# AN INVESTIGATION OF THE SUITABILITY OF THE CHALK RIVER SITE TO HOST A GEOLOGIC WASTE MANAGEMENT FACILITY FOR CRL'S LOW AND INTERMEDIATE LEVEL WASTES

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## ABSTRACT

Atomic Energy of Canada Limited (AECL) is investigating the suitability of the Chalk River Laboratories (CRL) site for hosting a Geologic Waste Management Facility (GWMF) as part of the Nuclear Legacy Liabilities Program (NLLP) funded through Natural Resources Canada (NRCan). The GWMF is envisioned to be an underground engineered-geological repository consisting of shafts, access tunnels and emplacement caverns located at a nominal depth of 500 to 1000 m in the bedrock at the CRL site.

A 5-year-long pre-project study was started in 2006 to assess the feasibility of the bedrock at the CRL site to host a GWMF. The pre-project feasibility study began with a review of various previous geological investigations performed in the bedrock at the CRL site.

The 2006-2010 pre-project feasibility study involved exploring the geoscience and engineering characteristics of the bedrock to depths of over one kilometre at the CRL site through surface investigations and the drilling and testing of seven new deep characterization boreholes into the CRL bedrock. The collected information and interpretations were used to construct three-dimensional (3D) deterministic computer models of the geology of the bedrock at the CRL site and surrounding area and of the associated groundwater-flow regime.

In order to technically assess the suitability of the CRL site, the GWMF feasibility study has conservatively assumed that all of the legacy and forecast Low and Intermediate Level Waste (LILW) at CRL would report to it. The 3D deterministic models were used within a preliminary performance and safety assessment model to assess the long-term safety of a hypothetical GWMF at the CRL site on the basis of future radionuclide and toxic substance releases. Other items important to a preliminary performance and safety assessment include an inventory of CRL's radioactive wastes and other contaminants that could be placed in the GWMF, the creation of the engineered waste emplacement rooms and barriers within the GWMF.

This paper describes the technical work undertaken and the general findings of the preliminary performance and safety assessment study.

## 1. PURPOSE AND SCOPE OF THE STUDY

The purpose of this five-year pre-project study, which began in 2006, was to assess the suitability of the bedrock at the 38.5 $km^2$ Chalk River Laboratories (CRL) site (Figure 1) to safely host a proposed Geologic Waste Management Facility (GWMF) for low- and intermediate-level radioactive waste (LILW) presently stored at the CRL site and for future LILW generated at CRL up to 2100. The Nuclear Legacy Liabilities Program (NLLP) requires that "A geological assessment of the CRL site for siting a geologic repository will be completed by the end of year five (5), as well as conceptual design work for the facility. [1]"

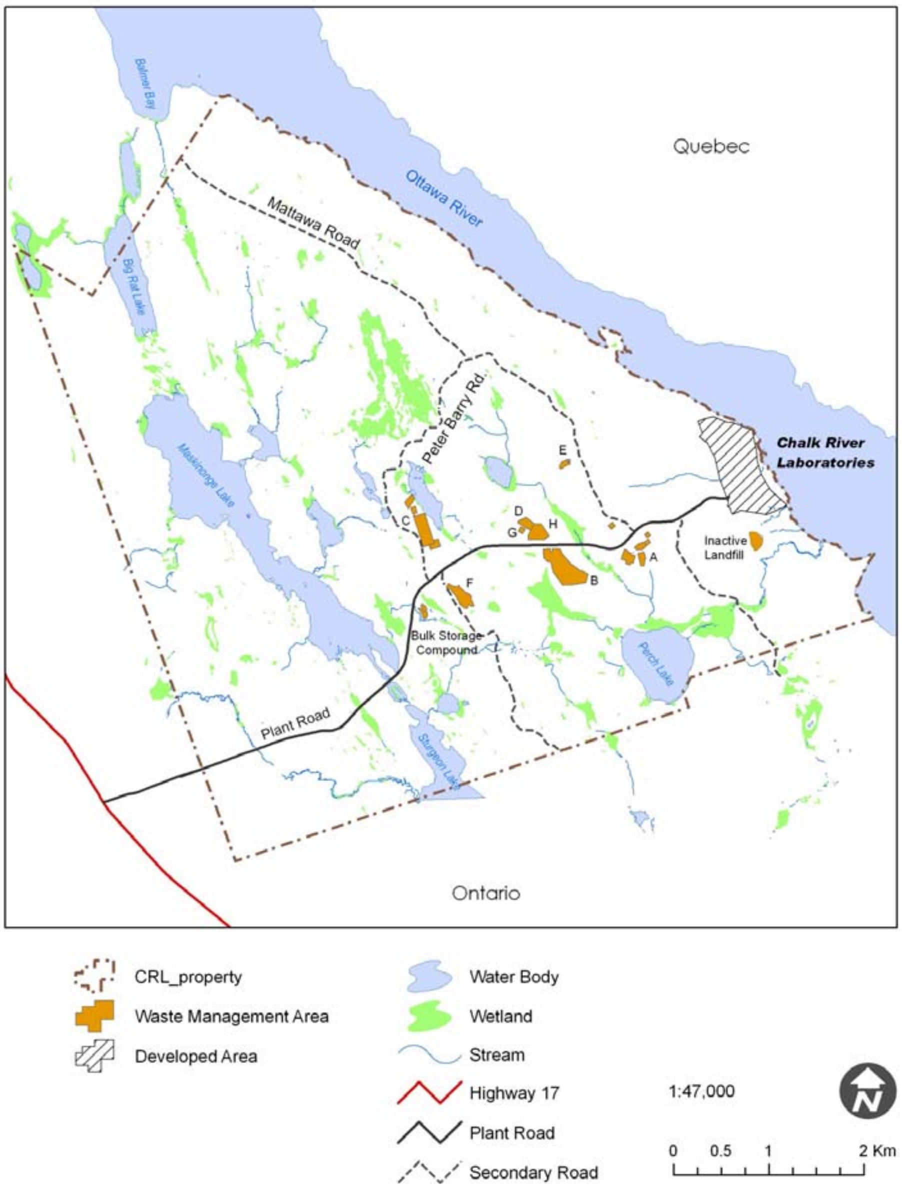



**Figure 1. AECL's Chalk River Laboratories site.**

The scope of work included the following [2]:

- Collect new information on geology, hydrogeology, geochemistry, seismicity, microbiology and geomechanics on the bedrock at CRL including the drilling and instrumentation of a series of seven deep boreholes to depths greater than 1000 m (Figure 2);
- Update the quantities of AECL's LILW and their characteristics;
- Derive a preliminary hydrogeological model of the bedrock at the CRL site pertaining to its physical and chemical contaminant-transport attributes to depths of 1000 m;
- Derive conceptual design options for all the necessary components and infrastructure required for a GWMF, including high-level cost estimates for the design options;
- Define the needs for and begin longer-term investigations on wasteform decomposition, gas generation and gas transport;
- Produce preliminary performance and safety analyses for a hypothetical reference GWMF repository at possibly viable locations and depths in the bedrock at the CRL site that yields dose rates to the most exposed individuals (i.e., the critical group) below the International Commission on Radiation Protection (ICRP) dose limit of $3x10^{-4}$ Sv/a for long-lived radioactive waste; and
- Produce recommendations for siting work, including detailed site characterization of potentially viable locations in the bedrock at CRL, should a decision be made to proceed with the GWMF project after the feasibility study.

Work commenced in 2006 to compile and analyze the pre-existing CRL site bedrock data. The primary sources of pre-existing data were from the early research and development activities from 1977 to 1983 for the Nuclear Fuel Waste Management Program (NFWMP) and from the Siting Task Force (STF) from 1992 and 1995.

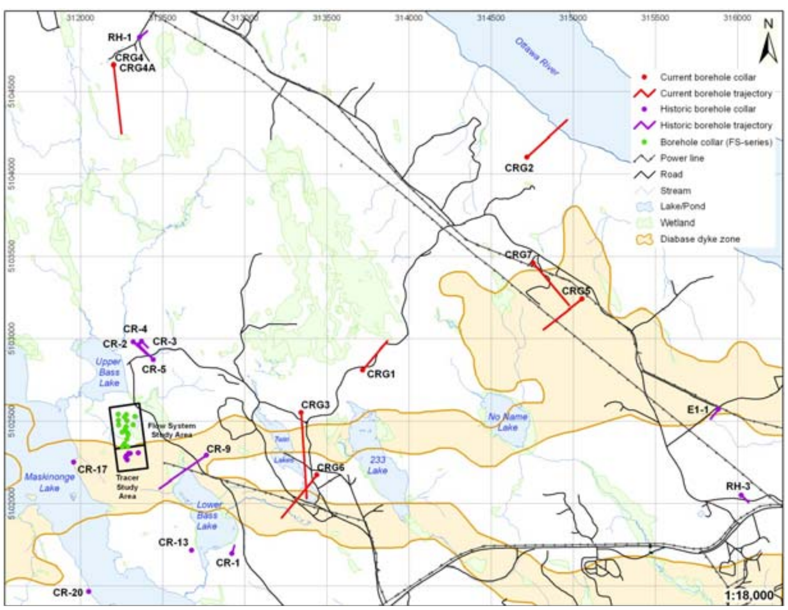



**Figure 2. Location of current CRG-series boreholes in relation to historic boreholes in part of the CRL site.**

## 2. GENERAL GWMF REQUIREMENTS

The proposed GWMF repository is an underground facility that isolates the toxic and radioactive components of the waste within an array of purposely built waste-emplacement chambers. To meet basic performance objectives, the repository and the features of its site must satisfy the following general requirements:

- Ensure stagnant to low-flow groundwater conditions within the confines of the repository, through appropriate choices of site locations and engineering features;
- Ensure long-term integrity of the repository structures and seals to protect and isolate the waste packages;
- Minimize contact of waste with standing water during waste-placement operations;
- Remain intact and sealed through all potential seismic and meteorological events over the service life of the repository;
- Facilitate repository closure;
- Minimize the need for long-term site maintenance and institutional control;
- Minimize radionuclide releases from the waste-emplacement chambers; and
- Provide appropriate venting systems to release gases generated within the waste-emplacement chambers.

The sole quantitative requirement used in this preliminary assessment is the ICRP safety requirement that the maximum dose rate to the critical group be below $3x10^{-4}$ Sv/a for long-lived radioactive waste.

## 3. PRELIMINARY CHARACTERISTICS OF THE CRL SITE

### 3.1 Geology

The CRL site is underlain by several stacked gneissic rock assemblages of Proterozoic age (i.e., possibly about 1.74- and/or 1.45-billion years before present (BP)) that have undergone high-grade metamorphism and polyphase, ductile deformation associated with the Grenville orogeny or mountain-building event (i.e., mainly between 1.19- and 1.06-billion years BP) [3]. The gneissic succession involves overlying and underlying, garnet-poor assemblages, composed of granitic and granodioritic gneisses, which are separated by a central garnet-rich assemblage composed mainly of monzonitic gneiss and quartzofeldspathic gneiss. Three phases of fold structures (F2 to F4) are considered to result from ductile thrusting and crustal extension during the Grenville orogeny. At a broad scale, the gneissic succession dips shallowly northward and is overprinted by macroscopic NW-SE trending (F3) folds, which impose an undulating structural configuration for the bedrock anatomy of the site.

The CRL site is situated within the northern margin of the Ottawa graben (i.e., fault valley), a major zone of fracturing and normal faulting that is generally about 40 km (up to 60 km) wide and extends about 700 km WNW-ESE from Lake Nipissing to the Montréal area, where it merges with the St. Lawrence graben. The graben developed originally in the late Precambrian and/or early Paleozoic age (i.e., between 0.59- and 0.54-billion years BP), in part following basement structures, and underwent significant block faulting much later during the Mesozoic age (possibly between 0.17- and 0.12-billion years BP). Surface and subsurface bedrock studies on the CRL site indicate the widespread distribution of three main, steeply dipping to subvertical fracture sets that display consistent orientations (NW, WNW and E-W) parallel to major faults and lineaments of the graben, with local fracture sets of other orientations. The borehole studies also define a commonly prominent, shallow-dipping to subhorizontal fracture set, which lies parallel to (and mimetic after) the folded and undulating gneissose fabric.

The bedrock of the CRL site exhibits an overall moderately fractured character (i.e., typified by a fracture frequency generally greater than 8 fractures/m) with common, dispersed highly fractured zones as well as, in places, sparsely fractured volumes of rock. The zones of sparsely fractured rock (i.e., commonly with median values of about 2 to 3 fractures/m) occur over relatively uninterrupted multi-decametre intervals, with the longer zones recognized to date up to 200 m in dimension in the deeper levels of the central part of the CRL site.

Most of the fractures contain fracture fillings and are sealed. Between 0.6% and 1.4% of the total fractures in each borehole comprise open and possibly open fractures (except 2.5% in borehole CRG2 that targeted the Mattawa fault). Fracture-filling materials include higher-temperature magmatic intrusions and lower-temperature mineral fillings. The magmatic-intrusive infillings involve (a) granite and tonalite veins, (b) biotite lamprophyre dykes and (c) diabase dykes of the Grenville dyke swarm intruded during the early rifting of the Ottawa graben. The mineral infillings reflect lower-temperature crystallization conditions and include chlorite, calcite, hematite, clays and sericite, epidote, iron-sulphide minerals (e.g., pyrite and pyrrhotite) plus local biotite, graphite, serpentine or talc, prehnite and zeolites (e.g., natrolite and thompsonite). Faults commonly have a neocrystallized or retrograde-alteration condition with many low-temperature infilling minerals, particularly chlorite, hematite and calcite.

The full lateral and vertical extent of the large volumes of relatively sparsely fractured rock are largely unknown but their presence implies that favourable bedrock conditions likely exist for locating the waste-emplacement areas of a potential GWMF. The results from hydrogeological testing in some of the new boreholes also indicates that very low permeability conditions exist due to the fracture-infilling materials in the CRL bedrock below 500-m depth.

### 3.2 Regional Seismicity

The West Québec seismic zone (WQSZ) is a broad NW-SE corridor of modern intraplate seismic activity extending from the Baskatong Reservoir area to Montréal. It is characterized by seismic events generally ranging from about 2 to 4.5 in magnitude on the Richter scale with rare events over 5. Earthquakes with an intermediate focal depth (i.e., 8-18 km) are clustered along a diffuse NW-SE corridor in western Québec that best defines the fundamental trend of the WQSZ, whereas those with shallow focal depths (i.e., 0-7 km) show a broader, relatively random distribution. Deeper earthquakes (i.e., >18 km) are confined to a few distinct clusters. The distribution of epicentres appears to be broadly limited to the north-east of the Ottawa graben, whereas those with shallow focal depths (i.e., 0-7 km) show a broader, relatively random distribution. Deeper earthquakes (i.e., >18 km) are confined to a few distinct clusters. The

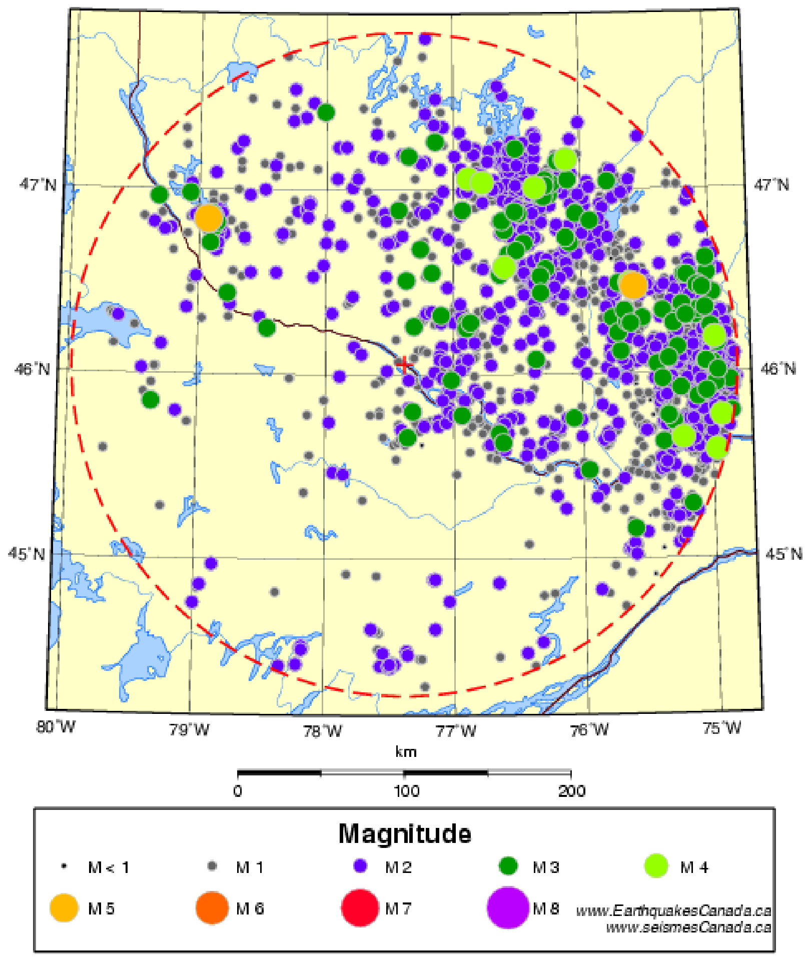



**Figure 3. Location of seismic events between 1985 and 2010 June in the West Québec Seismic Zone within 200 km of CRL (as noted by the red cross)**

distribution of epicentres appears to be broadly limited to the north-east of the Ottawa graben, which, itself, is relatively aseismic as compared to the WQSZ (Figure 3). Recorded epicentres within a 50 km radius around the CRL site attain a maximum magnitude of 3 on the Richter scale, indicating an apparent absence of significant destructive earthquake events [3]. This is consistent with the lack of evidence for neotectonic features from site-wide mapping, on-site trench investigations in post-glacial deposits and from historical seismic records, which provide proof that no damaging seismic events have occurred on the site for at least 10,000 years .

All safety related structures and systems for the proposed GWMF shall be seismically qualified to meet a yet-to-be updated regional design basis earthquake. This will be similar to current design basis earthquakes for other facilities co-located on the CRL site, but extended for longer time frames consistent with the duration of the long-term performance and safety assessment for the proposed facility. A microseismic monitoring system (MMS) was installed on the CRL site as part of this feasibility study to develop a database of local, small-scale seismic events as a complement to the regional, larger-scale events database for the determination of the long-term seismic hazard of the site. Data from the MMS have been collected since it was installed in 2007.

### 3.3 Bedrock in situ stresses, properties and strength

The in situ stress determinations of the bedrock indicate that the stresses in the CRL site are typical for the Canadian Shield. Any tunnels to be excavated in ungrouted blocks of rock bounded by faults (i.e., inter-block areas) are expected to be dripping to wet, with medium groundwater inflow rates ranging between 10 and 100 L/min along a 10-m-tunnel length. Cement grouting may be needed in the wetter areas as an expedient for construction, waste-emplacement operations and installation of sealing structures.

The rock mass is classified as poor quality in the faults and fracture zones to good quality in the intrablock zones. Indicated ground-support measures include local spot- to systematic-rock bolting with wire mesh in good to fair quality zones and the addition of shotcrete in poorer ground conditions.

### 3.4 Hydrogeology

Hydraulic testing has been completed in three new, deep boreholes and multilevel casing systems have been installed in these boreholes for the long-term monitoring of hydraulic heads and groundwater sampling within the CRL rock mass [4]. The hydraulic testing in the new boreholes suggests that the permeability of the intrablock regions of the CRL rock mass is generally low to very low ($< 10^{-16}$ $m^2$) below 500 m depth. Although the total fracture frequency can be relatively high, most of the fractures are sealed with fracture-infilling materials.

### 3.5 Geochemistry and Microbes

Reliable samples are not yet available from the new deep boreholes that were recently drilled at CRL due to the long recovery time required to establish chemical equilibrium following the highly disruptive drilling process. The only good groundwater samples were recovered from a single ~700-m-deep borehole drilled in 1979 (i.e., CR9) and refurbished with a multilevel casing system in 2006. The samples may not be representative of the entire CRL site. Three distinct groundwater chemical regimes are based on salinity. The upper 300 m has low chloride concentrations of 10 to 60 mg/L; the middle ~300 to 500 m has elevated levels from 150 to 200 mg/L; and the lower 500 to 700 m is slightly brackish with chloride concentrations of 1000 to 1600 mg/L [5]. The pH and Eh of the groundwater show ranges from 7.5 to 9.0 and +300 to +400 mV, respectively. The Eh values indicate that $O_2$ oxidizing conditions may be expected at the depths being considered for the GWMF repository.

The sampled groundwaters appear to be recent in age (i.e., ≤10,000 years) based on $^{14}C$ age-dating methods, possibly indicative of the incursion of post-glacial waters controlled by the timing of major isostatic rebound in the CRL area. The rocks have not experienced any appreciable U loss or gain during the past 350,000 to 1 million years despite the penetration of oxidizing groundwaters to a depth of about 380 m.

The indigenous microbial population in borehole CR9 appears to be mainly bacteria and only a small fraction of the population currently displays metabolic activity [6]. No attempt has been made to assess the effect of adding organic and inorganic compounds and any associated attached microbes from the LILW on the evolution of the ambient geochemical conditions. Microbes also play a role in radionuclide transport by sorption of radionuclides in and on both planktonic and sessile microbial cells and the resulting microbial populations will produce gases.

## 4. GROUNDWATER FLOW MODEL

Hydrogeological simulations were performed to assist in the assessment of the suitability of the bedrock at the CRL site for hosting a proposed GWMF [7]. The three-dimensional conceptual hydrogeological model represents an early geological framework of the CRL bedrock (Figure 4). The 165-$km^2$ subregional flow domain, extending to a depth of 3 km, is larger in area than the ~38.5 $km^2$ of the CRL site and includes eight major faults and fracture zones. A conservative technique for tracking groundwater flow was used (i.e., particle-tracking analysis) whereby nonsorbing particles are introduced into the model to determine the directions of the groundwater-flow paths and to estimate travel times from source locations to surface discharge.

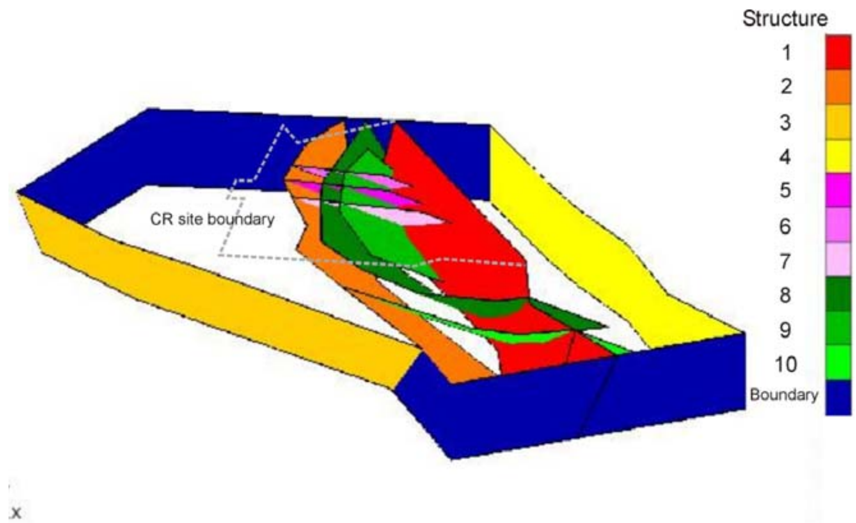



**Figure 4. Three-dimensional rendition of the preliminary conceptual hydrogeological model.**

The two hypothetical GWMF repositories were located in the modelled groundwater-flow field within the Maskinonge Lake discharge zone at depths of ~500 and ~1000-m on the hangingwall and footwall sides, respectively, of the shallowly dipping Maskinonge fracture zone that is suspected to underlie Maskinonge Lake (Figure 1).

The advective groundwater travel times from the ~500- and ~1000-m-deep hypothetical repositories to the Maskinonge Lake or to Sturgeon Lake surface-discharge areas (Figure 1) range from 2,000 to 53,000 years and from 18,000 to 57,000 years, respectively, from the various waste-emplacement sectors of the repositories in the Base Case simulation. Travel times shorter than 5,000 years originate from a small fraction of the hypothetical repository areas.

The CRL site appears to provide a moderately strong natural barrier against transport of radioactive or toxic contaminants from a proposed GWMF, as conceptualized from the early geological structural framework with the Base Case hydraulic properties and consideration of permeability distribution measurements from more recent hydraulic tests.

## 5. WASTE INVENTORY

The preliminary volumetric and radionuclide inventory for AECL's stored and planned operating and decommissioning wastes at CRL to 2008 is 267,000 $m^3$ and 22,000 TBq and projected to the year 2100 is 360,000 $m^3$ and 4,200 TBq, taking into account the radioactive decay of short-live radionuclides [8]. The total estimated volume is subdivided into six general waste groups as follows:

- Solid low-level waste (Solid LLW) 208,000 $m^3$
- Solid intermediate-level waste (Solid ILW) 48,000 $m^3$;
- Liquid ILW 320 $m^3$ (to be cemented before emplacement);
- Solid Decommissioning ILW 3,200 $m^3$;
- Liquid Dispersal Area LLW (LDA LLW) 19,000 $m^3$; and
- Waste Management Area F LLW (WMA F) 80,000 $m^3$.

The preliminary information is designated by source and waste classification so that decisions can be made on how various wastes can be managed in the future.

## 6. REPOSITORY AND COSTS

A high-level, reference GWMF repository design concept with an areal extent of about 1.6 to 2 $km^2$ is described, which consists of four potential design options, each with two shielding options, for a proposed GWMF containing the entire projected volume of CRL's LILW [9]. The total excavated volume for these options range from a high of 1.5 million $m^3$ of rock (i.e., 4.1 million tonnes) for 223 rooms with all of the waste contained in standard steel waste containers (B25 boxes) to a low of 0.76 million $m^3$ of rock (i.e., 21.7 million tonnes) for a combination of 115 rooms containing bulk LLW and 46 silos containing ILW.

The life cycle of the GWMF is composed of five project stages; siting, construction, operation, decommissioning and closure [10]. High-level cost estimates with an error band of 50% to +100% are produced for each option and alternatives, broken down by stage. Early total life-cycle cost estimates for emplacing the total volume of LILW (i.e., ~360,000 $m^3$) within a GWMF may range, at the maximum error level, from a low of $3.5 billion (i.e., maximum total unit cost of $9700/$m^3$) to a high of $4.3 billion (i.e., maximum total unit cost of $12,000/$m^3$) (in 2009 $ Cdn), depending on which waste-emplacement option and shielding alternative is considered. These estimates do not include any costs for waste characterization, packaging or storage.

Reducing the volume of waste reporting to the GWMF will reduce the variable-cost component of the GWMF, which is primarily a linear function of the LILW volume and associated waste-emplacement chambers, but not the fixed-cost component, which is a primarily a function of the fixed infrastructure (e.g., buildings, shafts and access tunnels). For example, the derived total median unit cost is estimated at $15,900/$m^3$ for 57,000 $m^3$ of ILW. This is comparable to 2001 published cost estimates (escalated to 2009 dollars) by OPG [11] for co-locating a long-lived ILW facility at a depth of 500 m with a Deep Geologic Repository (i.e., $15,000/$m^3$ for a packaged volume waste of 70,000 $m^3$). Here too, the cost is for emplacement only without the conditioning and packaging cost portions.

## 7. GAS GENERATION AND TRANSPORT

The GWMF-specific data required for a detailed quantification of gas generation and transport are still being assembled. Over the entire GWMF lifespan, the main volatile generated will be $H_2$ from corrosion of metals, followed by $CH_4$ and $CO_2$ from fermentation of organics [12]. The in situ indigenous microbial population in the bedrock of the CRL site and the supplied population within the wasteforms will consume the materials supplied by the LILW substrates and packages and will generate gases.

The initial generation rate of volatiles may be in the order of 300,000 $m^3$/year. If the volatile species are not transported, then the pressure would increase at a rate of ~0.1 MPa/year. Significant pressures can build up over time that may locally deflect the groundwater-flow regime and promote contaminated (e.g., $^{14}C$, $^{36}Cl$, $^{129}I$) gas-bubble release. At very high pressures, gas-induced fracturing of the moderately fractured rock mass is a possibility.

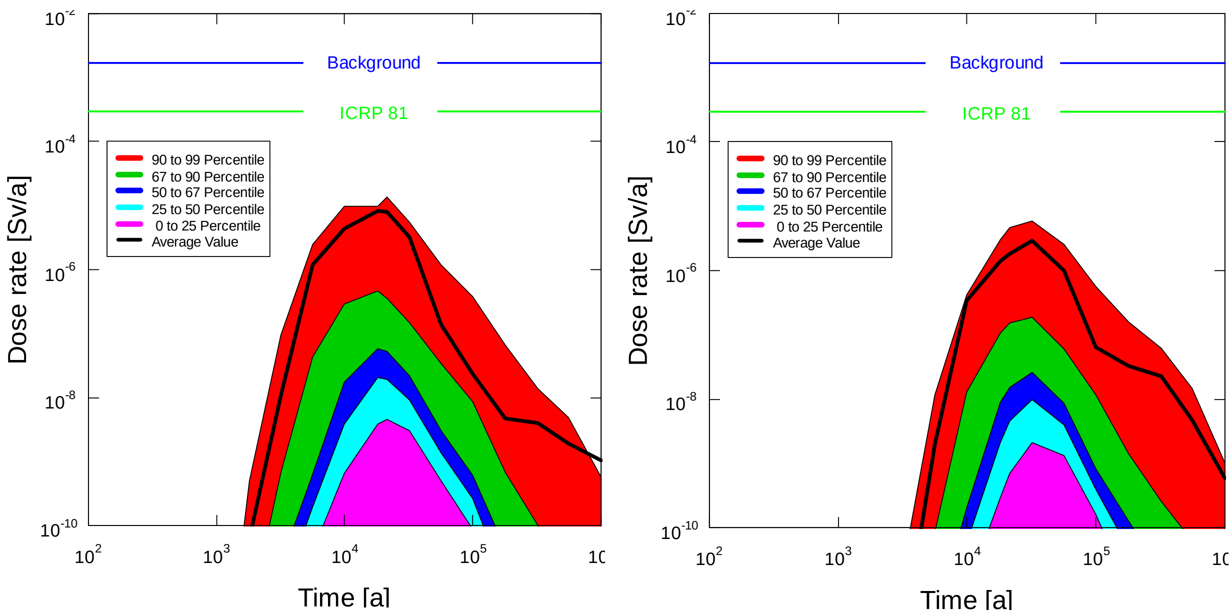
The processes for volatile generation and their subsequent transport involve numerous input parameters currently known with limited accuracy. Some of the potential consequences of gas generation and transient and possibly unstable two-phase flow transport are

- pressurization of the excavated repository volume with gas;
- partial desaturation of the local geosphere and desaturation of the most permeable formation or paths, particularly altering or modifying the desaturated groundwater draw-down cone created by the construction and operation of the proposed GWMF;
- dilation of flow paths by gas pressurization;
- potential damage to engineered sealing systems and structures or fracturing of bedrock, particularly in areas of very low permeability; and
- greater mass transport rates than that by liquid-phase flow through undisturbed bedrock.

The net result may be an increased rate of radionuclide transport, particularly for those radionuclides partitioning to the gas phase, which needs to be further analyzed.

## 8. PERFORMANCE AND SAFETY ASSESSMENT

Results from the normal-evolution-scenario simulations for the two hypothetical repository horizons analyzed by the Base Case hydrogeological modelling indicate that estimated dose rates to the critical group would be below the dose rate limit (i.e., $3\times10^{-4}$ Sv/a) recommended by the ICRP for long-term management of long-lived radioactive waste, even when taking into account a wide range of parameter uncertainties [13]. These include uncertainties in the diet of the critical group plus their farm's soil type, irrigation requirements and produce. Parameter uncertainties in the geosphere include elemental solubility limits in deep groundwaters, the sorption of moving contaminants onto minerals along a transport path and the rate at which contaminants are released from a protective container, concrete block or other protective matrix. Figure 5 shows early plots of total dose rates versus time for 1,000 randomly sampled simulations for both the 500-m-deep and 1,000-m-deep hypothetical repositories. In all cases the estimated dose rates fall well below the ICRP 81 limits. The systematic treatment of parameter uncertainty has included several different possibilities ('scenarios') into the assessment, notably the use of Maskinonge Lake sediment for the garden of the critical group (Figure 1).




(a) 500-m-deep Repository (b) 1,000-m-deep Repository

**Figure 5. Early estimates for the total (summed over all waste groups) average and percentile curves of estimated dose rate versus time from 1,000 randomly sampled simulations for the hypothetical (a) 500-deep-repository and the (b) 1,000-m-deep repository**

The systematic treatment of parameter uncertainty has included several different possibilities ('scenarios') into the assessment, notably the use of Maskinonge Lake sediment for the garden of the critical group (Figure 1). Overall, the results suggest that the total projected volume of the six LILW groups may be safely placed in a GWMF in the deep bedrock at CRL given the simplifications of the input geosphere parameters from the Base Case hydrogeological modelling and discounting low probability events that might act to disrupt the performance of the disposal system. Any effects from gas generation were not considered at this time as not enough is known about them.

The only significant contributors to dose rate, over the one-million-year time scale, are long-lived, mobile radionuclides that are not held up by engineered barriers. This is in agreement with other assessments of long-term radioactive waste management. The long-lived, nonsorbing radionuclides $^{129}$I, $^{36}$Cl and $^{14}$C are particularly important.

Sensitivity analyses show that estimated dose rates can be reduced by several orders of magnitude by locating high-hazard waste groups within repository sectors expected to possess the longest groundwater transit time to the surface. This suggests that the development of a waste-emplacement strategy could produce a significant benefit.

A formal probabilistic sensitivity analysis has not been carried out for the preliminary performance and safety assessment nor have the most important input parameters been identified that affect the maximum dose rate or affect the uncertainty in the dose rate.

## 9. UNKNOWNS AND UNCERTAINTIES

The characterization and analyses in this pre-project feasibility study are preliminary. The major unknowns and uncertainties in this pre-project study include the following:

- The general lack of knowledge and uncertainty to date of the nature (i.e., orientations, permeabilities) and pervasiveness of the fracturing system in the bedrock at the CRL site;
- No formal geosynthesis of the hydrogeological and hydrogeochemical data from all of the seven deep boreholes that were drilled during this pre-project feasibility study. Hydrogeological testing is still being performed in many of these new boreholes and so far only a few have been instrumented with multilevel borehole completion systems for long-term hydraulic-head monitoring and hydrogeochemical sampling. Sufficient time is needed for the hydraulic heads and groundwater chemistry conditions in the multilevel systems to stabilize from the drilling and testing disturbances before results are valid;
- A very simplified hydrogeological model (Base Case) was used based on an early geological model of the CRL bedrock that omits many of the details from a very recent upgraded bedrock geology model and lacks formal synthesis of the vast amount of new hydrogeologic and hydrogeochemical information that is being obtained by testing, monitoring and sampling in the new boreholes (see second bullet);
- The specific lack of detail on the radionuclide inventory for each of the LILW forms and general lack of knowledge on the compositions and masses of the LILW substrates needed for determining gas-generation rates;
- No formal analyses and estimates for potential gas-generation rates from the LILW nor the inclusion of two-phase flow in either the hydrogeological flow model or the resultant performance and safety assessment model; and
- A simplified normal-evolution-scenario performance and safety assessment based on the very simplified and preliminary Base Case hydrogeological model (see third bullet) that also omits the following: waste containers as engineered barriers; clay- or cement-based backfills; sorption of radionuclides to a sand-based backfill; lateral radionuclide diffusion or dispersion in the GEONET submodel; disruptive-event scenarios (e.g., inadvertent human intrusion such as a bedrock potable-water well, volcanism, fire, floods, glaciation and seismic events); and potential gas generation and release from the LILW in the GWMF.

## CONCLUSIONS

No features have been found to disqualify the bedrock of the CRL site from hosting a GWMF. The bedrock of the CRL site below a depth of 400 to 500 m appears to have a good potential to safely host a GWMF for CRL's LILW although the work to date is preliminary in nature [1]. The many unknowns and uncertainties, discussed above, will need to be addressed as part of any future detailed siting-characterization process, if the Government of Canada decides to initiate such a process.

## ACKNOWLEDGEMENTS

The authors would like to acknowledge the dedication and hard work of the entire GWMF feasibility team including all who worked in the field, in labs, in the core logging facility and in the office conducting the work, analyzing the data and reporting on the results. The GWMF feasibility study is funded by NRCan through the Nuclear Legacy Liabilities Program.

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