba-Geigy Canada Ltd;
- investigation for Thomas Construction Company Ltd. (1993 - 1997).

Groundwater contamination from the Bristol Aerospace Plant near Lockport, Manitoba;
- investigation for Mrs. Elizabeth Andresen and Miss Ursula von Krogh (in 1993).

Extensive water contamination in Elmira, Ontario caused by Uniroyal Chemical Ltd; investigation for various clients, most recently the Region of Waterloo (since 1989).

8) Permits to Take Water and Drinking Water Systems

Preparation of applications to the Ministry of the Environment to upgrade the drinking water systems for Camp NeeKauNis near Waubaushene, Ontario (since 2012).

Review of an application for a Permit to Take Water for a Water Bottling Operation (to be operated by CJC Bottling Limited), with water to be taken from a well which feeds the headwaters of Colborne Creek; for the Concerned Citizens of Northumberland (2001 - 2004).

Review of an application for a Permit to Take Water for a municipal water supply project (for the Village of Woodville), with water to be taken from pumping wells near 5 families' homes;
- for the Mariposa Aquifer Protection Association (2000 - 2004).

Review of an application for a Permit to Take Water for a Water Bottling Operation (to be operated by Artemesia Springs Limited), with water to be taken from a springwell which feeds a headwater stream of the Rocky Saugeen River;
- for the Water Protection Coalition of South Grey (1999 - 2001).

Review of an application for a Permit to Take Water for a Water Bottling Operation (to be operated by Aquafarms 93 Limited), with water to be taken from a spring and 3 pumping wells situated near the headwaters of the Beaver River;
- for Ms. Samantha Wickens and other local residents (in 1999).

Preparation of an application for a Permit to Take Water for a fish farming operation (to be operated by Van Aqua Inc.), with water to be taken from a pumping well near the Town of Burford in Brant County; for Mr. Peter Van Kruistum (in 1988).

9) Reviews/Investigations Related to Impacts of Major Water-Takings

Impacts of ongoing pumping of municipal supply wells K50/K51 in Wilmot Township;
- review for Wilmot Center Monitoring Program Public Liaison Committee (since 2003).

Impacts of ongoing dewatering of the Canadian Gypsum Company mine near Hagersville Ontario;
- review for residents of 3rd Line, Six Nations Indian Reserve (1999-2003).

10) Reviews/Investigations related to Impacts from Pits, Quarries, and Mines

Investigation of potential impacts from the Miller Braeside Quarry near Braeside, Ontario;
- review for Friends Addressing Concerns Together in McNab/Braeside (since 2008).

Investigation of potential impacts from the unlicensed Nichol Quarry near Hagersville, Ontario;
- review for the Mississaugas of the New Credit First Nation (since 2007).

Impacts of the proposed expansion of the Nelson Aggregates Quarry near Mount Nemo, Ontario;
- review for Protecting Escaparment Rural Land (2005-2007).

Cumulative impacts of the proposed Halminen Quarry and Lafarge Quarry near Buckhorn, Ontario;
- review for Friends of Life in the Kawarthas (2004 - 2006).

Impacts of the proposed expansion of the Graham Brothers Aggregates Limited gravel pit near Caledon, Ontario; review for Dr. David Sylvester (2000 - 2001).

Impacts of the proposed Nichol Gravel Limited quarry near Hagersville, Ontario;
- review for the Mississaugas of the New Credit First Nation (1999 - 2001).

Impacts of well interference from the Canadian Gypsum Company mine near Hagersville;
- investigation for several families on the Six Nations Reserve (1999 - 2003).

Impacts of well interference from the Dunnville Rock Products Quarry near Dunnville;
- investigation for Mr. Ken Ricker and Mrs. Ethel Ricker (1997 - 2000).

Impacts of water takings asssociated with the Acton Quarry near Acton, Ontario;
- review for Protect Our Water and Environmental Resources (1997-2007).

Impacts of a quarry proposed adjacent to Mitchell Lake, near Victoria Road, Ontario;
- review for the Northern Victoria Ratepayers Association (1997 - 1999).

Impacts of a quarry, proposed to be located on the Bruce Peninsula;
- review for Mr. Ziggy Kleinau (1996).

Impacts of a proposed gravel pit, to be sited near Grippen Lake, Ontario;
- review for Township Residents Against Pit Pollution (1995 - 1998).

Impacts of a gravel pit to be built in an Earth Science Area of Natural Interest (ANSI);
- review for Ms. Jeanette Mazur (1995 - 1996).

Impacts of the proposed Seeley and Arnill Quarry near Orillia, Ontario;
- review for Mr. David Lowry (1993 - 1997)

Impacts of a proposed expansion of the Walker Brothers Quarry, near St. Catharines;
- review for Mrs. Ronnie DeMeel (1992).

Impacts of six (6) proposed gravel pit operations in Oro Twp., Ontario;
- review for Dr. E.J. Beaton and Dr. A.C. Beaton (1990 - 1992).

11) Participation in Public Hearings

An application to site a quarry in a Provincially Significant Wetland Complex near Duntroon, Ont;
• before the Ontario Municipal Board;
• Decision dated August 24, 2012.

A hearing into the proposed Darlington 'B' New Nuclear Power Plant Project;
• before the Canadian Nuclear Safety Commission;
• Decision dated August 17, 2012.

An application to develop a quarry in the Niagara Escarpment Plan area near Duntroon, Ontario;
• before the Joint Board;
• Decision dated June 18, 2012.

An application to develop a gravel pit in the Municipality of Grey Highlands, Ontario;
• before the Ontario Municipal Board;
• Decision dated April 30, 2008.

An application to massively expand the Dufferin Aggregates Milton Quarry;
• before the Joint Board;
• Decision dated June 8, 2005.

An application for conversion of 81 cottages into permanent homes adjacent to a World Biosphere Reserve, Class 1 Wetland and Wilderness Area in Turkey Point;
• before the Ontario Municipal Board;
• Decision dated August 13, 2002.

An application to develop a quarry near Mitchell Lake and Victoria Road, Ontario;
• before the Ontario Municipal Board;
• Decision dated January 22, 1999.

An application to develop a gravel pit adjacent to a Class 1 Wetland along the shore of Lake Katchewanooka near Lakefield, Ontario;
• before the Ontario Municipal Board;
• Decision dated June 4, 1998.

An application to develop a quarry near Kinmount, Ontario;
• before the Ontario Municipal Board;
• Decision dated August 18, 1995.

An act (Bill 62) to amend the Environmental Protection Act to phase out landfilling in the Niagara Escarpment Plan Area;
• before the Standing Committee on the Administration of Justice;
• Bill 62 received Royal Assent June 23, 1994.

An application to expand the Eastview Road Landfill Site near Guelph, Ontario;
• before the Environmental Assessment Board;
• Decision EP 92-02 dated September 22, 1993.

An application to develop six (6) gravel pits on the Oro Moraine in Oro Twp.;
• before the Ontario Municipal Board;
• Decision dated July 23, 1993.

An application to expand the Storrington Landfill Site;
• before the Environmental Assessment Board;
• Decision EP 91-01 dated March 31, 1993.

An amendment (No. 52/89) to the Niagara Escarpment Plan to delete waste disposal sites as a permitted land use in lands protected by the Plan;
• before a Niagara Escarpment Commission Hearing Officer;
• Decision dated Oct. 22, 1991.

An appeal against a zoning bylaw and a proposed plan of subdivision (which allowed construction of a golf course on a Class 1 Wetland);
• before the Ontario Municipal Board;
• Decision dated August 29, 1990.

An application to expand the Seeley and Arnill Aggregates Ltd. gravel pit in Oro Twp.;
• before the Ontario Municipal Board;
• Decision dated May 29, 1990.

An application to expand Essex County Landfill No. 3;
• before the Environmental Assessment Board;
• Decision EP 89-02 dated December 12, 1989.

An application to expand the Town of Cobourg landfill;
• before the Environmental Assessment Board;
• Decision EP 89-01 dated October 16, 1989.

Appendix 2

References

There is a voluminous amount of documentation available regarding the DGR proposal and the EIS. We did a good deal of "browsing" through the various documents. Major references which were reviewed in the course of preparing this report included the following:

Analysis of the impact of groundwater withdrawal associated with the construction of the DGR shafts, OPG DGR. File DGR-TM-3400(P). February 2012. Prepared by J. F. Sykes.

Consolidated Responses to JRP's Information Requests for DGR Project. 2013.

DGR EA Follow-Up Monitoring Technical Support Document, OPG's Deep Geologic Repository Project. March 2011. Prepared by Nuclear Waste Management Association.

DGR Project Consolidated Commitment List, OPG's Deep Geologic Repository Project. July 2013. Prepared by Nuclear Waste Management Association.

Environmental Impact Statement, OPG's Deep Geologic Repository Project. March 2011. Prepared by Golder Associates Ltd.

Excavation Damaged Zones Assessment, OPG's Deep Geologic Repository Project. March 2011. Prepared by Fracture Systems Ltd.

Geology Technical Support Document, OPG's Deep Geologic Repository Project. March 2011. Prepared by Golder Associates Ltd.

Geosynthesis. OPG's Deep Geologic Repository Project. March 2011. Prepared by Nuclear Waste Management Association.

Hydrology and Surface Water Quality Technical Support Document, OPG's Deep Geologic Repository Project. March 2011. Prepared by Golder Associates Ltd.

Malfunctions, Accidents, and Malevolent Acts Technical Support Document, OPG's Deep Geologic Repository Project. March 2011. Prepared by AMEC NSS Ltd.

Water Quality Modelling Results for the Stormwater Management Pond. Technical Memorandum, OPG's Deep Geologic Repository Project. December 18, 2012. Prepared by Golder Associates Ltd.