

**Canada's Deep Geological Repository for Used Nuclear Fuel – An Update on the Status of the Geoscientific Site Evaluation Process – 14643**

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**ABSTRACT**

The Nuclear Waste Management Organization (NWMO) is responsible for implementing Adaptive Phased Management (APM), the approach selected by the Government of Canada for long-term management of used nuclear fuel generated by Canadian nuclear reactors. The ultimate objective of APM is the centralized containment and isolation of Canada's used nuclear fuel in a Deep Geological Repository in a suitable crystalline or sedimentary rock formation.

In May 2010, the NWMO published and initiated a nine-step site selection process to find an informed and willing community to host a deep geological repository for Canada's used nuclear fuel. The site selection process is designed to address a broad range of technical and social, economic and cultural factors as identified through dialogue with Canadians and Aboriginal peoples. The suitability of potential candidate sites will ultimately be assessed against a number of site evaluation factors, both technical and social in nature. The suitability of candidate areas will be assessed in a stepwise manner over a period of many years and include three main steps: Initial Screenings; Preliminary Assessments; and Detailed Site Characterizations.

The Preliminary Assessment is conducted in two phases consisting of desktop (Phase 1) and field investigations (Phase 2). In November 2013, NWMO completed Phase 1 Preliminary Assessments for the first eight communities that entered into the Preliminary Assessment step. At this early phase of assessment, multidisciplinary studies have identified differences between communities in two important study areas. The first involves the geoscientific characteristics of the communities, including geological settings and structural histories, and associated complexities and uncertainties. Communities with greater geoscientific uncertainties and complexities are considered to have less potential to meet the APM Project requirements, as it would be more difficult and challenging to assemble a robust safety case. The second area involves differences in the potential for the APM Project to align with priorities and objectives of the community, and for the community to sustain interest in learning about the project.

This paper provides an update on the site evaluation process and describes the approach, methods and criteria that are being used to conduct the geoscientific Preliminary Assessment. The community well-being assessment is discussed in a companion paper (Facella, 2013).

**INTRODUCTION**

The Nuclear Waste Management Organization (NWMO) is responsible for implementing Adaptive Phased Management (APM), the approach selected by the Government of Canada for long-term management of used nuclear fuel generated by Canadian nuclear reactors. The ultimate

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objective of APM is the centralized containment and isolation of Canada's used nuclear fuel in a Deep Geological Repository in a suitable crystalline or sedimentary rock formation at a depth of approximately 500 m (1,640 ft).

The repository will consist of access and service shafts and a series of tunnels leading to placement rooms where used fuel will be placed and sealed in competent rock using a multi-barrier system which includes long-lived specially designed containers, clay-based sealing materials and the rock itself. The repository performance will be monitored throughout all phases of implementation and will also remain retrievable for an extended period of time.

Through a collaborative process in 2008 and 2009, NWMO worked with interested Canadians to develop the decision-making framework for selecting a site for the APM Project. The site selection process is designed to ensure safety, security and protection of people and the environment. Reflecting the guidance provided by Canadians, the site selection process is built on a set of principles that reflects the values and priorities of Canadians on this issue. The process also contains a number of steps and decision making points that Canadians told us need to be part of the process. These steps are illustrated in Table 1 and described in more detail in NWMO's site selection process document (NWMO, 2010).

A total of twenty-two communities, three in the Province of Saskatchewan and nineteen in the Province of Ontario, entered the site selection process by expressing interest in learning more about Canada's plan for the long-term management of used nuclear fuel and the APM Project (Step 2). As communities expressed interest, the NWMO undertook an Initial Screening as part of Step 2 studies and began working with each community as they learned about the project and reflected upon their interest in it. The purpose of the Initial Screening was to determine whether, based on readily-available information and five screening criteria, there were any obvious conditions that would exclude the community from further consideration in the site selection process. The initial screenings identified that twenty-one of the communities contained geological formations that would be potentially suitable for hosting a deep geological repository. One community, Red Rock, Ontario, was not considered a suitable candidate for continuing in the site selection process.

Of the twenty-one communities that successfully completed an Initial Screening, twenty have entered into Step 3 (Preliminary Assessments) of the site selection process as of December 2013. The NWMO began working with these communities to conduct a Preliminary Assessment to further assess their potential suitability. The ultimate objective of the Preliminary Assessment is to select one, possibly two, communities for detailed site characterizations (Step 4). The Step 3 Preliminary Assessment is a multidisciplinary desktop study integrating both technical and community well-being studies, including geoscientific suitability, engineering, transportation, environment and safety, as well as social, economic, and cultural considerations. The Preliminary Assessment is conducted in two phases consisting of desktop (Phase 1) and field investigations (Phase 2) as described in Table 1.

In November 2013, NWMO completed Step 3 (Phase 1) Preliminary Assessments for the first eight communities that entered into this step. Four communities (Creighton in Saskatchewan, and Ignace, Hornepayne and Schreiber in Ontario) were assessed as having strong potential to meet site selection requirements and were identified for further study (Figure 1). The communities of English River First Nation and Pinehouse in Saskatchewan, and Ear Falls and Wawa in Ontario,

were not selected for more detailed study. These findings do not affect work ongoing in the 13 other communities that are involved in earlier stages of the process (Figure 1).

This paper provides an update on the site evaluation process and describes the approach, methods and criteria that are being used to conduct the geoscientific Step 3 Preliminary Assessment. The community well-being assessment is discussed in a companion paper (Facella, 2013).



Figure 1: Communities in the Site Selection Process as of December, 2013

**Table 1: Steps in the Site Selection Process – At a Glance**

<b>Getting Ready</b>	<b>NWMO publishes the finalized siting process, having briefed provincial governments, the government of Canada, national and provincial Aboriginal organizations, and regulatory agencies on the NWMO's activities.</b> The NWMO will continue briefings throughout the siting process to ensure new information is made available and requirements which might emerge are addressed.
<b>Step 1</b>	<b>NWMO initiates the siting process with a broad program to provide information, answer questions and build awareness among Canadians about the project and siting process.</b> Awareness-building activities will continue throughout the full duration of the siting process.
<b>Step 2</b>	<b>Communities identify their interest in learning more and request an initial screening be conducted.</b> At the request of the community, the NWMO will evaluate the potential suitability of the community against a list of initial screening criteria.
<b>Step 3</b>	<p><b>For interested communities, a preliminary assessment of potential suitability is conducted.</b> At the request of the community, the NWMO will conduct a preliminary assessment collaboratively with the community to determine whether a site has the potential to meet the detailed requirements for the project. Interested communities will be encouraged to inform surrounding communities, including potentially affected Aboriginal communities and governments, as early as possible to facilitate their involvement.</p> <p><b>Phase 1:</b> For interested communities passing initial screening, a preliminary desk-top assessment is conducted. Some communities may be screened out based on these assessments. (approximately 18 months)</p> <p><b>Phase 2:</b> Field investigations and expanded regional engagement proceed with smaller number of communities. (potentially 3 years)</p>
<b>Step 4</b>	<b>For interested communities, potentially affected surrounding communities are engaged if they have not been already, and detailed site evaluations are completed.</b> In this step, the NWMO will select one or more suitable sites from communities expressing formal interest for regional study and/or detailed multi-year site evaluations. The NWMO will work collaboratively with these communities to engage potentially affected surrounding communities, Aboriginal governments and the provincial government in a study of health, safety, environment, social, economic and cultural effects of the project at a broader regional level (Regional Study), including effects that may be associated with transportation. Involvement will continue throughout the siting process as decisions are made about how the project will be implemented.
<b>Step 5</b>	<b>Communities with confirmed suitable sites decide whether they are willing to accept the project and propose the terms and conditions on which they would have the project proceed.</b>
<b>Step 6</b>	<b>NWMO and the community with preferred site enter into a formal agreement to host the project.</b> The NWMO selects the preferred site, and the NWMO and community ratify a formal agreement.
<b>Step 7</b>	<b>Regulatory authorities review the safety of the project through an independent, formal and public process and, if all requirements are satisfied, give their approvals to proceed.</b>
<b>Step 8</b>	<b>Construction and operation of an underground demonstration facility proceeds.</b>
<b>Step 9</b>	<b>Construction and operation of the facility.</b>

### STEP 3 PRELIMINARY ASSESSMENT

The NWMO has adopted an integrated approach to Preliminary Assessments. As outlined in the site selection process (NWMO, 2010), assessments focus on safety and community well-being, through study of many technical, scientific and social requirements for the project. This early phase of the assessment is guided by four overarching questions:

1. Safety, security and protection of people and the environment are central to the siting process. ***Is there potential to find a safe site?***
2. The project will be implemented in a way that will foster long-term well-being of the community. ***Is there potential to foster the well-being of the community through implementation of the project, and what might need to be put in place (e.g. infrastructure, resources, planning initiatives) to ensure this outcome?***
3. At a later step in the process, the community must demonstrate it is informed and willing to host the project. ***Is there potential for citizens in the community to continue to be interested in exploring this project through subsequent steps in the site selection process?***
4. The project will be implemented in a way that will foster the long-term well-being of the surrounding area. ***Is there potential to foster the well-being of the surrounding area and to establish the foundation to move forward with the Project?***

These broad questions are addressed through a series of multidisciplinary studies, including geoscientific suitability, engineering, transportation, environment and safety, as well as social, economic and cultural considerations (Figure 2).

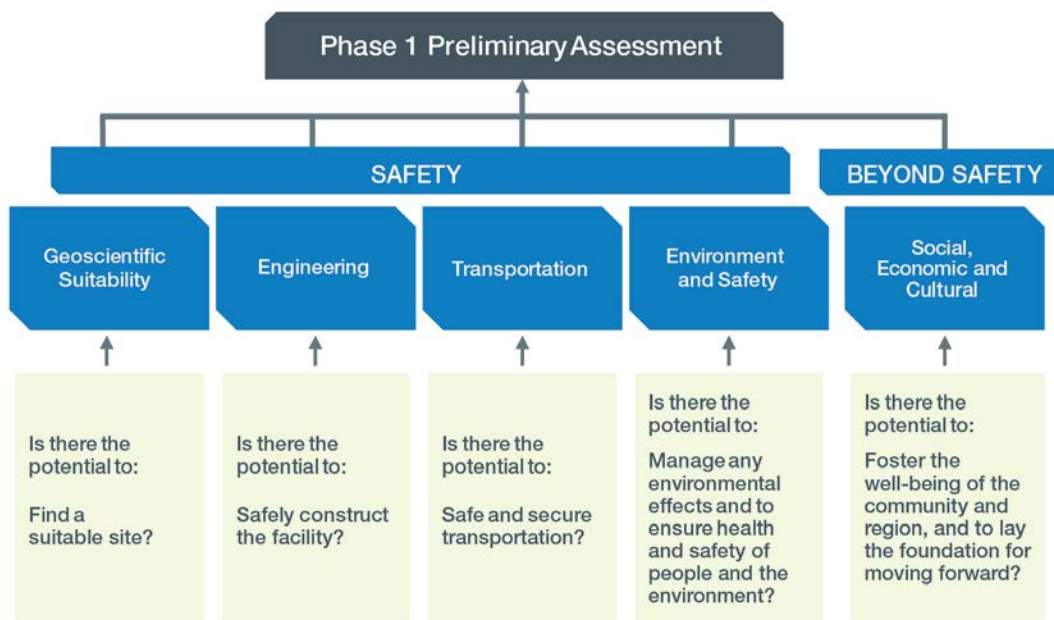


Figure 2: Structure of Step 3 Preliminary Assessments

### **Geoscientific Preliminary Assessment Component**

The objective of the geoscientific component of the Preliminary Assessment is to assess whether a candidate area contains general areas that have the potential to satisfy the geoscientific evaluation factors outlined in the site selection process document (NWMO, 2010). The Preliminary Assessment is conducted in two phases:

**Phase 1 - Desktop Study:** For all communities electing to be the focus of a preliminary assessment. This phase involves desktop studies using available geoscientific information and a set of key geoscientific characteristics and factors that can be realistically assessed at the desktop phase of the preliminary assessment.

**Phase 2 - Preliminary Field Investigations:** For a subset of communities selected by the NWMO, to further assess potential suitability. This phase will involve a site investigation that includes high resolution geophysical surveys, geological mapping and the drilling of a few deep boreholes.

The Phase 1 Desktop Geoscientific Preliminary Assessment included the following review and interpretation activities:

- Detailed review of available geoscientific information such as geology, structural geology, natural resources, hydrogeology and overburden deposits;
- Interpretation of available geophysical surveys (magnetic, electromagnetic, gravity, radiometric);
- Lineament studies using available satellite imagery, topography and geophysical surveys to provide information on the characteristics such as location, orientation and length of interpreted structural bedrock features;
- Terrain analysis studies to help assess overburden type and distribution, bedrock exposures, accessibility constraints, watershed and subwatershed boundaries, groundwater discharge and recharge zones; and
- The identification of general potentially suitable areas based on key geoscientific characteristics and the systematic application of NWMO's geoscientific site evaluation factors.

Suitability of potential general areas is evaluated against a number of geoscientific site evaluation factors, organized under five safety functions that a site would need to ultimately satisfy in order to be considered suitable:

1. **Safe containment and isolation of used nuclear fuel:** Are the characteristics of the rock at the site appropriate to ensuring the long-term containment and isolation of used nuclear fuel from humans, the environment and surface disturbances caused by human activities and natural events?

2. ***Long-term resilience to future geological processes and climate change:*** Is the rock formation at the siting area geologically stable and likely to remain stable over the very long term in a manner that will ensure the repository will not be substantially affected by geological and climate change processes such as earthquakes and glacial cycles?
3. ***Safe construction, operation and closure of the repository:*** Are conditions at the site suitable for the safe construction, operation and closure of the repository?
4. ***Isolation of used fuel from future human activities:*** Is human intrusion at the site unlikely, for instance through future exploration or mining?
5. ***Amenable to site characterization and data interpretation activities:*** Can the geologic conditions at the site be practically studied and described on dimensions that are important for demonstrating long-term safety?

Based on the overall findings of the Phase 1 desktop preliminary assessments, considering both technical and community well-being factors presented in Figure 2, a subset of communities will be considered in Phase 2 of the preliminary assessment.

#### **FINDINGS: STEP 3 (PHASE 1) GEOSCIENTIFIC DESKTOP PRELIMINARY ASSESSMENT FOR THE EIGHT INITIAL COMMUNITIES**

NWMO has completed an initial group of Step 3, Phase 1 Preliminary Assessments in collaboration with the communities that expressed interest in learning about Canada's plan for the safe, long-term management of used nuclear fuel. This group consists of the first eight communities that entered the site selection process, including: Creighton, Pinehouse and English River First Nation in Saskatchewan and Ear Falls, Ignace, Schreiber, Hornepayne and Wawa in Ontario.

The findings of the Phase 1 Preliminary Assessment for each of the first eight communities are summarized in an integrated report and a series of supporting documents. All reports are posted on NWMO's website ([http://www.nwmo.ca/sitingprocess\\_phase1](http://www.nwmo.ca/sitingprocess_phase1)). At this early phase of assessment, multidisciplinary studies have identified differences between communities in two important study areas. The first involves the geoscientific characteristics of the communities, including geological settings and structural histories, and associated complexities and uncertainties. Communities with greater geoscientific uncertainties and complexities are considered to have less potential to meet the APM Project requirements, as it would be more difficult and challenging to assemble a robust safety case. The second area involves differences in the potential for the APM Project to align with priorities and objectives of the community, and for the community to sustain interest in learning about the project. This paper provides an overview of the desktop geoscientific assessments. The community well-being assessments are discussed in a companion paper (Facella, 2013).

The geoscientific suitability of the communities was assessed in a consistent manner using a wide range of data sources, including geophysical surveys, geological maps, technical reports and papers, and government geoscientific databases. Geoscientific suitability is the first consideration in identifying communities and areas that warrant further study, as no decision will be made that compromises safety.

The assessments showed that each community contains general areas that have the potential to satisfy the geoscientific safety requirements for hosting a deep geological repository. However, the assessment identified varying degrees of geoscientific complexity and uncertainty between communities, reflecting their different geological settings and structural histories. On the basis of both geoscientific and social considerations, four of the eight communities were identified as having strong potential to meet site selection requirements and have been identified as candidates for Phase 2 of the Preliminary Assessment. These communities include Creighton in Saskatchewan, and Ignace, Hornepayne and Schreiber in Ontario (Figure 1). Findings to date do not confirm suitability of any site, and no community has expressed willingness to host the project at this early point in the site evaluation process.

The Phase 1 Geoscientific Desktop Preliminary Assessment also identified several geoscientific characteristics that would need to be better understood in each of the communities through Phase 2 Preliminary Field Investigations, these relate to:

- The geological characteristics relevant for assessing the containment and isolation function of the potential host rock, including rock type, lithological homogeneity, thickness and lateral extent;
- The potential influence of known and interpreted structures such as fractures, faults and dykes on the integrity of the host rocks and the ability to find siting areas with sufficient volumes of suitable rock;
- The potential impact of surface conditions within the candidate areas on site characterization and repository construction. These include the distribution and thickness of the overburden deposits (surficial soils), topography and surface water bodies; and
- The potential for the repository to be disturbed by future human activities through exploration and exploitation of natural resources.

### **NEXT STEPS: STEP 3 (PHASE 2) GEOSCIENTIFIC PRELIMINARY FIELD INVESTIGATIONS**

For communities that continue to Phase 2 of the preliminary assessment (Table 1), the next phase of work involves more intensive technical studies, community learning and engagement activities. Technical evaluation of potentially suitable areas will continue to focus on geoscientific suitability, engineering, transportation, environment and safety. Engineering designs, transportation assessments, environment assessments and safety assessments will be further developed and refined over the course of Phase 2 to determine whether all technical and safety criteria can be met and are not discussed further herein.

Geoscientific preliminary field investigations will provide site-specific information that will be used to further assess the geoscientific uncertainties identified during Phase 1 studies, and provide more insight into the suitability of each area. Activities will include a sequence of high-resolution airborne geophysical surveys and focused geological field mapping to ground-truth lithology and structural features, followed by limited deep borehole drilling and testing. The community, surrounding communities, and Aboriginal peoples will be engaged to help refine the list of potentially suitable siting areas.



### **Incorporating Aboriginal Traditional Knowledge in the site selection process**

Aboriginal peoples have a special relationship with the natural environment, and unique stewardship responsibilities that are part of this relationship. The knowledge that comes from this relationship with the land brings special understanding to the broad range of factors that should be considered in field studies, social assessments, and assessing benefits and effects to be managed.

The NWMO will work together with Aboriginal communities in potential siting areas to respectfully apply Traditional Knowledge to both technical safety and community well-being aspects of the site selection process. Traditional Knowledge will also guide the NWMO's engagement with Aboriginal communities and local Elders, providing guidance on spiritual and cultural considerations, and developing and maintaining effective and meaningful relationships between generations and within and between communities. The NWMO expects that integrating Aboriginal Traditional Knowledge into the identification and assessment of potentially suitable sites will lead to an expanded set of considerations to assess the suitability of a site, new and different approaches to data collection and interpretation, and a perspective on ways of life that will be important to informing more detailed studies.

### **CONCLUSION**

The Preliminary Assessment is a multi-disciplinary study, integrating both technical and community well-being studies, including geoscientific suitability, engineering, transportation, environment and safety, as well as social, economic and cultural considerations. The Preliminary Assessment is conducted in two phases consisting of desktop (Phase 1) and field investigations (Phase 2). As of November 2013, NWMO has completed Phase 1 Preliminary Assessments for eight communities that are in the site selection process. Four of the eight communities show strong potential to meet site selection requirements and have been identified as candidates for Phase 2 of the Preliminary Assessment. These communities include Creighton in Saskatchewan, and Ignace, Hornepayne and Schreiber in Ontario. These findings do not affect work ongoing in the 13 other communities that are involved in earlier stages of the process.

The objective of the Phase 1 Geoscientific Desktop Preliminary Assessment component was to determine whether the community contains general areas that have the potential to meet the geoscientific evaluation factors outlined in the site selection process document (NWMO, 2010). While the assessments showed that each of the eight communities contains general areas that have the potential to satisfy the geoscientific safety requirements for hosting a deep geological repository, the assessment identified varying degrees of geoscientific complexity and uncertainty between communities, reflecting their different geological settings and structural histories. The Phase 1 studies also identified several geoscientific characteristics that would need to be better understood in each of the communities through Phase 2 Preliminary Field Investigations. Phase 2 activities will include airborne geophysical surveys, geological field mapping, and deep borehole drilling and testing. These activities will further evaluate the site's ability to meet the safety functions that a site would need to ultimately satisfy in order to be considered suitable.

**REFERENCES**

1. Facella, 2013. Site Selection Canada's National Repository for Used Nuclear Fuel. WMSymp paper 14602.
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