NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

Preliminary Assessment for Siting a Deep Geological Repository for Canada's Used Nuclear Fuel

The Corporation of the Township of Hornepayne, Ontario

FINDINGS FROM PHASE ONE STUDIES

APM-REP-06144-0001

NOVEMBER 2013

About the NWMO and its work

The Nuclear Waste Management Organization (NWMO) was created by Canada’s nuclear energy generators in 2002 as a requirement of the *Nuclear Fuel Waste Act*. The Act requires the NWMO to study, recommend and then implement a plan for the long-term management of used nuclear fuel in Canada.

The NWMO approaches its work with the following vision: the long-term management of Canada's nuclear waste in a manner that safeguards people and respects the environment, now and in the future.

The NWMO is guided by five fundamental values:

Integrity: We will conduct ourselves with openness, honesty and respect for all persons and organizations with whom we deal.

Excellence: We will pursue the best knowledge, understanding and innovative thinking in our analysis, engagement processes and decision-making.

Engagement: We will seek the participation of all communities of interest and be responsive to a diversity of views and perspectives. We will communicate and consult actively, promoting thoughtful reflection and facilitating a constructive dialogue.

Accountability: We will be fully responsible for the wise, prudent and efficient management of resources, and be accountable for all our actions.

Transparency: We will be open and transparent in our process, communications and decision-making, so that the approach is clear to all Canadians.

The work of the NWMO is subject to federal regulatory oversight and is regulated under the *Nuclear Safety and Control Act*. The NWMO's work is required to meet all applicable regulatory standards and requirements for protecting the health and safety of persons, the environment and national security, and to respect Canada's international commitments on the peaceful use of nuclear energy. For financial surety, its work is also required to be fully funded by the waste-producing organizations through independently managed trust funds.

Preface

Since May 2010, the Nuclear Waste Management Organization (NWMO) has worked collaboratively with interested communities to implement Adaptive Phased Management (APM), Canada's plan for the safe, long-term care of used nuclear fuel. At this early point in the multi-year site selection process, the focus of work is on exploring potential to meet specific requirements to safely host a deep geological repository and Centre of Expertise, the core components of Canada's plan.

Findings summarized in this document have emerged from studies conducted as part of Phase 1 of the Preliminary Assessment, the initial phase of study in Step 3 of the nine-step process for selecting a site. The document reviews the outcome of desktop studies that explored the potential to find a site that can safely and securely contain and isolate used nuclear fuel from people and the environment for the long time period required. It also summarizes learning that transpired through working with the community to build understanding about APM and to explore the project's potential to align with the long-term vision of the community in a way that contributes to its well-being.

The Township of Hornepayne is one of 21 communities engaged in exploring potential interest in hosting this national infrastructure project. Findings from its Phase 1 preliminary assessment are intended support the Township and the NWMO in taking stock of the community's potential to meet the requirements for hosting APM facilities. These assessments also provide the basis upon which the NWMO will identify a smaller number of communities to be the focus of the next phase of more detailed studies.

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The journey of the Township of Hornepayne in the APM process began in December 2010 when the Mayor and Council approached the NWMO to learn more about the program. This request came to the NWMO in response to an open invitation to learn more about APM, with the understanding the community could end its involvement at any time. Highlights of Hornepayne's engagement to date in this Learn More process are provided below.

In March 2011, Council representatives, community members and the Municipal Clerk received a briefing from the NWMO in Toronto about Canada's plan and the site selection. They also toured OPG's Pickering waste management facility to learn how used nuclear fuel is managed.

Later in March 2011, the Hornepayne Council passed a resolution requesting an initial screening of the community's potential suitability for the project. In March 2011, the NWMO delivered a presentation at a Council meeting to review the plan for conducting the initial screening and to confirm details of the work.

Upon completing this work in June 2011, the NWMO and the contractor that conducted the work presented findings of the screening to Council. Copies of the final report (summary version, as well as detailed report) were also provided. The report's findings indicated that *"the review of readily available information and application of the five initial screening criteria did not identify obvious conditions that would exclude the Township of Hornepayne from further consideration in the site selection process.*"
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At the invitation of Council, in June 2011 the NWMO convened an open house in Hornepayne to share initial screening results and information about the project and site selection process. Individuals and groups who met with the NWMO during this event included Town Council and staff, students, representatives from the business community, seniors, and emergency and health-care first responders.

The Township has actively pursued learning opportunities to become better informed about the project and nuclear waste management in general. To make information about the project and the site selection process readily available to community members, Council asked the NWMO to set up an information kiosk about the APM project at the municipal office.

In June 2011, a small delegation from the community attended the Federation of Canadian Municipalities conference to hear from representatives of Swedish communities who had been involved in a similar site selection process. Community representatives also attended meetings in the community in July 2011 by environmental groups to hear alternative perspectives. In September 2011, representatives of Hornepayne attended the Canadian Nuclear Society conference in Toronto to learn from the perspective of a broad range of specialists, and to hear first-hand about progress, issues and challenges associated with nuclear waste management practices in Canada and other countries. In September 2011, community representatives also met with the Canadian Nuclear Safety Commission (CNSC) at its office in Ottawa to learn about the regulatory framework and oversight for the APM project, meet individual subject matter experts and have questions addressed. The costs associated with these learning activities were covered by the NWMO as part of a funding program provided to interested communities.

In Fall 2011, Council expressed an interest in learning more about Preliminary Assessments, the next step in the site selection process. At their request, in November 2011 the NWMO provided a briefing that outlined what would be involved should the Township wish to proceed to this step.

After further consideration, Council passed a resolution in December 2011 expressing its interest in continuing to learn more about APM and to initiate feasibility studies by proceeding to Step 3 for the first phase of preliminary assessment activities.

To facilitate learning and dialogue in the community, Council established a Community Liaison Committee (CLC). Members were selected through an open invitation process. The committee's inaugural meeting was held in November 2011. The CLC was directed by Council to help facilitate involvement of community members in learning about the project in an open and inclusive manner, and to help inform NWMO studies.

In the period that followed, the Council, the CLC and the NWMO worked together to review plans for the range of technical and social well-being studies associated with the Phase 1 assessment process. They also reviewed the resource program available to the community to support activities to learn about and reflect on its interest in the project, encourage local discussion, and engage with the NWMO as the assessment was undertaken. The community worked closely with the NWMO to plan local dialogues and engagement, as well as early outreach to surrounding communities and Aboriginal people.

To support engagement in the assessment process, the CLC established a monthly meeting schedule, with NWMO staff attending as requested to be part of the discussion and work with the committee to complete preliminary assessment studies. These meetings were advertised in advance and opened to the public. The committee also appointed a CLC project coordinator, established a CLC website and a regular community newsletter, sought presentations from NWMO staff specialists about topics of interest to CLC members, and helped organize open houses. At these open houses, NWMO specialists used interactive exhibits, videos, poster displays and printed materials to help explain various aspects of APM and answer questions about the project.

Working collaboratively, the Township, the CLC and the NWMO undertook a wide range of outreach activities with local individuals and groups such as first responders, educators, health-care providers, business leaders, environmental groups, and community members. To support ongoing dialogue with the community, the NWMO opened a local office in the community in 2012. The NWMO also took part in a number of community activities, such as the Hornepayne winter festival and the family fishing derby, as a way to interact with residents and share information about the project. A broad range of community leaders was engaged through individual briefings and conversations held as part of the study process.

The CLC made a visit to an OPG interim storage facility at Darlington in November 2012 and met with CNSC representatives at a CLC meeting held in March 2013. Community representatives also attended meetings held in the community in November 2012 by environmental groups to hear alternative perspectives. In September 2012, a small community delegation attended the International Conference on Geological Repositories to learn about how other countries are approaching site selection processes.

The CLC actively involved the community in the development of a community profile and community well-being assessment report. Open houses were organized to share the progress of studies and learning, and to seek input from community members.

Open houses were convened in the Spring of 2012 to engage community members in discussion of the work involved in Phase 1 studies and in the Fall to report on findings of work to date.

Led by the CLC, outreach and engagement activities in 2013 included hosting the NWMO's Mobile Transportation Exhibit. This exhibit provided community members an opportunity to see a licensed used fuel transportation container, and learn more about the robust regulations, policies and procedures that must be met. The exhibit's visit to the community in July 2013 coincided with Family Fishing Day.

Recognizing the importance of engaging surrounding communities and Aboriginal peoples in discussion about this project, the Township and the NWMO began to reach out to groups and individuals beyond the community in a very preliminary way. This outreach included First Nations and Métis communities, mayors and Council members of neighbouring communities, and a variety of regional groups, including the Northeast Superior Mayors' Group.

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The objective of the site selection process, through several phases of progressively more detailed assessments, is to arrive at a single location for both the deep geological repository for Canada's used nuclear fuel and for the Centre of Expertise. The preferred site will need to ensure safety and security for people and the environment and contribute to the well-being of the area. Selecting a site will require many more years of detailed technical, scientific and social study and assessments, and much more engagement with interested communities, as well as surrounding communities and Aboriginal peoples.

With 21 communities engaged in exploring their interest and suitability for hosting APM, the site selection process must provide a basis for progressively identifying a smaller number of communities for more detailed assessment. Through increasingly more detailed studies, communities with strong potential to meet the project's specific requirements will be identified to become the focus of further assessment.

This process of stepwise reflection and decision-making will be supported by a sequence of assessments and engagement that will enable the NWMO and communities to learn more about the suitability of each potential siting area and make decisions about where to focus more detailed work. Communities may choose to end their involvement at any point during the site evaluation process until a final agreement is signed, subject to all regulatory requirements being met and regulatory approvals received.

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1. INTRODUCTION

1.1 The Purpose of This Document

Since May 2010, the Nuclear Waste Management Organization (NWMO) has worked with interested communities to implement Adaptive Phased Management (APM), Canada's plan for the long-term care of used nuclear fuel. Over the past two years, the NWMO has worked collaboratively with interested communities to begin to explore their potential to meet site selection requirements for locating the deep geological repository and Centre of Expertise, the core components of Canada's plan.

Following a road map for decision-making that was developed collaboratively through two years of public engagement, the site selection process is now advancing through a multi-year series of steps and engagement to ensure, above all, that the site which is selected is safe and secure, and meets the highest scientific, professional and ethical standards.

This document, together with a series of supporting reports, captures learning to date from the Phase 1 Preliminary Assessment conducted with the Township of Hornepayne, Ontario.

Findings summarized in this document have emerged from studies conducted as part of Phase 1 of the Preliminary Assessment – the initial phase of study in Step 3 of the nine-step site selection process. The document reviews the outcome of desktop studies that explored the potential to find a site which can safely and securely contain and isolate used nuclear fuel from people and the environment for the long time period required. It also summarizes the learning that has emerged through working with the community to help them understand the safety of the project, and explore the potential for the project to align with the values and aspirations of the community over the long term and contribute to the well-being of the community and area.

The findings presented in this Phase 1 report are intended to provide input to early stock-taking of the potential for the community to meet the requirements to host the APM facilities. It is also intended to be an aid in NWMO decision-making to identify the smaller number of communities as the focus of more detailed Phase 2 studies, should the community be willing to continue in the process.

1.2 Towards Partnership

Although the focus of this assessment is the Township of Hornepayne, it is understood that a broader partnership involving surrounding communities and Aboriginal peoples would be needed in order for the project to proceed in this or any other area.

Through working with Hornepayne and other communities involved in the site selection process in Phase 1 activities, and initial outreach with surrounding communities and Aboriginal peoples, the nature and shape of the partnerships required to implement the APM Project is beginning to emerge. This project will only proceed with the involvement of the interested community, surrounding communities and potentially affected Aboriginal peoples in an area working in partnership to implement the project.

1.3 A Matter of Responsibility

For decades, Canadians have been using electricity generated by nuclear power reactors in Ontario, Quebec and New Brunswick. Just over 2 million used fuel bundles have been produced. When used nuclear fuel is removed from a reactor, it is considered a waste product, is radioactive and requires careful management. Although its radioactivity decreases with time, chemical toxicity persists and the used fuel will remain a potential health risk to people and the environment for many hundreds of thousands of years. Canada's used nuclear fuel is now safely stored on an interim basis at licensed facilities located where it is produced. Putting in place a plan for the long-term, safe and secure management of used nuclear fuel for the protection of people and the environment is an important responsibility that Canadians share. Through dialogues with citizens and Aboriginal peoples across Canada, the NWMO has heard that this generation wants to move forward in dealing with our used nuclear fuel, believing it to be imprudent and unfair to future generations to wait any longer.

1.4 The Foundation of Canada's Plan

The Government of Canada selected Canada's plan for the long-term management of used nuclear fuel in 2007. The plan, called Adaptive Phased Management, involves the development of a large national infrastructure project in an informed and willing host community. The project involves the long-term containment and isolation of used nuclear fuel from people and the environment in a deep geological repository in a suitable rock formation. It also involves the development of a Centre of Expertise and transportation plan.

As required by the *Nuclear Fuel Waste Act*, 2002, the NWMO is responsible for implementing Canada's Plan. The NWMO is committed to carrying out its work collaboratively with interested and affected citizens and organizations in a manner that is socially acceptable, technically sound, environmentally responsible and economically feasible.

Adaptive Phased Management (APM) – At a Glance:

- *Was developed through a nationwide dialogue between 2002 and 2005*
- *Was selected as Canada's plan by the Government of Canada in 2007, consistent with the* Nuclear Fuel Waste Act
- *Key features include:*
  - *Safe and secure centralized containment and isolation of used nuclear fuel in a repository deep underground in a suitable rock formation*
  - *A series of steps and clear decision points that can be adapted over time*
  - *An open, inclusive and fair siting process to identify an informed and willing host community*
  - *Opportunities for people and communities to be involved throughout the implementation process*
  - *Optional temporary shallow storage at the central site, if needed*
  - *Long-term stewardship through the continuous monitoring of used fuel*
  - *Ability to retrieve the used fuel over an extended period should there be a need to access the waste or take advantage of new technologies*
  - *Financial surety and long-term program funding to ensure the necessary money will be available for the long-term care of used nuclear fuel*

1.5 The Site Selection Process

Through a collaborative process in 2008 and 2009, the NWMO worked with interested Canadians to develop the decision-making framework for selecting a site for the project. The site selection process is laid out in the NWMO's document: "*Moving Forward Together: Process for Selecting a Site for Canada's Deep Geological Repository for Used Nuclear Fuel*" (NWMO, 2010).

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 that these Canadians told us need to be part of the decision-making process to ensure it is an appropriate one for Canada, as set out in the table on the next pages.

Phase 1 Preliminary Assessments are conducted as part of Step 3 activities early in the site selection process. Several additional steps must be completed over the course of the next several years before a preferred site will be identified and environmental assessment and regulatory review will be sought. Interested communities may leave the site selection process at any time during this process until a final agreement is signed, subject to all regulatory requirements being met and regulatory approval received.

It is fundamental to the siting process that only an informed and willing community be selected to host the project as evidenced by a compelling demonstration of willingness involving community residents. The project will only be implemented in an area in which robust safety requirements can be met and well-being will be fostered.

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

Getting Ready	**The 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**. The NWMO will continue briefings throughout the siting process to ensure new information is made available and requirements which might emerge are addressed.
Step 1	**The 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.** Awareness-building activities will continue throughout the full duration of the siting process.
Step 2	**Communities identify their interest in learning more, and the NWMO provides detailed briefing. An initial screening is conducted.** At the request of the community, the NWMO will evaluate the potential suitability of the community against a list of initial screening criteria.
Step 3	**For interested communities, a preliminary assessment of potential suitability is conducted.** At the request of the community, the NWMO will conduct a feasibility study collaboratively with the community to determine whether a site has the potential to meet the detailed requirements for the project. Regional engagement will be initiated, and an initial review of transportation considerations will be conducted. Interested communities will be encouraged to inform surrounding communities, including potentially affected Aboriginal communities and governments, as early as possible to facilitate their involvement.
	Phase 1: For interested communities passing the Initial Screening, a preliminary desktop assessment is conducted. Some communities may be screened out based on these assessments (one year or more).
	Phase 2: Field investigations and expanded regional engagement proceed with smaller number of communities (three to four years).
Step 4	**For interested communities, potentially affected surrounding communities are engaged if they have not been already, and detailed site evaluations are completed.** 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.

Step 5	**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.**
Step 6	**The NWMO and the community with the preferred site enter into a formal agreement to host the project.** The NWMO selects the preferred site, and the NWMO and community ratify a formal agreement.
Step 7	**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.** The implementation of the deep geological repository will be regulated under the *Nuclear Safety and Control Act* and its associated regulations to protect the health, safety and security of Canadians and the environment, and to respect Canada's international commitments on the peaceful use of nuclear energy. Regulatory requirements will be observed throughout all previous steps in the siting process. The documentation produced through previous steps, as well as other documentation that will be required for a licence application, will be formally reviewed by regulatory authorities at this step through an Environmental Assessment, and if this assessment is successful, then licensing hearings related to site preparation (and possible construction) of facilities associated with the project. Various aspects of transportation of used nuclear fuel will also need to be approved by regulatory authorities.
Step 8	**Construction and operation of an underground demonstration facility proceeds.**
Step 9	**Construction and operation of the facility**.

1.6 Initial Community Involvement

Communities involved in this stage of work 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 part of an open invitation process.

With this expression of interest, the NWMO undertook an Initial Screening as part of Step 2 studies and began working with the 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.

For communities that successfully completed an Initial Screening and decided to enter Step 3 of the site selection process (Preliminary Assessments), the NWMO began working with the community to conduct a preliminary assessment. The purpose of Preliminary Assessments is to continue the learning and reflection process within the community, begin to involve surrounding communities and Aboriginal peoples in the process, and further explore the potential for the community to meet the detailed requirements for the project with more detailed scientific and technical studies.

Currently, there are 21 communities involved in the site selection process (20 are in Step 3; one is in Step 2). Figure 1-1 maps the locations of these communities in Saskatchewan and Ontario.

Figure 1-1: Communities Currently Involved in the Site Selection Process

1.7 Approach to Preliminary Assessments

Preliminary Assessments address siting factors and criteria as described in the NWMO's document: "*Moving Forward Together: Process for Selecting a Site for Canada's Deep Geological Repository for Used Nuclear Fuel*" (NWMO, 2010). Preliminary Assessment studies in Step 3 of the siting process are being conducted in two phases, with the opportunity for stock-taking by both the community and the NWMO throughout.

- ***Phase 1:*** Assessments are conducted with all communities that successfully completed an Initial Screening and asked to be the focus of a Preliminary Assessment. This phase involves desktop studies to explore the potential to meet safety requirements, and includes studies of engineering, geoscientific suitability, environment and safety, and transportation. This phase also involves community-learning about the project, and engagement and reflection on the potential for the project to foster the well-being of the community and fit with its long-term vision. Working with communities, this phase also explores early indications as to whether it would be possible to sustain interest in learning through subsequent phases of work required to support informed decision-making and a compelling demonstration of willingness at a future stage. This phase begins to involve surrounding communities and Aboriginal peoples in a dialogue about the project that would continue in future phases. This phase of work is completed in a year or more.

- ***Phase 2:*** Assessments are conducted with a smaller number of interested communities selected by the NWMO based on the outcome of Phase 1 studies. Phase 2 work will further assess potentially suitable areas through detailed technical studies and field investigations. This phase also involves more detailed exploration of the potential to foster the well-being of the community. Learning and engagement are expanded to involve surrounding communities and Aboriginal peoples in exploring the potential to foster the well-being of the larger area, interest in the project, and the foundation to work together in partnership to implement the project. Together, the NWMO, potentially suitable communities, surrounding communities and Aboriginal peoples will reflect upon the suitability of the community and area to host the APM Project. Phase 2 Preliminary Assessments are expected to require approximately three to four years to complete.

The focus of the preliminary assessments to date has been on Phase 1. The two-phased approach to assessments is discussed in "*Preliminary Assessment of Potential Suitability – Feasibility Studies*" (NWMO, 2011).

The NWMO has adopted an integrated approach to Preliminary Assessments, with assessments focused on safety and community well-being through study of many technical, scientific and social requirements for the project.

In assessing the siting factors and criteria, four overarching research questions have guided this early phase of Preliminary Assessment, and have been a focus of reflection by both the NWMO and the community. These questions are discussed in more detail in *Preliminary Assessment of Potential Suitability – Feasibility Studies* (NWMO, 2011).

1. Safety, security and protection of people and the environment are central to the siting process. ***Is there potential to find a safe site?***

   Safety was examined through several perspectives:
   - **Potential to find a site with suitable geology.**
   - **Potential to safely construct the facility at the potential site.**
   - **Potential for safe and secure transportation to the potential site.**
   - **Potential to manage any environmental effects and to ensure safety of people and the environment.**

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 the 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 were addressed through a series of studies as outlined in the following figure.

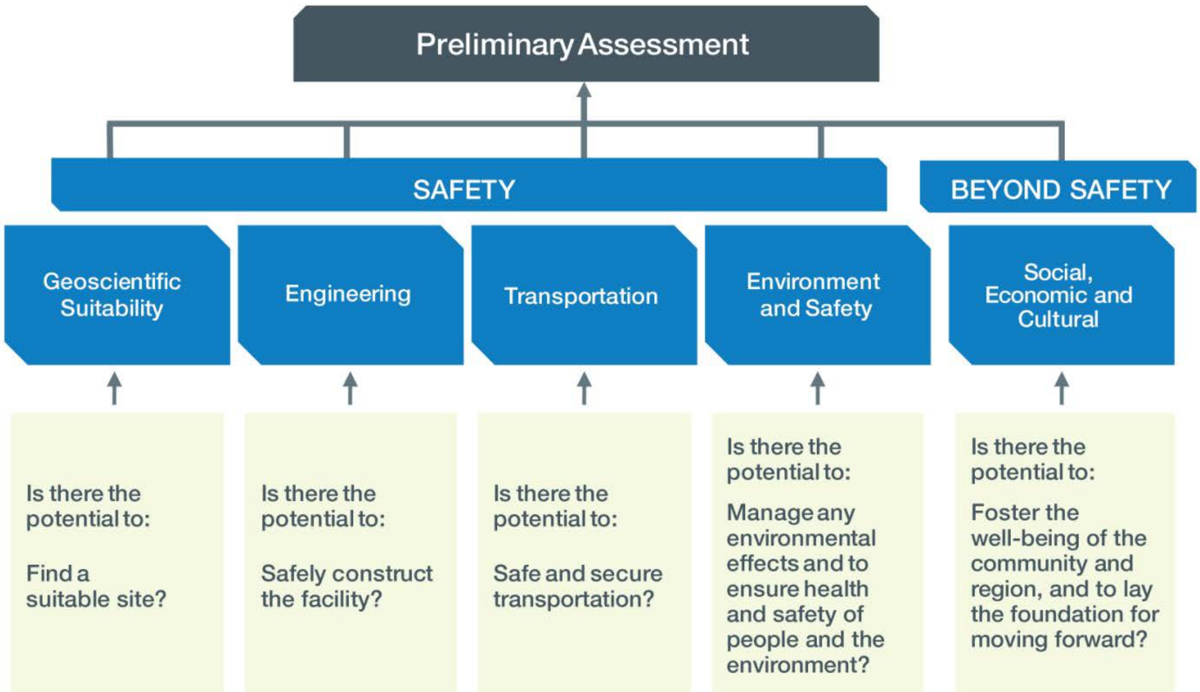

Figure 1-2: The Phase 1 Preliminary Assessment Studies

In Phase 1, studies have involved a range of activities. Some activities have been completed by expert consultants, such as the assessment of the geological characteristics of the area, which is one of several studies focused on assessing the potential to find a safe site. Other activities were completed in partnership with the community; for instance, exploring the potential for the project to be implemented in a way that contributes to the long-term well-being of the community. Throughout, the NWMO has worked with community leaders to engage residents, and begin to reach out to surrounding communities, Aboriginal peoples and others in the area to involve them in the work. In Phase 2, these studies will be expanded through commencement of fieldwork and broadened engagement with communities progressing to Phase 2.

As discussed in the NWMO site selection process, the suitability of potential sites is assessed against a number of site evaluation factors, organized under six safety functions a site would need to satisfy to be considered suitable (NWMO, 2010). Phase 1 safety assessment studies initiated exploration of a subset of these factors using a desktop study approach. Phase 2 assessments will include field studies and borehole investigation, which will allow for a broadening of the assessment to more comprehensively address the evaluation factors. The six safety evaluation factors are:

- ***Safe containment and isolation of used nuclear fuel****:* Are the characteristics of the rock at the site appropriate to ensuring long-term containment and isolation of used nuclear fuel from humans, the environment and surface disturbances caused by human activities and natural events?
- ***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 process such as earthquakes and glacial cycles?
- ***Safe construction, operation and closure of the repository****:* Are conditions at the site suitable for the safe construction, operation and closure of the repository?
- ***Isolation of used fuel from future human activities:*** Is human intrusion at the site unlikely, for instance through future exploration or mining?
- ***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?
- ***Safe transportation:*** Does the site have a route that exists or is amenable to being created that enables the safe and secure transportation of used fuel from storage sites to the repository site?

A number of factors beyond safety were identified for assessment of the potential for the project to foster the well-being of the interested community (NWMO, 2010). Phase 1 community well-being studies were focused on each community that expressed interest in learning about the project. For this reason, the studies addressed the subset of factors pertaining to the community. Phase 2 studies are designed to expand the assessment to consider factors related to the surrounding area, including surrounding communities and Aboriginal peoples. The factors beyond safety are:

- **Potential social, economic and cultural effects during the implementation phase of the project, including factors identified by Aboriginal Traditional Knowledge.**
- **Potential for enhancement of the community's and the region's long-term sustainability through implementation of the project, including factors identified by Aboriginal Traditional Knowledge.**
- **Potential to avoid ecologically sensitive areas and locally significant features, including factors identified by Aboriginal Traditional Knowledge.**
- **Potential for physical and social infrastructure to adapt to changes resulting from the project.**
- **Potential to avoid or minimize effects of the transportation of used nuclear fuel from existing storage facilities to the repository site.**

In order to ensure a broad, inclusive and holistic approach to assessment in these areas, a community well-being framework was identified to help understand and assess the potential effects of the APM Project. This framework was used to help explore the project, understand how the community and the surrounding area may be affected should the project be implemented in the area, and identify opportunities to leverage the project to achieve other objectives important to people in the area.

1.8 Next Steps

The objective of the site selection process, through several phases of progressively more detailed assessment, is to arrive at a single location for the deep geological repository and Centre of Expertise. It will take several more years of detailed technical, scientific and social study and assessments, and more engagement with interested communities, their neighbours and Aboriginal peoples before a preferred safe site for the project can be confirmed.

With 21 communities exploring potential interest and suitability for hosting the project, the siting process must provide a basis to progressively narrow the focus to communities with strong potential to meet requirements until a single preferred site and area is identified. These decisions will be supported by a sequence of assessments and engagement designed to enable the NWMO and communities to learn more about the potential suitability of each area and decide whether to proceed to the next stage.

The process of narrowing down the communities engaged in site selection commenced in Fall 2013 and will continue gradually over several years as more technical and social assessments are completed.

- By the end of 2013, the NWMO will implement an initial phase of narrowing down based on the results of Phase 1 Preliminary Assessment for an initial group of eight communities (English River First Nation, Pinehouse, Creighton, Ear Falls, Ignace, Schreiber, Hornepayne and Wawa). A number of these communities with strong overall potential to meet the site selection requirements are identified as warranting further study through Phase 2 assessments.

- In 2014, the NWMO expects to complete Phase 1 Preliminary Assessments as requested for all remaining communities in the site selection process. As these assessments are completed, another phase of narrowing down will be implemented, with communities showing strong potential to be suitable identified for further study in Phase 2.

- Beginning in 2014, Phase 2 Preliminary Assessment studies will take place over a multi-year period with a smaller number of communities with relatively strong potential to host APM. Over this period, field studies will commence, and engagement will be broadened. Building on earlier studies, Phase 2 will include preliminary geoscientific- and environment-focused field investigations, more detailed social and economic studies, awareness building and deepening learning and reflection by the interested community, and broadening of engagement to involve surrounding communities and Aboriginal peoples in learning and assessment of the suitability of the area.

- By the end of the second phase of study, one or possibly two communities with strong potential to meet requirements to host the facility will be the focus of Step 4, Detailed Site Characterization. This step will include extensive studies to assess and confirm safety, and may require an additional three to five years or more to complete. Findings will support identification of the preferred location that will be the focus of a regulatory approvals process led by the Canadian Nuclear Safety Commission (CNSC).

1.9 Moving Forward in Partnership

Each community engaging in Phase 1 Preliminary Assessments has helped initiate the process of relationship building that is needed to support the implementation of APM. The NWMO has learned a great deal from communities over the course of these initial studies about working together to envision the project and how best to implement the project with those potentially affected.

Through work with interested communities, and initial outreach to surrounding communities and Aboriginal peoples, the NWMO is learning about the nature and shape of partnerships that will be required to implement the APM Project together. Involving surrounding communities and Aboriginal peoples in learning and decision-making will be an important focus of activity of Phase 2 work with communities that proceed in the siting process. The implementation of Canada's plan will only proceed with the involvement of the interested community, surrounding communities and potentially affected Aboriginal peoples working in partnership to implement the project.

As Canada continues along the path of implementing APM, it will take our best knowledge and expertise, the continued leadership of communities, and all of us working together to ensure the safe long-term management of Canada's used nuclear fuel.

1.10 Organization of Report

Findings from the Phase 1 for the Township of Hornepayne are outlined in the chapters of this report. The chapters are based on a series of supporting technical documents, each of which are identified in the relevant chapter.

Report Overview

- ***Chapter 2*** – Brief introduction to the community.
- ***Chapter 3*** – Preliminary assessment of Engineering, which explores the potential to safely construct the facility at the potential site.
- ***Chapter 4*** – Geoscientific preliminary assessment, which explores the potential to find a suitable site within the community or surrounding area.
- ***Chapter 5*** – Preliminary Environment and Safety assessment, which explores the potential to manage any environmental effects and to ensure safety of people and the environment.
- ***Chapter 6*** – Preliminary assessment of Transportation, which explores the potential for safe and secure transportation to the potential site.
- ***Chapter 7*** – Preliminary Social, Economic and Cultural assessment, which explores the potential to foster the well-being of the community and surrounding area, and potential to create the foundation for community and area confidence and support needed to implement the project.
- ***Chapter 8*** – Taking into account the assessment in each of the major fields of investigation, this chapter concludes with reflections on potential suitability of the community and area and a discussion of the work which would be required if a decision were made to proceed to further studies.

2. INTRODUCTION TO THE TOWNSHIP OF HORNEPAYNE

The Township of Hornepayne is a community situated in northern Ontario, within Algoma District. It is located approximately 130 kilometres southwest of the Town of Hearst, the nearest urban centre, and 400 kilometres north of Sault Ste. Marie on Highway 631. The Township is a main stop on the Canadian National Rail (CN Rail) line, with VIA Rail providing passenger rail service in easterly and westerly directions.

The history of Hornepayne is closely tied to the railway line. The railway continues to operate in the area with an active rail yard. In 2011, the reported population of Hornepayne was 1,050. Residents in Hornepayne are employed primarily in the forestry and railroad sectors.

Figure 2-1 shows Hornepayne and the surrounding area. There are a number of Aboriginal communities and organizations in the Hornepayne area, including Brunswick House First Nation, Chapleau Cree First Nation, Constance Lake First Nation, Michipicoten First Nation, Missanabie Cree First Nation, Ojibways of the Pic River (Heron Bay) and Pic Mobert First Nation. Métis Councils in the area include Greenstone Métis Council, Superior North Shore Métis Council and Thunder Bay Métis Council as represented by Lakehead/Michipicoten/Nipigon Traditional Territory Consultation Committee and Chapleau Métis Council, Métis Nation of Ontario Timmins Council, Northern Lights Métis Council and Temiskaming Métis Council as represented by Abitibi/Temiskamingue and James Bay Traditional Territory Consultation Committee and the Métis Nation of Ontario.

A more in-depth discussion of Hornepayne and the surrounding area is contained in the Community Profile (DPRA Canada, 2013) and is woven throughout the chapters of this report, including the geoscientific characteristics of the Hornepayne area, the natural environment, transportation infrastructure, and the people and activities which contribute to the well-being of the community.

Figure 2-1: Hornepayne and Surrounding Lands

Safety: Potential to Find a Site Which Will Protect People and the Environment Now and in the Future

Any site that is selected to host the Adaptive Phased Management (APM) Project must be demonstrated to be able to safely contain and isolate used nuclear fuel for a very long period of time. The preferred site will need to address scientific and technical siting factors that acknowledge precaution and ensure protection for present and future generations.

A fundamental component of APM is the long-term containment and isolation of used nuclear fuel in a deep geological repository. The ability of the deep geological repository to safely contain and isolate used nuclear fuel relies on the form and properties of the waste, the human-made or engineered barriers placed around the waste, and the natural barriers provided by the host rock formation in which the repository will be located.

Transportation is an important consideration in the assessment of the safety of any site. In order for a site to be considered technically safe, a transportation route must be identified, or be capable of development, by which used nuclear fuel can safely and securely be transported to the site from the locations at which it is currently stored. Physical security aspects of the project and site, and potential to meet Canadian Nuclear Safety Commission (CNSC) requirements, are also important and will be assessed at a later phase of study.

The potential to find a safe site is examined from four perspectives. In each, a strong potential must be demonstrated to meet or exceed the regulatory expectations of the CNSC, the guidance of the International Atomic Energy Agency and evolving international best practice. The four perspectives are:

Engineering – Is there the potential to safely construct the facility in the area?

Geoscientific suitability – Is there the potential to find a site in the area with suitable geoscientific characteristics?

Environment and safety – Is there the potential to manage any environmental effects and to ensure health and safety of people and the environment in the area?

Transportation – Is there the potential for safe and secure transportation from interim storage facilities to a site located in the area?

Preliminary Assessments at this phase of work focus on the potential to find broad siting areas in the vicinity of the interested community that entered the site selection process, and meet engineering, geoscientific, environment and safety, and transportation requirements at a high level. Should the community be selected to proceed to Phase 2, the next phase of work will involve identification of specific locations for more detailed studies. These safety-related studies, particularly those related to understanding geoscientific suitability and environmental effects, would be conducted collaboratively with the community, surrounding communities and Aboriginal peoples in the area as possible.

Throughout this work, the NWMO will look to Aboriginal peoples as practitioners of Traditional Knowledge to help, to the extent they wish, to guide the decisions involved in site selection and ensure that the factors and approaches used to assess the site appropriately interweave Traditional Knowledge.

Learning to date is summarized in the four chapters which follow.

3. PRELIMINARY ASSESSMENT OF ENGINEERING

3.1 Engineering Assessment Approach

The objective of the engineering preliminary assessment is to assess the potential to safely construct and operate the facility in the Hornepayne area. The chapter also identifies infrastructure that would be required to safely construct and operate the facility in Hornepayne. This chapter presents a brief description of the facilities to be constructed and the characteristics of used fuel as the material to be managed, identifies specific infrastructure requirements for the project in this community, and concludes with a community-specific estimate of cost. The findings of the preliminary assessment to determine the engineering feasibility to safely construct the Adaptive Phased Management (APM) facility in Hornepayne are presented at the end of this chapter.

3.2 Characteristics of the Material to Be Managed: Used Nuclear Fuel

For decades, Canadians have been using electricity generated by nuclear power reactors in Ontario, Quebec and New Brunswick. When used nuclear fuel is removed from a reactor, it is considered a waste product, is radioactive and requires careful management. Although its radioactivity decreases with time, chemical toxicity persists and the used fuel will remain a potential health risk for many hundreds of thousands of years. For this reason, used fuel requires careful management essentially indefinitely.

The nuclear fuel in Canadian (CANDU) reactors is natural uranium dioxide (UO_2) which is pressed into ceramic pellets and placed inside a fuel element or sheath made of a zirconium-tin alloy. The most common type of fuel bundle contains 37 fuel elements which are welded to end plates to form a bundle.

Each fuel bundle has a length of about 0.5 metre, a diameter of about 0.10 metre and a mass of about 24 kilograms. Other types of CANDU fuel bundles have similar dimensions and mass, but differ in the number or configuration of the fuel elements. The reference design for a deep geological repository assumes an out-of-reactor cooling period of 30 years which results in a thermal output of 3.5 watts per bundle.

A standard CANDU fuel bundle is illustrated in Figure 3-1.

Figure 3-1: CANDU Fuel Bundle

To date, Canada has produced just over two million used fuel bundles. If Canada's existing reactors operate to the end of their planned lives, including planned refurbishments, the inventory that will need to be managed in the APM facility could be 4 million bundles or more, depending on future operating experience. The NWMO reviews projected used fuel inventories annually and has conservatively assumed a reference used fuel inventory of 4.6 million used CANDU fuel bundles (Garamszeghy, 2012).

The repository will need to be large enough to contain and isolate the volume of used fuel from existing plants in Canada. The specific amount of used fuel to be placed in the repository will be agreed with the community using the best information available at the time, and an open and transparent consultation process involving surrounding communities and others who are interested and potentially affected. Regulatory review processes and approvals, which are required by law before the project can proceed, will be based on a specific fuel inventory and will involve an open and transparent consultation process.

3.3 Conceptual Description of the APM Facility

A conceptual reference design has been developed by the NWMO as a basis for planning and costing. Some aspects of the reference design may be refined through discussions with potential host communities and those in the surrounding area to ensure that it better addresses their values, needs and preferences while still maintaining its primary safety functions. Some aspects of the reference design will also be refined through technology development and demonstration programs conducted in Canada and internationally. Other aspects of the design can only be confirmed once a potential site has been identified and site-specific technical and scientific studies have been completed. Canada's plan, called Adaptive Phased Management, is designed to be implemented collaboratively with an informed and willing host community.

The reference design of the APM facility is a self-contained complex with a combination of surface and underground structures designed to provide multiple engineered and natural barriers to safely contain and isolate Canada's used nuclear fuel over the long term. The APM facility will require a dedicated surface area of about 600 metres by 550 metres for the main surface buildings and about 100 metres by 100 metres for the ventilation shaft area. In addition, the APM facility will need an off-site storage area of about 700 metres by 700 metres for the rock excavated from the underground repository; its location would be selected in consultation with the community of Hornepayne and surrounding region.

An illustration of the conceptual APM facility is shown in Figure 3-2.

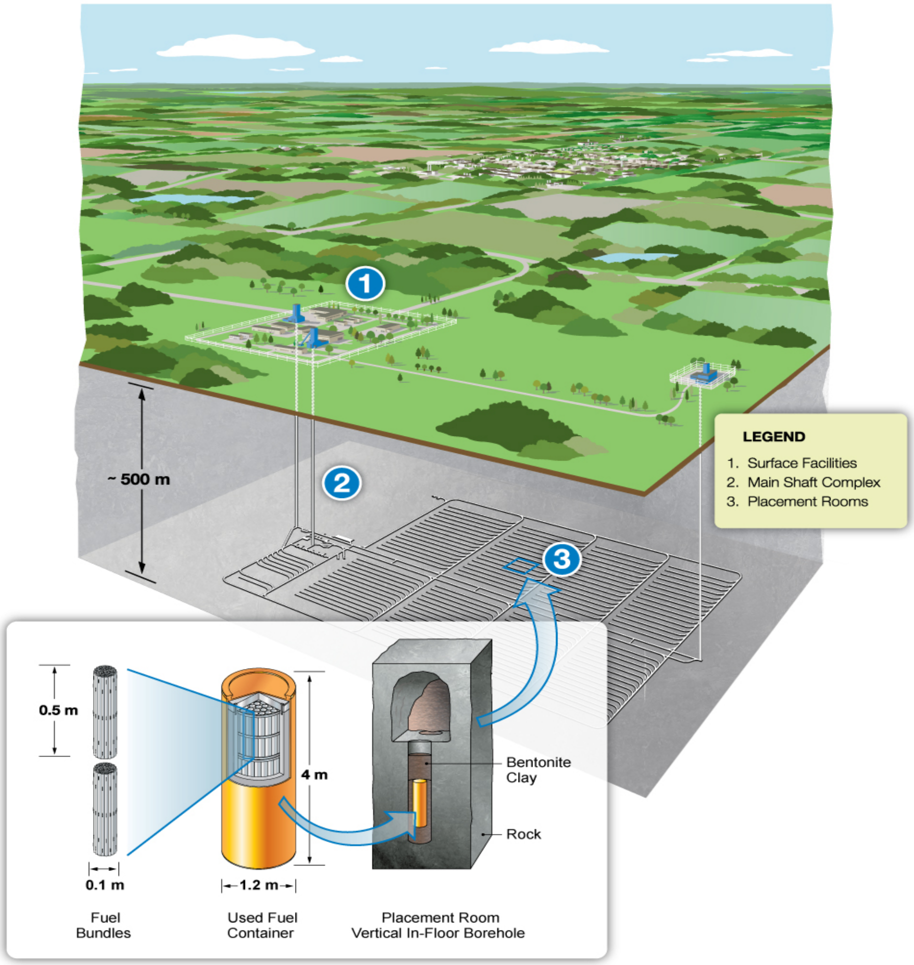

Figure 3-2: Illustration of an APM Facility

The underground footprint of the repository will depend on a number of factors, including the particular characteristics of the rock at the preferred site, the final design of the repository and the inventory of used fuel to be managed.

The layout of the underground repository has been developed for a projected reference inventory of 4.6 million used CANDU fuel bundles. It would require a subsurface area of about 2 kilometres by 3 kilometres at a depth of approximately 500 metres in suitable rock. The exact depth and layout will depend on the characteristics of the chosen site.

3.4 APM Surface Facilities

The used nuclear fuel will be transported from the licensed interim storage facilities at the reactor sites to the APM facility in transportation packages certified for road, rail and ship (CNSC, 2013). The packages will be received at the Used Fuel Packaging Plant where the used fuel bundles will be transferred into corrosion-resistant used fuel containers. The used fuel containers will be filled, sealed, inspected and dispatched for placement in the underground repository.

The APM surface facilities consist of a Nuclear Security Protected Area for all buildings and activities associated with the receiving, handling and storage of used nuclear fuel, and a Balance of Site for the remaining buildings and activities. The Nuclear Security Protected Area includes the Used Fuel Packaging Plant, the main shaft and service shaft buildings, auxiliary building, quality control offices, laboratory, active waste handling facilities, switch yard, transformer area and the powerhouse.

The Balance of Site includes the administration building, fire hall, security monitoring room, ventilation shaft building, cafeteria, garage, warehouse, water and sewage treatment plants, helicopter pad, fuel storage tanks, water storage tanks, air compressor building, an aggregate plant, concrete batch plant and sealing materials compaction plant. An off-site rock pile for the excavated rock from the underground repository would also be required.

The principal APM surface facilities are illustrated in Figure 3-3. The key structures in the APM surface facilities are described below.

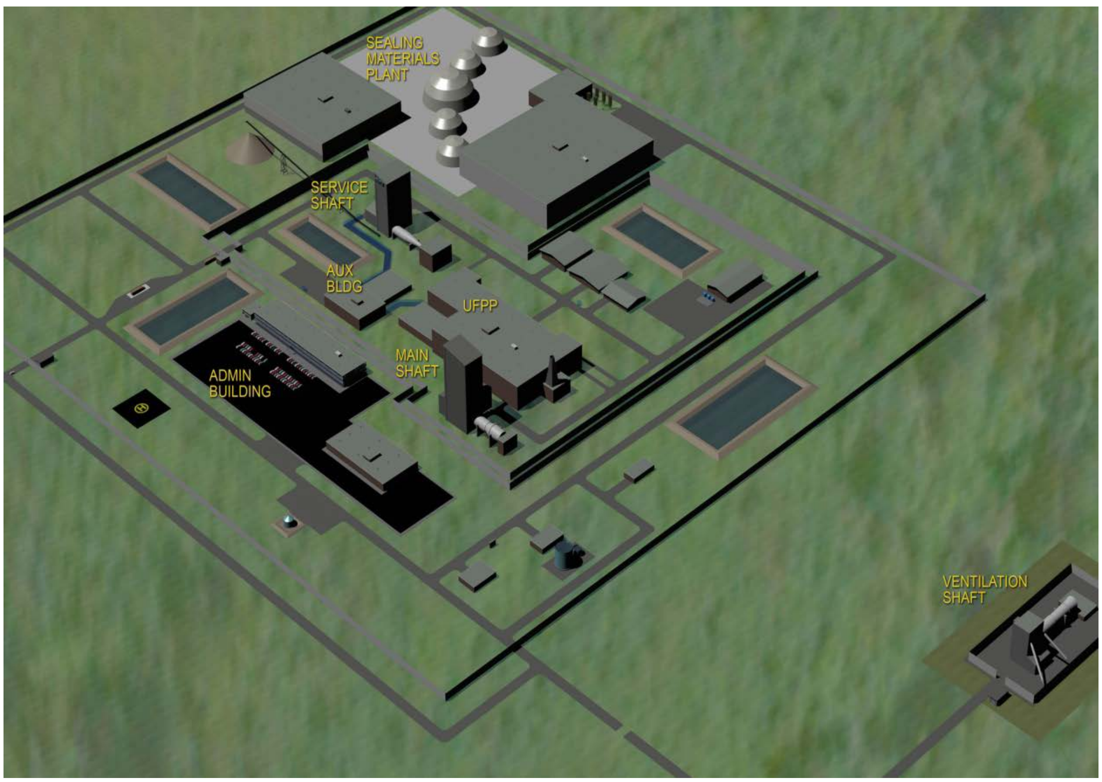

Figure 3-3: APM Surface Facilities

3.4.1 Used Fuel Container

The used fuel container is one of the principal engineered barriers in the multi-barrier deep geological repository concept. The key features of the design of the used fuel container are corrosion resistance, mechanical strength, geometry, capacity and compatibility with surrounding sealing materials such as bentonite clay.

The reference design of the used fuel container employs an outer corrosion-resistant material and an inner supporting material. The container is designed for a load of 45 megapascals, which will withstand the combined mechanical and hydraulic pressures in a repository, including glacial events with up to 3 kilometres of ice combined with lithostatic loads at 500 metres depth, and the swelling pressure of the bentonite buffer seal surrounding the container. The NWMO is examining several used fuel container designs for the deep geological repository and will further study, test and refine these designs over time.

The deep geological repository will require thousands of used fuel containers over the operating period. The used fuel containers and supporting components will be manufactured and assembled at the Container Manufacturing Plant, which could potentially be located in the community or surrounding region. For each year of operation, hundreds of used fuel containers will need to be manufactured and shipped to the repository site.

An example of a design for a used fuel container in crystalline rock is illustrated in Figure 3-4. It employs an outer corrosion-resistant shell and an inner vessel for strength. This reference container holds 360 used fuel bundles distributed in six layers of 60 bundles per layer in three steel baskets (with two bundle layers per basket). Other configurations with differing numbers of bundles are also possible. The final design will affect the number of containers required.

For a reference used fuel inventory of 4.6 million bundles, a total of 12,800 of these used fuel containers would be placed in the repository. At a placement rate of 333 containers per year (i.e., one to two containers per working day), the used fuel containers would be placed underground over a 38-year operating period.

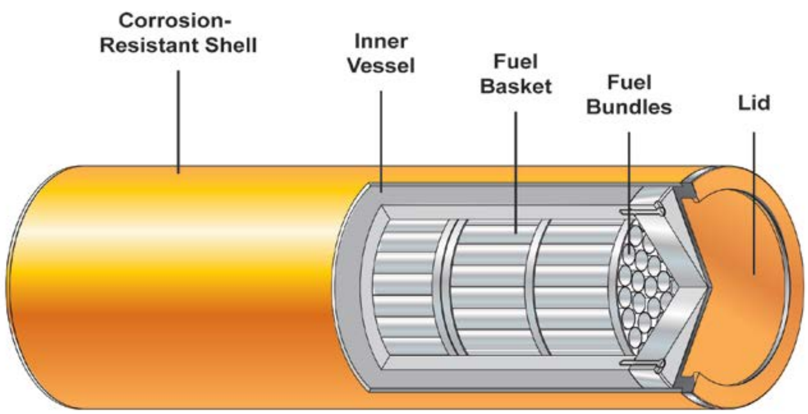

Figure 3-4: Used Fuel Container for a Deep Geological Repository

3.4.2 Used Fuel Packaging Plant

The Used Fuel Packaging Plant is an important facility for transferring Canada's used nuclear fuel from interim storage to a deep geological repository. The Used Fuel Packaging Plant encompasses all necessary areas and equipment for receiving used fuel transported from the interim storage sites to the repository, receiving empty containers, loading used fuel into the containers, and sealing, inspecting and dispatching filled containers for underground transfer and placement in the deep repository. There are also provisions for cutting open and emptying any used fuel containers that do not fulfill specified requirements following non-destructive testing and examination.

To ensure reliable delivery of used fuel containers to the deep geological repository, the plant includes storage areas for used fuel, empty containers and filled containers. Used nuclear fuel will be packaged and placed in the repository as it is received; thus it is expected that there will be only minimal storage of used fuel in the Used Fuel Packaging Plant for a short duration of time.

A conceptual layout of the Used Fuel Packaging Plant is illustrated in Figure 3-5.

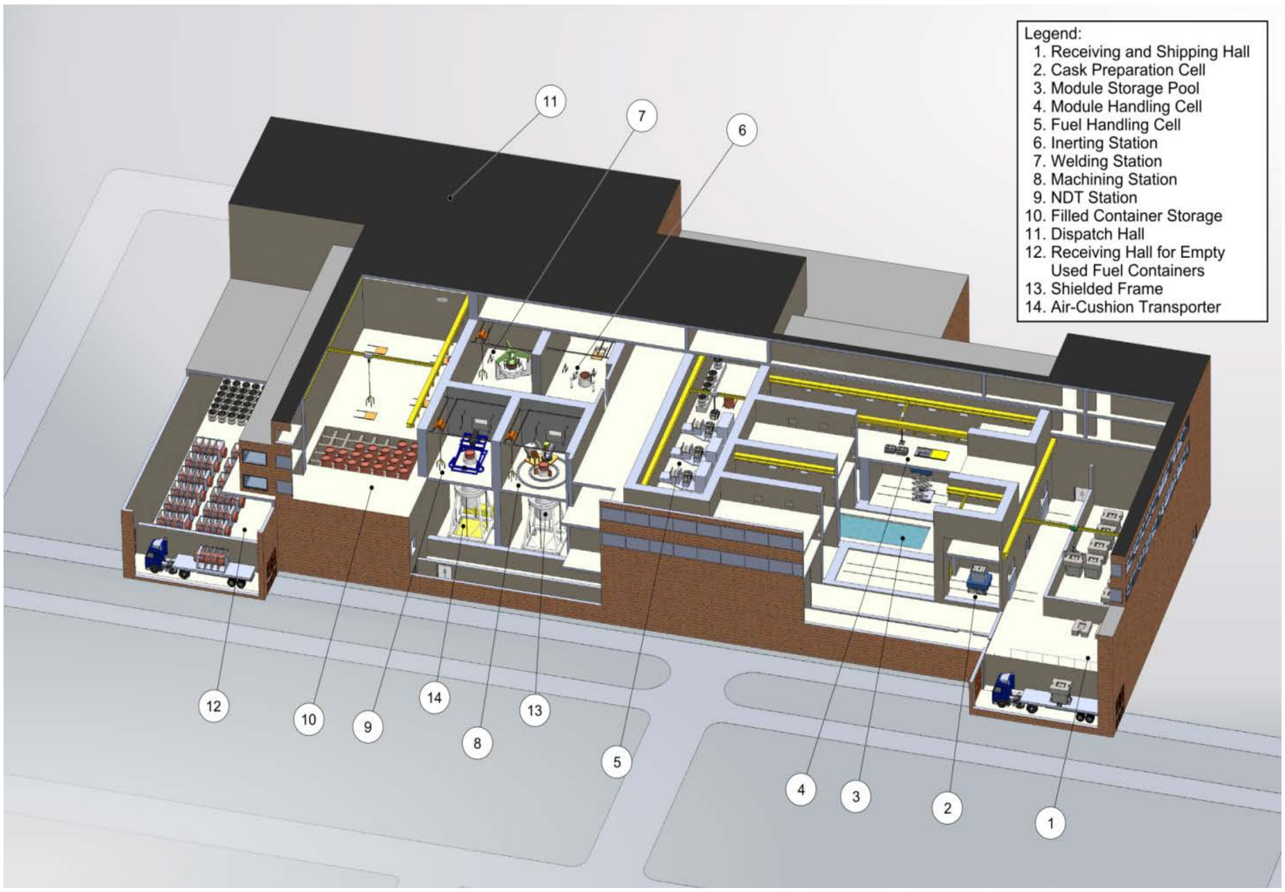

Figure 3-5: Conceptual Layout of a Used Fuel Packaging Plant

3.4.3 Sealing Materials Production Plants

The sealing materials production plants provide the clay-based and cement-based engineered barriers in the repository to backfill and seal the excavation openings, and to inhibit groundwater movement and microbial activity, thus inhibiting radionuclide transport in the region surrounding the used fuel containers.

As per the reference design, the sealing materials to be prepared at the production plants could include such materials as:

- Highly compacted buffer: bentonite clay disks and rings
- Dense backfill composed of: bentonite clay, lake clay, and aggregate
- Light backfill composed of: bentonite clay and sand

- Gapfill composed of: bentonite clay pellets
- Shaft seal composed of: bentonite clay and sand
- Low-heat high-performance concrete

The aggregate plant will consume a portion of the excavated rock from the repository to manufacture the crushed rock and sand for the backfill and concrete. These products would be stockpiled and stored on-site for use in the compaction plant for preparation of buffer disks, rings and dense backfill blocks using a large press (see Figure 3-6).

Figure 3-6: Example of a Large Press for the Sealing Materials Compaction Plant

3.4.4 Shafts and Hoists

The conceptual reference design for the APM Project includes three shafts to facilitate the transfer of rock, material, equipment and people between the surface facilities and the underground repository. The three shafts are:

- Main Shaft: with a finished inside diameter of 7 metres and will convey the used fuel containers within a shielded transfer cask. The Main Shaft has a friction hoist with a design payload of 63.5 tonnes.
- Service Shaft: with a finished inside diameter of 6.5 metres and will convey personnel, equipment, waste rock and sealing materials such as bentonite clay. The Service Shaft has a drum hoist with a design payload of 10 tonnes and can carry up to 50 people.

- Ventilation Shaft: with a finished inside diameter of 6.5 metres, handles the majority of the repository exhaust to the surface and is able to support mine rescue or evacuation efforts, if required during operations. The Ventilation Shaft has a drum hoist with a design payload of 1.6 tonnes.

The headframes for the three shafts will be of slip-formed concrete construction for a durable and easily maintainable structure, one that will provide a high level of protection against weather-related disturbances. All shafts will be concrete lined to minimize inflow of water and to provide a durable, easy-to-maintain surface. The shaft infrastructure and concrete lining will be removed during decommissioning of the underground repository.

During closure, the shafts will be sealed, and all headframes and peripheral equipment will be removed.

3.5 Underground Facilities

The deep geological repository is a network of underground tunnels, access drifts, placement rooms for used fuel containers, supporting infrastructure, and provision for an underground facility for site-specific demonstration of repository technology.

The repository is expected to be constructed at a single elevation at a depth of about 500 metres below ground surface. The exact depth will be determined as part of the detailed site characterization and final design. Excavation of rock is primarily done with controlled drill and blast or with the use of rock boring technology.

An example design and layout of a repository based on the in-floor placement of used fuel containers in boreholes drilled along the room centre line is illustrated in Figure 3-7. This approach for container placement is consistent with reference repository designs developed by the national radioactive waste management organizations in Sweden (SKB) and in Finland (Posiva). Each placement room is designed to be 5.5 metres high with a length of 396 metres and a centre-to-centre room spacing of 40 metres. Within a placement room, the in-floor boreholes are about 2 metres in diameter and have a centre-to-centre spacing of 4.2 metres.

Each borehole in the floor along the placement room centre line has a used fuel container surrounded by highly compacted bentonite buffer disks, rings and gapfill pellets. The placement room above the boreholes is filled with backfill materials such as a bentonite/sand mixture and other sealing materials. Each group of placement rooms, or a “placement panel,” would require about three to four years to develop and would be constructed in parallel with container placement operations in a previously completed panel in another area of the repository.

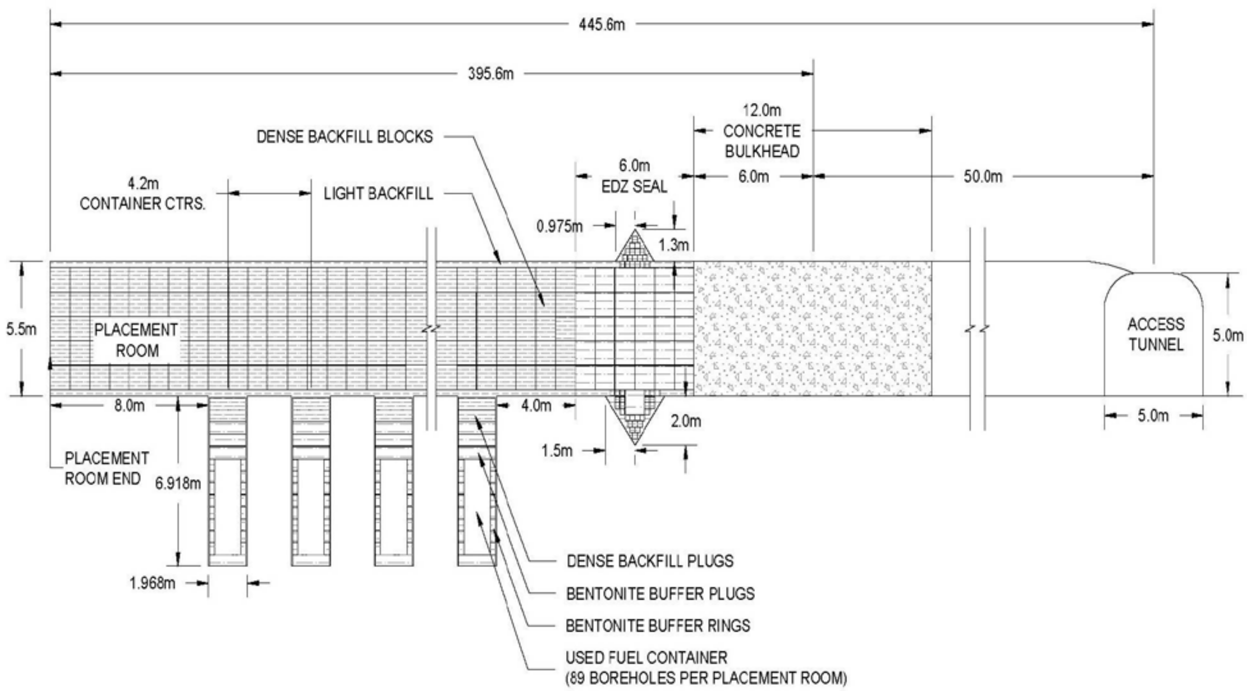

Figure 3-7: In-Floor Borehole Placement of Used Fuel Containers

The placement room spacing and used fuel container spacing are conservatively designed to ensure the repository meets thermal-mechanical design requirements (e.g., at least 25 centimetres of buffer with temperatures below 100°C).

The repository layout is expected to have a rectangular configuration with two central access drifts and two perimeter access drifts connected by perpendicular tunnels (crosscuts) that provide access to the used fuel container placement rooms. The placement rooms are grouped in panels, as illustrated in Figure 3-8. The exact arrangement of the panels will depend on the site (e.g., to avoid any potential fractures in the rock mass). The entrance to the rooms has a 50-metre turning radius to facilitate the movement of the container transfer cask and related systems.

After used fuel container placement, the room will be filled with dense backfill blocks. Light backfill will be placed in the interstitial spaces and compacted in situ to fill the residual volume between the backfill blocks and the excavated rock. A 6-metre-thick bentonite seal and a 10- to 12-metre-thick concrete bulkhead will be used to seal the entrance to the placement rooms. Monitoring equipment will be installed to confirm the performance of the repository system.

The repository design includes provision for an underground demonstration facility (UDF) located near the main shaft and service shaft area. The purpose of the underground demonstration facility is to support site-specific demonstration of repository technology such as placement and retrieval of used fuel containers, and long-term tests such as corrosion and monitoring tests.

An example underground layout for a deep geological repository would require an underground footprint of about 2 kilometres by 3 kilometres, as illustrated in Figure 3-8.

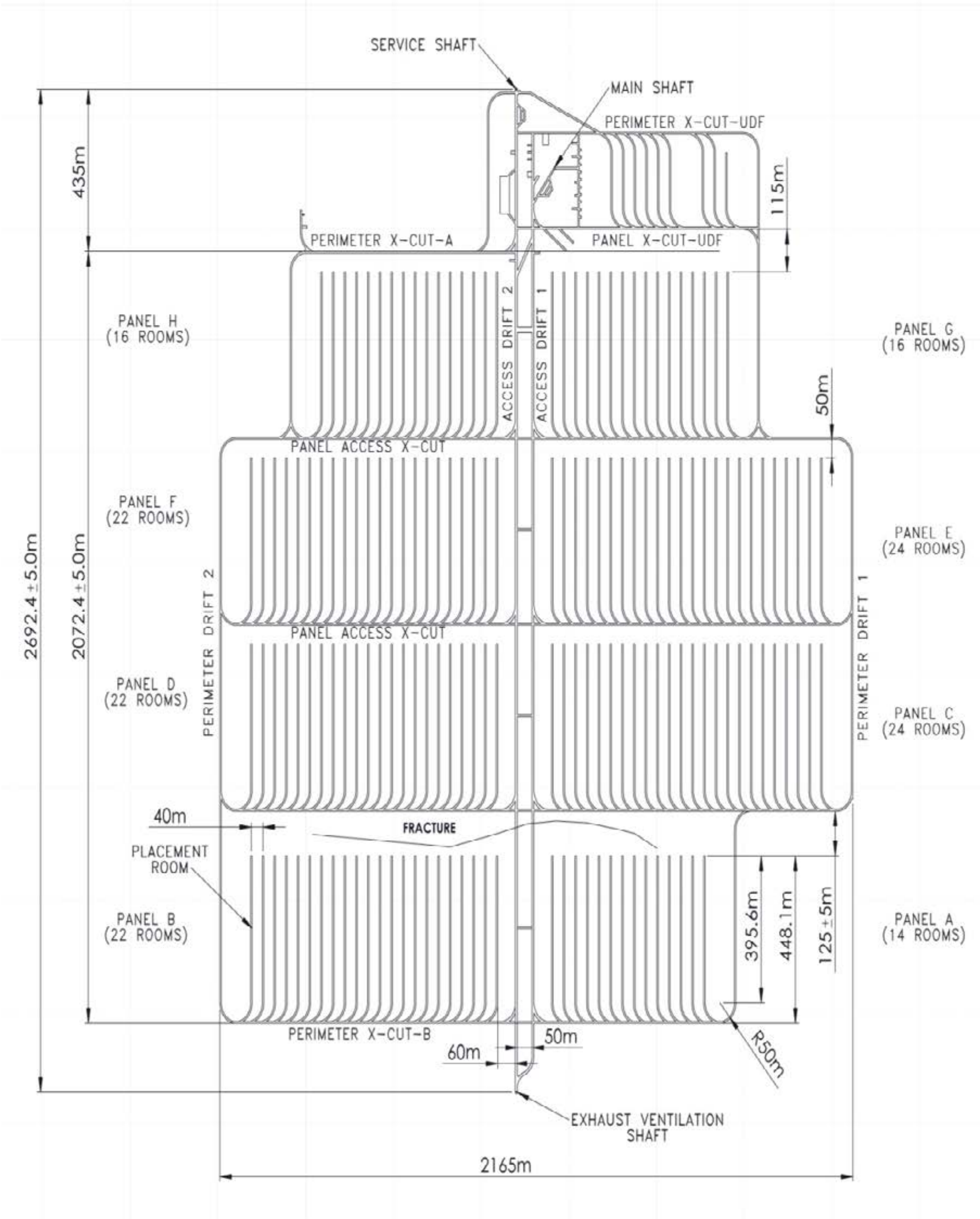

Figure 3-8: Example Underground Layout for a Deep Geological Repository

3.6 Centre of Expertise

A Centre of Expertise will be established in communities selected for detailed evaluation in the later stages of the site selection process. The centre will be located in or near the community, as determined in collaboration with the community. Its purpose will be to support the multi-year testing and assessment of the site on technical safety and community well-being related dimensions, which are key components of the site selection process. It will be the home for an active technical and social research and technology demonstration program during this period, involving scientists and other experts in a wide variety of disciplines, including geoscience, engineering, and environmental, socio-economic and cultural impact assessment.

The design details of the Centre of Expertise will be developed with the community and the surrounding region, with their preferences in mind. The centre could be designed as a focus for engaging members of the community to learn more about the project, and to view the scientific and engineering work-in-progress involved in site assessment, through public viewing galleries and interactive displays. The centre will attract many visitors per year, including scientists, experts and community members from around the world. The centre could highlight and demonstrate the science and technology being used to determine the suitability of the site, and could be used as a meeting and learning centre for the community to welcome visitors.

Should the site ultimately be selected to host the deep geological repository, the Centre of Expertise would be expanded to support site verification, construction and operation activities, and become a hub for knowledge sharing across Canada and internationally.

3.7 Engineering Feasibility in the Hornepayne Area

The Township of Hornepayne and the surrounding region is located on the Canadian Shield in an area that is characterized by moderate relief which is amenable for the construction of an APM facility. The Hornepayne area contains existing infrastructure that could be used for the APM Project, including a highway and a high-voltage transmission line. In addition, Hornepayne has a major rail line that passes through the town which could facilitate the transport of goods and materials to the site.

In order to implement the APM Project at a particular site in the Hornepayne area, it is anticipated that the following infrastructure would be needed:

- Main APM surface facilities including:
    - Used Fuel Packaging Plant
    - Main Shaft, Service Shaft and Ventilation Shaft Complexes
    - Sealing Materials Compaction Plant
    - Administration Building, Fire Hall and Cafeteria
    - Quality Control Offices and Laboratory
    - Water Treatment Plant
    - Storage Areas and Commons Services
- A few tens of kilometres of highway to provide access to the APM facility;
- A few tens of kilometres of high-voltage transmission line to supply up to 32 megawatts of electricity;
- A few kilometres of water pipe to supply up to 200 cubic metres of water per day;
- A Centre of Expertise;

- Provision for accommodation for temporary workers for the limited period of construction; and
- An excavation rock storage area within a few tens of kilometres of the APM facility.

As well, there are opportunities for a number of components associated with the APM repository to potentially be developed locally to improve the well-being of the community or surrounding region. These include a Container Development Laboratory and a Container Manufacturing Plant, as well as infrastructure associated with the transportation of used fuel from the interim storage locations to the site of the APM facility.

The development of this infrastructure has been assumed in the APM repository design and cost estimate prepared for financial planning purposes.

3.8 Engineering Costs for Hornepayne

The APM facility is a large national infrastructure project funded by the waste owners. A cost estimate for a deep geological repository and a used fuel transportation system has been developed for a reference inventory of 4.6 million used fuel bundles. As noted in Section 3.2, the NWMO reviews projected used fuel inventories annually and has conservatively assumed a reference used fuel inventory of 4.6 million used CANDU fuel bundles.

The estimated cost for the APM facility in Hornepayne – that is the deep geological repository and surface handling facilities, as well as the Centre of Expertise – is $20.1 billion (2010 $). (The transportation costs from the interim storage facilities at the reactor sites to the central APM facility in Hornepayne have been calculated separately and are discussed in Chapter 6.) This cost estimate includes site selection and approval, construction, operation, extended monitoring, decommissioning and closure.

A summary of the project cost estimate by implementation phase is given in Table 3-1. The first year of project implementation, year Y01, is 2010. The cost estimate includes labour, materials and equipment, fuel, utilities, taxes, fees, accommodation, communication and other expenses.

Table 3-1: Estimated Expenditures by Implementation Phase

Project Phase	Year	Cost 2010 $ ($ billion)
Site Selection and Approvals	Y01 – Y15	$1.5
Construction	Y16 – Y25	$3.6
Operation	Y26 – Y63	$12.0
Extended Monitoring	Y64 – Y133	$1.8
Decommissioning and Closure	Y134 – Y163	$1.2
	Total:	**$20.1**

The annual cash flow (2010 $) for the deep geological repository is illustrated in Figure 3-9.

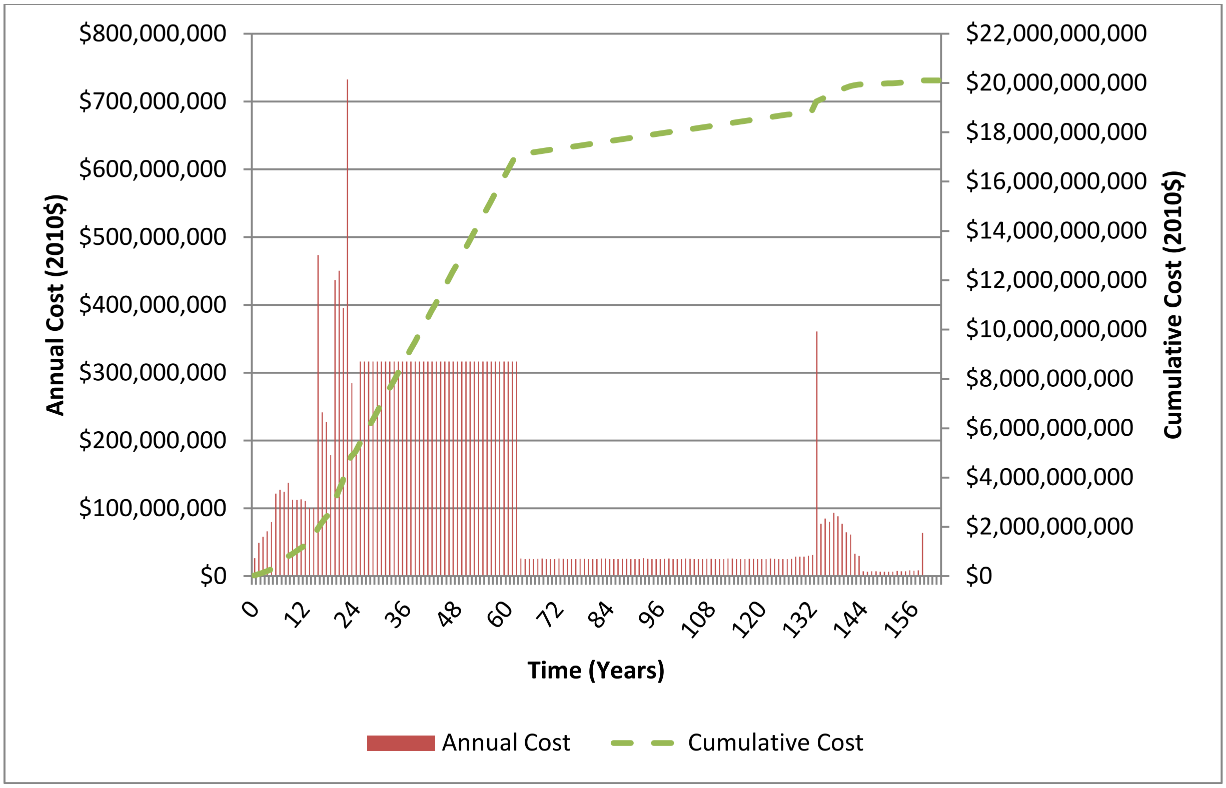

Figure 3-9: APM Cost Estimate for a Deep Geological Repository in Hornepayne

3.9 Engineering Findings

The engineering assessment of the Hornepayne area found that the APM facility has the potential to be safely constructed and operated. The surface land is characterized by moderate relief, and sufficient space exists outside protected areas and major bodies of water to successfully locate the surface facilities. Additional information on the physical geography of the area is presented in Section .3.1. There are few surface topography features that would limit the construction and operation of the surface and underground facilities required by the APM Project. Further, Hornepayne is located close to key infrastructure for the APM facility, including highways and high-voltage transmission lines. As well, an existing main rail line could facilitate the transport of goods and materials to the community (see transportation discussion in Chapter 6).

There are opportunities for new businesses and additional infrastructure associated with the APM repository to potentially be located in the community to enhance economic development and community well-being. This infrastructure could include the Container Development Laboratory and the Container Manufacturing Plant. The development of these facilities would be determined collaboratively with the community.

As more information on the geology and characteristics of potential candidate sites becomes available in later phases of the APM Project and further input is obtained from the community and surrounding region, the APM facility design, layout and engineering feasibility will be further refined.

4. PRELIMINARY ASSESSMENT OF GEOSCIENTIFIC SUITABILITY

4.1 Geoscientific Preliminary Assessment Approach

The objective of the Phase 1 desktop geoscientific preliminary assessment is to assess whether the Hornepayne area contains general areas that have the potential to satisfy the geoscientific evaluation factors outlined in the site selection process document (NWMO, 2010). This chapter presents a summary of a detailed desktop geoscientific preliminary assessment conducted by Geofirma Engineering Ltd. (Geofirma, 2013a). The assessment focused on the Township of Hornepayne and its periphery, which are referred to as the “Hornepayne area” (Figure 4-1). The boundaries of the Hornepayne area shown on Figure 4-1 have been defined to encompass the main geological features within the Township and its surroundings.

The desktop geoscientific preliminary assessment built on the work previously conducted for the initial screening (Golder, 2011) and included the following activities:

- Detailed review of available geoscientific information such as geology, structural geology, natural resources, hydrogeology, and overburden deposits;
- Interpretation of available geophysical surveys (magnetic, gravity, radiometric, electromagnetic);
- 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 factors such as overburden type and distribution, bedrock exposures, accessibility constraints, watershed and subwatershed boundaries, and groundwater discharge and recharge zones; and
- The identification and evaluation of general potentially suitable areas based on key geoscientific characteristics and the systematic application of the NWMO’s geoscientific site evaluation factors.

The details of these various studies are documented in a main Geoscientific Suitability Report (Geofirma, 2013a) and three supporting documents: Terrain Analysis (JDMA, 2013); Geophysical Interpretation (PGW, 2013); and Lineament Interpretation (Geofirma, 2013b).

4.2 Geoscientific Site Evaluation Factors

As discussed in the NWMO site selection process, the suitability of potential sites is evaluated in a staged manner through a series of progressively more detailed scientific and technical assessments using 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 (NWMO, 2010).

- ***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?

- ***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 process such as earthquakes and glacial cyles?
- ***Safe construction, operation and closure of the repository****:* Are conditions at the site suitable for the safe construction, operation and closure of the repository?
- ***Isolation of used fuel from future human activities:*** Is human intrusion at the site unlikely, for instance through future exploration or mining?
- ***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?

The assessment was conducted in two steps. The first step assessed the potential to find general potentially suitable areas within the Hornepayne area using key geoscientific characteristics that can realistically be assessed at this stage of the assessment (Section 4.4.1). The second step assessed whether identified potentially suitable areas have the potential to ultimately meet all the safety functions outlined above (Section 4.4.2).

The remainder of this chapter provides an overview of the geoscientific characteristics of the Hornepayne area (Section 4.3), followed by a summary of the geoscientific assessment of suitability (Section 4.4).

4.3 Geoscientific Characteristics of the Hornepayne Area

The following sections provide a summary of available geoscientific information for the Hornepayne area as they relate to physical geography, bedrock geology, quaternary (surficial) geology, seismicity, structural geology, hydrogeology and natural resources.

4.3.1 Physical Geography

A detailed discussion of the physical geography of the Hornepayne area is provided in the terrain analysis report (JDMA, 2013). The Hornepayne area exhibits topographic and drainage features that are typical of the Abitibi Upland physiographic region of Ontario (Thurston, 1991), a broadly rolling surface of Canadian Shield bedrock that occupies most of north-central Ontario.

Topography in most of the Hornepayne area is fairly flat, except for a broad upland that shows higher elevations and a more rugged topography in the southwestern quadrant of the Hornepayne area (Figure 4-2). Relief variation in the Hornepayne area is approximately 220 metres, with the major relief contrast observed between the rugged upland in the southwestern quadrant of the area and the relatively flat lowland covering much of the remainder of the area. Topographic highs generally correspond to bedrock outcrops, while topographic lows are generally areas of thicker overburden. An exception to this generalization is found in a locally elevated area in the northern part of the Hornepayne area, north of Nagagamisis Lake, which shows increased overburden thickness associated with a moraine (Figure 4-2).

About 16 per cent of the Hornepayne area is occupied by water bodies, including lakes and wetlands. The vast majority of lakes in the area are very small in size (less than 1 to 2 square kilometres). There are three lakes greater than 20 square kilometres, including Nagagami Lake, Obakamiga Lake and Nagagamisis Lake (Figure 4-1).

4.3.2 Bedrock Geology

Information on the bedrock geology of the Hornepayne area was obtained from publicly available reports and geologic maps, as well as from the geophysical interpretation conducted as part of this preliminary assessment (PGW, 2013). The main desktop preliminary geoscientific assessment report (Geofirma, 2013a) provides a detailed description of the regional and local geology of the Hornepayne area. Geological mapping at a regional scale (i.e., 1: 250,000) is available for the entire Hornepayne area. More detailed mapping exists only along the western and southwestern margins of the area. Low-resolution geophysical data (i.e., aeromagnetic data) provide complete coverage of the Hornepayne area, with an 805-metre line spacing. Higher-resolution aeromagnetic data (200 metres line spacing) exists for the western portion and southeast corner of the Hornepayne area.

As shown on Figure 4-3, the bedrock geology in the Hornepayne area is dominated by two main geological units that are separated by the east-west–trending Wawa-Quetico subprovince boundary. The southern half of the Hornepayne area is underlain by granitic rocks of the Black-Pic batholith of the Wawa Subprovince. The northern half is dominated by the metasedimentary and granitic intrusions of the Quetico Subprovince. Thin slivers of volcanic rocks of the Manitouwadge-Hornepayne greenstone belt are mapped within the Black-Pic batholith and along the subprovince boundary.

The initial screening (Golder, 2011) identified the Black-Pic batholith and the rocks of the Quetico Subprovince in the Hornepayne area as potentially suitable for hosting a deep geological repository. Rocks of the Manitouwadge-Hornepayne greenstone belt were deemed not suitable due to their lithological heterogeneity, structural complexity and potential for mineral resources.

The Black-Pic batholith is a large multi-phase intrusion that extends for approximately 1,700 square kilometres within the Hornepayne area. It was emplaced between approximately 2.720 and 2.689 billion years ago (Jackson et al., 1998; Zaleski et al., 1999). In the Hornepayne area, it is mostly composed of gneissic tonalite, with associated foliated tonalite and granitic phases. Distinct granitic phases of the Black-Pic batholith are mapped in the southeastern quarter of the Hornepayne area (Figure 4-3). The geophysical interpretation of the Black-Pic batholith shows that magnetic variability within the intrusion is generally very subtle, particularly in the gneissic tonalite phase. The data reveals little evidence of lithological contacts. Potential lithological variations are hindered by the low resolution of the data, and masked by the magnetic response of the numerous dykes in the Hornepayne area (PGW, 2013). The thickness of the batholith is unknown, but based on the regional extent of the intrusion, it is expected to be greater than 1 to 3 kilometres (Szewcyk and West, 1976; Percival et al., 2012).

In the northern half of the Hornepayne area, the metasedimentary rocks are mostly composed of metasedimentary gneisses and migmatites (i.e., highly metamorphosed sedimentary rocks that underwent partial melting). These metasedimentary rocks have an estimated thickness of about 7.5 kilometres (Percival, 1989), although the thickness is interpreted to slightly decrease along the border of the Quetico and Wawa subprovinces (Percival, 1989). The deposition of the original sedimentary rocks was initiated approximately 2.698 billion years ago, and its termination is constrained to approximately 2.688 billion years ago (Zaleski et al., 1999). Granitic intrusions mapped within the Quetico Subprovince in the Hornepayne area are interpreted to be likely derived from partial melting of the surrounding metasedimentary rocks (Percival, 1989; Williams et al., 1991), but no information is available on their age, thickness, or detailed lithological characteristics. The boundaries of these mapped granitic intrusions are also not well-defined on the geophysical datasets (PGW, 2013).

The Hornepayne area is crosscut by numerous dykes as it lies within the regional dyke swarms that are prevalent along and northeast of the northeastern shoreline of Lake Superior. Available geologic mapping and lineament interpretation (Section 4.3.4.2) show that abundant northwest- and northeast-trending dykes crosscut all the geologic units within the Hornepayne area (Figure 4-3). The northwest-trending Matachewan swarm intruded approximately 2.45 billion years ago, while the northeast-trending Biscotasing and Marathon/Kapusaksing swarms are estimated to be approximately 2.17 and 2.11 billion years old, respectively (Heaman, 1997; Halls et al., 2008).

4.3.3 Quaternary Geology

The terrain analysis report (JDMA, 2013) provides a detailed description of the Quaternary geology of the Hornepayne area. The Quaternary cover in the Hornepayne area is dominated by glacial deposits that accumulated with the progressive retreat of the Laurentide Ice Sheet during the end of the Wisconsinan glaciation (JDMA, 2013; Geofirma, 2013a).

As shown on Figure 4-4, Quaternary deposits are more extensive in the northern and northeastern portions of the Hornepayne area, covering about 80 per cent and 59 per cent of the granitic intrusions and metasedimentary rocks of the Quetico Subprovince, respectively. Quaternary cover is more discontinuous in the western and southern parts of the Hornepayne area, with bedrock exposure mapped for approximately 50 per cent of the Black-Pic batholith (JDMA, 2013; Geofirma, 2013a).

Information on measured overburden thickness is limited to a small number of water wells mostly located within the Township of Hornepayne and to a small number of diamond drill holes (Figure 4-4). Recorded depths to bedrock in the Hornepayne area generally range from 0 to 15 metres, with greater depths of up to 38 metres recorded in a few locations. Overburden is likely to be thickest in bedrock valleys and in the northern and eastern parts of the Hornepayne area (JDMA, 2013; Geofirma, 2013a). These observations provide an indication of the typical values and variability in overburden thicknesses that can be expected in the Hornepayne area.

4.3.4 Structural Geology

4.3.4.1 Mapped Faults

The east-west–trending Quetico-Wawa subprovince boundary, which crosscuts the Hornepayne area, is characterized as a regional shear zone. While evidence of faulting along the subprovince boundary is usually not well-documented, a few east-west–trending faults are mapped along sections of the subprovince boundary in the Hornepayne area (Figure 4-3). Interpretation of available geophysical data in the Hornepayne area identified a high abundance of subparallel magnetic lineations along the subprovince boundary that are most likely associated with an approximately 15-kilometre-wide zone of deformation straddling the mapped boundary (PGW, 2013). A limited number of smaller-scale northeast- and northwest-trending faults are also mapped in the Hornepayne area. These faults are mostly mapped in the vicinity, and along the Wawa-Quetico subprovince boundary (Figure 4-3).

As mentioned in Section 4.3.2, rocks in the Hornepayne area are also crosscut by numerous dykes. It is known that dyke emplacement could induce structural damage to the host rock between the dykes that is not easily quantifiable on geophysical data alone (e.g., Meriaux et al., 1999). At this stage of the assessment, the presence and extent of such damage remain uncertain and would need to be investigated during subsequent site evaluation stages.

4.3.4.2 Lineament Interpretation

A detailed lineament study was conducted for the Hornepayne area using multiple datasets (Geofirma, 2013b). Lineaments are linear features that can be observed on remote sensing and geophysical data and that may represent geological structures (e.g., fractures). However, at this stage of the assessment, it is uncertain if interpreted lineaments are a reflection of real geological structures and whether such structures extend to depth. The assessment of these uncertainties would require detailed geological mapping and borehole drilling.

Surficial lineaments were interpreted using remote sensing data consisting of satellite imagery (SPOT) and digital elevation model data (CDED). Surficial lineaments are interpreted as linear traces along topographic valleys, escarpments, and drainage patterns such as river streams and linear lakes. These linear traces may represent the expression of fractures on the ground surface which may not extent to significant depth. Figure 4-5 shows surficial lineaments interpreted in the Hornepayne area. The observed density and distribution of surficial lineaments is influenced by overburden cover, which masks surface expressions of potential fractures. Higher surficial lineament densities are observed in the western and southwestern portions of the Hornepayne area, where bedrock is mostly exposed. In addition, the density of interpreted surficial lineaments is higher in the vicinity of the Wawa-Quetico subprovince geological boundary, which is a known zone of structural intensity and complexity (Geofirma, 2013b).

Geophysical lineaments were interpreted from available aeromagnetic data. They are less affected by the presence of overburden and reflect potential structures that may or may not have surficial expressions. However, the density and distribution of geophysical lineaments is influenced by the resolution of the available aeromagnetic coverage. Geophysical lineaments interpreted in the Hornepayne area are shown on Figure 4-6. The figure shows that the density of geophysical lineaments is higher in the western portion of the Hornepayne area where high-resolution magnetic data are available. This observation suggests that geophysical lineament density in the remainder of the Hornepayne area may be similar to that observed where high-resolution aeromagnetic data exist.

Figures 4-5 and 4-6 also show the classification of surficial and geophysical lineaments by length (longer than 1, 5 and 10 kilometres). The figures show that the spacing between lineaments increases as shorter lineaments are filtered out. Longer lineaments are more likely to extend to greater depth than shorter lineaments.

The majority of the geophysical lineaments identified in the Hornepayne area are interpreted as dykes, which show well-defined orientations trending northwest and northeast (Figure 4-6). Although a large number of these dykes are identifiable in the aeromagnetic data, there is some uncertainty regarding the distribution and density of the dykes. Main uncertainties are related to: the potential for smaller-scale dykes to be present between interpreted dykes; and the potential underestimation of geophysical lineaments due to the predominance and masking effect of the dyke signal in the geophysical dataset.

In summary, the lineament interpretation indicated a variable density of lineaments across the Hornepayne area. At this stage of the assessment, it is uncertain whether interpreted lineaments represent true bedrock structural features (e.g., individual fractures or fracture zones) and whether these features extend to typical repository depths. This would need to be investigated during subsequent site evaluation stages through detailed geological mapping and borehole drilling.

4.3.5 Erosion

There is no site-specific information on erosion rates for the Hornepayne area. Past studies reported by Hallet (2011) provide general information on erosion rates for the Canadian Shield. The average erosion rate from wind and water on the Canadian Shield is reported to be a few metres per 100,000 years. Higher erosion rates are associated with glaciation. The depth of glacial erosion depends on several regionally specific factors, such as the ice sheet geometry, topography, and history, as well as local geological conditions, such as overburden thickness, rock type and pre-existing weathering. Various studies aimed at assessing the impact of glaciations on erosion over crystalline rocks reported average erosion rates varying from 10 or 20 metres, to up to 120 metres over 3 million years (Flint, 1947; White, 1972; Laine, 1980 and 1982; Bell and Laine, 1985; and Hay et al., 1989).

4.3.6 Seismicity and Neotectonics

4.3.6.1 Seismicity

The Hornepayne area lies within the Canadian Shield, where large parts have remained tectonically stable for the last 2.5 billion years (Percival and Easton, 2007). Figure 4-7 shows the locations and magnitudes of seismic events recorded in the National Earthquake Database (NEDB) for the period between 1985 and 2011 in the Hornepayne area (NRCan, 2012). Over this time period, all recorded seismic events in the Hornepayne area had magnitudes lower than 3 (Nuttli Magnitude, m_N). As of May 2012, the most recent earthquake was on March 4, 2011, and was a 2.4-magnitude event, located 32 kilometres south of the settlement area of Hornepayne.

4.3.6.2 Neotectonic Activity

Neotectonics refers to deformations, stresses and displacements in the Earth's crust of recent age or which are still occurring. These processes are related to tectonic forces acting in the North American plate, as well as those associated with the numerous glacial cycles that have affected the northern portion of the plate during the last million years, including all of the Canadian Shield (Shackleton et al., 1990; Peltier, 2002).

The geology of the Hornepayne area is typical of many areas of the Canadian Shield, which have been subjected to numerous glacial cycles during the last million years. Postglacial isostatic rebound is still occurring across most of Ontario. Present-day uplift rates are about 10 millimetres per year near Hudson Bay, where the ice was thickest at the last glacial maximum (Sella et al., 2007). The uplift rates generally decrease with distance from Hudson Bay and change to subsidence (1–2 millimetres per year) south of the Great Lakes. Present-day rebound rates in the Hornepayne area should be well below 10 millimetres per year, likely between 2 and 4 millimetres per year.

No neotectonic structural features are known to occur within the Hornepayne area. McMurry et al. (2003) summarized several studies conducted in a number of other granitic intrusions in the

Canadian Shield and in the crystalline basement in western Ontario. These studies found that fractures below a depth of several hundred metres in plutonic rocks are ancient features. Subsequent stresses, such as those caused by plate movement or by continental glaciation, generally have been relieved by reactivation along the existing zones of weakness rather than by the formation of large new fracture zones.

4.3.7 Hydrogeology

Information on groundwater in the Hornepayne area was obtained from the Ontario Ministry of the Environment (MOE) Water Well Record (WWR) database. Water wells in the Hornepayne area obtain water from the overburden or the shallow bedrock, and are mostly located in the settlement area of Hornepayne (Figure 4-4). The MOE water well database contains 71 water well records in the Hornepayne area, which provided useful information on depth to bedrock, yield and other parameters noted in Table 4-1.

Table 4-1: Water Well Record Summary for the Hornepayne Area

Water Well Type	Number of Wells	Total Well Depth (Metres)	Static Water Level (Metes Below Ground Surface)	Tested Well Yield (Litres per Minute)	Depth to Top of Bedrock (Metres)
Overburden	38	3–29	0.3–13.4	0–182	Not Applicable
Bedrock	33	11–119	0.6–8.5	0–15	0.6–38.4

4.3.7.1 Overburden Aquifers

There are 38 water well records in the Hornepayne area that can be confidently assigned to the overburden aquifer, ranging in depth from 3 to 29 metres. Well yields are variable with recorded values of 0 to 182 litres per minute. These well yields reflect the purpose of the wells (private residential supply) and do not necessarily reflect the maximum sustained yield that might be available from overburden aquifers. The limited number of well records and their concentration in the vicinity of the settlement area of Hornepayne limits the interpretation of available information regarding the extent and characteristics of overburden aquifers in the Hornepayne area.

4.3.7.2 Bedrock Aquifers

No information was found on deep bedrock groundwater conditions in the Hornepayne area at a typical repository depth of approximately 500 metres. In the Hornepayne area, there are 33 well records that can be confidently assigned to the shallow bedrock aquifer, ranging from 11 to 119 metres in depth, with most wells between 20 and 60 metres deep. The Ontario Ministry of the Environment (MOE) Water Well Records (WWR) indicate that no potable water supply wells are known to exploit aquifers at typical repository depths in the Hornepayne area or anywhere else in northern Ontario.

4.3.7.3 Regional Groundwater Flow

There is little known about the hydrogeologic properties of the deep bedrock in the Hornepayne area, as no deep boreholes have been drilled for this purpose. Experience from other areas in the Canadian Shield has shown that active groundwater flow in bedrock is generally confined to shallow fractured localized systems, and is dependent on the secondary permeability associated with the fracture network (Singer and Cheng, 2002). For example, in Manitoba's Lac du Bonnet batholith, groundwater movement is largely controlled by a fractured zone down to about 200 metres depth (Everitt et al., 1996).

The low topographic relief of the Canadian Shield tends to result in low hydraulic gradients for groundwater movement in the shallow active region (McMurry et al., 2003). At greater depths, hydraulic conductivity tends to decrease as fractures become less common and less interconnected (Stevenson et al., 1996; McMurry et al., 2003). Increased vertical and horizontal stresses at depth tend to close or prevent fractures, thereby reducing permeability and resulting in diffusion-dominated groundwater movement (Stevenson et al., 1996; McMurry et al., 2003). However, fracture networks associated with deep faults and shear zones will influence advective groundwater flow around bodies of rock characterized by diffusion-controlled conditions.

There is no site-specific information on the hydraulic characteristics of the dykes interpreted for the Hornepayne area. Information from mines in the Canadian Shield (Raven and Gale, 1986), and other geological settings shows that dykes may act as either pathways or barriers for groundwater flow in a host rock. Their hydraulic characteristics depend on a wide range of factors that include their frequency and location within the host rock, their orientation with respect to the direction of groundwater flow, their mineralogical composition, degree of alteration and their potential association with brittle deformation structures (e.g., Ryan et al., 2007; Svensson and Rhén, 2010; Gupta et al., 2012; Holland, 2012), including both pre-existing structures and those developed as a result of dyke emplacement.

The exact nature of deep groundwater flow systems in the Hornepayne area would need to be evaluated at later stages of the assessment, through the collection of site-specific information.

4.3.8 Hydrogeochemistry

No information on groundwater hydrogeochemistry was found for the Hornepayne area. However, available literature indicates that groundwater within the Canadian Shield can be subdivided into two main hydrogeochemical regimes: a shallow freshwater flow system; and a deep, typically saline water flow system (Singer and Cheng, 2002).

Gascoyne et al. (1987) investigated the saline brines found within several plutons of the Canadian Shield and identified a chemical transition at around 300 metres depth marked by a uniform, rapid rise in total dissolved solids (TDS) and chloride. This was attributed to advective mixing above 300 metres, with a shift to diffusion-controlled flow below that depth. It was noted that major fracture zones within the bedrock can, where present, extend the influence of advective processes to greater depths and hence lower the transition to the more saline conditions characteristic of deeper, diffusion-controlled conditions.

Groundwater research carried out in Atomic Energy of Canada Limited's (AECL) Whiteshell Underground Rock Laboratory (URL) in Manitoba reported TDS values ranging from 3 to 90 grams per litre at depths of 300 to 1,000 metres (Gascoyne et al., 1987; Gascoyne, 1994; 2000; 2004). In some regions of the Canadian Shield, TDS values exceeding 250 grams per litre have been reported at depths below 500 metres (Frape et al., 1984).

4.3.9 Natural Resources

Information regarding the mineral resource potential for the Hornepayne area has been obtained from a variety of sources, as described by Geofirma (2013a). Figure 4-8 shows the areas of active exploration interest based on active mining claims (MNDM, 2012), as well as known mineral occurrences identified in the Ontario Geological Survey Mineral Deposit Inventory Version 2 (OGS, 2004).

There are no past or currently producing mines within the Hornepayne area. The potential for economically exploitable metallic mineral resources in the Hornepayne area is generally low and limited to the volcanic rocks of the Manitouwadge-Hornepayne greenstone belt. A few base metal and sulphide occurrences are reported associated with greenstone slivers along the Wawa-Quetico subprovince boundary and within the Black-Pic batholith (Figure 4-8). While economic metallic mineralizations are found in the Manitouwadge-Hornepayne greenstone belt west of the Hornepayne area, the economical viability of identified occurrences within the Hornepayne area has not been proven to date. No known economic mineralization has been identified to date within the Black-Pic batholith or metasedimentary rocks in the Hornepayne area.

The gneissic tonalite of the Black-Pic batholith represents a potential source of dimension stone where homogeneous exposures with few fractures can be found (Williams and Breaks, 1996). However, no quarrying is known to have occurred in the Hornepayne area, where the potential for non-metallic mineral potential is considered low.

The Hornepayne area is located in a crystalline rock geological setting where the potential for petroleum resources is negligible and where no hydrocarbon production or exploration activities are known to occur.

4.3.10 Geomechanical and Thermal Properties

There is no information available on the general geomechanical properties of the granitic Black-Pic batholith and metasedimentary rocks of the Quetico Subprovince in the Hornepayne area. However, there is a fair amount of data from comparable geologic units in the Canadian Shield that can provide insight into the possible rocks mass properties in the Hornepayne area (Geofirma, 2013a). There are also no site-specific thermal conductivity values or detailed quantitative mineral compositions for the Hornepayne area. Some useful generic comparisons are provided in a summary of thermal conductivity values for granite, granodiorite and tonalite in the main geoscientific suitability report (Geofirma, 2013a). Site-specific geomechanical and thermal properties of the potentially suitable geological units within the Hornepayne area would need to be investigated during subsequent field evaluations stages.

4.4 Potential Geoscientific Suitability of the Hornepayne Area

This section provides a summary of how key geoscientific characteristics were applied to the Hornepayne area to assess whether it contains general areas that have the potential to satisfy the NWMO's geoscientific site evaluation factors (Section 4.4.1). The potential of identified areas to ultimately satisfy all geoscientific evaluation factors and safety functions outlined in the NWMO's site selection process is also described (Section 4.4.2).

4.4.1 Potential for Finding General Potentially Suitable Areas

The potential for finding general areas that are potentially suitable for hosting a deep geological repository was assessed using the key geoscientific characteristics briefly described below.

- ***Geological Setting:*** Areas of unfavourable geology identified during the initial screening (Golder, 2011) were not considered. Such areas include rocks of the Manitouwadge-Hornepayne greenstone belt, in the southern half of the Hornepayne area and along the subprovince boundary (Figure 4-3). These geologic units were considered not suitable due to their lithological heterogeneity, structural complexity and potential for mineral resources. Metasedimentary and intrusive rocks in the northern half of the Hornepayne area, as well as rocks of the Black-Pic batholiths, were considered as potentially suitable host rocks. The characteristics of these geological units are further discussed in Sections 4.4.1.1 and 4.4.1.2.

- ***Structural Geology:*** Areas within or immediately adjacent to regional faults and shear zones were considered unfavourable. The main structural feature within the Hornepayne area is the Quetico-Wawa subprovince boundary, which crosscuts the Hornepayne area (Figure 4-3). It is characterized as a regional shear zone, with an interpreted deformation zone of about 15 kilometres wide (PGW, 2013). The thickness of potentially suitable units was also considered when identifying potentially suitable areas. Metasedimentary rocks of the Quetico Subprovince are estimated to be about 7.5 kilometres thick. The Black-Pic batholith is expected to be greater than 1 to 3 kilometres in thickness, which is largely sufficient for the purpose of siting a deep geological repository.

- ***Lineament Analysis:*** In the search for potentially suitable areas, there is a preference to select areas that have a relatively low density of lineaments, particularly a low density of longer lineaments as they are more likely to extend to greater depth than shorter lineaments (Section 4.3.4.2). For the purpose of this assessment, all interpreted lineaments (fractures and dykes) were conservatively considered as conductive (permeable) features. In reality, many of these interpreted features may be sealed due to higher stress levels at depth and the presence of infilling.

- ***Overburden:*** The distribution and thickness of overburden cover is an important site characteristic to consider when assessing amenability to site characterization of an area. For practical reasons, it is considered that areas covered by more than 2 metres of overburden deposits would not be amenable to trenching for the purpose of structural mapping. This consideration is consistent with international practices related to site characterization in areas covered by overburden deposits (e.g., Finland; Andersson et al., 2007). At this stage of the assessment, preference was given to areas with greater mapped bedrock exposures. The extent of bedrock exposure in the Hornepayne area is shown on Figure 4-4. Areas mapped as bedrock terrain are assumed to be covered, at most, with a thin veneer of overburden and are therefore considered amenable to geological mapping.

- ***Protected Areas:*** The only provincial park in the Hornepayne area is the Nagagamisis Provincial Park (425 square kilometres), which overlies a portion of the granitic and metasedimentary rocks in the northern half of the Hornepayne area (Figure 4-1). This provincial park was excluded from consideration.

- ***Natural Resources:*** The potential for natural resources in the Hornepayne area is shown on Figure 4-8. Areas with known potential for exploitable natural resources were excluded from further consideration. These include the volcanic rocks of the Manitouwadge-Hornepayne greenstone belt. The mineral potential of the potentially suitable geological units identified above is considered to be low. At this stage of the assessment, areas of active mining claims located in geologic environments judged to have low mineral resource potential were not systematically excluded.

- ***Surface Constraints:*** Areas of obvious topographic constraints (e.g., density of steep slopes), large water bodies (wetlands, lakes), and accessibility were considered for the identification of potentially suitable areas. While areas with such constraints were not explicitly excluded at this stage of the assessment, they are considered less preferable than areas without such constraints, all other factors being equal. The distribution of surface water bodies across the Hornepayne area is relatively uniform (Figure 4-1), with larger lakes covering part of the metasedimentary rocks (e.g., Nagagami and Nagagamisis lakes), and portions of the Black-Pic batholith (e.g., Obakamiga, Kabinakagamisis and Cameron lakes). Topography is generally flat, with a more rugged terrain in the southwestern sector of the Hornepayne area (Figure 4-2). Most of the central and northeastern portions of the Hornepayne area are accessible by Highway 631 and a number of existing logging roads. Access to the western part and portions of the eastern part of the Hornepayne area by the existing road network is limited (Figure 4-1).

The consideration of the above key geoscientific characteristics and constraints revealed that the Hornepayne area contains general areas that have the potential to satisfy the NWMO's geoscientific site evaluation factors. These areas are located within the granitic rocks of the Black-Pic batholith and the metasedimentary rocks of the Quetico Subprovince. Interpreted surficial and geophysical lineaments are shown on Figures 4-5 and 4-6, respectively. The other geoscientific characteristics are shown on Figure 4-9.

At this early stage of the assessment, the boundaries of the identified general potentially suitable areas are not yet defined. The location and extent of specific potentially suitable areas would need to be refined through more detailed assessments and field evaluations.

4.4.1.1 General Potentially Suitable Areas Within the Black-Pic Batholith

As discussed in Section 4.3.2, the Black-Pic batholith is a large multi-phase intrusion that extends across the southern half of the Hornepayne area, with an estimated thickness greater than 1 to 3 kilometres. The batholith is separated from the metasedimentary rocks of the Quetico Subprovince by the east-west trending Wawa-Quetico subprovince boundary, which is characterized as a major shear zone. The Black-Pic batholith has low potential for natural resources, and is mostly free of protected areas and significant surface constraints (i.e., topography and large water bodies). Identification of potentially suitable areas within this intrusion was mainly based on geological setting, structural geology (e.g., setback from the Wawa-Quetico subprovince boundary), lineament analysis and overburden cover.

Two general potentially suitable areas were identified in the Black-Pic batholith. One potentially suitable area was identified along the south-central margin of the Hornepayne area, south of Hornepayne Lakes and between Mitchell Lake and Star Lake. The other potentially suitable area lies in the western portion of the Black-Pic batholith, between Granitehill Lake, Cholette Lake and Obakamiga Lake (Figure 4-9). Both areas show relatively good bedrock exposure and are away from the subprovince boundary. However, given the resolution of available data, the potential impact of the subprovince boundary on the suitability of the two identified areas would need to be further assessed during subsequent site evaluation stages. The magnetic signature in the two potentially suitable areas is the most subdued of the entire Black-Pic batholith, which may suggest lithological homogeneity (PGW, 2013).

Additional insight into the potential suitability of the two identified areas is provided by the analysis of interpreted lineaments. The two areas identified in the south-central and western portions of the Black-Pic batholith encompass areas of low density of geophysical lineaments, most of which have been interpreted as dykes (Figure 4-6). The density of geophysical lineaments in the western potentially suitable area remains low despite the higher resolution of available geophysical data as compared to the south-central area. Interpreted dykes within the two areas are generally consistent with those mapped by the Ontario Geological Survey, with spacing between geophysical dyke lineaments on the order of 3 to 5 kilometres and well-defined northwest and northeast orientations (Figure 4-6). As discussed in Section 4.3.4.2, although a large number of these dykes are identifiable in the aeromagnetic data, there still remain some uncertainties regarding the distribution, density and structural impact of the dykes in the Hornepayne area. It is possible that smaller-scale dykes may exist in between the interpreted dykes in the Hornepayne area, but these may not be identifiable on geophysical data.

The assessment of potentially suitable areas within the Black-Pic batholith also took into consideration interpreted surficial lineaments. Figure 4-5 shows the surficial lineament density within the Black-Pic batholith to be generally moderate with some high density areas in the west where bedrock exposure is predominant and along the subprovince boundary. However, surface lineament density over the general potentially suitable areas in the south-central and western portions of the batholith is amongst the lowest of the intrusion, despite good bedrock exposure, suggesting a less fractured rock mass in these areas.

Potentially suitable areas identified in the Black-Pic batholith comprise predominantly Crown land and do not contain any protected areas. The areas are free of active mining claims (Figure 4-9). The area in the south-central portion of the batholith is easily accessible by Highway 631. However, access to the potentially suitable area to the west is limited (Figure 4-1).

4.4.1.2 Potentially Suitable Areas Within the Metasedimentary Rocks

The northern half of the Hornepayne area is mostly underlain by metasedimentary rocks of the Quetico Subprovince (Figure 4-3), with an interpreted thickness of about 7.5 kilometres. These metasedimentary rocks have low potential for natural resources, and are mostly free of protected areas and significant surface constraints (i.e., topography and large water bodies). Therefore, the differentiating factors for identifying potentially suitable areas within these rocks were considered to be geological setting, structural geology (setback from the subprovince boundary), overburden cover, and to a limited extent, lineament analysis.

The assessment of the key geoscientific factors identified one general potentially suitable area located immediately northeast of the Township of Hornepayne, and east of Highway 631. The area shows good bedrock exposure (Figure 4-9) and lies away from the subprovince boundary. However, at this stage of the assessment, it is uncertain to what extent the suitability of this area is affected by the deformation zone associated with the subprovince boundary. Also, while the bedrock in the potentially suitable area is mapped entirely as metasedimentary rock, lithological homogeneity is uncertain at this stage due to the varying degree of metamorphism that these rocks experienced in the past.

Figure 4-6 shows that geophysical lineament density over the metasedimentary rocks of the Quetico Subprovince is generally low with higher density of geophysical lineaments in the western portion, where higher-resolution geophysical data is available. The density of geophysical lineaments in the potentially suitable area northeast of the Township is fairly low. Northwest-trending lineaments in this area are interpreted as dykes, some of which are coincident with dykes mapped by the Ontario Geological Survey. The spacing between interpreted/mapped dykes and fractures in the potentially suitable area are on the order of 1.5 to 4 kilometres, suggesting the potential for structurally bounded rock volumes of sufficient size to host a deep geological repository. However, as discussed in the previous section, there still remain inherent uncertainties regarding the distribution, density and structural impact of the dykes in the Hornepayne area.

Figure 4-5 shows that the density of surficial lineaments ranges from low to high within the Quetico Subprovince in the Hornepayne area, with the highest densities to the west along the subprovince boundary and where predominant bedrock exposure exists. Surficial lineament density over the identified potentially suitable area is fairly low despite good bedrock exposure, which suggests a less fractured rock mass.

The potentially suitable area northeast of the Township comprises predominantly Crown land, and does not contain any protected areas or active mining claims, as shown on Figure 4-9. Access to this area is easy via an extensive network of recreation roads and Highway 631.

In summary, three general potentially suitable areas were identified within the Black-Pic batholith and the metasedimentary rocks of the Quetico Subprovince based on geology, structural geology, bedrock exposure, and lineament interpretation. These potentially suitable areas appear to have favourable lineament density, good bedrock exposure, low potential for economically exploitable natural resources, and lie away from the Wawa-Quetico subprovince boundary. The areas are also outside protected areas and are generally accessible.

Inherent uncertainties remain in relation to the potential influence of the subprovince boundary; the potential presence of smaller-scale dykes not identifiable on aeromagnetic data; the potential underestimation of geophysical lineaments due to the masking effect of dykes on the aeromagnetic signal; and the potential damage of the host rock due to dyke emplacement. These uncertainties would need to be further assessed through more detailed field evaluations, including the acquisition and interpretation of higher-resolution airborne geophysical surveys, field geological mapping and the drilling of boreholes.

4.4.1.3 Other Areas

Given the large geographic extent of the Hornepayne area, it may be possible to identify other general potentially suitable areas. However, the three areas identified are those judged to best meet the key geoscientific characteristics outlined in Section 4.4.1, based on the currently available information.

4.4.2 Evaluation of General Potentially Suitable Areas in the Hornepayne Area

This section provides a brief description of how the three identified potentially suitable areas were evaluated to verify if they have the potential to satisfy the geoscientific safety functions outlined in the NWMO's site selection process and discussed in Section 4.2. At this early stage of the site evaluation process, where limited geoscientific information is available, the intent is to assess whether there are any obvious conditions within the identified potentially suitable areas that would fail to satisfy the geoscientific safety functions.

4.4.2.1 Safe Containment and Isolation of Used Nuclear Fuel

This function requires that the geological, hydrogeological, chemical and mechanical characteristics of a suitable site: promote long-term isolation of used nuclear fuel from humans, the environment and surface disturbances; promote long-term containment of used nuclear fuel within the repository; and restrict groundwater movement and retard the movement of any released radioactive material. This requires that the repository be located at a sufficient depth, typically around 500 metres, in a sufficient rock volume with characteristics that limit groundwater movement.

As discussed in previous sections, the estimated thickness of both the Black-Pic batholith and the metasedimentary rocks of the Quetico Subprovince is more than 1 kilometre. Therefore, the rock in the three potentially suitable areas within these geologic units is likely to extend well below typical repository depths (approximately 500 metres), which would contribute to the isolation of the repository from human activities and natural surface events.

Analysis of interpreted lineament spacing, including dykes, indicates that the three identified general areas in the Hornepayne area have the potential to contain structurally bounded rock volumes of sufficient size to host a deep geological repository (Geofirma, 2013b). The classification of lineaments by length shows that the spacing between lineaments increases as shorter lineaments are filtered out. Longer lineaments are more likely to extend to greater depth than shorter lineaments. All three general areas are located away from the Wawa-Quetico subprovince boundary, which is characterized as a major regional shear zone. However, the potential impact of this deformation zone on the suitability of the three general areas would need to be further assessed.

As discussed in Geofirma (2013a), there is limited information on the hydrogeologic properties of the deep bedrock in the Hornepayne area. However, as discussed in Section 4.3.7.3, available information for similar geological settings in the Canadian Shield indicates that active groundwater flow within structurally bounded blocks tends to be generally limited to shallow fracture systems, typically less than 300 metres. At greater depths, hydraulic conductivity tends to decrease as fractures become less common and less interconnected. Experience from other areas also shows that ancient faults and fractures similar to those in the Hornepayne area are often sealed by infilling materials, which results in a much reduced potential for groundwater flow at depth. The Hornepayne area lies within a region of dyke swarms, and numerous dykes have been mapped and interpreted (Figures 4-3 and 4-6). As summarized in Section 4.3.7.3, available information from other geological settings shows that dykes may act as either pathways or barriers for groundwater flow in a host rock. The influence of dykes on the hydrogeological regime at depth depends on a wide range of factors that need to be investigated on a site-specific basis through detailed geological mapping and the drilling of deep boreholes.

Information on other geoscientific characteristics relevant to the containment and isolation functions of a deep geological repository, such as the mineralogy of the rock, the geochemical composition of the groundwater and rock porewater, the thermal and geomechanical properties of the rock, is limited for the Hornepayne area. The review of available information from other locations with similar geological settings did not reveal any obvious conditions that would suggest unfavourable mineralogical or hydrogeochemical characteristics for the bedrock underlying the three general areas identified within the Hornepayne area (Geofirma, 2013a).

In summary, the review of available geoscientific information, including completion of a lineament analysis of the area, did not reveal any obvious conditions that would fail the three identified general areas to satisfy the containment and isolation functions. Potential suitability of these areas would need to be further assessed.

4.4.2.2 Long-Term Resilience to Future Geological Processes and Climate Change

This safety function requires that the containment and isolation functions of the repository are not unacceptably affected by future geological processes and climate changes, including earthquakes and glacial cycles. A full assessment of these processes requires detailed site-specific data that would be typically collected and analyzed through detailed field investigations. The assessment would include understanding how the site has responded to past glaciations and geological processes, and would entail a wide range of detailed studies involving disciplines such as seismology, hydrogeology, hydrogeochemistry, paleohydrogeology and climate change. At this early stage of the site evaluation process, the long-term stability function is evaluated by assessing whether there is any evidence that would raise concerns about the long-term stability of the three general potentially suitable areas identified in the Hornepayne area.

The Hornepayne area is located in the Superior Province of the Canadian Shield, where large portions of land have remained tectonically stable for the last 2.5 billion years. As discussed in Section 4.3.6.1, seismic records show that the Hornepayne lies within a low seismicity area.

The geology of the Hornepayne area is typical of many areas of the Canadian Shield, which have been subjected to numerous glacial cycles during the last million years. Glaciation is a significant past perturbation that could occur again in the future. However, as discussed in Section 4.3.6.2, findings from various studies conducted in other areas of the Canadian Shield suggest that deep hydrogeological and hydrogeochemical conditions in crystalline rocks, particularly plutonic intrusions, have the potential to remain largely unaffected by past perturbations such as glacial cycles. As discussed in Sections 4.3.5 and 4.3.6.2, other related long-term processes such as glacial rebound (land uplift) and erosion are expected to be low and unlikely to affect the performance of a repository in the Hornepayne area.

In summary, available information indicates that the identified general potentially suitable areas in the Hornepayne area have the potential to satisfy the long-term stability function. The review did not identify any obvious conditions that would cause the performance of a repository to be substantially altered by future geological and climate change processes. The long-term stability of the Hornepayne area would need to be further assessed through detailed multidisciplinary site-specific geoscientific and climate change site investigations.

4.4.2.3 Safe Construction, Operation and Closure of the Repository

There are few surface constraints that would limit the construction of surface facilities in the three general potentially suitable areas identified in the Hornepayne area. These areas are characterized by moderate topographic relief, and each contains enough surface land outside protected areas and major water bodies to accommodate the required repository surface facilities.

From a constructability perspective, limited site-specific information is available on the local rock strength characteristics and in-situ stresses for potentially suitable geologic units in the Hornepayne area. However, as discussed in Section 4.3.10, there is a fair amount of information at other locations of the Canadian Shield with similar types of rock that could provide insight into what might be expected for the Hornepayne area in general. Available information suggests that granitic and gneissic metasedimentary rock units within the Canadian Shield generally possess good geomechanical characteristics that are amenable to the type of excavation activities involved in the development of a deep geological repository (Geofirma, 2013a).

The three general areas are situated in areas having a reasonable amount of bedrock exposure. At this stage of the site evaluation process, it is not possible to accurately determine the exact thickness of the overburden deposits in these areas due to the low resolution of available data. However, it is anticipated that overburden cover is not a limiting factor in any of the identified general areas.

In summary, the three identified general areas in the Hornepayne area have good potential to satisfy the safe construction, operation and closure function.

4.4.2.4 Isolation of Used Fuel From Future Human Activities

A suitable site must not be located in areas where the containment and isolation functions of the repository are likely to be disrupted by future human activities. These include areas containing economically exploitable natural resources or groundwater resources at repository depth.

No known economic mineralization has been identified to date within the Black-Pic batholith or metasedimentary rocks of the Quetico Subprovince in the Hornepayne area (Section 4.3.9). Also, the review of available information did not identify any groundwater resources at repository depth for the Hornepayne area. As discussed in Section 4.3.7, the Ontario Ministry of the Environment Water Well Records indicate that no potable water supply wells are known to exploit aquifers at typical repository depths in the Hornepayne area or anywhere else in northern Ontario. Experience from other areas in the Canadian Shield with similar types of rock has shown that active groundwater flow in crystalline rocks is generally confined to shallow fractured localized systems.

In summary, the potential for the containment and isolation functions of a repository in the Hornepayne area to be disrupted by future human activities is low.

4.4.2.5 Amenability to Site Characterization and Data Interpretation Activities

In order to support the case for demonstrating long-term safety, the geoscientific conditions at a potential site must be predictable and amenable to site characterization and data interpretation.

Factors affecting the amenability to site characterization include geological heterogeneity; structural and hydrogeological complexity; accessibility; and the presence of lakes or overburden with thickness or composition that could mask important geological or structural features.

The bedrock in the two general areas identified in the Black-Pic batholith is mapped as relatively homogeneous and fairly easy to characterize. As discussed in Section 4.3.2, there is uncertainty associated with the lithological homogeneity of the metasedimentary rocks containing the third potentially suitable area, mainly due to the variable degree of metamorphism and migmatization that these rocks experienced. However, at this stage of the assessment, such uncertainties are not expected to greatly affect site characterization.

Interpreted geophysical lineaments, mainly dykes, in the general potentially suitable areas exhibit distinct and well-defined orientations (i.e., northwest and northeast), which facilitates the mapping and interpretation of these features. The degree of structural complexity associated with the orientation of lineament features in three dimensions would need to be further assessed through detailed site investigations in future phases of the site selection process.

The identification and field mapping of structures is strongly influenced by the extent and thickness of overburden cover and the presence of large water bodies. The three identified general potentially suitable areas are amenable to site characterization as they contain sufficient areas with good bedrock exposure and limited surface water cover.

In summary, the review of available information did not indicate any obvious conditions which would make the rock mass in the three identified general areas unusually difficult to characterize.

4.5 Geoscientific Preliminary Assessment Findings

The objective of the Phase 1 geoscientific preliminary assessment was to assess whether the Hornepayne area contains general areas that have the potential to satisfy the geoscientific site evaluation factors outlined in the NWMO's site selection document (NWMO, 2010).

The preliminary geoscientific assessment built on the work previously conducted for the initial screening (Golder, 2011) and focused on the Township of Hornepayne and its periphery, which are referred to as the "Hornepayne area" (Figure 4-1). The assessment was conducted using available geoscientific information and key geoscientific characteristics that can be realistically assessed at this early stage of the site evaluation process. Where information for the Hornepayne area was limited or not available, the assessment drew on information and experience from other areas with similar geological settings on the Canadian Shield. The key geoscientific characteristics used relate to: geology; structural geology; interpreted lineaments; distribution and thickness of overburden deposits; surface conditions; and the potential for economically exploitable natural resources. The 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, gravity, radiometric, electromagnetic);
- 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 factors such as overburden type and distribution, bedrock exposures, accessibility constraints, watershed and subwatershed boundaries, and groundwater discharge and recharge zones; and
- The identification and evaluation of general potentially suitable areas based on key geoscientific characteristics and the systematic application of the NWMO's geoscientific site evaluation factors.

The desktop geoscientific preliminary assessment showed that the Hornepayne area contains at least three general areas that have the potential to satisfy the NWMO's geoscientific site evaluation factors. Two of these areas are within the Black-Pic batholith of the Wawa Subprovince. The other area is located within the metasedimentary rocks of the Quetico Subprovince.

The Black-Pic batholith and the metasedimentary rocks of the Quetico Subprovince hosting the three identified potentially suitable areas appear to have a number of geoscientific characteristics that are favourable for hosting a deep geological repository. They have sufficient depth and extend over large areas. The bedrock within the three potentially suitable areas has relatively good exposure. All three areas have low potential for natural resources and contain limited surface constraints.

While the identified general potentially suitable areas appear to have favourable geoscientific characteristics for hosting a deep geological repository, there are inherent uncertainties that would need to be addressed during subsequent stages of the site evaluation process. The main uncertainties are associated with the influence of the geological subprovince boundary that crosscut the Hornepayne area, the presence of numerous dykes, the low resolution of available geophysical data over most of the Hornepayne area, and the variable degree of metamorphism that the metasedimentary rocks experienced in the geological past.

All three identified potentially suitable areas are away from the deformation zone associated with the Wawa-Quetico subprovince boundary. However, the potential impact of this deformation zone on the three potentially suitable areas needs to be further assessed.

The Hornepayne area contains numerous dykes as it lies within regional dyke swarms. While the spacing between mapped and interpreted dykes and lineaments appears to be favourable, the low resolution of available geophysical data and the dykes could be masking the presence of smaller-scale dykes and fractures not identifiable from available data. Also, given the variable degree of metamorphism that the metasedimentary rocks have undergone in the geological past, the homogeneity of these rocks would need to be further assessed in subsequent site evaluation stages.

Should the community of Hornepayne be selected by the NWMO to advance to Phase 2 study and remain interested in continuing with the site selection process, several years of progressively more detailed studies would be required to confirm and demonstrate whether the Hornepayne area contains sites that can safely contain and isolate used nuclear fuel. This would include the acquisition and interpretation of higher-resolution airborne geophysical surveys, detailed geological mapping and the drilling of deep boreholes.

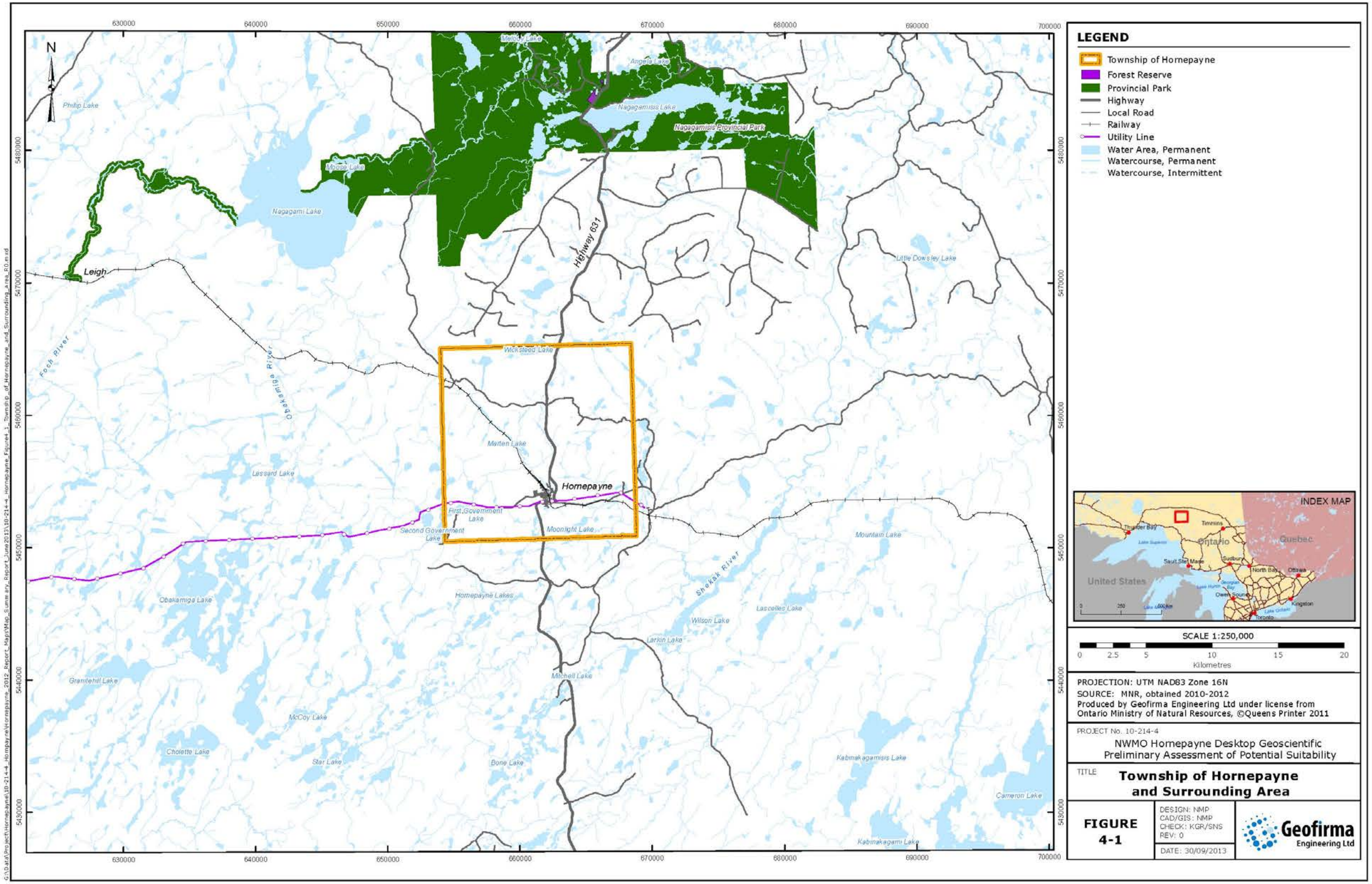

Figure 4-1: Township of Hornepayne and Surrounding Area

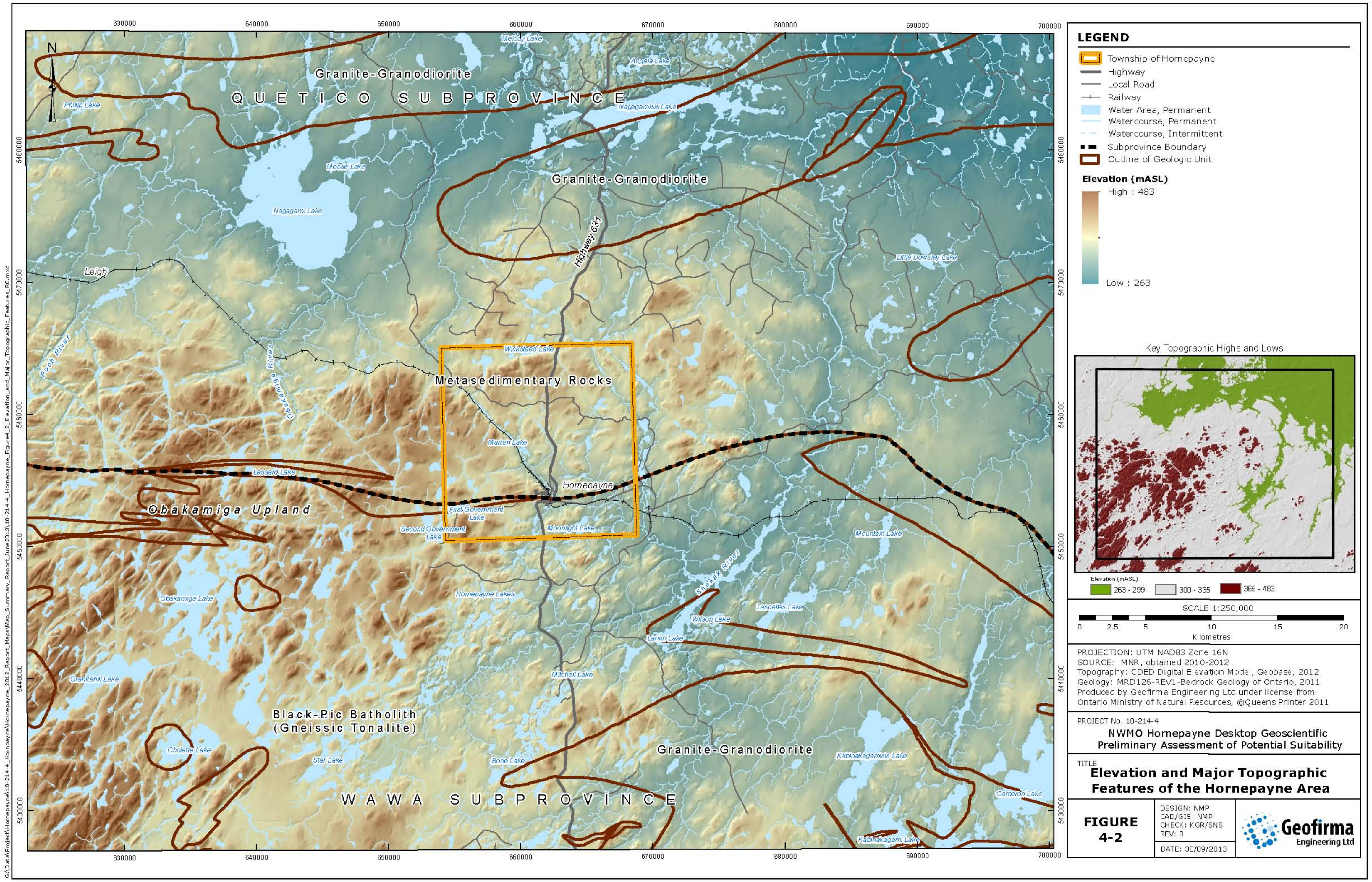

Figure 4-2: Elevation and Major Topographic Features of the Hornepayne Area

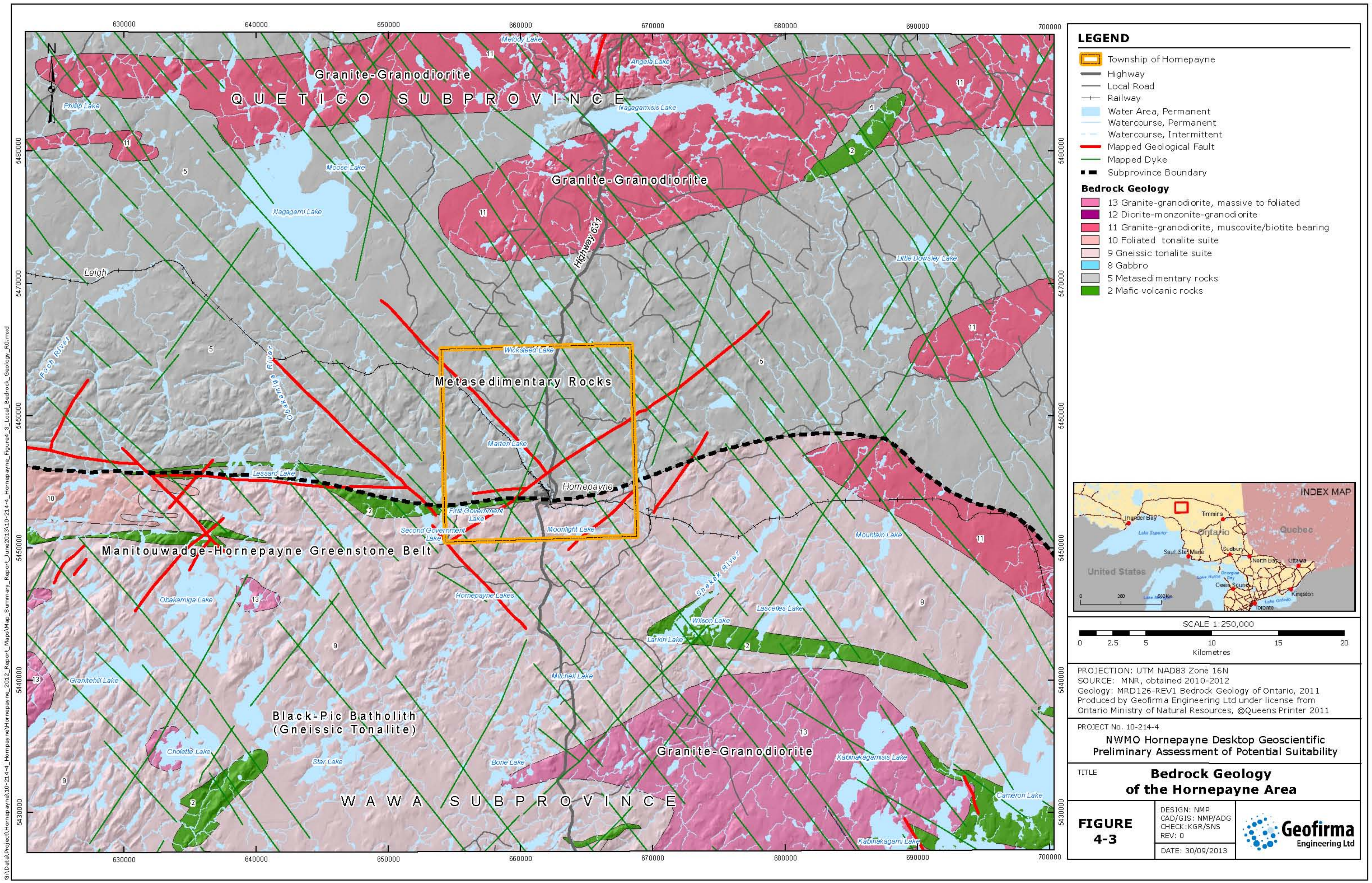

Figure 4-3: Bedrock Geology of the Hornepayne Area

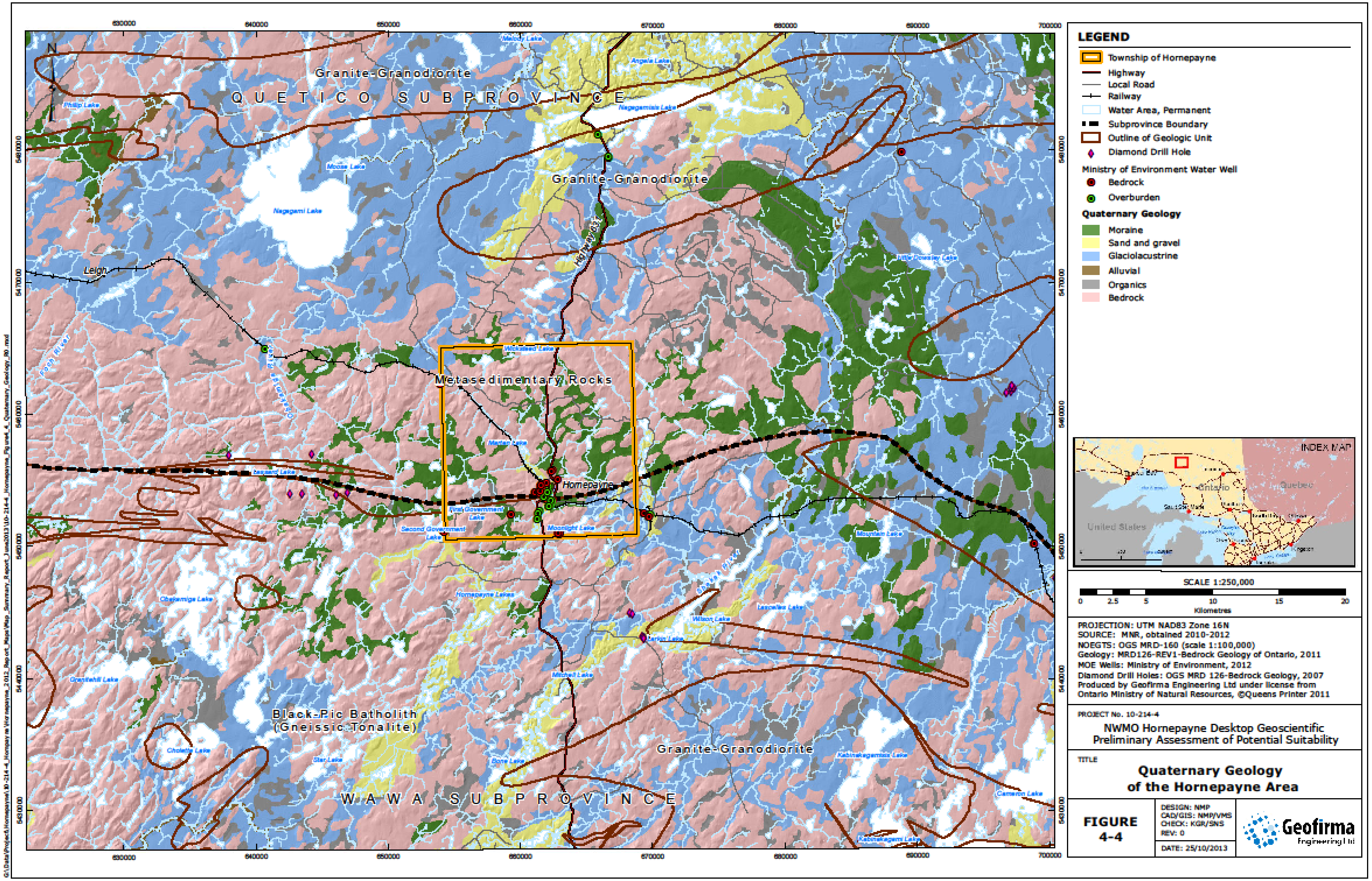

Figure 4-4: Quaternary Geology of the Hornepayne Area

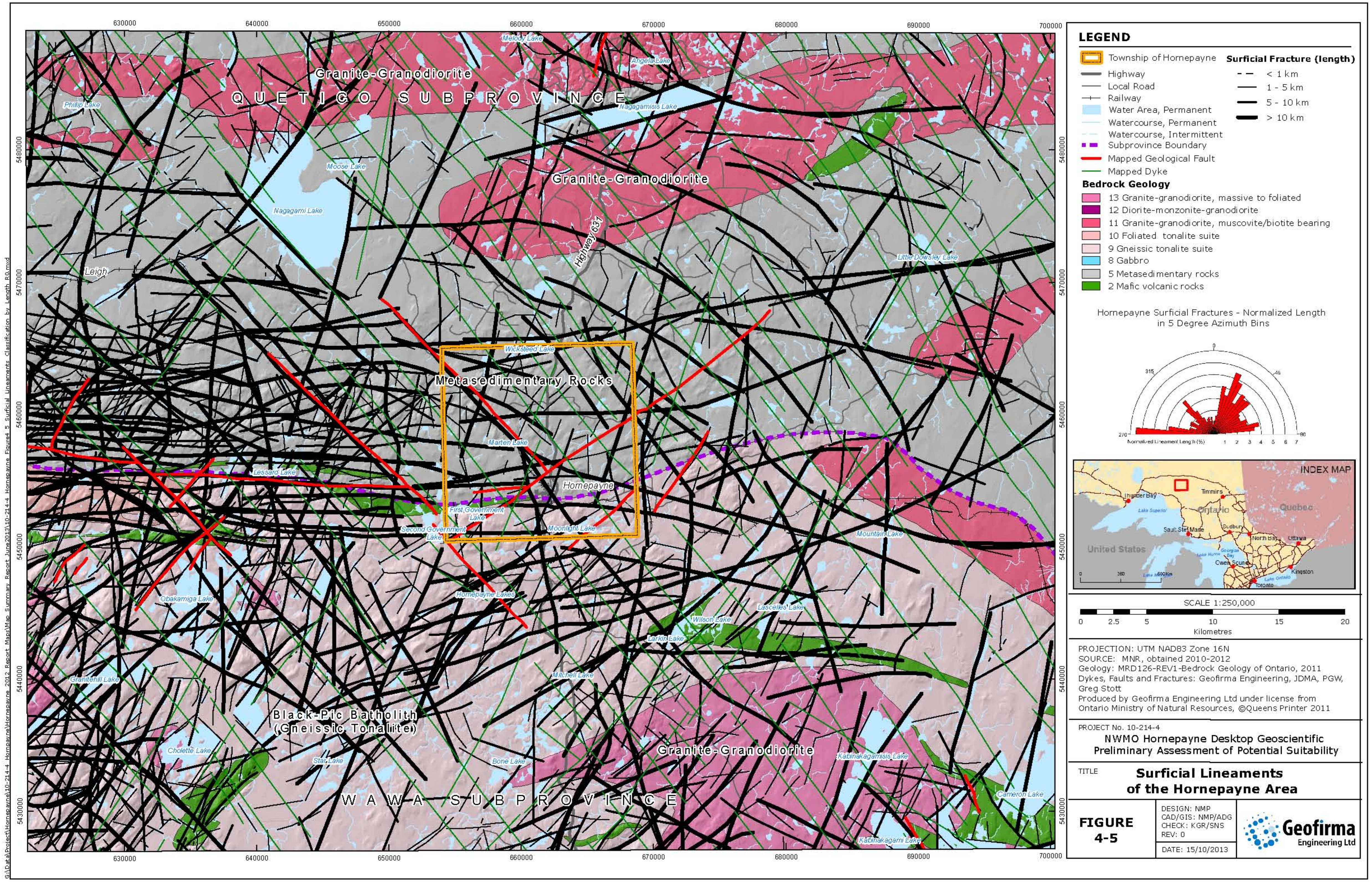

Figure 4-5: Surficial Lineaments of the Hornepayne Area

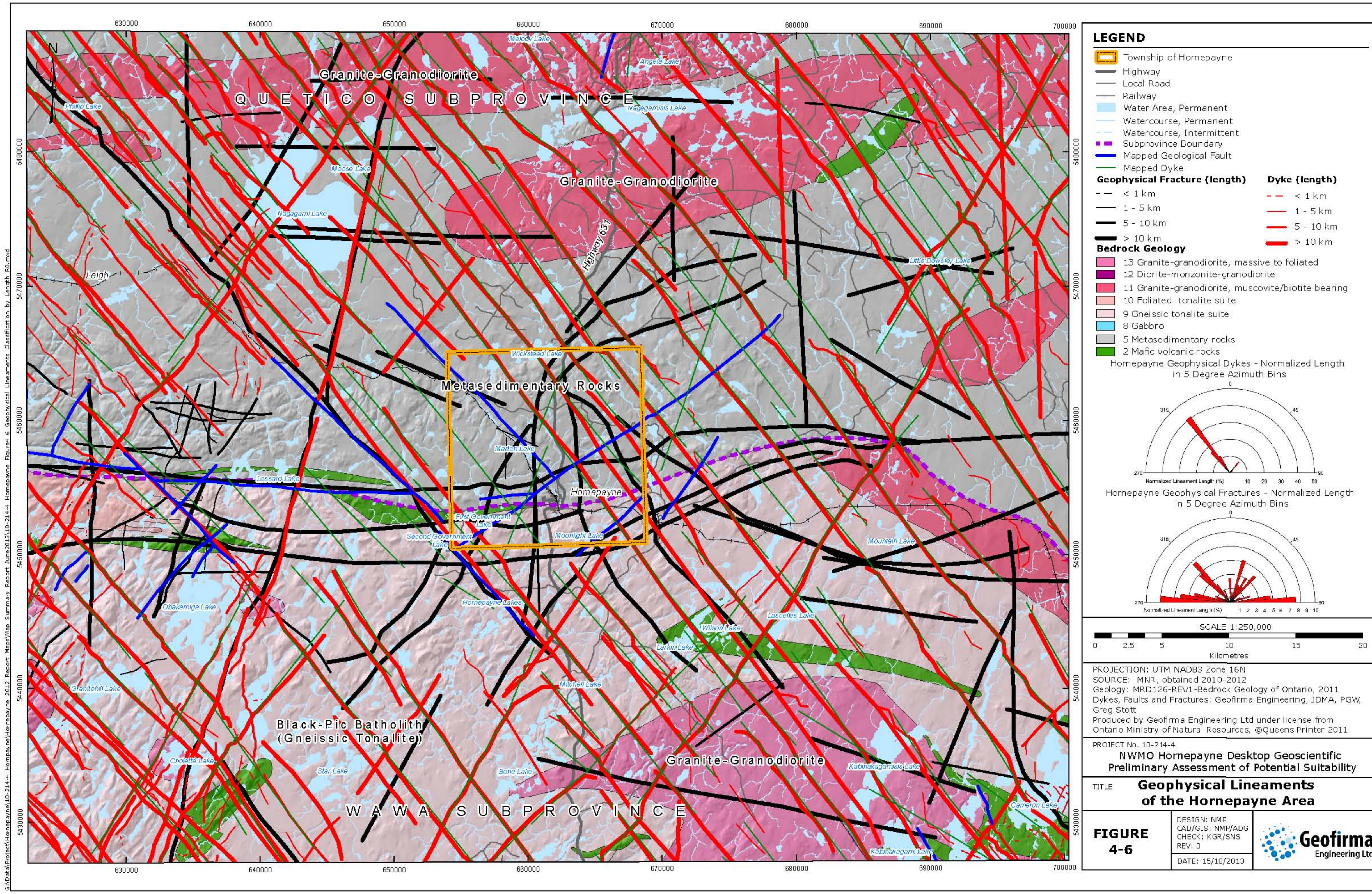

Figure 4-6: Geophysical Lineaments of the Hornepayne Area

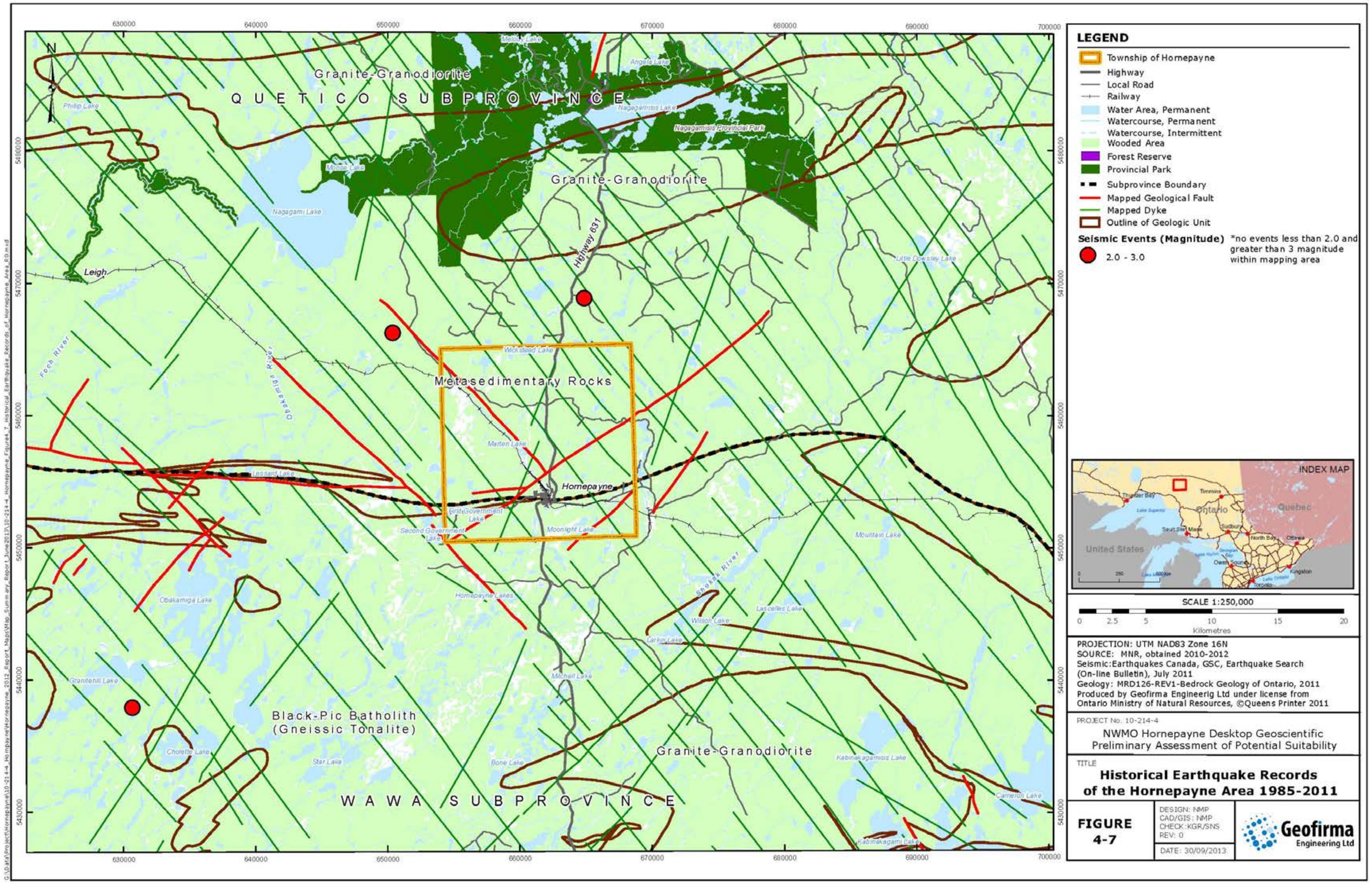

Figure 4-7: Historical Earthquake Records of the Hornepayne Area 1985–2011

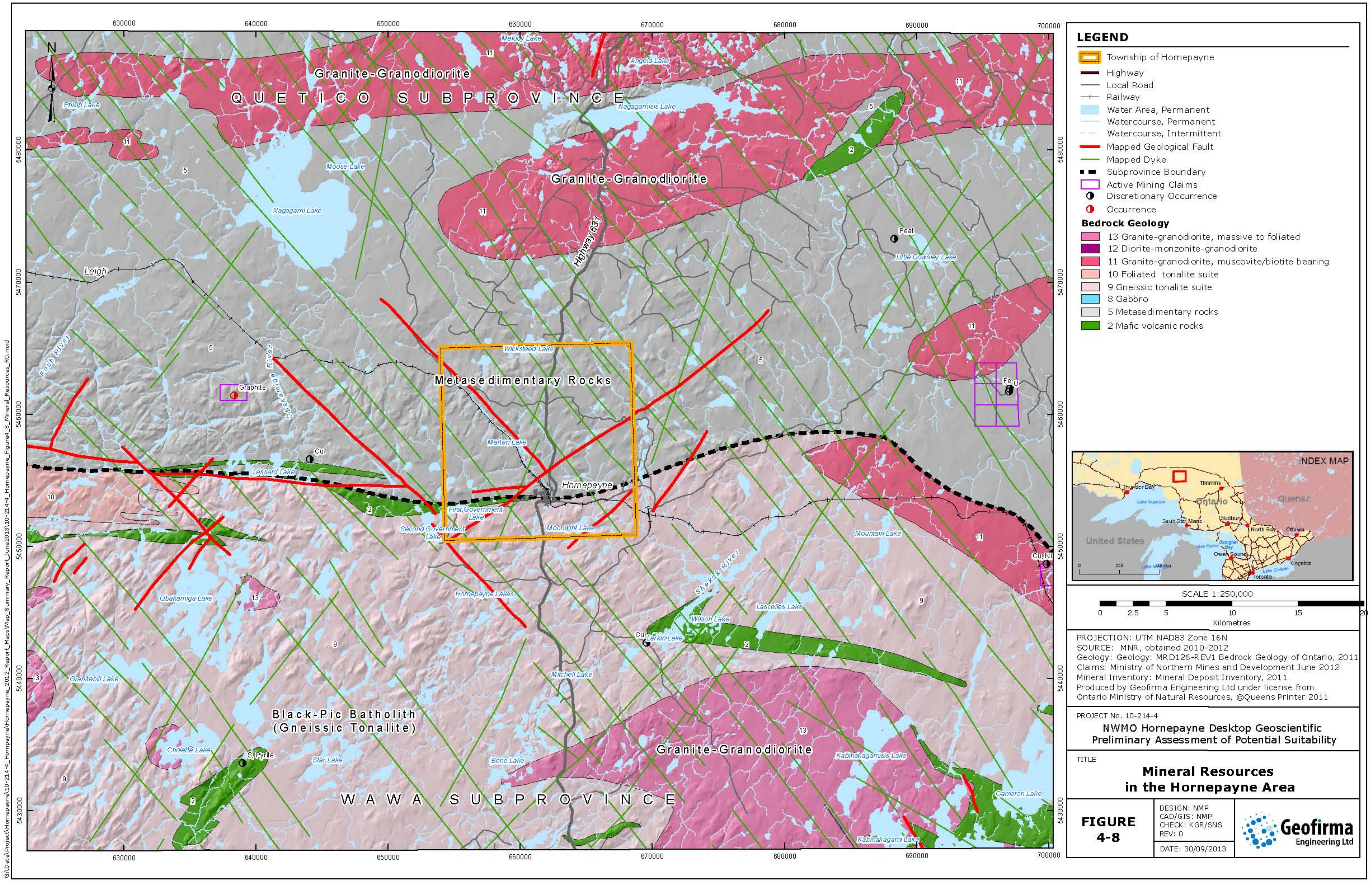

Figure 4-8: Mineral Resources in the Hornepayne Area

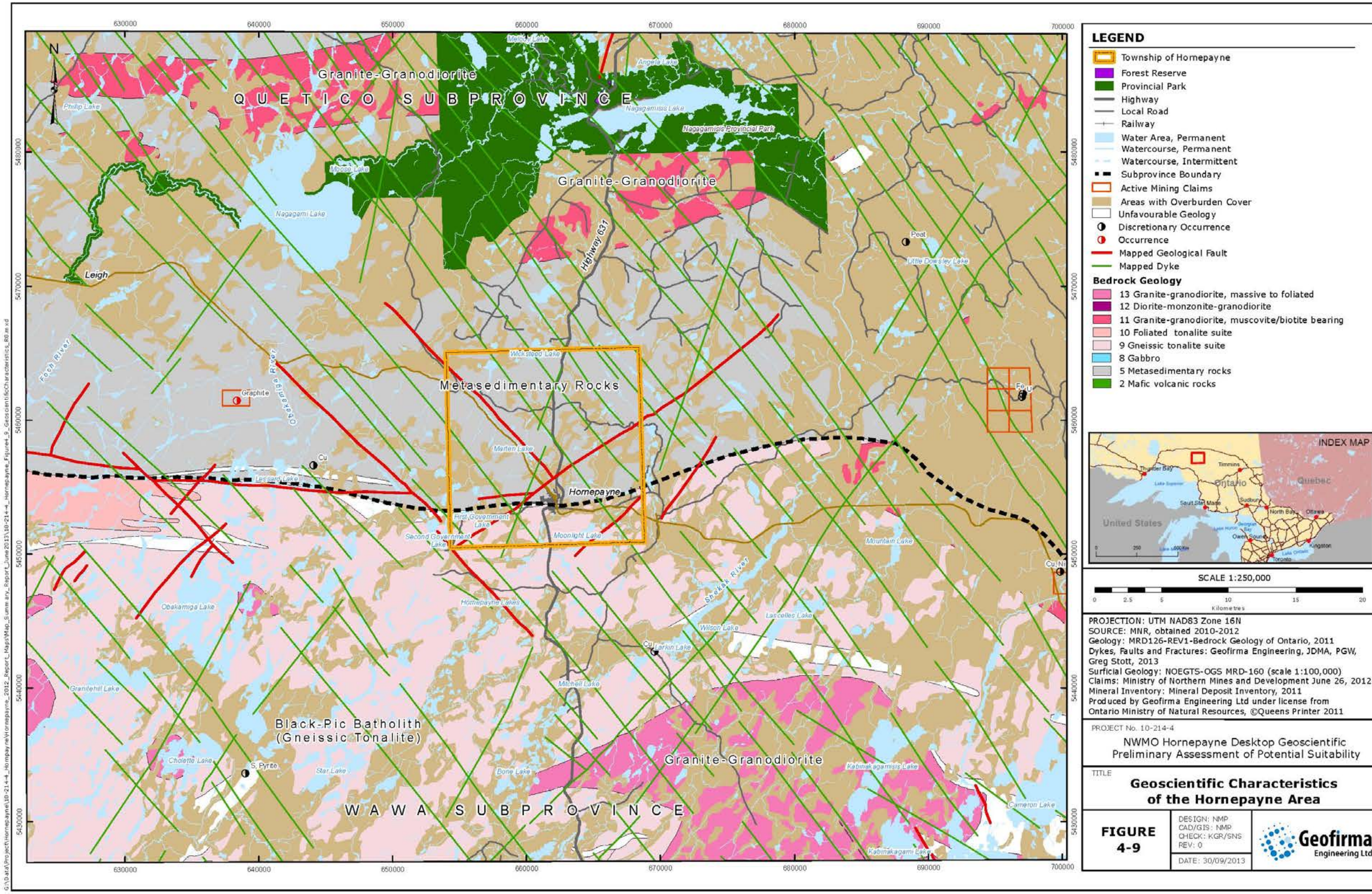

Figure 4-9: Geoscientific Characteristics of the Hornepayne Area

5. PRELIMINARY ENVIRONMENT AND SAFETY ASSESSMENT

5.1 Environment and Safety Assessment Approach

The objective of this preliminary assessment is to assess the potential to ensure the health and safety of people and the environment in the Hornepayne area, and to explore the potential to manage any environmental effects that might result from the Adaptive Phased Management (APM) Project. This is achieved by considering the following questions:

1. Is there anything in the natural environment that would preclude siting the repository somewhere in the Hornepayne area?
2. If the repository is located somewhere in the Hornepayne area, would environmental effects which could not be managed be likely to occur during siting, construction, operation, or decommissioning and closure of the repository?
3. If the repository is located somewhere in the Hornepayne area, would postclosure health or environmental effects which could not be managed be likely to occur?

The assessment presented here takes into account the following factors:

- Safe containment and isolation of used nuclear fuel;
- Safe construction, operation and closure of the repository; and
- Potential to avoid ecologically sensitive areas and locally significant environmental and cultural features.

The assessment is conducted at a desktop level (i.e., based on readily available information). It is expected that surface natural environment information is not uniformly available within the Hornepayne area, so that a lack of identified features in some locations could simply be due to data limitations. It is also clear that there is limited information at typical repository depths, which limits the ability to make substantive comments on postclosure safety beyond those presented in the geoscientific assessment (Chapter 4). It is intended that suitability of potential siting areas will be further evaluated in a staged manner through a series of progressively more detailed scientific and technical studies. As part of these future activities, discussions with interested communities, surrounding communities, and Aboriginal peoples, as well as field studies, would be undertaken to aid in the characterization of environmental conditions.

The Initial Screening criteria include that there must be sufficient available land and that the available land must be outside protected areas, heritage sites, provincial parks and national parks (NWMO, 2010). This chapter begins to provide information on environmental features in the Hornepayne area, which may help inform the identification of potential suitable sites during subsequent stages of the site selection process.

The information presented in this chapter includes the following:

- General description of the environment;
- Assessment of potential effects on people and the environment in various project phases through closure and monitoring; and
- Assessment of postclosure safety aspects.

5.2 Description of the Environment

The environment and safety assessment is conducted within a defined geographic area around Hornepayne, referred to as the “Hornepayne area.” For the purpose of this preliminary assessment, the area considered is the same as that selected for geoscientific assessment shown in Figure 4-1.

A detailed description of the environment for the Hornepayne area is provided in Golder (2013). Summary information is presented here.

5.2.1 Communities and Infrastructure

Figure 5-1 shows the location of Hornepayne within the regional area. Figure 5-1 also shows the infrastructure and major land use within the Hornepayne area, including the locations of parks, protected areas and Crown reserve lands.

The Township of Hornepayne is approximately 205 square kilometres in size (LIO, 2012), with a population of 1,050 (Statistics Canada, 2012). The settlement area is 340 kilometres east of Thunder Bay, 260 kilometres west of Timmins, and 300 kilometres north of Sault Ste. Marie, based on straight line distances (i.e., as the crow flies).

There are a number of Aboriginal communities and organizations in the Hornepayne area, including Brunswick House First Nation, Chapleau Cree First Nation, Constance Lake First Nation, Michipicoten First Nation, Missanabie Cree First Nation, Ojibways of the Pic River (Heron Bay) and Pic Mobert First Nation. Métis Councils in the area include Greenstone Métis Council, Superior North Shore Métis Council and Thunder Bay Métis Council as represented by Lakehead/Michipicoten/Nipigon Traditional Territory Consultation Committee and Chapleau Métis Council, Métis Nation of Ontario Timmins Council, Northern Lights Métis Council and Temiskaming Métis Council as represented by Abitibi/Temiskamingue and James Bay Traditional Territory Consultation Committee and the Métis Nation of Ontario.

The main transportation route through the Hornepayne area is Highway 631, which passes through the centre of the area in a north-south orientation, and through the Township of Hornepayne. A rail corridor runs east-west through the Hornepayne area, and a high-voltage electrical distribution line runs eastward into Hornepayne from Manitouwadge. There is an airport within the Township and a float plane base to the west. There are no gas pipelines recorded within the Hornepayne area. There are four operating landfills and one waste water treatment plant.

The 425-square-kilometre Nagagamisis Provincial Park, located 15 kilometres north of the Township of Hornepayne, is the only provincial park or reserve in the Hornepayne area. There are no conservation reserves.

The Ontario Archaeological Sites Database identifies 21 known archaeological sites in the Hornepayne area, with one of these found within the Township of Hornepayne. The site within the Township of Hornepayne is a pre-contact Aboriginal isolated find (a chert flake), on the south shore of Wicksteed Lake, north of the Hornepayne area. A total of 14 Late Woodland and/or historic Algonkian archaeological sites and one historic Euro-Canadian trading post site have been located in Nagagamisis Provincial Park. More recently, a cultural heritage assessment in 2000 and 2001 documented 20 Aboriginal heritage values sites in the Nagagamisis area (HFMI, 2007), as well as 30 culturally modified trees that were used by First

Nations peoples to mark burial sites, campsites and portages. Local heritage sites would be further confirmed in discussion with the community and Aboriginal peoples in the area, should the community proceed in the site selection process.

Trapline Licence Areas are located in much of the Hornepayne area.

As discussed in Section 4.3.7, water wells in the Hornepayne area obtain water from the overburden or shallow bedrock. The Ontario Ministry of the Environment (MOE) water well database contains records for 71 water wells in the Hornepayne area, ranging from 3 to 119 metres in depth (MOE, 2012). No potable water supply wells are known to exploit aquifers at typical repository depths in the Hornepayne area or anywhere else in northern Ontario.

5.2.2 Natural Environment

As described in Chapter 4, the geology of the Hornepayne area is dominated by the Canadian Shield. The Hornepayne area lies in the Abitibi Highlands, featuring the broadly rolling surfaces of Canadian Shield bedrock that occupies most of north-central Ontario, either exposed at surface or shallowly covered with Quaternary glacial deposits. The land surface is generally rugged with elevations ranging from 483 metres above sea level in the southwest, six kilometres west of Obakamiga Lake to 263 metres above sea level reflecting the continental drainage divide located to the southwest of Hornepayne in the vicinity of Granitehill Lake.

Geologically, the Hornepayne area straddles the Quetico and Wawa subprovinces of the Superior Province of the Canadian Shield, with the boundary between the two subprovinces running in the east-west direction. The southern half of the Hornepayne area comprises granitic rocks of the Black-Pic batholith of the Wawa Subprovince; the northern half is dominated by the metasedimentary rocks and granitic intrusions of the Quetico Subprovince. Thin slivers of volcanic rocks of the Manitouwadge-Hornepayne greenstone belt are mapped within the Black-Pic batholith and along the subprovince boundary.

The Hornepayne area has a boreal climate and is characterized by long, cold winters, and short, cool to mild summers. Most precipitation falls between May through October from low pressure systems formed in the American upper Midwest and the Canadian prairies. During the winter, Arctic low pressure systems move southward into the region bringing very cold temperatures and little precipitation.

Figure 5-2 shows the significant natural features within the Hornepayne area, including watershed boundaries, significant ecological areas, wintering areas, calving and spawning sites, and nesting areas for known rare species. This information will be further developed in the future through discussions with interested communities and Aboriginal peoples, as well as field studies, should the community proceed in the site selection process.

The Hornepayne area is located within the Nagagami River tertiary watershed, which has its origin in a series of lakes and creeks to the south of the Hornepayne area that flow in a northeasterly direction; they are joined by the Nagagamisis River east of Nagagamisis Lake. Lands in the southwest Hornepayne area form part of the White River tertiary watershed, which flows southwest to Lake Superior. The eastern portion of the Hornepayne area is within the Upper Kabinakagami River tertiary watershed, which flows to the northeast towards James Bay via the Kabinakagami, Missinaibi and Moose rivers.

Fisheries information for the Nagagami Forest area is limited and was collected by the Ministry of Natural Resources (MNR) in the 1970s and 1980s (JRML, 2011). The Hearst Forest area contains mostly coolwater fisheries on the clay belt and coldwater fisheries associated with the eskers (HFMI, 2007). Coldwater fisheries in this area typically support natural brook trout populations, and the main sport fish targeted are walleye, northern pike and trout. The largest aquatic habitat features include the Nagagami and Nagagamisis Lakes to the north, the Granitehill and Obakiamiga Lakes to the southwest, and the Larkin, Kabinakagamisis, Kabinakagami and Cameron Lakes to the southeast of the Township of Hornepayne. The fish populations in these lakes are managed to maintain and maximize their size and availability to both locals and tourists. Lake sturgeon is a species that is classified as threatened in the *Species at Risk Act*, 2012, and can be found within the Hornepayne area.

Forestry is a major industry in the area and includes a number of private timber companies currently managing forestry operations, including the Olav Haavaldsrud Timber Company Ltd., operating in this area since 1953. The Hornepayne area lies within the Boreal Forest Region and primarily two Forest Management Units (FMUs): the Nagagami FMU 390; and the Hearst FMU 601. Portions of the Bic Pic Forest and the White River FMU are also contained within the region. The region's forests provide habitat for wildlife, including game, fur-bearing mammals and fish. Management of woodland caribou, moose, and marten populations, and concentration and nesting areas for raptors, herons and waterfowl are a particular concern to the Ministry of Natural Resources (MNR, 2009).

The Natural Heritage Information Centre (NHIC, 2012) identified no species observed within the Hornepayne area that are listed as endangered, threatened or special concern either under the Ontario *Endangered Species Act*, 2007, or the Federal *Species at Risk Act*, 2012. However, using habitat range mapping, 13 endangered, threatened or special concern species are identified to have a range that overlaps the Hornepayne area (ROM, 2012; Oldham and Weller, 2000; Cadman et al., 2007; Holmes et al., 1991). The western portion of the Hornepayne area is part of both continuous and discontinuous woodland caribou (threatened provincially and federally) habitat as identified in Ontario's Woodland Caribou Conservation Plan (MNR, 2009). The ranges for provincially endangered eastern cougar and golden eagle also extend to the region, as does provincially threatened lake sturgeon (northwestern Ontario population) as mentioned above. Further data collection through site-specific surveys and potential discussions with interested communities and Aboriginal peoples would be needed to refine habitat use and suitability for these species, should the community proceed in the site selection process.

5.2.3 Natural Hazards

Natural hazards may be important with respect to operational and postclosure safety of the repository. Potential natural hazards that could occur in the Hornepayne area are described in the Environment Report (Golder, 2013). A preliminary qualitative assessment of the potential natural hazards is summarized below.

- Earthquakes – Low risk – Located in a seismically stable region of the Canadian Shield and has a low seismic hazard rating (NRCan, 2010) (see Chapter 4 for additional information).
- Tornadoes/Hurricanes – Low risk – Located in an area with a low tornado frequency (less than 0.1 tornadoes per year/10,000 square kilometres), but where there is a potential for F0–F1 tornadoes (Sills et al., 2012) and is located outside the geographic area where hurricanes occur.

- Flooding – Low risk – General risk of flooding is low due to small catchment areas and modestly rugged terrain. Risk will vary based on specific location.
- Drought – Low risk – Risk of drought is low and unlikely to affect the viability of local water sources.
- Snow/Ice – Low risk – Total average annual snowfall is moderate (250 centimetres), and extreme snowfall events are uncommon.
- Fire – Possible risk – Forest fires occur in the area, although historically they have been less than 10 square kilometres in size and have affected less than one per cent of the area over a 35-year period.
- Landslide – Low risk – General risk of landslide is low due to stable slopes of modest gradients and low seismic hazard rating. Risk will vary based on specific location.
- Tsunami – Negligible risk – Low seismic hazard rating and absence of sufficiently large water bodies.

5.2.4 Environment Summary

Table 5-1 presents summary information for the Hornepayne area taken from the Environment Report (Golder, 2013).

Table 5-1: Summary of Environmental Features Within the Hornepayne Area

Environmental Feature	Summary
Protected Areas	
Known Heritage Sites (Including Archaeological Sites)	Yes
Provincial Parks, Conservation Reserves	Yes
Wetlands	Yes
Infrastructure	
Availability of Major Water Source Within 5 kilometres	Yes
Major and Minor Road Access	Yes
Major Utility Alignments	Yes
Nearby Communities	Yes
Land Use	
Water Body/Wetland Coverage	9%/7%
Active Agriculture	No
Active Forestry	Yes
Active Trapping and Hunting	Yes
Active Sport or Commercial Fishery	Yes
Natural Environment	
Potential Habitat Area for Endangered/Threatened/Species at Risk	Yes
Presence of Known Important Terrestrial Habitat Areas	Yes
Presence of Known Important Aquatic Habitat Areas	Yes

Environmental Feature	Summary
Areas of Natural and Scientific Interest (ANSIs) and Earth or Life Science Sites	Yes
Natural Hazards	
Occurrence of Forest Fires	Yes
Potential for Earthquakes	Low
Potential for Tornadoes or Hurricanes	Low
Potential for Flooding, Drought, Extreme Snow and Ice	Low
Potential for Landslides	Low

5.3 Potential Environmental Effects

This section presents the results of a high-level screening assessment performed to identify potential interactions between the project and the environment. The assessment considers:

- Activities associated with each project phase through closure and monitoring;
- Potential interaction of the activities with the environment;
- Environmental components that could be affected by the interaction;
- Potential effects of the interaction with the environmental components; and
- The potential for mitigation measures to avoid or minimize adverse effects.

The interactions, effects and mitigation measures are determined by reference to existing Canadian and international environmental assessments, and not through site-specific analyses. Lastly, a judgment of the significance of residual adverse effects is made assuming implementation of feasible management or mitigation.

Since specific candidate site(s) within the Hornepayne area have not been defined, the assessment reflects general conditions across the area. A full environmental assessment would eventually be completed for any preferred site once determined, in accordance with the *Canadian Environmental Assessment Act*, 2012.

The environment is described by individual environmental components, each of which represents physical, biophysical, or social features that could be affected by the project. Environmental components used to understand the potential for environment effects at this preliminary assessment phase are:

- Atmospheric Environment: air quality, noise, vibration and light;
- Subsurface Environment: geology, hydrogeology, and groundwater quality;
- Aquatic Environment: surface water quality, surface water quantity and flow, sediment quality, and aquatic habitat and communities including sensitive species;
- Terrestrial Environment: vegetation communities, soil quality, wildlife habitat and communities, natural heritage features and sensitive species;
- Radiation and Radioactivity: radiation dose to humans, including members of the public and project workers, and radiation dose to non-human biota; and
- Cultural Resources: Aboriginal heritage resources and Euro-Canadian heritage resources.

5.3.1 Potential Effects During the Site Selection Process

As explained in Section 1.5, the site selection process includes the identification of potential sites within the smaller number of communities and subsequent detailed investigations of preferred sites in communities that continue in the site selection process. These investigations will involve field surveys to better characterize the site-specific environment, including airborne geophysics, detailed geological mapping, drilling and testing of boreholes, and environmental surveys. Activities may include line cutting and temporary road construction activities to construct access routes to sites undergoing detailed evaluation.

Table 5-2 summarizes the generic project-environment interactions that could occur during the site selection process. These activities may result in environmental effects associated with noise, vegetation clearing for site access, drilling/blasting and increased traffic. Site-specific project-environment interactions for the Hornepayne area would need to be evaluated during subsequent steps of the site selection process.

Implementation of an environmental management plan for these activities would be expected to reduce the effects. For example, drilling fluids associated with site exploration boreholes would be contained at the site and disposed of appropriately. In addition, the location of drill sites and the alignment of roads for access to drill sites (if required) would be determined collaboratively with the community and Aboriginal peoples, and be designed to avoid protected areas, habitat areas for species of conservation concern and heritage sites. Timing of construction activities would be controlled to mitigate effects on biota if any potential interactions are identified.

Overall, no project-environment interactions are identified that would prevent activities associated with site selection in the Hornepayne area.

Table 5-2: Potential Interactions With the Biophysical Environment During Site Selection Process

Environmental Component	Main Considerations	Is there Potential for an Effect?	Is Management and Mitigation Possible?	Are Significant Residual Effects Anticipated?
Atmospheric Environment	Vehicle emissions, dust, noise, light, vibration from blasting	Yes	Yes	No
Subsurface Environment	Change in groundwater quality and flow from site clearing and blasting	Yes	Yes	No
Aquatic Environment	Change in surface water quality and flow from site clearing, disturbance to aquatic habitat or biota from access construction, vibration due to blasting	Yes	Yes	No
Terrestrial Environment	Clearing and disturbance to terrestrial habitat or biota from access construction, noise, vibration from blasting, increase in traffic	Yes	Yes	No

Environmental Component	Main Considerations	Is there Potential for an Effect?	Is Management and Mitigation Possible?	Are Significant Residual Effects Anticipated?
Radiation and Radioactivity	None – no additional radiation beyond natural background	No	—	—
Cultural Resources	Disturbance of archaeological resources from clearing	Yes	Yes	No

5.3.2 Potential Effects During Construction

The Construction Phase comprises the development of the selected site, construction of facilities, utilities and infrastructure necessary to support development and operation of the project, and excavation of the underground facilities and some of the placement rooms. During this phase, surface and underground facilities will be installed and commissioned, and will be ready to begin receiving used fuel. This phase could take 10 or more years to complete. A general description of the facility is provided in Chapter 3. Site preparation and construction would occur following completion and approval of an environmental assessment under the *Canadian Environmental Assessment Act*, 2012, and after applicable permits have been obtained.

A substantial workforce would be expected. Since the Township of Hornepayne and its periphery contain a large area in which the repository could be located, accommodations for the temporary construction workers would be needed; the location of this camp would be determined collaboratively with the community, surrounding communities and Aboriginal peoples in the area. The accommodations could have capacity for up to 600 temporary workers, and include supporting facilities such as kitchen and dining areas (see Chapter 3). Planning of such accommodations and facilities would be undertaken collaboratively with the community and take into account opportunities for fostering well-being of the community and area as discussed in Chapter 7.

Lay-down areas with storage and yard facilities for materials and equipment will also be necessary. It is assumed that new access road and railway systems may be required to provide access to the project site.

Temporary infrastructure to support the construction workforce and activities, including sewage treatment, water supply, and waste management facilities, would be made available at the project site until permanent infrastructure (i.e., powerhouse, water treatment plant, sewage treatment plant, landfill) are established. Electricity for site preparation activities and for early construction activities is assumed to be provided by diesel generators. Heating for construction trailers and any temporary worker accommodations is assumed to use natural gas or propane.

During site preparation, the main activities would include clearing existing vegetation, levelling the site, and installing site drainage systems to manage surface run-off. Fuel storage and water storage tanks would also be located at the site to facilitate construction activities.

The major activity during construction would be the development of underground facilities. Repository construction begins with shaft sinking and full development of underground tunnels and service areas. This will include development of the Underground Demonstration Facility.

The service shaft, waste shaft and upcast ventilation shaft would be excavated by controlled drill and blast techniques. Repository access tunnels would also use controlled drill and blast techniques or rock boring technology, designed to minimize damage to the surrounding rock. Once the shafts and access tunnels are complete, the first panel of placement rooms would be excavated. The remainder of placement room excavations would take place during the Operation Phase.

For a 4.6 million fuel bundle repository, storage of the excavated rock is expected to require an area of about 700 metres by 700 metres, with a height between 3 metres and 6 metres. A small portion of the excavated rock would be maintained on-site to support aggregate operations, with the balance transferred to the excavated rock disposal area, whose location would be determined collaboratively with the community and area (Chapter 3). The disposal area will include a stormwater run-off pond to collect and manage the effluent before release to the environment in accordance with applicable regulatory requirements. Depending on the composition of the excavated rock and the consequence of its exposure to environmental conditions, some consideration may need to be given to the potential production of acid rock drainage. Any mitigating measures required will form part of the overall environmental management program that will be developed in detail in later steps of the site selection process.

The construction of both above ground and underground facilities will require dewatering, as well as surface water run-off management, during the construction stages. Intermediate and deep groundwater generated during dewatering will require treatment for dissolved solids (e.g., iron and manganese) prior to release into the environment, whereas shallow groundwater and surface water run-off is not likely to require significant treatment. Water taking and water discharge into the environment will be strictly managed in accordance with Provincial regulations.

During this phase, it would also be necessary to construct the permanent surface buildings and complete installation of common services, including waste management systems, utilities, and process and potable water supplies. Given that landfill space in the Hornepayne area is limited, and taking into account that many existing local commercial facilities operate their own landfills, it is assumed that a landfill would be constructed and operated at the project site throughout the Construction, Operation, Extended Monitoring, and Decommissioning and Closure Phases. It is assumed that an aggregate (rock crushing) plant and a concrete batch plant would need to be established on-site, and then operate as necessary until the repository is closed.

Buildings and facilities that are designated to be within the Nuclear Security Protected Area of the complex would be surrounded by a security fence, and lighting would be provided along the fence and at building entrances. A perimeter fence around the entire complex would also be installed. The fenced portion of the site is anticipated to occupy an area of about 600 metres by 550 metres, with an additional fenced portion measuring about 100 metres by 100 metres located some distance away, housing a ventilation shaft. During this phase, water would be required primarily for drilling and excavation, for concrete mixing, and for worker drinking and personal use. Service water would be provided from a local, suitable source.

Current planning assumptions indicate the duration of this period would be about 10 years. The material requirements during this phase (water, cement, rock movement, traffic) would be of a scale and nature similar to other large mine or construction projects.

Table 5-3 summarizes the project-environment interactions that are expected to occur during the Construction Phase. This phase is the most disruptive to the biophysical environment.

Construction activities may result in environmental effects associated with vegetation clearing, drilling and blasting, excavation, excavated rock storage, hardening of surfaces, placement of infrastructure, surface water and groundwater management, emissions from vehicles and equipment, dust, noise and increased traffic.

In-design mitigation measures and implementation of an environmental management plan would reduce the environmental effects. Measures may include selection of infrastructure and corridor locations to avoid protected areas, habitat areas for communities or species of conservation concern, or heritage sites. Equipment will be designed to control emissions to air and to reduce noise. Dewatering for subsurface construction, surface water drainage management, operational and potable water supply, and waste water management would be designed and implemented in compliance with applicable regulations.

Within the Hornepayne area, it is anticipated, based simply on the amount of area, that sites exist that avoid protected areas, and therefore, site preparation and construction activities could be undertaken. Feasibility will be reliant on appropriate understanding of the environmental conditions at the site scale, in-design mitigation, and compliance with an environmental management plan designed around applicable legislation.

Overall, no project-environment interactions are identified that would prevent activities associated with site preparation and construction in the Hornepayne area.

Table 5-3: Potential Interactions With the Biophysical Environment During Construction

Environmental Component	Main Considerations	Is there Potential for an Effect?	Is Management and Mitigation Possible?	Are Significant Residual Effects Anticipated?
Atmospheric Environment	Vehicle and equipment emissions, dust, noise, light, vibration due to blasting	Yes	Yes	No
Subsurface Environment	Change in groundwater quality and flow due to withdrawal for supply, drawdown for drilling and construction dewatering, and management of run-off from hardened surfaces	Yes	Yes	No
Aquatic Environment	Change in surface water quality or flow, disturbance to aquatic habitat or biota due to placement of infrastructure and required water supply, vibration due to blasting	Yes	Yes	No
Terrestrial Environment	Clearing and disturbance to terrestrial habitat or biota from infrastructure or rock pile placement, noise, vibration from blasting, increase in traffic	Yes	Yes	No

Environmental Component	Main Considerations	Is there Potential for an Effect?	Is Management and Mitigation Possible?	Are Significant Residual Effects Anticipated?
Radiation and Radioactivity	Doses to humans and biota from radon and natural rock activity	Yes	Yes	No
Cultural Resources	Disturbance of archaeological resources from clearing, placement of infrastructure, blasting	Yes	Yes	No

5.3.3 Potential Effects During Operation

The Operation Phase includes the receipt, packaging and placement of used fuel in the repository. For a fuel inventory of 4.6 million bundles, repository operations would last about 38 years (Chapter 3). Facility operations would only begin when all approvals, including a Canadian Nuclear Safety Commission (CNSC) operating licence, have been received.

All used fuel manipulations will take place in the Used Fuel Packaging Plant. This is a multi-story reinforced concrete structure designed for receiving empty used fuel containers, receiving filled transportation casks, transferring used fuel bundles from the transportation casks to the used fuel containers, and sealing, inspecting and dispatching filled used fuel containers for placement in the repository. Each placement site would be sealed following container placement. Once all sites in a placement room are sealed, the entire room would be closed and sealed.

Most steps in the packaging process are remotely operated, taking place in radiation-shielded rooms. Radioactive areas are maintained at a slightly negative pressure to preclude the spread of contamination. Ventilation air is cleaned, filtered, and monitored prior to leaving the facility. Radioactive releases during normal operation are anticipated to be a very small fraction of the regulatory limits.

To meet regulatory requirements, the safety analysis will investigate the consequences of upsets and accidents occurring during the Operation Phase. While the specific events to be analyzed will be defined in the future, such occurrences as loss of power, loss of ventilation and dropping of a container will be addressed to verify and demonstrate robustness of the design. Analysis of similar events at other proposed used fuel repositories indicates the consequences are anticipated to be well below the regulatory limits.

An environmental monitoring system will be established to monitor for environmental effects, to optimize facility performance and to demonstrate regulatory compliance. The environmental monitoring program would consist, as a minimum, of the following components:

- Groundwater Monitoring;
- Stormwater/Surface Water Monitoring;
- Air Quality Monitoring;
- Meteorological Monitoring; and
- Seismic and Vibration Monitoring.

Maintenance of the equipment and facilities, including safety checks and inspections, would be routinely undertaken during this phase. Support activities that would be carried out include preparation of buffer, backfill and repository sealing materials used in borehole and placement room sealing, rock crushing and concrete mixing. The main external supplies would be the containers and the clay seal materials, which would be shipped through the area to the site.

The Operation Phase also includes continued excavation of additional placement rooms, which could involve drilling and blasting, tunnel boring, removal of rock and continued operation of the excavated rock stockpile area.

Raw water for the site would be sourced locally at the rate needed to meet the demands of site personnel, concrete production, sand production and dust control. Water is not required for cooling of the used fuel.

Sewage collected from all serviced buildings will be piped to a Sewage Treatment Plant for treatment to provincial standards prior to discharge.

Several ponds will be established to affect either process water or stormwater control. All the ponds will be lined over their base and embankments with polyethylene for protection and to prevent water infiltration into the ground. Collected flows will be quality monitored and treated as required before being directed to downstream process (e.g., aggregate crushing plant) or to the off-site discharge.

Low- and intermediate-level radioactive waste will be handled as separate waste streams. Active solid waste may be generated in the Used Fuel Packaging Plant, the Auxiliary Building and the active liquid waste treatment process. These wastes would consist of such things as modules from the incoming transport containers, filters, spent resins, and cleaning materials.

Active solid wastes that are not or cannot be decontaminated to free-release limits will be placed into approved transportation containers and shipped off-site to a licensed long-term management facility.

Active liquid waste may be generated in the Used Fuel Packaging Plant and the Auxiliary Building. These wastes would originate from decontamination of used fuel modules, cell wash downs, and the wet decontamination of irradiated fuel transport casks and containers. Active liquid waste would be managed in two facilities – a storage building and a waste treatment building, with the storage building incorporating secondary containment for spills or leaks. Most of these liquids will be cleaned on-site and returned to the environment with any residuals being sent to off-site disposal.

Monitoring would be conducted throughout the Operation Phase, including a period of time after the last used fuel containers have been placed prior to the start of decommissioning.

Activities could include emissions monitoring, environmental monitoring, repository performance monitoring, and maintenance activities. Postclosure monitoring is discussed in Section 5.4.

Table 5-4 summarizes the project-environment interactions that are expected to occur during the Operation Phase. Implementation of an environmental management plan, well-defined operating procedures, and followup on a comprehensive monitoring program would be expected to reduce the environmental effects.

Overall, no project-environment interactions are identified that would prevent operating the repository in the Hornepayne area.

Table 5-4: Potential Interactions With the Biophysical Environment During Operation

Environmental Component	Main Considerations	Is there Potential for an Effect?	Is Management and Mitigation Possible?	Are Significant Residual Effects Anticipated?
Atmospheric Environment	Vehicle and equipment emissions, dust, noise, light, vibration due to underground blasting	Yes	Yes	No
Subsurface Environment	Change in groundwater quality and flow due to withdrawal and dewatering, and management of run-off from hardened surfaces and the excavated rock pile	Yes	Yes	No
Aquatic Environment	Change in surface water quality or flow, disturbance to aquatic habitat or biota due to placement of infrastructure and required water supply, run-off from surfaces and the rock pile, and vibration due to underground blasting	Yes	Yes	No
Terrestrial Environment	Disturbance to terrestrial habitat or biota from infrastructure or rock pile placement/run-off, noise, vibration from blasting, increase in traffic	Yes	Yes	No
Radiation and Radioactivity	Doses to humans and biota from radon, natural rock activity and repository operation	Yes	Yes	No
Cultural Resources	Disturbance to local enjoyment of the area	Yes	Yes	No

5.3.4 Potential Effects During Decommissioning and Closure

The Decommissioning and Closure Phase of the project would begin once placement operations have been completed, sufficient performance monitoring data have been collected to support approval to decommission, a decommissioning licence has been granted, and the community has agreed to proceed to this phase. This phase would end when the repository has been sealed and all surface facilities have been decontaminated and removed. Monitoring would continue for a period of time as determined in discussion with regulatory authorities and the community. The main activities undertaken during this phase would include:

- Decontamination, dismantling, and removal of surface and underground infrastructure and facilities, including water intake structures;
- Sealing of tunnels, shafts and service areas;
- Sealing of all surface boreholes and those subsurface boreholes not required for monitoring;
- Closure of the on-site landfill; and
- Monitoring as necessary.

Once the repository is sealed and all buildings and facilities are removed, the area must be shown to meet regulatory limits for the agreed-upon end-state land use. This would include landscaping and restoration of natural habitat on the site.

Before the facility is closed, used fuel handling activities would cease, all the underground placement rooms would be sealed, and any related radiological emissions would stop. During closure, any residual radioactive materials would be removed. Structures used for radioactive work would be carefully dismantled to limit the amount of dust produced. Any radioactive soil would be managed in accordance with applicable regulations or guidelines. The radiological releases are anticipated to be a small fraction of regulatory limits and no greater than those during the Operation Phase.

Table 5-5 summarizes the project-environment interactions that are expected to occur during the Decommissioning and Closure Phase. The potential environmental effects are expected to be similar to those encountered during construction, with the exception of the presence of residual radioactive materials.

The implementation of an environmental management plan specific to this phase of the project, along with continued occupational dose management programs, would reduce potential effects on humans and the environment. More generally, the net effect of the decommissioning and closure would be to reduce the surface footprint of the repository and therefore would in general be beneficial to the environment after completion

Overall, no project-environment interactions are identified that would prevent decommissioning and closing the repository in the Hornepayne area.

Table 5-5: Potential Interactions With the Biophysical Environment During Decommissioning and Closure Activities

Environmental Component	Main Considerations	Is there Potential for an Effect?	Is Management and Mitigation Possible?	Are Significant Residual Effects Anticipated?
Atmospheric Environment	Vehicle and equipment emissions, dust, noise, and light	Yes	Yes	No
Subsurface Environment	Change in groundwater quality and flow due to closure of system for withdrawal for supply and management of run-off from hardened surfaces and the rock pile	Yes	Yes	No
Aquatic Environment	Change in surface water quality or flow, disturbance to aquatic habitat or biota due to removal of infrastructure, run-off from the rock pile and required water supply	Yes	Yes	No
Terrestrial Environment	Clearing and disturbance to terrestrial habitat or biota from infrastructure or rock pile removal, noise, increase in traffic	Yes	Yes	No
Radiation and Radioactivity	Doses to humans and biota from radon and from residual radioactivity during infrastructure removal operations	Yes	Yes	No
Cultural Resources	Disturbance to local enjoyment of the area	Yes	Yes	No

5.3.5 Potential Effects During Monitoring

The conceptual project design makes provision for up to two periods of monitoring; however, specific details would be developed in collaboration with the local community. The first of these periods would occur during operation after the placement activities are completed and prior to the initiation of the Decommissioning and Closure Phase. The other monitoring period may occur during decommissioning. Activities during these monitoring periods could involve monitoring conditions in the repository itself, as well as monitoring environmental factors in the geosphere and biosphere (i.e., subsurface and surface environments).

Monitoring activities may require human presence. Such activities could include managing boreholes and acoustic monitors, and conducting air, water and biology surveys or sampling. These would likely use existing borehole sites and roads. When compared to the environmental effects associated with the earlier project phases, potential environmental effects associated with conducting this monitoring are likely to result in fewer environmental effects and are therefore not discussed further.

Following site restoration and a period of monitoring, and with community agreement, a licence to abandon the site would be obtained. In this regard, “abandon” (a term that exists within the regulatory framework) means that the site would not require ongoing regulatory controls and licensing by the CNSC. While further monitoring would not be legally required, monitoring could be continued depending on arrangements with the local community. It is possible that permanent markers would be installed to inform future generations of the presence of the sealed repository.

5.4 Postclosure Safety

5.4.1 Postclosure Performance

In the repository design, the radioactivity is initially contained within the used nuclear fuel. The bulk of the used fuel (98 per cent) is solid ceramic uranium dioxide.

The used nuclear fuel is sealed in durable metal containers and placed in an engineered structure excavated deep within a stable rock formation. The layout of the repository would be a network of tunnels and placement rooms designed to accommodate the rock structure and stresses, the groundwater flow system, and other subsurface conditions at the site. A clay buffer material would surround each container, and backfill material and other seals would close off the rooms and fill the shafts.

The rock and deep groundwater that surround the repository would provide stable mechanical and chemical conditions that would promote containment of the wastes for long times.

After closure, the repository would initially (within about 100 years) heat up to a maximum temperature of around 100°C and then slowly cool back to ambient rock temperatures. Within several hundred years, natural groundwater within the rock would seep back into the facility and re-saturate the space in the clay buffer and room backfill. During this same period, the majority of the initial (and more radioactive) fission products in the used fuel would decay to stable, non-radioactive elements. However, the residual radioactivity is still hazardous, and would include long-lived fission products, actinides and uranium decay products.

The potential effects of the used fuel repository over the very long term would be from potential releases of radionuclides and other non-radioactive contaminants leached or dissolved from the placed used fuel. These contaminants could migrate into the bedrock and deep groundwater, and could eventually reach the surface environment.

5.4.2 Postclosure Assessment

To support the design and to check the long-term site safety, a postclosure safety assessment would be performed. In this assessment, computer models are applied to a suite of analysis cases to determine potential effects on the health and safety of persons and the environment. The assessment time frame extends from closure until the time at which the maximum impact is predicted, with a one-million-year baseline adopted based on the time period required for the used fuel radioactivity to decay to essentially the same level as that in an equivalent amount of natural uranium.

The postclosure assessment does not predict the future, but instead examines potential consequences from various postulated scenarios, ranging from likely to “what if.” The Normal Evolution Scenario represents a reasonable extrapolation of the site and repository, and accounts for anticipated significant events such as glaciation. Sensitivity studies assume degraded performance of various components of the multi-barrier system to demonstrate the conclusions are not especially sensitive to uncertainties in the input information. Disruptive Scenarios postulate the occurrence of unlikely events leading to possible penetration of barriers and abnormal loss of containment.

Assessing the postclosure suitability of the Hornepayne area and specific sites therein for hosting the used fuel repository requires substantive site-specific information on the geology at repository depth. The suitability of the local geology for hosting a repository is discussed in Chapter 4. This geoscience assessment addresses factors such as:

- ***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?
- ***Long-term resilience to future geological processes and climate change –*** Are the rock formations beneath the siting area adequate, such that they will not be substantially altered by natural geological disturbances and events such as earthquakes and climate change?
- ***Safe construction, operation and closure of the repository –*** Are rock conditions at the site suitable for the safe construction, operation and closure of the repository?
- ***Isolation of used fuel from future human activities –*** Is human intrusion at the site unlikely, for instance, through future natural resource exploration or extraction?

At present, due to the limited information on the geology available at this stage in the assessment process, it is not possible to conduct a detailed postclosure safety assessment. Therefore, the current postclosure safety assessment conclusion is the same as the assessment presented in Chapter 4, where it is judged that there are geological units that are potentially suitable for hosting the repository within the Hornepayne area.

However, it is possible to draw on the results from a number of postclosure safety assessments examining similar but hypothetical sites and repository designs, in order to build confidence in long-term safety.

Four major postclosure safety assessments for a deep geological repository for used CANDU fuel, located at hypothetical sites on the Canadian Shield, have been carried out over the past 20 years (AECL, 1994; Goodwin et al., 1996; Gierszewski et al., 2004; NWMO, 2012). Similar studies assessing repository concepts in crystalline rock have also been published in other countries, notably Sweden (SKB, 2011) and Finland (Posiva, 2007). Although the geologic environment and details of the repository concept vary from study to study, all studies found that management of used nuclear fuel in a deep geological repository is a safe viable option for protecting humans and the environment from the associated long-term hazards. A brief summary of the scenarios analyzed in the Canadian postclosure safety assessments is provided to illustrate this point.

The most likely scenario by which any radionuclide from a deep geological repository can reach the biosphere is through transport from a failed or defective container through the water within the rock porosity. Due to the multiple engineered barriers and the relatively impermeable nature of the Canadian Shield at suitable sites, the analyses show that most of the radioactivity would remain trapped within or near the repository and decay away. The small amounts reaching the biosphere after thousands of years lead to maximum dose rates for suitable sites that are orders of magnitude below the regulatory dose limit (i.e., 1.0 milliSievert (mSv) per year) and the Canadian background dose rate (i.e., roughly 1.8 mSv/year).

The impacts can also be assessed by comparing the calculated concentrations or flux of any radionuclides migrating from the repository to the surface with the concentrations or fluxes of naturally occurring radionuclides. These comparisons indicate that the impacts of any migrating radionuclides would be less than the impacts associated with naturally occurring radionuclides.

The potential chemical toxicity hazard posed by a deep geological repository has also been examined (NWMO, 2012). While the used fuel does not contain hazardous chemicals, it is largely uranium (a heavy metal), and it contains small amounts of other elements that can be toxic in sufficiently high concentrations. Safety assessments indicate that the natural and engineered barriers can provide effective protection against transport of potentially hazardous elements from the repository.

In practical terms, there would be no noticeable effect at the site or surrounding environment.

5.5 Climate Change Considerations

5.5.1 Near-Term Climate Change

Due to the long duration of the project, it is prudent to consider how climate change might have an influence on the repository site.

Over the course of the project lifespan from site preparation to closure (approximately a century), regional climate parameters such as temperature, precipitation and wind could be altered. These changes could lead to, for example, an increase or decrease in surface waters, extent of forestry, local agriculture, storm frequency and intensity, or the frequency of forest fires.

While such changes could affect the schedule, they will have essentially no effect on the safety of the repository during the Operation Phase. As noted earlier, water is not required to maintain cooling of the used fuel, so any interruptions to the water or power supply would have essentially no effect on public safety. The range in weather conditions would be taken into account in the design of surface facilities (e.g., by ensuring that the repository shaft collars are located above areas that could be affected by flooding).

Climate change could alter habitat suitability and availability for aquatic and terrestrial biota, with a shift in the composition of plant communities towards those better adapted to warmer conditions. This shift in forest type could, in turn, affect available habitat for boreal-oriented species. Development of re-vegetation plans at closure would take into account how plant community attributes may be altered in response to climate change.

During postclosure, the depth of the repository and the applied sealing measures essentially isolate the repository from all surface effects except glaciation, which is discussed in the next section.

5.5.2 Glaciation

The Canadian Shield has been covered by ice sheets for nine major glacial cycles over the past one million years. These cycles, with a period of approximately 100,000 years, are believed to be largely related to variations in solar insolation and the location of the continents.

The continents will not change position significantly over the next million years, and the variation in solar insolation is predictable based on known earth orbital dynamics. Studies indicate that over the next 100,000 years or so, the amplitude of insolation variations will be smaller than during the last glacial cycle (Berger and Loutre, 2002). It is also clear that the composition of greenhouse gases is presently significantly larger than usual. Such conditions could suppress the initiation of a glacial cycle for 50,000 years or longer. Beyond this time, a larger reduction in solar insolation is anticipated, and therefore a stronger trigger to initiate a new glacial cycle will occur.

While the timing of the onset of the next cycle cannot be determined, the first ice sheet advance over the repository site is not anticipated to occur within the next 60,000 years, with even longer delays (up to 500,000 years) proposed in some studies (Berger and Loutre, 2002; Archer and Ganopolski, 2005). This implies that a significant time period is available for radioactivity levels in the used fuel to decay prior to glacial onset.

The geology of the Hornepayne area is typical of many areas of the Canadian Shield. A review of the findings of previous field studies involving fracture characterization found that fractures below a depth of several hundred metres in a number of plutons in the Canadian Shield are ancient features. Subsequent stresses, such as those caused by glaciation, generally have been relieved by reactivation along the existing zones of weakness rather than by formation of large new fracture zones. The repository would be located to avoid or minimize contact with fracture zones.

Glacial/interglacial cycling will affect hydrogeological conditions in the overburden and shallow bedrock groundwater zones. Future ice sheets will cause significant changes in the surficial physical environment and the shallow groundwater zone in relation to the formation of permafrost, altered hydraulic pressures and flow rates, and penetration of glacial recharge waters. In low porosity, low permeability systems, geochemical and isotopic data suggest that only the upper, actively circulating groundwater system was affected by past glaciations, with deeper, denser, high-salinity waters largely unaffected.

The effects of glaciation on a deep repository have been assessed in the Glaciation Scenario study for a hypothetical site on the Canadian Shield (Garisto et al., 2010). The study shows that the net impact would not be significantly different from that associated with the assumption of a constant climate and the consequences would be well below regulatory limits.

Site-specific studies are necessary to understand potential effects over the long term that could occur because of the presence of the closed used fuel repository. Subject to these studies, it is assumed that the repository can be placed sufficiently deep that it would not be affected by glaciation.

5.6 Environment and Safety Findings

Based on the available environmental information and the anticipated project activities, no environmental conditions have been identified that would preclude siting the repository somewhere within the Hornepayne area. The assessment has identified some specific areas that would be excluded as they contain parks and protected areas. Subsequent to the identification of more specific potential siting areas, a more definitive environmental evaluation could result in the exclusion of additional areas based on such things as, for example, the presence of migration routes, the proximity to important habitats and cultural sensitivity. Discussions with interested communities, surrounding communities, and Aboriginal peoples, as well as field studies, would be needed to fully characterize the environmental conditions in these potential siting areas.

The findings also indicate that the Site Selection, Construction, Operation, Decommissioning and Closure, and Monitoring Phases will result in effects to the environment. Because many of these effects would be similar to other large industrial or mining projects, it is anticipated that the long-term interactions or potential environmental consequences can be managed or mitigated through a combination of in-design features, operating procedures, and implementation of a sound environmental management plan. These mitigating measures would be defined in later phases of the project as more information becomes available.

At present, due to the limited information on the geology at depth available at this stage in the assessment process, it is not possible to conduct a site-specific postclosure safety assessment. The current postclosure safety conclusion is therefore the same as the assessment in the geoscientific suitability chapter (Chapter 4), where it is judged that there are geological units that are potentially suitable for hosting the repository. Site-specific safety assessments would be created at later phases of the project when more information on the local geology becomes available.

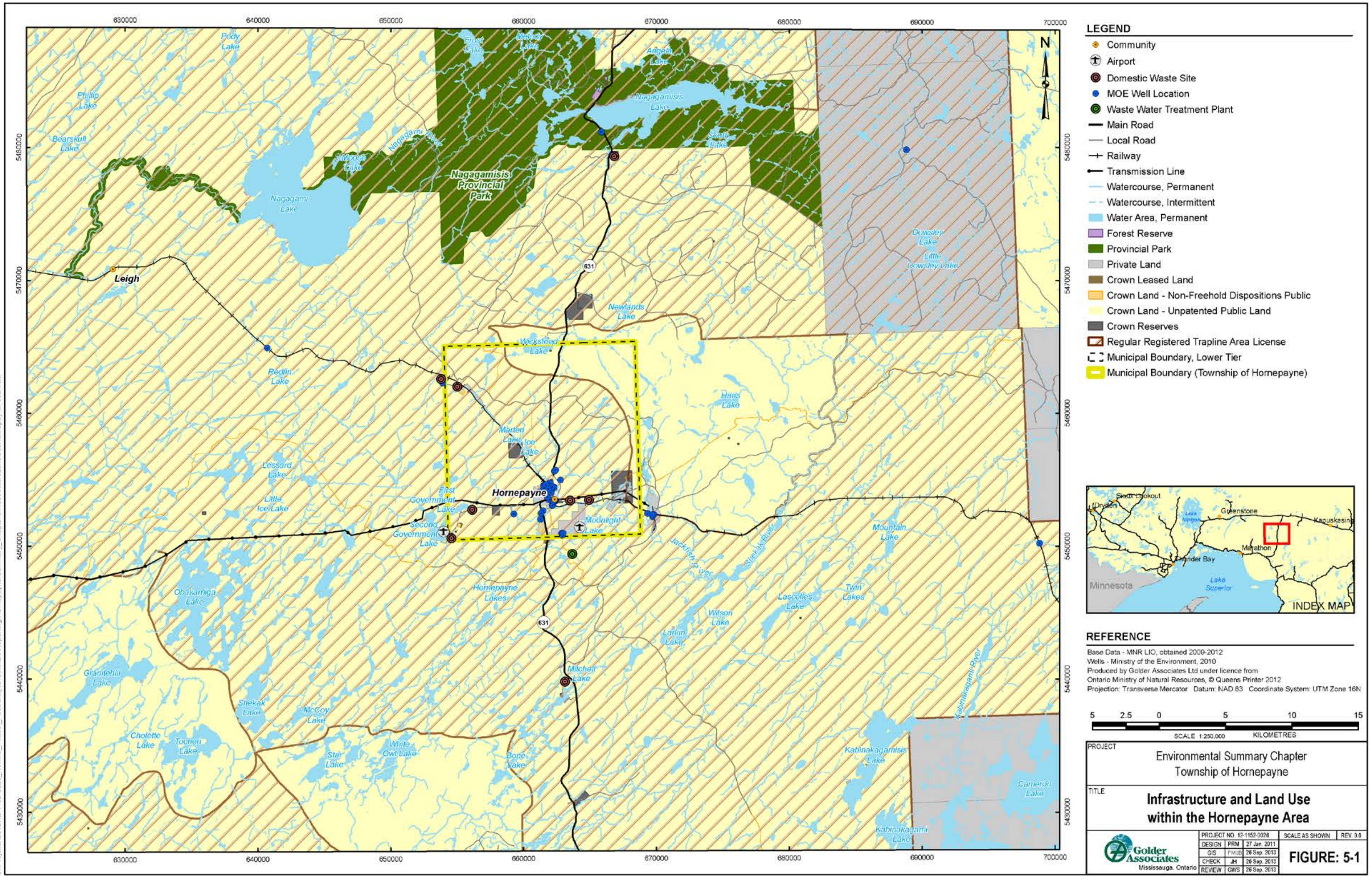

Figure 5-1: Infrastructure and Land Use Within the Hornepayne Area

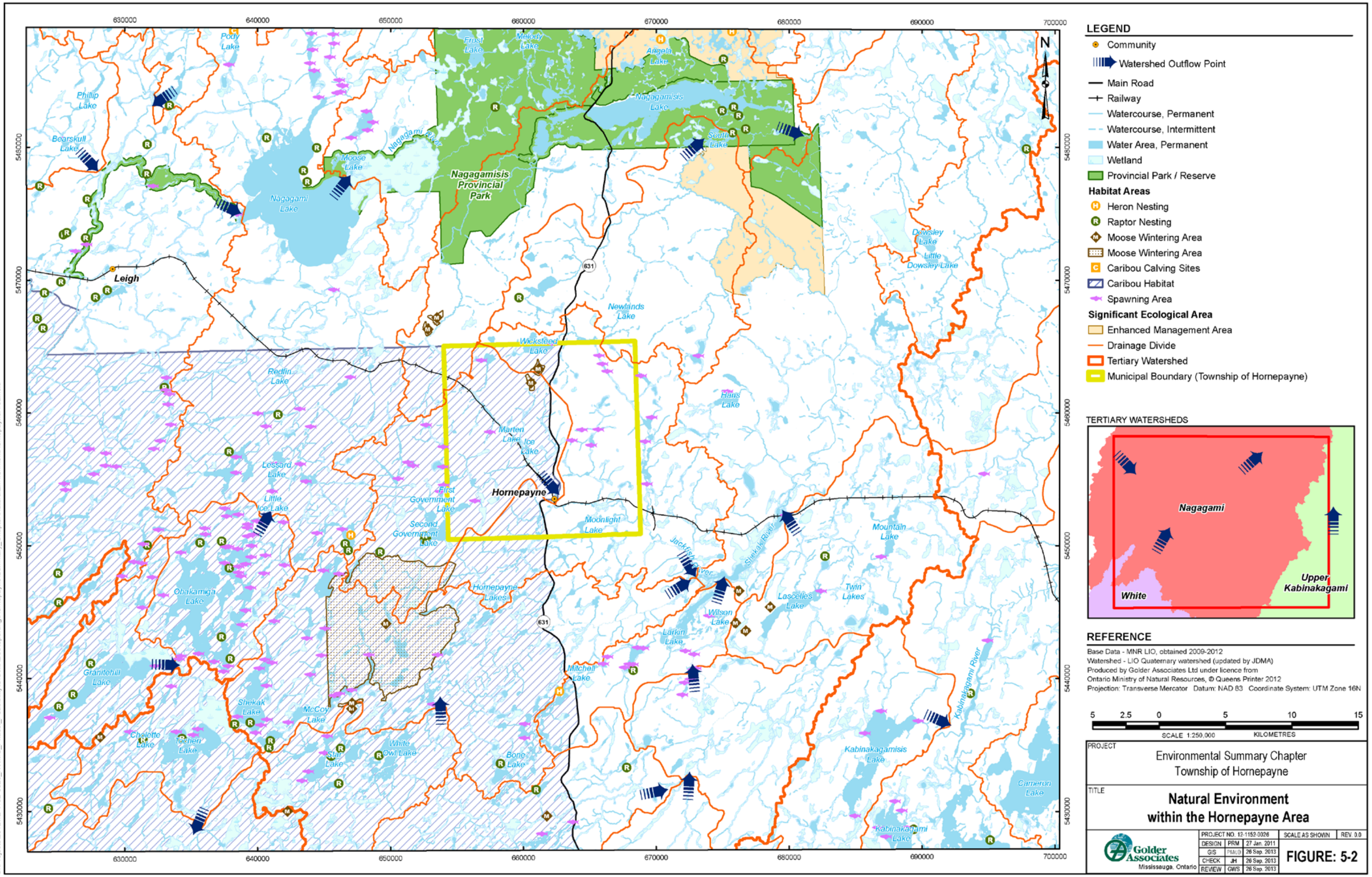

Figure 5-2: Natural Environment Within the Hornepayne Area

6. PRELIMINARY ASSESSMENT OF TRANSPORTATION

6.1 Transportation Assessment Approach

Canada's used nuclear fuel is currently located at seven interim storage sites located in four provinces. The ability to transport used nuclear fuel using existing or developing transportation systems is an integral element of a long-term management plan.

For more than 40 years, Canadian and international experience has demonstrated that used nuclear fuel can be transported safely and securely. The NWMO is committed to maintaining this high standard of safety and will meet or exceed regulatory safety requirements. The NWMO is employing the Adaptive Phased Management (APM) project management approach in planning and operating its transportation program. In support of this approach, the NWMO is monitoring and incorporating lessons learned from successful used fuel and radioactive material transportation programs in Canada and other countries.

The approach taken in preparing this chapter serves two functions. First, it describes the comprehensive transportation safety regulation and oversight processes that the NWMO will meet and how the NWMO plans to meet them. Second, it presents results of a desktop analysis that was prepared based on publicly available transportation information, supplemented by information provided by the community and observations during staff visits to selected communities. As part of Step 3 of the Siting Process, a feasibility analysis was prepared and focused on the following question: "Can a transportation route be identified or developed for the safe and secure transportation of used nuclear fuel to the site from the locations at which it is stored?" The findings of the transportation assessment on the feasibility of locating the APM Project in the Hornepayne area are presented at the end of the chapter.

In reviewing the available and/or developing transportation infrastructure, there is no intent to select a preferred mode of transportation or a preferred route, or to commit to specific operational details related to a future transportation system. These activities will be addressed through a future dialogue with federal, provincial and local authorities, and communities along potential transportation routes as a large group with a shared interest.

6.2 Regulatory Framework

The safe and secure transportation of used nuclear fuel is regulated through a comprehensive, multi-agency framework of regulations, oversight and inspections. The process builds on the legal and traditional roles of federal, provincial and local agencies.

The responsibility for regulating the safe transportation of used nuclear fuel in Canada is jointly shared by the Canadian Nuclear Safety Commission (CNSC) and Transport Canada. The *Nuclear Safety and Control Act*, 1997, the *Packaging and Transport of Nuclear Substances Regulations* and the *Nuclear Security Regulations* authorize the CNSC to regulate all persons who handle, offer for transport, transport or receive nuclear substances. The *Transportation of Dangerous Goods Act*, 1992, and Transport Canada's *Transportation of Dangerous Goods Regulations* regulate the safe commercial transport of listed hazardous goods, including used nuclear fuel.

The CNSC and Transport Canada regulations follow the International Atomic Energy Agency's (IAEA) Safety Standards Series regulations (Safety Requirements No. TS-R-1) (IAEA, 2000).

The CNSC and Transport Canada regulations cover the certification of the package design, the licence to transport, security planning, training requirements for the shipper and transporter, emergency response planning and communication procedures. These requirements are in addition to the normal commercial vehicle and rail operating and safety regulations and are similar to those used internationally. Packages designed for the transport of used nuclear fuel in Canada must be certified and licensed by the CNSC.

The provinces are responsible for developing, maintaining and operating the road infrastructure, for conducting safety inspections of the commercial vehicles and their drivers, and for law enforcement. Local governments provide traffic law enforcement and emergency response resources in the event of a transportation incident. The interaction and co-operation between these agencies provide for a comprehensive regulatory and oversight process ensuring the safe and secure transportation of used nuclear fuel.

6.2.1 Canadian Nuclear Safety Commission

The *Nuclear Safety and Control Act*, 1997, established the CNSC as the responsible agency for regulating possession of radioactive materials; for the design, testing, and certification of transport packages; and for regulating the safe and secure transport of nuclear substances in Canada. The CNSC works closely with Transport Canada in creating safety regulations, reviewing transportation operations, transport security and emergency response plans, training of the persons involved in transporting radioactive substances, and the oversight of radioactive material shippers.

The CNSC's *Packaging and Transport of Nuclear Substances Regulations* and *Nuclear Security Regulations* set out a comprehensive framework for the transportation of radioactive material, including the package design requirements, operational controls during transport, security from threats, loading and unloading, and inspection and maintenance requirements for the package. The regulations also require quality control at every step of the transport process.

The CNSC establishes the criteria and certifies the design of all Type B transport packages (the type required to transport used fuel), including those to be used by the NWMO. The CNSC requires that a Type B package pass strict testing which simulates transportation accident conditions, such as the package being in a collision, being hit by sharp objects, being engulfed in a petroleum fuel fire and being submerged in 200 metres of water. During these tests, the package must be able to meet the public protection requirements for the radioactive material while in transport.

6.2.2 Transport Canada

The *Transportation of Dangerous Goods Act*, 1992, and the *Transportation of Dangerous Goods Regulations* regulate the transportation of all dangerous goods within Canada, including the classification, packaging, labelling, documentation, safe handling, emergency response planning, training, and conveyance of such goods. In order to perform this function, Transport Canada has classified all dangerous goods into one of nine classes. Used nuclear fuel is designated as Class 7, "Radioactive Material."

The Transport Canada regulations prescribe the labels and safety marks that must be placed on any package and vehicle while transporting dangerous goods. These labels and placards provide valuable information to emergency responders when they respond to an accident and assist them in determining what safety precautions are needed as they carry out their life-saving and firefighting duties. Transport Canada requires that all persons handling, transporting, and/or offering to transport dangerous goods must be trained in the safe handling of the materials as applicable to their assigned duties.

Transport Canada and provinces have a shared responsibility for the safety of trucks and their operators. For highway vehicles, this includes the licensing of vehicles, vehicle safety inspections, and the qualification and hours of service requirements for operators. For rail, Transport Canada inspects the operating companies for compliance with vehicle, operations, signals, track, motor, and crew safety regulations. The provinces, through an Administrative Agreement process, have taken the lead for enforcing compliance with Transport Canada's safety requirements.

6.2.3 Provincial and Local Safety Responsibilities

The provinces have the legal authority for regulating all highway transportation functions, and through the Administrative Agreement with Transport Canada, they can enforce safety regulations for Class 7 shipments. Along with Transport Canada, the provinces enforce vehicle and driver safety through both scheduled and random inspections.

Provinces also develop, maintain and operate the provincial highway systems over which the NWMO shipments will travel. Some of these systems have operating limitations caused by weather, soils, highway geometry, tunnels and bridges. As the provinces adopt their transportation improvement plans, some of these limitations may be addressed, thereby improving the system safety.

Local governments, through their first responders, provide the initial resources when responding to emergency and law enforcement incidents. They are also enabled to enforce local and provincial regulations governing safety and commercial vehicle operation. Local communities are responsible for developing, operating and maintaining local streets and roadways.

6.3 Transportation Safety

The NWMO will be the responsible party for shipping Canada's used nuclear fuel to a repository. The NWMO is planning on using the Used Fuel Transportation Package (UFTP) for the transport of used fuel. In July 2013, the CNSC re-certified the UFTP as meeting their current regulations (CNSC, 2013).

6.3.1 Used CANDU Nuclear Fuel

CANDU nuclear fuel is a solid uranium dioxide ceramic pellet and is used to produce electricity for Canadians. The pellets are placed into a corrosion-resistant metal tube of a zirconium alloy. Typically, 37 of these tubes are held together in a cylindrical array called a fuel bundle. After the fuel bundle expends its heat producing energy, it is removed from the reactor and placed in a pool of water similar to a swimming pool to cool. Additional information on used nuclear fuel is provided in Section 3.2.

The radioactivity of used fuel drops quickly following removal from the reactor. After being out of the reactor for seven to 10 years, the radioactivity has decayed by 99 per cent, and the fuel bundles are placed into interim dry storage containers. The fuel is held in these containers until readied for transport to a repository. Based on the current Preliminary Waste Acceptance

Criteria, the used fuel accepted for transport to the repository facility will have been out of the reactor for 10 years or more.

6.3.2 Used Fuel Transportation Package

The NWMO will be transporting the used fuel bundles to the APM repository facility in the Used Fuel Transportation Package (UFTP), which will be certified by the CNSC using the current regulations at the time of shipment.

To be certified, the UFTP must pass a series of performance tests as specified in the CNSC regulations, thereby demonstrating its ability to withstand severe impacts, fire and immersion in deep water[1]. These tests are designed to ensure that the radioactive material is not released during a transportation accident and that radiation levels outside the package are well below the regulatory dose limits.

The UFTP is a cube about 2 metres in size (see Figure 6-1). When filled, the UFTP will carry approximately 5 tonnes of used CANDU fuel. The total package weight, when filled, is about 35 tonnes. As shown in Figure 6-1, the UFTP can hold a total of 192 bundles of used CANDU fuel in two storage racks, which are called modules. The UFTP body is manufactured from a single piece of stainless steel with walls approximately 27 centimetres thick.

The seal between the cask lid and body is provided by a double gasket, and the lid is attached with 32 bolts. Seal integrity is tested prior to and after each shipment.

[1] For more information on package performance tests, see http://nuclearsafety.gc.ca/eng/licenseesapplicants/packagingtransport/certification-process-for-transport-packages.cfm.

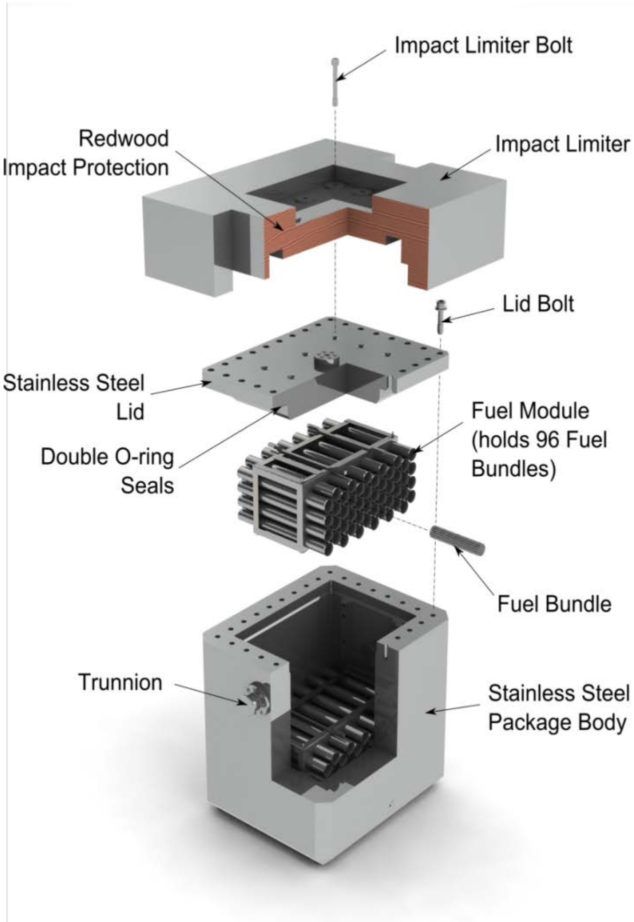

Figure 6-1: Used Fuel Transportation Package

6.3.3 Commercial Vehicle Safety

Commercial vehicle and driver safety are important to the NWMO. All commercial vehicles carrying dangerous goods are subject to Transport Canada safety requirements and inspection. The NWMO vehicles will be inspected for safety defects at the points of origin and destination. They are also subject to scheduled and random safety inspections by Transport Canada and the provinces as they travel the roadways. This is standard practice within the Canadian transport industry and for radioactive material shipments internationally.

6.3.4 Radiological Safety

Packages used to transport used fuel are designed in accordance with the requirements prescribed by the CNSC's *Packaging and Transport of Nuclear Substances Regulations*. The CNSC regulations are based on standards set by the IAEA and tested through use and practice. The objective of the regulations is to ensure that the radiation levels from the package will allow safe handling and transport, and in the event of an accident, the package will prevent a radiological release that exceeds applicable regulatory criteria.

The packages are designed to shield radiation such that levels on the outside of the package are below regulatory limits. Through procedures minimizing the handling of the package, the total radiation dose to the handling and transport personnel can be kept at a low level. Experience from existing shipments both within Canada and internationally demonstrates that this goal can be readily achieved.

6.3.5 Radiological Dose

Radiation is found in many forms. People are exposed to natural background radiation every day from the ground, building materials, air, food, outer space (cosmic rays), and even from elements occurring naturally in the body. The CNSC *Radiation Protection Regulations* have set an annual radiation dose limit of 1 milliSievert (mSv) per year for members of the public to limit exposure from nuclear-related activities. The radiation dose is about half of the average background radiation dose received by Canadians (1.8 mSv/year). For comparison, the typical dose received from one dental X-ray is approximately 0.01 mSv.

Radiological doses to the public from used fuel transport have been calculated for members of the public. Three scenarios were identified to estimate radiological doses to the public: 1) residents along the transport route; 2) persons sharing the transport route; and 3) persons sharing the refueling and rest stops. The highway mode was conservatively chosen as the example since the shipments will be sharing the roadway and refueling stops with the public, and there will be a larger number of shipments using this mode.

Table 6-1 shows the annual maximum individual dose to the public for each of the three scenarios (Batters et al., 2012). In all cases, the maximum individual dose to the public under routine transport and accident conditions is well below the regulatory public dose limit of 1.0 mSv per year.

Table 6-1: Maximum Public Individual Dose Due to Used Fuel Transported by Road

Annual Dose	Distance to Package	Frequency (Per Year)	Dose (mSv/year)	Assumptions/Comments
During Transport				
Resident Along Transport Route	30 m	620 shipments	0.000 013	Person living 30 m from route exposed to all 620 shipments (including 1 unplanned stop).
Public in Vehicle Sharing Route	10 m	2 shipments	0.000 22	Person in vehicle 10 m from transport package for 1 hour twice per year.
During ½-Hour Rest Stop				
Public in Vicinity at Rest Stop	15 m	31 shipments	0.000 12	Trucks alternate between 10 rest stops. Person present at given stop 5 per cent of time (i.e., 5 per cent of shipments).

The NWMO is committed to protecting its workers, drivers, and the public, and will apply the “As Low As Reasonably Achievable (ALARA) principle” in the design of the transportation system and during operations. This includes the proper use of shielding and dosimetry combined with the application of radiation control techniques and operating procedures. As part of the NWMO’s transportation planning process, additional dose studies will be conducted for workers (i.e., drivers, inspectors, emergency responders).

6.4 Used Fuel Quantities and Transport Frequency

The baseline used fuel inventory being used for the APM feasibility studies is 4.6 million fuel bundles (Garamszeghy, 2012). The distribution of the fuel bundles is provided in Table 6-2. Using the UFTP, the NWMO Transport Program anticipates it will require about 24,000 truck trips over 38 years to move the inventory to the repository site.

The APM facility is designed to process approximately 120,000 used fuel bundles per year, which equates to receipt of approximately 620 UFTPs per year. However, the total number of shipments will depend on the chosen transport mode. For instance, a tractor-trailer can transport one 35-tonne UFTP at a time; whereas, rail shipments may contain multiple UFTPs in a single train.

Table 6-2: Estimated Used Fuel Quantities by Owner

Owner	Number of Used Fuel Bundles
Ontario Power Generation	4,026,000
Atomic Energy of Canada Limited	32,600
Hydro-Québec	268,000
New Brunswick Power	260,000
TOTAL (rounded)	**4,600,000**

6.5 Used Fuel Transportation Experience

Used nuclear fuel has been transported routinely in Canada since the 1960s, with over 500 used nuclear fuel shipments having been made to date (Stahmer, 2009). Since the closing of AECL’s reactor at Rolphton, Ontario, the number of used fuel shipments has averaged between three and five shipments per year.

Used fuel shipments are common in other countries such as the United Kingdom, France, Germany, Sweden and the United States. Over the past 40 years, worldwide there have been more than 23,000 shipments of used fuel. Great Britain and France average 550 shipments per year, mainly by rail. In the United States, used fuel shipments take place mainly by road and total approximately 3,000 shipments to date. In Sweden, approximately 40 trips by water are made between the reactor sites and the central storage facility each year.

There have been no serious injuries, fatalities or environmental consequences attributable to the radioactive nature of the used nuclear fuel being transported since the establishment of the IAEA Transport Regulations over 50 years ago.

6.6 Transportation Operations

6.6.1 Responsibility

The NWMO will have overall responsibility for transportation of used nuclear fuel to the repository. This includes planning, licensing, training, safe operation, security, and tracking of all shipments. The NWMO will work with the CNSC, Transport Canada, the provinces and local agencies to ensure workers and first responders are adequately trained prior to commencing shipments. The NWMO will ensure that all transportation equipment, packages and transportation activities (whether for road and rail shipments) meet regulatory requirements.

The NWMO transportation process is planned to begin with loading the used fuel into the UFTP by the reactor owner. The NWMO will certify that the packages are loaded in accordance with the CNSC and Transport Canada regulations. Upon dispatch, the vehicle and drivers will be subject to a safety inspection. The vehicle, UFTP and driver would also be inspected at the repository.

The driver of the vehicle will be responsible for cask safety during transport. The driver will ensure that all documentation, labelling and safety requirements have been met prior to departure and continue to be met en route. An escort travelling with the vehicle will be responsible for the physical security of the package and vehicle, communications, tracking, and monitoring of the locks and seals.

First response to radiological emergencies will be provided by trained first responders in accordance with the command and control process described in the Emergency Management Framework for Canada, local and provincial plans, and existing mutual aid agreements. The NWMO will provide an emergency response plan to the CNSC, Transport Canada and the provinces. The NWMO will co-ordinate its planning with the provinces and first responders along the designated routes to provide used fuel specific training and conduct exercises. It is anticipated that the existing agreements between nuclear facilities in Ontario, Manitoba, Quebec and New Brunswick will be expanded to accommodate the requirements of the NWMO shipments.

6.6.2 Communications

A NWMO central command centre will provide a single point of contact for all transportation-related communications. This allows quick access to shipment information and tracking, and would serve as a single point of contact for incident commanders, the CNSC, and Transport Canada. Communications during a trip would be in accordance with a Transportation Security Plan, which will be approved by the CNSC.

The function of the transport command centre is expected to be roughly the same for all shipments, independent of mode. The centre will be responsible for tracking all shipments and normal vehicle communications, and in the event of a transport incident, it will be the primary contact for incident commanders. The transport command centre will notify local emergency response agencies for assistance, such as the local police, fire, and the emergency response teams. There will also be a return-to-normal operations and recovery plan to address those activities needed to return the shipment to normal operations and complete the trip to the repository.

6.6.3 Security

Security is focused on preventing diversion, physical damage or sabotage of the UFTP. Security will be multi-layered, consisting of a combination of: intelligence gathering; engineered, deterrent and response measures to protect the UFTP; the use of information safeguards to protect shipment information; and multi-agency response agreements.

Security provisions during transportation will ensure that the used nuclear fuel will receive adequate physical protection against threats and will be in accordance with the requirements of the CNSC's *Nuclear Security Regulations* pursuant to the *Nuclear Safety and Control Act*, 1997. The CNSC Regulatory Guide G-208 "Transportation Security Plans for Category I, II or III Nuclear Material" (CNSC, 2003) will be used for guidance to establish and implement Transportation Security Plans.

6.6.4 Emergency Response Planning

Emergency response resources include local law enforcement, firefighting, first responders, medical triage, and leaders of affected communities. The NWMO will work with the CNSC, Transport Canada, the provinces and local responders to encourage co-operative emergency response planning, and to identify and address training and exercise needs.

The NWMO will work with the CNSC and local response agencies to co-ordinate planning and preparedness activities based on the CNSC's *HazMat Team Emergency Response Manual for Class 7 Transport Emergencies (INFO-0764, Rev. 2)* (CNSC, 2009) and Transport Canada's *Emergency Response Guidebook* (Transport Canada, 2012). Additionally, the NWMO will incorporate the current *Emergency Management Framework* (Public Safety Canada, 2011) guidance agreed to by Public Safety Canada, the provinces and local response agencies.

6.7 Transportation Logistics to Hornepayne

Figure 6-2 presents a generalized description of the highway and railroad transport processes for used nuclear fuel from interim storage sites to an APM repository site. An APM repository site located near Hornepayne would be accessible by truck via existing roadways and a service road to the receiving facilities.

If rail is a preferred mode, rail service could be extended from the existing switch yard on Railway Crescent in Hornepayne to a service spur leading to the receiving facility at the repository.

Hornepayne is located on Highway 631, which connects the two Trans-Canada Highway branches, Highway 17 and Highway 11, west of Hearst, Ontario (see Figure 6-3). Hornepayne is also situated on the Canadian National Railway (CNR) mainline approximately 500 kilometres east of Thunder Bay and 450 kilometres north of Sault Ste. Marie. Both the highway and railway systems are maintained to the highest standards and are important to the interprovincial movement of goods and services.

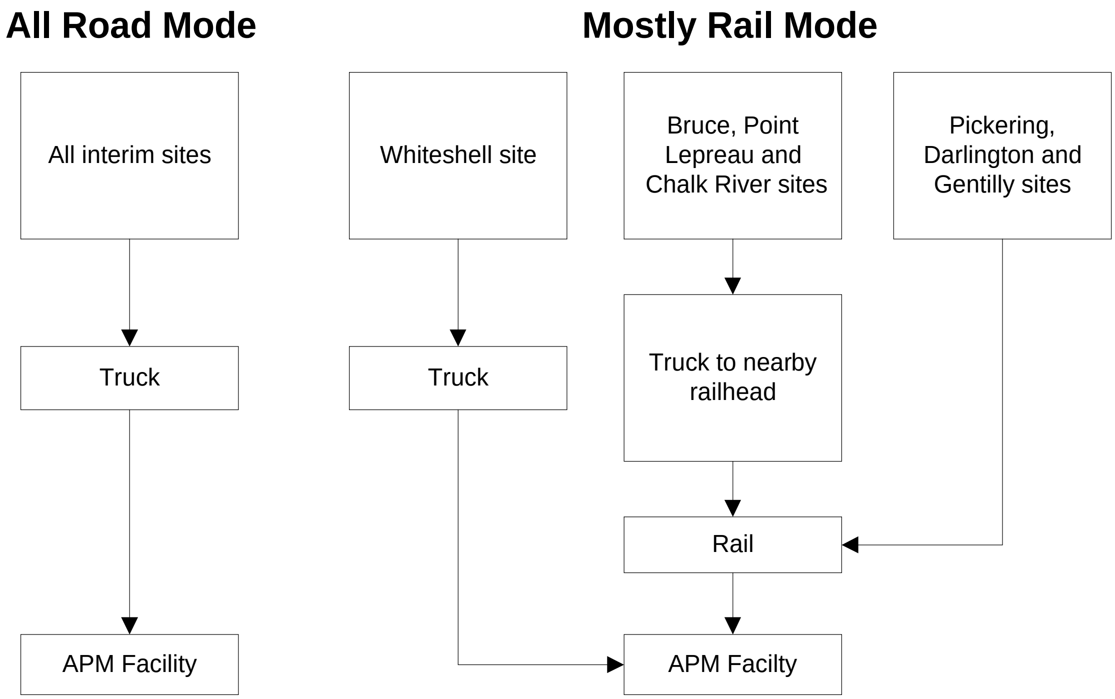

Figure 6-2: Example Transport Processes for Used Nuclear Fuel

Figure 6-3: Becker Road, Highway 631 and CNR Switch Yard in Hornepayne

6.7.1 Existing Transport Infrastructure

Travel distances from the interim storage sites to a repository site near Hornepayne, Ontario, are summarized by mode of transportation in Table 6-3.

Table 6-3: Transport Summary From Interim Storage Sites to Hornepayne, Ontario

Transport Scenario	Transport Mode	Number of Shipments	Return Distance (Kilometres)
All Road	Road	24,000	56,180,000
Mostly Rail	Road	11,700	1,792,000
	Rail	2,400	5,424,000

6.7.2 Road Transport From Interim Storage to a Repository

The shortest transport routes and associated distances for road transport are provided in Table 6-4. In general terms, the road system begins at the interim storage site and uses local roads to access the national highway system. The highway system includes Highway 631 which passes through Hornepayne, Ontario. As planned, an existing local access road would be used or a new road constructed to provide access from Highway 631 to the repository site.

In Step 3 of the APM Siting Process, the following transportation question is to be answered:

"Can a transportation route be identified or developed for the safe and secure transportation of used nuclear fuel to the site from the locations at which it is stored?"

To address this question, the following road transportation characteristics were considered:

1. Is there a continuous public road system connecting the interim storage facilities to the community capable of supporting an average of two heavy trucks per day for the duration of a 38-year transportation campaign?
   a. Are there design, operating or structural deficiencies which would limit the use of a segment of the roadway system by heavy trucks (i.e., weight limits for bridges, narrow lanes, etc.)? If so, is there a transportation improvement program in place to address those deficiencies?
   b. Are there two or more serviceable routes providing access from the interim storage facilities to the community? (Required by the *Nuclear Safety and Control Act*.) If not, is one planned?
   c. Are there travel limitations regarding the use of the roadway by heavy trucks due to reoccurring weather or seasonal conditions?

2. Are there emergency response resources for those roadways providing access from the Canadian national roadways to the community, and what are their capacities?

Table 6-4: All Road Transport From Interim Storage Sites to Hornepayne, Ontario

Interim Storage Site	Distance Site to Repository (Kilometres)	Number of Shipments	Return Distance (Kilometres)
1 – Whiteshell	1,120	2	4,500
2 – Bruce	1,150	10,220	23,510,000
3 – Pickering	1,030	4,150	8,549,000
4 – Darlington	1,030	6,720	13,840,000
5 – Chalk River	900	30	54,000
6 – Gentilly	1,330	1,500	3,990,000
7 – Point Lepreau	2,150	1,450	6,235,000
	Totals (rounded)	**24,000**	**56,180,000**

In this assessment, transportation distances are determined by the shortest routes between the interim storage sites and the repository. Preferred routes will be determined by the NWMO in co-operation with local communities and those communities located along the transportation corridor.

Truck access from the interim storage sites to Hornepayne, Ontario, can be accomplished entirely by existing roadways. Based on the Ontario Ministry of Transportation records, there are no significant impediments to travel between the interim storage sites and Hornepayne area. The average daily travel (vehicle) count for the Hornepayne segment of Highway 631 is 480 vehicles per day (MTO, 2009). Two trucks a day more added to the existing traffic count would be a small increase (less than 0.4 per cent).

The Ontario Ministry of Northern Development and Mines Northern Highways Program (MNDM, 2012) includes the resurfacing of Highway 631 south of Hornepayne and also includes the rehabilitation of culverts.

The local road system within Hornepayne supports the current residential uses and in general is not built to support large trucks on a routine basis. Therefore, local road upgrades and/or an access road may be required to service a potential repository site.

Hornepayne is accessible via an alternative route, although it involves additional mileage. The alternative route is Highway 17, west to White River, then north on Highway 631, entering Hornepayne on Highway 631 from the south.

Emergency response resources are provided by the Hornepayne Fire Department, the Algoma Emergency Medical Services (EMS) and the Ontario Provincial Police. The Fire Department is a member of the Algoma District Mutual Aid Program, providing help to other communities in emergencies, as far away as Chapleau, Spanish and Wawa. The Hornepayne Community Hospital provides a full range of health-care services, including 24-hour emergency nursing coverage.

6.7.3 Railroad Transport From Interim Storage to a Repository

In answering the question, "Can a transportation route be identified or developed for the safe and secure transportation of used nuclear fuel to the site from the locations at which it is stored?", the following rail transportation characteristics were considered:

> Is there a continuous rail system connecting the interim storage facilities to the community capable of supporting an average of one 24- to 28-car train per week for the duration of a long-term shipping campaign?
>
> 1. Are there design, operating or structural deficiencies which would limit the use of a segment of the railway system by heavy trains (i.e., weight limits for bridges, track condition, sharp curves, steep grades, etc.)? If so, is there a plan in place to address these deficiencies?
> 2. Are there two or more serviceable routes providing access from the interim storage facilities to the community? (Required by the CNSC for security reasons.) If not, is one planned?
> 3. Is there an operating intermodal facility near the interim sites or the community? If not, could one be developed?
> 4. Are there travel limitations regarding the use of the railway consisting of heavy cars due to reoccurring weather or seasonal conditions?

Hornepayne is located on the Canadian National (CN) Railroad mainline. The shortest transport routes and associated distances for mostly rail mode transport are provided in Table 6-5.

Rail service between the interim storage sites, via an intermodal transfer near the storage sites and the switch yard in Hornepayne is feasible. The switch yard offers an opportunity to construct either an intermodal transfer facility or to construct a switch to a local line providing direct service to the repository site.

The NWMO's rail transportation requirement would be equivalent to one train per week with 10 to 12 UFTPs (an estimated total car count of between 24 and 28 cars (with buffer cars), 2 power units and a security car). Canadian railroads have endorsed the Association of American Railroads' OT-55 Recommended Railroad Operating Practices for Transportation of Hazardous Materials (AAR, 2013; AAR, 2009); therefore, the used fuel trains could be operated as key trains, with an 80 kilometres per hour speed limit and special operating procedures.

To address the need for alternative routing, the Canadian Pacific railroad operates a trans-Canada rail line south of Hornepayne. Trains could use the southern route and transfer the used fuel transportation packages to trucks at White River for the trip to a repository. This option does add mileage to the routing.

Table 6-5: Mostly Rail Transport From Interim Storage Sites to Hornepayne, Ontario

Interim Storage Site	Distance Site to Repository (Kilometres)	Number of Shipments	Return Distance (Kilometres)
1 – Whiteshell	**1,120[a]**	**2**	**4,500**
2 – Bruce	**80[b]**	**10,220**	**1,635,000**
	1,110	1020	2,264,000
3 – Pickering	920	420	773,000
4 – Darlington	950	670	1,273,000
5 – Chalk River	**120[c]**	**30**	**7,200**
	690	3	4,100
6 – Gentilly	1,520	150	456,000
7 – Point Lepreau	**50[d]**	**1,450**	**145,000**
	2,180	150	654,000
Totals (rounded)	**Road**	**11,700**	**1,792,000**
	Rail	2,400	5,424,000

Notes:
[a] Road mode from Whiteshell to repository site near Hornepayne
[b] Road mode from Bruce to railhead near Goderich
[c] Road mode from Chalk River to railhead near Mattawa
[d] Road mode from Point Lepreau to railhead near Saint John
Bold text indicates road mode transportation; rail mode transportation is shown in plain text.

6.7.4 Weather

There are no vehicle weight restrictions on Highway 631 during the spring thaw months. Similarly, no weather or seasonal restrictions were identified for rail transport to Hornepayne, Ontario.

6.7.5 Carbon Footprint

Carbon footprint is a representation of the impact transportation has on the environment. Greenhouse gas emissions produced by the transport of used fuel from the interim storage facilities to the repository site have been calculated for both the all road and mostly rail transport scenarios.

All road transport of 4.6 million fuel bundles from the interim storage sites to an APM facility near Hornepayne, Ontario, would produce approximately 1,760 tonnes of equivalent carbon dioxide emissions per year. Over the 38-year operating period of the APM facility, the all road transport of used fuel would produce approximately 67,300 tonnes of equivalent carbon dioxide emissions.

Transport by mostly rail mode would produce approximately 900 tonnes of equivalent carbon dioxide emissions per year.

In comparison, an average car produces approximately 5.1 tonnes of equivalent carbon dioxide emissions per year. Emissions from intermodal handling activities are assumed to contribute about 2 per cent of total emissions.

6.7.6 Conventional Accidents

It is important when discussing safe transportation to make a distinction between radiological incidents and traffic accidents. Incidents are controlled through the design of the transportation package and execution of operating procedures. Based on international experience, the design of the container, coupled with rigorous operating procedures, is sufficient to prevent any incident from occurring. Conventional traffic accidents are random and unexpected. Therefore, they are considered as part of the planning process and quantified using statistical analyses based on the distance travelled.

In 2009, the Ontario Ministry of Transportation reported a traffic accident rate of 1.7 collisions per 1 million kilometres travelled for Ontario (MTO, 2009), one of the lowest rates in North America. Accident frequency is proportional to the distance travelled. Using a return distance of 56.2 million kilometres, about 96 road collisions have been estimated over the 38-year operating period of the APM facility.

6.7.7 Transportation Costs to Hornepayne

This section considers the used nuclear fuel transportation logistics from the existing interim storage sites to a hypothetical APM repository site located near Hornepayne, Ontario, to estimate transportation costs. Existing surface mode transport infrastructure and transport distances from the interim used fuel storage sites to Hornepayne by road mode for a baseline used fuel inventory of 4.6 million bundles are examined.

A summary of the transport costs (based on the APM repository design and cost estimate prepared for financial planning purposes) from the interim used fuel storage sites to a hypothetical APM repository site located near Hornepayne, Ontario, for road and rail mode of transport is provided in Table 6-6. The cost of transporting used nuclear fuel from the seven interim storage sites to Hornepayne is projected at $1.10 billion over the 38-year campaign (in constant 2010 $). The variance is $17.4 million over the reference case estimate, or 1.4 per cent higher.

Table 6-6: Used Fuel Transportation Program Costs – 4.6 Million Bundles

Total Cost	Transportation to Hornepayne	Variance to Reference Case	
Package Loading and Transportation	**$1,100,000,000**	**$17,400,000**	**1.6%**
Cost Breakdown			
Route and System Development	$19,000,000	$0	0%
Safety Assessment	$5,290,000	$0	0%
Capital Equipment and Facilities	$333,000,000	$6,210,000	2%
Operations	$564,000,000	$10,200,000	2%
Environmental Management	$8,400,000	$0	0%
Decommissioning	$43,700,000	$977,000	2%
Program Management	$127,000,000	$0	0%
Note: [a] All costs are rounded to three significant digits			

6.8 Transportation Findings

This transportation assessment includes two major components: a description of regulatory oversight, including how the requirements are being met by the NWMO transportation program; and a desktop analysis of transportation logistics assuming available transport infrastructure. If the APM Project were to be located in the Hornepayne area, the repository would be accessible by truck and railroad using existing roadways and railways. It is assumed that the necessary connecting road, railway and intermodal infrastructure would be constructed, thereby providing access from existing storage sites to the repository. Improvements to the transportation and intermodal infrastructure would be reviewed in detail in Phase 2 studies, should the community continue in the site selection process.

Hornepayne is located on Highway 631 about 100 kilometres north of White River and Trans-Canada Highway 17. Highway 631 extends north from Hornepayne, 70 kilometres to a junction with Highway 11, the second Trans-Canada Highway. This provides two access routes into Hornepayne. The Ontario Ministry of Transportation maintains Highway 631 as an all weather regional highway providing access to the region. The current roadway would support the traffic generated by the construction, operation and closure of a repository.

Hornepayne is a railway divisional point on Canadian National (CN) Railway's trans-Canada rail line. This means that CN maintains double-track service through the community, two sets of switching tracks and maintenance/service centre in Hornepayne. The switching tracks and open land adjacent to the rail lines offer several locations for a potential intermodal transfer facility. If a service rail line is built to serve the repository site, a local switch could be configured into the current system for a minimum cost.

The transport of used fuel is a highly regulated activity. The NWMO's transportation program is being developed to meet all aspects of the regulations, including packaging, radiological, security, emergency response and conventional vehicle safety requirements.

Beyond Safety – Potential to Foster Community Well-Being With the Implementation of the Project Now and in the Future

As discussed in the previous chapters, any site that is selected to host the Adaptive Phased Management (APM) Project must be demonstrated to be able to safely contain and isolate used nuclear fuel, protecting humans and the environment over the very long term. The preferred site will need to address scientific and technical siting factors that acknowledge precaution and ensure protection for present and future generations. The previous chapters have explored, in a preliminary way, the potential to meet the safety-related requirements of the project. These requirements are fundamental, and no siting decision will be made that compromises safety.

Once confidence is established that safety requirements can be met, the potential for the project to help foster the well-being, or quality of life, of the local community and area in which it is implemented becomes an important consideration. At this stage of study, Preliminary Assessments in this area are designed to explore the potential for the project to align with the vision and objectives of the community, and potential to help the community to advance to the future it has set out for itself. It is understood that this project may not align with the vision and objectives of all communities. For this reason, Preliminary Assessment in this area is an important input to the siting decision. The ability of the community to benefit from the project, and the resources that would be required from the NWMO to support the community in achieving this benefit, would be a consideration in the selection of a site after all safety considerations have been satisfied. The project will only be implemented in an area in which well-being will be fostered.

The project offers significant employment and income to a community and surrounding area, including the opportunity for the creation of transferable skills and capacities. However, with a project of this size and nature, there is the potential to contribute to social and economic pressures that must be carefully managed to ensure the long-term health and sustainability of the community and area. Surrounding communities and Aboriginal peoples in the area will need to be involved in decision-making. The project can only be implemented with the involvement of the interested community, surrounding communities and Aboriginal peoples working together in partnership to implement the project.

Preliminary Assessments at this phase of work focus on the potential to foster well-being through the project in the community that has expressed interest and entered the site selection process. Should the community be selected to proceed to more detailed studies, the next phase of work will begin to explore the potential for the project to also align with the vision and objectives of surrounding communities and of the Aboriginal peoples in the area, as well as their interest in implementing the project together.

The NWMO will continue to look to Aboriginal peoples as practitioners of Traditional Knowledge to help, to the extent they wish, to guide the decisions involved in site selection, and ensure that the factors and approaches used to assess the potential to contribute to the well-being of the community, surrounding area and Aboriginal peoples appropriately interweave Traditional Knowledge throughout the process.

Learning to date from preliminary studies, and engagement with the community, is summarized in the chapter that follows.

7. PRELIMINARY SOCIAL, ECONOMIC AND CULTURAL ASSESSMENT

7.1 Approach to Community Well-Being Assessment

This chapter provides a preliminary overview of the potential for the project to foster the well-being of the Township of Hornepayne, Ontario. More detailed information can be found in the Hornepayne Community Profile (DPRA Canada, 2013a) and Community Well-Being Assessment report (DPRA Canada, 2013b). The overview uses a community well-being framework to understand and assess how the Adaptive Phased Management (APM) Project may affect the social, economic and/or cultural life of Hornepayne. It also discusses the relative fit of the APM Project for the community and the potential to create the foundation of confidence and support required for the implementation of the project.

A number of factors were identified as minimum criteria to consider in the multi-year process of study to assess the potential to foster well-being (NWMO, 2010a).

- Potential social, economic and cultural effects during the implementation phase of the project.
- Potential for enhancement of the community's and the region's long-term sustainability through implementation of the project.
- Potential to avoid ecologically sensitive areas and locally significant features.
- Potential for physical and social infrastructure to adapt to changes resulting from the project.
- Potential to avoid or minimize effects of the transportation of used nuclear fuel from existing storage facilities to the repository site.

Factors identified by Aboriginal Traditional Knowledge will help inform this assessment. In order to ensure that a broad, inclusive and holistic approach is taken to assessment in these areas, a community well-being framework was identified to help understand and assess the potential effects of the APM Project. This framework was used to help explore the project, understand how communities and the surrounding area may be affected should the project be implemented in the area, and identify opportunities to leverage the project to achieve other objectives important to people in the area.

The framework encourages exploration of the project through five different "lenses."

- ***People or Human Assets*** – How might the implementation of the project affect people?
- ***Economics or Economic Assets*** – How might the implementation of the project affect economic activity and financial health of the area?
- ***Infrastructure or Physical Assets*** – How might the implementation of the project affect infrastructure and the physical structures that the community has established?
- ***Society and Culture or Social Assets*** – How might the implementation of the project affect the sense of belonging within the community and among residents, and the services and network of activities created to serve the needs of community members?
- ***Natural Environment or Natural Assets*** – How might the implementation of the project affect the natural environment and the community's relationship with it?

In Phase 1 of this assessment, which is the focus of this report, the intent is to explore the potential to foster the well-being of the community, and for this reason, the subset of factors and considerations related to the community are addressed at this time. Regional considerations are noted where early insight is available; however, more detailed work would be conducted in Phase 2 should the community be selected to proceed to this phase of work.

Throughout the discussion, there are references to “the surrounding area.” For the purpose of this discussion, the surrounding area is roughly defined by the interrelationships with the nearby communities and patterns of activity by community members (such as shopping, leisure and other economic activities) as currently understood. Input to understanding the surrounding area was received through discussions and meetings with community members and would be refined through further engagement in subsequent phases of work.

7.1.1 Activities to Explore Community Well-Being

Dialogue with interested communities and those in the surrounding area is needed to begin to identify and reflect upon the broad range of effects that the implementation of the project may bring. In concert with the community, the NWMO worked to develop an understanding of the community today, and its goals and aspirations for the future. To this end, information has been assembled and studied through a variety of means, including strategic planning activities, engagement activities, community visits and tours, briefings, one-on-one discussions, consultant observations, Community Liaison Committee meetings, open houses, and the development of a community profile.

7.1.2 Assumptions of the APM Project – Drivers of Community Well-Being

The APM Project is currently in the early stages of design, and for this reason, there remains flexibility in the nature and scope of its implementation. This provides an opportunity for the project to be structured and operated in a manner that suits the conditions and aspirations of the community and surrounding area. However, it is important at this early stage of the preliminary assessment to understand the potential implications of the project on the community and its surrounds. This requires some basic assumptions about the project and initial effects. The starting assumptions for this preliminary assessment include the following:

1. The on-site labour workforce required by the APM Project is in the range of 400 to 1,200 jobs, and further jobs (indirect and induced) and community wealth creation will result from project spending for goods and services and employee income spending (NWMO, 2012). The following table summarizes the estimated number of direct, on-site jobs throughout the life of the APM Project, which spans over 150 years.

Table 7-1: On-Site Workforce

APM Phase	Number of Years (Approx.)	Direct Jobs per Year (Approx.)	Primary Skills Required
Construction	10	400–1,200	Mining, engineering, geoscience, safety assessment, manufacturing, construction, trades, project management, social science, engagement, communication, transportation
Operation	30 or more	700–800	Mining, engineering, geoscience, safety assessment, manufacturing, trades support, project management, social science, engagement, transportation
Extended Monitoring	50 or more	100–150	Geoscience, safety assessment, mining
Decommissioning and Closure	30	200–300	Mining, construction, trades, geoscience, safety assessment, regulatory affairs
Long-Term Monitoring	100 or more	25–50	Environmental, health and safety monitoring

2. Realization of employment benefits within a community will depend on a variety of factors such as:

    a. Preference for local hiring and sourcing from local businesses;
    b. Training of local residents for positions in the project or in supporting services; and
    c. Planning to prepare for and leverage future opportunities.

    This project will be implemented through a long-term partnership involving the community, neighbouring communities and Aboriginal peoples in the area, and the NWMO. Only through engagement, dialogue and collaboration will the NWMO ensure that needs are addressed at each stage of the process, and determine the specifics of how a partnership arrangement would work. For illustration purposes only, employment opportunities could be in the order of hundreds of new jobs (direct, indirect and induced) within the local area (AECOM, 2010). However, it will be up to the community to determine the nature and scope of how it wishes to grow in discussions with the NWMO.

3. The NWMO is committed to working with communities and those in the surrounding area to optimize the benefits that will positively contribute to the overall well-being of the area.

The following figure provides a graphical representation of the direct and indirect effects that may result from the siting of the APM Project. The figure illustrates how the project could be the impetus for growth in population, business activity and municipal finances.

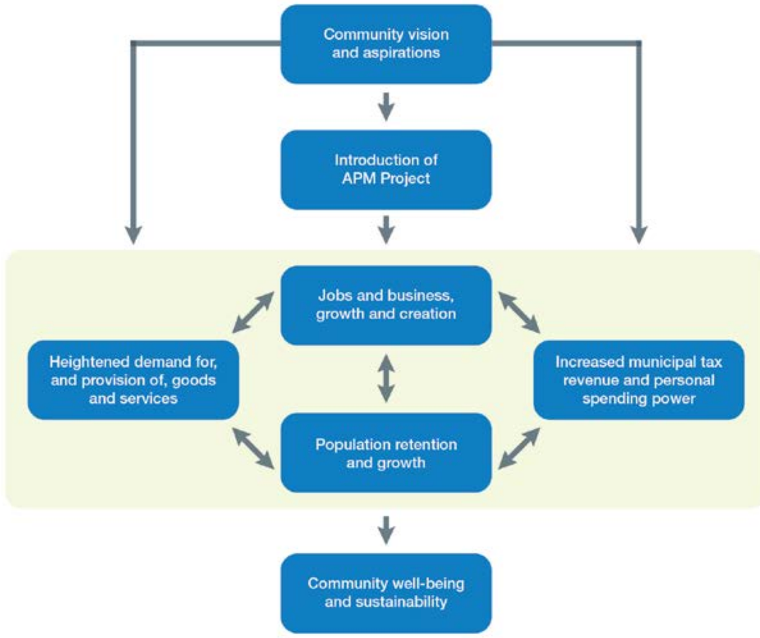

Figure 7-1: Direct and Indirect Effects From the Project

7.2 Community Well-Being Assessment – Implications of the APM Project for Hornepayne

The potential effect of the project, should it be implemented in the Hornepayne area, on the people, economics, infrastructure, social assets and natural environment of Hornepayne is discussed below. The discussion starts with an overview of the aspirations and values of Hornepayne, as the NWMO has come to understand them. This understanding of well-being from the community's perspective is the starting point for the assessment and informs the discussion throughout.

7.2.1 Community Aspirations and Values

The Township of Hornepayne is a resilient community, having faced significant social, cultural and economic change. The greatest changes in the community, also in recent years, included changes in the local economy and closure of the town mall. The Hornepayne community faces an aging and declining population and gaps in key infrastructure. Economic growth and population growth to past levels of prosperity remain priorities.

The Township of Hornepayne conducted strategic planning activities in 2011 leading to the adoption of the *Strategic Plan for the Community of Hornepayne* (Hornepayne Community Adjustment Committee, 2011). The Plan was prepared in consultation with community members and identifies future opportunities, including growth of the local economy. The Plan also recognizes that Hornepayne has experienced past challenges and is currently undergoing transition. Hornepayne's vision is:

> *"To position Hornepayne to take advantage of business opportunities and promote the successful growth of those endeavours while providing the best possible care and services to the citizens of Hornepayne."*

An aspiration of the community is the continued support for resource-based industries to help stabilize population in the community and surrounding area. This will provide a greater level of security and sustainability to the community.

The Strategic Plan for the Community of Hornepayne (Hornepayne Community Adjustment Committee, 2011) also identified a number of common values shared by individuals, agencies and businesses. These values are:

i. Public safety supersedes all economic needs;
ii. Municipal revenues are public funds for the betterment of municipal services that are applied to the greater community good and delivered in an open and accountable fashion;
iii. Quality of life extends beyond economic returns and includes quality education, health and social services, safe and free public space, access to affordable leisure and recreational facilities;
iv. Private sector initiatives are at the core of the Hornepayne economic structure and competitiveness is defined and achieved through standard market conditions without government interference;
v. The natural resource based industries including forestry, tourism and transportation are the economic foundations on which Hornepayne has been developed and are the heritage that will ensure prosperity and a stable future;
vi. All sectors must work harmoniously to preserve existing businesses and facilitate the development of new businesses;
vii. Environmental sustainability and effective management of natural resources are critical elements of a long term and prosperous future;
viii. The cultural diversity of the local population is an integral part of the Hornepayne Community and its future.

The following sections describe the implications of the APM Project for each of the community well-being "lenses" or asset categories.

7.2.2 Implications for Human Assets

Hornepayne has experienced a decline in population in recent times. This has also been the trend in most small communities in northern Ontario. Many of these towns have historically been dependent on resource-based industries and have all been susceptible to "boom-bust" cycles. Mass migration has occurred from northern communities to other centres with growing workforce needs with populations in search of more diverse and reliable employment.

Hornepayne is no exception to this trend. The current population stands at approximately 1,050 residents, which is much less than what the community was 25 years ago. Hornepayne has experienced out-migration resulting from a loss of employment opportunities. The population is aging, and the community struggles to attract and retain younger people of working age.

Population decline is a primary concern for the people of Hornepayne, and there is strong desire to grow. The community has said it would like to see its population increase to about double its current size. Population decline has affected other aspects of the community also, with retail outlets closing – particularly the Hornepayne Town Centre which closed in 2010. There have also been reductions in recreational and community services and facilities.

The APM Project has the potential to help the community to achieve its population goal. This growth will rejuvenate the schools, retail options and community facilities and services. The APM Project would likely utilize any existing skilled labour force and attract a new skilled and diverse workforce, as well as attracting new families. The project offers the opportunity for local residents to obtain opportunities in direct, indirect and induced jobs.

The APM Project has the potential to have a positive effect on the Human Assets of Hornepayne. The project will bring direct, indirect and induced jobs. Jobs are the backbone of population growth. The APM Project is a long-term project, with a much longer lifespan than other resource-based developments typical of northern Ontario. It has the potential to be a driver for population retention and growth. While it is expected that some people involved in the construction and operations of the project will chose to reside in other (larger) communities, preliminary economic modelling suggests that hundreds of jobs could be held by persons residing in Hornepayne (AECOM, 2010). With additional community development and support provided by the NWMO, it is possible that these job numbers could be increased. These new jobs will bring spouses, partners and families, and so it can be expected that the population in Hornepayne could increase significantly, which is a community aspiration. The increased population will be a boost to Hornepayne and will be a catalyst for spinoff growth and development, which is the priority aspiration for the town at the present time.

Skills and labour supply would likely diversify and expand with the increased population and as a result of the on-site and in-community job opportunities. Indirect and induced jobs will also create opportunities for skills diversification and attract new residents with different levels of expertise. The APM Project will capitalize on the existing labour force skills and expertise and attract other highly educated and skilled workers. The project will provide opportunities for skilled workers and ongoing training, as well as opportunities for the next generations to pursue education paths to take advantage of careers associated with the project. There are major and positive educational benefits from the APM Project, including an increased population driving expanding enrolment and educational programming opportunities and potential partnerships with post-secondary institutions. It is further expected that the site itself will be an international Centre of Expertise and thus attract attention from around the world.

With respect to education, Hornepayne has experienced a decline in enrolment and staff at educational facilities, as well as a reduction in programming in recent years. Community education facilities are underutilized given current population levels. It is hoped that the APM Project would stimulate career aspirations and interest in education and training.

Basic health-care facilities are available at the Hornepayne Community Hospital; however, any specialist services require travel outside the community. Emergency response services are available in the community, and there is an emergency response plan in place. Residents of

Hornepayne are able to access health services through the Porcupine Health Unit and Ontario Telemedicine Network, and connect to a larger hospital in Hearst. The APM Project will result in an increased demand on health and safety facilities to support an influx of new residents and workers.

The APM Project has the potential to bring positive net benefits to the Human Assets of Hornepayne should the project be implemented in the area. It would help the community realize its aspiration and goals, and it would drive development and expansion in other aspects of its community well-being.

7.2.3 Implications for Economic Assets

At the moment, employment in Hornepayne is at a point of equilibrium. The economy of Hornepayne has been in decline with the closure of many businesses, which has had a ripple effect across the community. The population decline has seriously affected the retail and services sector and recreational facilities and programs. However, overall employment levels within the community have remained relatively stable. On the positive side, the presence of two major employers in the community, Canadian National Railway and Olav Haavaldsrud Timber Company Limited continue to provide employment opportunities. Increased forestry activities in the general area are creating new employment opportunities. Counterpoint to this, however, has been a decline in other sectors that have forced residents to leave the community to find work elsewhere in northern Ontario and beyond. This is particularly prevalent amongst the younger generation. It is hoped that the APM Project will provide desired stable employment and career opportunities for local people.

The APM Project will give the community a significant boost in population with the concurrent expansion of retail and services, and new demands for education and community services. Household incomes remain stable in Hornepayne, due in part to business and employment stability at CN Rail and recent growth at the Olav Haavaldsrud Timber Company. The APM Project will further create local jobs and stimulate growth in household income and wealth creation.

Tourism has long been a secondary part of the local economy. The tourism industry in Hornepayne is largely dependent on the American market, which is in decline. There are some fly-in, fly-out outfitters in the area surrounding Hornepayne; however, since 2010 there has been little local tourism accommodation available to residents and visitors to Hornepayne. There is some concern that the APM Project may adversely affect tourism through the potential for negative perceptions due to the project. Conversely, there is also the potential for new visitors to the area who come to learn more about the project.

In Hornepayne, there is an active Economic Development Corporation looking to attract new businesses to the area. There is the potential for the APM Project to improve business development opportunities through its own presence and the creation of associated business opportunities.

Municipal fiscal circumstances are currently challenging. Business closures, out-migration and vacant properties have left the community with a weak revenue base. The community is fiscally challenged to cover long-term capital needs. The APM Project will increase municipal revenues. The APM Project will also allow Hornepayne to develop a more balanced tax base to ensure the maintenance of community infrastructure and services. Optimizing benefits may require assistance from the NWMO in terms of planning.

Should the APM Project locate in the Hornepayne area, the net economic effects will be positive. A key attribute is the direct and indirect job creation it will bring to the community in terms of direct and indirect employment and career opportunities. Further induced employment will also occur in the community as a result of income spending by direct and indirect workers. The presence of long-term, well-paying job opportunities will change the economic complexion of the community. Out-migration will slow as residents will be able to find work locally. In-migration will happen as Hornepayne will become an employment centre. Residents with jobs and money means household incomes will climb, and concomitantly, so will household expenditures. More households and greater expenditures open up market opportunities for local businesses to service the expanding needs of a growing and more affluent population. These conditions will in turn help to reverse the decline in existing businesses and also bring new business into the community, thereby adding to the vitality and diversity of the local retail service fabric. This helps to address a key plank of the community's aspirations.

The economic buoyancy created among residents and local businesses will have positive implications for municipal finance. The assessment base will grow, and it will be more equitably spread across industry, residential and commercial components. Although operating costs and capital requirements will rise given growth in the community and the associated increase in demand for services, careful financial management should ensure that short- and long-term costs can be better covered by the strong municipal revenue base.

Economic development in an expanding community is a much easier task than it is in one that is declining. The APM Project is of a scope, scale and longevity that businesses will be attracted to the community to take advantage of the opportunities for the supply of goods and service to the project itself and the population it has brought into the community. Were the APM Project to be located in the area, Hornepayne will need to be proactive in looking at where new businesses can locate and the support services that they will require for long-term operation.

Should the APM Project locate in Hornepayne, the net economic effects are expected to be positive: jobs and business opportunities will be created and incomes will grow. The presence of long-term and stable job opportunities will change the economic complexion of the community. Out-migration of youth will slow, and in-migration will occur as Hornepayne becomes an employment centre. More households and greater expenditures open up market opportunities for local businesses to service the expanding needs of a growing and more affluent population. These conditions align with the community's aspirations for economic growth.

7.2.4 Implications for Infrastructure

Basic municipal infrastructure is in place in Hornepayne, although some facilities may need upgrading or replacing. Housing stock appears to be in a good state of repair, and there is potential for growth – including 68 vacant lots, most of which are serviced. A new water treatment facility was completed in 2007 with a capacity to serve 3,000 residents. The APM Project may place increased demands on existing infrastructure and may necessitate facility replacements in some cases; however, the project would generate municipal revenues that can be applied to facility operation and maintenance, upgrading, and replacement.

Hornepayne is situated on the CN mainline and is a critical staffing centre, which handles over 20 trains per day. Passenger rail service is also available in the community. The Hornepayne Municipal Airport is currently unmanned, but appears to only require modest maintenance and possible upgrading. The APM Project would increase road, rail, and airport usage, and this may necessitate upgrading and expansions.

Hornepayne has available housing for the time being, but will need to develop and service land to handle the influx of workers during the construction and operation phases. Additionally, the influx of workers may place increased demand on the entire municipal infrastructure.

In terms of housing, the APM Project will bring an influx of individuals and families to the community who will quickly absorb the available or vacant housing stock. At the same time, a variety of new housing can be expected to be developed to further accommodate the rental and ownership needs of individuals and families. The absorption of new and existing homes will reinforce property prices, increase tax rolls and remove properties from tax arrears. Although there is strong upside for housing with the APM Project, there is also a potential downside that needs to be carefully managed. If demand outstrips supply, price escalation will occur and the complement of affordable housing may be very low. A further note of caution with respect to housing is that supply limitations particularly during the construction phase may see a strong uptake of motel rooms by workers with the consequence that tourists and travellers might be displaced. Over the course of the undertaking, attention will need to be carefully focused on maintaining an equitable housing supply/demand balance, as well as protection of tourist/traveller accommodations and other related services, to prevent unwanted consequences in that industry.

Overall, the changes in community well-being related to the physical assets of Hornepayne as a result of the APM Project appear to be positive. The APM Project has the potential to create increased demand for housing and municipal services, but also additional revenue sources for them. With respect to housing, there will be demand for a range of housing stock, and there may be some project-related price escalation which needs to be managed.

7.2.5 Implications for Social Assets

Hornepayne is a resilient community in which people pull together to meet its needs, but there was a major blow to the community when the Hornepayne Town Centre mall closed. The result, though, was to see the community redouble efforts to stabilize itself. Hornepayne currently has a number of recreational facilities and programs such as minor hockey, adult hockey, figure skating and intramural sports; however, the decline in population has led to program reductions and facility closures in recent years such as the closure of the public pool. The financial circumstances of the Township do not permit continued investments in some services and associated infrastructure. The APM Project will bring an increased population to the community, thereby boosting participation and involvement. As such, this population may place demands on existing facilities, services and organizations and may create the need for new facilities and services. It will also lead to the reopening of facilities and programs. This transition may require planning assistance.

Hornepayne has a strong sense of pride associated with its history and natural environment. Outdoor activities such as cross-country skiing, snowmobiling, hunting and fishing are popular activities. The community is a quiet and safe community for families and has some organizations that supply social services to the community. Although the APM Project could double the existing population, there is a desire to preserve the community character.

The APM Project will make more demands on community and social services, but the increased population will also provide the tax base and volunteer base to meet needs. Overall, given that the APM Project may double the population of Hornepayne, the NWMO will need to work with the community to ensure a measured increase in population so that old and new residents can adjust to each other, and to maintain the strong sense of community identity.

The APM Project would have a net positive benefit on the Social Assets of the community were it to be implemented in the area. With respect to the community recreational facilities and programs and also the social services and organizations, the increased population associated with the APM Project would be expected to increase demand on these resources. However, this increased population would also be expected to heighten participation rates and create a larger base of human resources for volunteers. Increased funding and participation would allow Hornepayne to upgrade and expand its recreational and social programs. Based on discussions with the community, the project would be expected to have a positive influence on the dynamics of the community by providing a more stable population base through the retention of younger families and youth, and by providing the ability to support its middle-aged and senior populations.

7.2.6 Implications for Natural Environment

The natural environment is a source of pride for the community of Hornepayne and its residents. Hornepayne and area residents regularly use the surrounding area for recreational activities. Fishing and hunting are important to the community as are the snowmobile and ATV trails. These natural features will likely be attractive to many of the new APM Project employees.

There are some parks and open spaces in the area, including Nagamasis Provincial Park, Hearst Forest, and further away, the Chapleau Crown Game Preserve, all of which are considered important features of the area by residents. Increased population will result in increased visitor numbers, and also potential for increased demand and heightened pressure on natural areas. Growth of nature base and ecotourism is also desired by the community. There may be a need for the Township, aided by the NWMO, to ensure that sensitive areas are protected, and the carrying capacity of the areas is not exceeded. Further environmental studies would be needed to understand the scale and extent of any environmental effects. With proper planning and dialogue, resources would remain protected and increased demand would be managed.

As outlined in Chapter 5, initial studies on the potential environmental effects associated with the project suggest that the APM Project is unlikely to have any significant negative effect on the natural environment which makes up the parks and protected areas near the community, taking into account mitigation that will be applied. There is the potential that visitation to the Provincial Park may experience some decline with the presence of the facility as some people may be less likely to visit the area. However, there are many examples of Provincial Parks that are situated close to or nearby nuclear facilities (e.g., Darlington, MacGregor Point and Inverhuron Provincial Parks) where visitation has not been affected. It is expected that through working with park managers and clearly communicating with the public, any negative perceptions can be mitigated, and project activity may even be leveraged to take advantage of increased population growth and visitation associated with the project. Further study is required to better understand and predict the potential effects of the project on visitor perception and use of the area.

As would be the case with any large project, natural areas might be affected during the various phases of the project. As outlined in Chapter 5, effective mitigation and environmental protection measures will ensure that the overall environmental integrity of the area is maintained. It is understood at this point in time that no significant negative environmental effects are likely during the construction, operation and decommissioning phases of the used fuel repository, taking into account mitigation that will be applied.

The project contains some flexibility with respect to on-site building designs and energy use to be consistent with broad environmental and social values. For example, the ability to use renewable sources of electric power, where feasible, coupled with energy-efficient building designs might limit the overall carbon footprint of the project.

7.2.7 Summary of APM and Its Implications for Hornepayne

Based on the foregoing discussion, the APM Project has the potential to be a very good fit for the community of Hornepayne. The APM Project has the potential to enable the aspirations of the community to be achieved, and through this, foster well-being as Hornepayne defines it. Based on discussions with the community, it is understood that the APM Project would provide economic growth, stability and growth of the population. Table 7-2 provides a summary for all five asset categories.

The introduction of the APM Project to a relatively remote northern Ontario community such as Hornepayne will create significant change. Positive changes could include:

- Employment and business opportunities (direct and indirect)
- Population growth due to in-migration of workers may encourage greater utilization of local community assets (infrastructure, housing, facilities and services)
- Utilization of available, serviced land
- Ability to retain youth/young families in the community
- Improved education and training, development of a skilled workforce
- Enhanced self-sufficiency for individuals, families and the community as a whole
- Improved tax base/municipal revenues

It is recognized that some tourist operators may be concerned about the effect of the APM Project as some people may be less likely to visit the area. However, others can see positive implications for the tourist industry as a result of increased population and tourism visitation to the area.

Some natural areas may be affected by the APM Project. Effective mitigation and environmental protection measures would ensure that the overall environmental integrity of the area is maintained.

Table 7-2: Overall Community Well-Being Implications

Criteria/Measures	CWB Is Enhanced When …	Current Hornepayne Profile		Possible Hornepayne Profile With APM Project		Observations and Implications
OVERALL CWB IMPLICATIONS:						
Human Assets	Population growth occurs, and youth are retained in the community.	Declining	⬅	Enhanced	➡	• APM Project would bring population growth, which is a key priority and aspiration for the community. • Youth would be retained through increased employment opportunities, and new residents would be attracted to the area. • Educational and health-care resources would be enhanced.
Economic Assets	Employment opportunities are available, and tax base increases to fund community services and facilities.	Stable	▭	Enhanced	➡	• There will be increased employment opportunities and a more diverse range of jobs. • Increased funding through a wider tax base would provide additional financial resources for Hornepayne to fund its infrastructure projects, educational developments, community and recreational facilities and programs, and social services and organizations. • The increased jobs from the APM Project would be the catalyst for Hornepayne to enhance its community well-being.
Infrastructure	Infrastructure is maintained or improved to meet the needs of the community.	Stable	▭	Enhanced	➡	• The APM Project, while placing increased demands on some of the infrastructure and services, would overall provide increased funding to improve and enhance existing services.
Social Assets	Opportunities exist for recreation and social networking. Community is cohesive, and community character is enhanced.	Stable	▭	Enhanced	➡	• The community would see an overall benefit to its Social Assets through increased participation and funding to its recreational facilities and programs, as well as its social services and organizations. • With proper planning and communication, no serious social divisions would be expected to occur in the community. • Interest in the project appears to be very positive, and the community is largely cohesive on this issue.
Natural Environment	Natural areas, parks and conservation reserves are preserved and maintained for use and enjoyment.	Positive	➡	Environment – Integrity Maintained	▬	• Some natural areas might be affected by the APM Project. • Effective mitigation and environmental protection measures will ensure that the overall environmental integrity of the area is maintained. • It is understood at this point in time that no significant negative environmental effects are likely during the construction, operation and decommissioning phases of the used fuel repository.

Legend	
Declining – Negative	⬅
Neutral – Stable	▭
Environment – Integrity Maintained	▬
Increasing – Enhanced – Positive	➡
Uncertain	△

7.3 Criteria to Assess Factors Beyond Safety – Summary in Hornepayne

The previous discussion has taken a holistic approach to the assessment, taking into account the aspirations of the community and the implications of the project for community well-being. The NWMO acknowledges that the process of assessment of community well-being needs to be collaborative and reflective of the community. Before initiating the siting process, and beginning to engage interested communities in the assessment process to understand their aspirations, the NWMO identified five evaluation factors which, at a minimum, would need to be addressed (NWMO, 2010a). Table 7-3 draws on information outlined in the previous discussion to understand the potential to foster well-being in Hornepayne against these original factors. The table summarizes preliminary findings about the implications of the APM Project, were it to be implemented in the community, on various factors of well-being. For many evaluation factors, four measures are used: maintained, enhanced, diminished or uncertain. For other evaluation factors, two measures are used: yes or no. The overall conclusion using these evaluation factors and the understanding that has emerged to date is consistent with that outlined in the previous sections.

Over the course of discussions and conversations, the community identified a number of other important areas for consideration. The community expressed a strong desire to better understand how to engage neighbouring communities, communities on transportation routes, and in particular, area Aboriginal communities. Hornepayne realizes that it would be essential to develop relationships with all the foregoing to support the implementation of the project.

Table 7-3: Summary Table of Criteria to Assess Factors Beyond Safety

Factors Beyond Safety	Evaluation Factors to Be Considered	Indication	Discussion Based on Preliminary Assessment
Potential social, economic and cultural effects during the implementation phase of the project, including factors identified by Aboriginal Traditional Knowledge	Health and safety of residents and the community	Maintained	• There is a strong safety case as outlined in Chapter 5; however, the community is eager to learn more about safety and health considerations to enhance their confidence in the safety of the project.
	Sustainable built environments	Enhanced	• Community infrastructure and built fabric will be enhanced through project activities and investments in the community.
	Sustainable natural environments	Maintained	• Some natural areas might be affected by the APM Project. • Effective mitigation and environmental protection measures will ensure that the overall environmental integrity of the area is maintained. • It is understood at this point in time that no significant negative environmental effects are likely during the construction, operation and decommissioning phases of the used fuel repository.
	Local and regional economy and employment	Enhanced	• Significant employment and population growth would occur in Hornepayne and surrounding communities – hundreds of new jobs might be created in Hornepayne. • With these jobs comes the potential to double the current population of Hornepayne. • New opportunities would be created for local businesses to serve the project and growing population.
	Community administration and decision-making processes	Enhanced	• Local leadership has demonstrated interest in the project, and going forward, it is expected that local leadership will ensure residents have opportunities to learn more and engage in community decision-making.
	Balanced growth and healthy, livable communities	Enhanced	• Hornepayne has aspirations to grow its population and economy as platforms for its strategic plan. • The APM Project generally appears to be a fit with primary community goals and aspirations for economic development and growth.
Potential for enhancement of the community's and region's long-term sustainability through implementation of the project, including factors identified by Aboriginal Traditional Knowledge	Health and safety of residents and the community	Maintained	• There is a strong safety case as outlined in Chapter 5. Engagement of surrounding communities is beginning, and further dialogue will be required to understand and address questions and concerns about safety and health considerations related to the repository and transportation of used nuclear fuel.
	Sustainable built environments	Enhanced	• Infrastructure and built fabric will be enhanced through project activities and investments in the community and surrounding areas.
	Sustainable natural environments	Maintained	• Some natural areas may be affected by the project. • Effective mitigation and environmental protection measures will be required to ensure that the overall environmental integrity of the area is maintained.
	Local and regional economy and employment	Enhanced	• Substantial employment and economic development opportunities would extend to the surrounding region.
	Community administration and decision-making processes	Enhanced	• Engagement of surrounding communities has been initiated and is co-ordinated and ongoing. • Surrounding community leadership has demonstrated interest in the project, and going forward, it is expected they will be able to make informed and effective decisions.
	Balanced growth and healthy, livable communities	Enhanced	• Engagement of surrounding communities has been initiated and is co-ordinated and ongoing. • Surrounding area communities are collectively seeking economic development and growth in the region. • The APM Project generally appears to be in alignment with these aspirations.
Potential to avoid ecologically sensitive areas and locally significant features, including factors identified by Aboriginal Traditional Knowledge	Ability to avoid ecologically sensitive areas and locally significant features	Yes	• As outlined in previous chapters of this report, the region contains suitable sites for the project, thus providing flexibility in selecting specific sites that can avoid ecologically sensitive areas and local significant features.
Potential for physical and social infrastructure to adapt to changes resulting from the project	Potential for physical infrastructure to be adapted to implement the project	Yes	• There are no major infrastructure limitations in Hornepayne or the surrounding region to impede project implementation. • Hornepayne and the surrounding areas are highway and rail accessible, and have social and economic support services and capacity to absorb the anticipated growth in population and economic activity. • Some investments would be required to accommodate specific infrastructure deficiencies such as schools, recreational facilities, housing, etc.
	Potential for social infrastructure to be adapted to implement the project	Yes	• The community of Hornepayne appears to have the necessary core of social infrastructure in place to plan and adapt to changes resulting from the project.

Factors Beyond Safety	Evaluation Factors to Be Considered	Indication	Discussion Based on Preliminary Assessment
	The NWMO resources required to put in place physical and social infrastructure needed to support the project	To Be Determined	• In all likelihood, Hornepayne would require assistance in terms of planning, and human and financial resources. • Further studies would be required to explore the specifics of these requirements.
Potential to avoid or minimize effects of the transportation of used nuclear fuel from existing storage facilities to the repository site	The availability of transportation routes (road, rail, water) and the adequacy of associated infrastructure and potential to put such routes in place	To Be Determined	• As outlined in Chapter 6, Hornepayne is located on the CN mainline and is accessed by Highway 631. • Hornepayne also has the infrastructure in place to provide access through its airport, should renovations and other resources enable it to reopen. • The community and region have access to multiple modes of transportation. • However, engagement of surrounding communities would be required to help build understanding and address questions and concerns.
	The availability of suitable safe connections and intermodal transfer points, if required, and potential to put them in place	To Be Determined	• Engagement of surrounding communities and those on potential transportation routes would be required to understand and address questions and concerns.
	The NWMO resources (fuel, people) and associated carbon footprint required to transport used fuel to the site	900–1,760 tonnes of equivalent carbon dioxide emission is expected to be produced per year	• As outlined in Chapter 6, in a scenario of all road transport of 4.6 million fuel bundles from the interim storage sites to an APM facility near Hornepayne, approximately 1,760 of equivalent carbon dioxide emissions are expected to be produced per year. • In a scenario of transport by mostly rail mode, approximately 900 of equivalent carbon dioxide emissions are expected.
	The potential for effects on communities along the transportation routes and at intermodal transfer points	To Be Determined	• As outlined in Chapter 6, there is a robust technical safety case for the safe and secure transport of used nuclear fuel. However, engagement of surrounding communities and those on potential transportation routes would be required to help build understanding and address questions and concerns.

7.4 Overview of Engagement in Hornepayne

The NWMO has engaged with Hornepayne leadership and community members, and has begun to engage surrounding communities and Aboriginal peoples through a variety of means, including:

- Several community open houses;
- Regular attendance at the Community Liaison Committee meetings;
- Both informal and structured interviews with community members;
- Facilitating the Community Liaison Committee website and newsletters;
- Discussion with school groups;
- Preparation of written materials;
- Informal tours and visits with local residents;
- Attendance at Hornepayne Fishing Derby;
- "Ask the NWMO" columns in regional newspapers;
- Meetings with nearby First Nations;
- Attendance at regional meetings, conferences (e.g., with Northeast Superior Regional Chiefs' Forum, Northeast Superior Mayors' Forum, and Federation of Northern Ontario Municipalities);
- NWMO Mobile Transportation Exhibit; and
- Nuclear waste management facility tours.

Initial discussions with a cross-section of community leaders, briefings and conversations with community groups, and conversations with residents during open houses suggest there is interest in the community to continue to learn about the project and consider hosting the project in the area. To this end, opportunities for preliminary discussions were sought with:

1. Local political leaders (e.g., mayor and councillors);
2. Members of the Nuclear Waste Community Liaison Committee;
3. Local business owners/operators;
4. Local service providers (e.g., emergency services, social services, education);
5. Surrounding community leaders;
6. Residents; and
7. First Nations and Métis communities in the vicinity.

Based on discussions with the above, there appears to be growing potential to sustain interest in the local community. There appears to be a strong and growing interest to continue and move forward with the siting process.

Through the Northeast Superior Mayors' Group and other outreach and engagement activities, Hornepayne has taken steps to engage its neighbours, including Aboriginal peoples, and has begun to set the foundation for further constructive consideration of the project and opportunity to work collaboratively to explore the project and interest in the broader area. These steps have elicited positive interest from some surrounding communities, and discussions are ongoing.

7.4.1 Summary of Issues and Questions Raised

In Hornepayne, the majority of the persons engaged were interested in learning more, were supportive of their community being involved in the siting process and look forward to next steps. A small number of individuals continue to express concerns about the community's involvement in the process. Several key interests were recurring and identify the areas which the community is most interested in learning more about. The core key interests expressed include:

- Economic benefit and opportunities for growth;
- Health, safety and environmental risks in and around the site; and
- Transportation.

In addition to these core key interests, two secondary key interests included:

- NWMO Process and Project Description Details; and
- Consultation.

Going forward, engagement with surrounding communities will need to continue. Hornepayne looks forward to ongoing engagement with the NWMO to learn more about the project, and to work with the NWMO in a long-term partnership that will optimize well-being in the community and surrounding area.

7.5 Community Well-Being – Summary Findings

At the outset of the site selection process, the NWMO framed four key questions, respectively addressing safety, the well-being of the community, the well-being of surrounding area communities, and the potential to foster sustained interest in exploring this project through subsequent steps in the site selection process (NWMO, 2011). The discussion that follows addresses and elaborates on a subset of these questions related to community well-being in the context of Hornepayne.

The preceding discussion has looked at implementation of the APM Project in Hornepayne and the implications this might have on the community well-being of Hornepayne. Additionally, key issues and concerns identified through engagement activities have been highlighted. Through desktop research, dialogue with community members and leaders, and ongoing analysis, it is understood that Hornepayne has some interest in considering hosting the APM Project in the area to realize growth and development opportunities within the community and surrounding area.

There appears to be high potential for the APM Project to foster the well-being of Hornepayne. The project is understood to be compatible with community aspirations, including the desire to see growth and stability. There is also an expectation that the APM Project will assist Hornepayne in achieving its goals. In addition, the project is seen by residents and leaders as an opportunity for sustainable growth and the development they desire.

The community of Hornepayne understands that this siting process, in partnership with the NWMO, will assist their community over time to get the information they require to reflect upon their willingness to continue in the site selection process and to decide whether or not they are interested in continuing to the next phase of studies.

There is a high potential for sustained interest in the local community. This is evidenced by strong community leadership to continue participation in the site selection process. There is also a strong commitment to moving forward as there is no indication at this time that Hornepayne could not remain committed throughout the subsequent steps.

There is potential for the APM Project to foster well-being in the communities surrounding Hornepayne. Preliminary discussions with residents and officials of the surrounding communities have revealed an interest in the potential economic development benefits offered by the project. However, further discussions will be required to assess the implications of the project for surrounding area communities. This project will be implemented through a long-term partnership involving the community, neighbouring communities and Aboriginal peoples in the area, and the NWMO. Only through engagement, dialogue and collaboration will the NWMO ensure that needs are addressed at each stage of the process, and identify the specifics of how a partnership arrangement could work.

There is high potential for sustained interest in the surrounding communities as Hornepayne has demonstrated a proactive approach to engaging its neighbours, including members of the Northeast Superior Mayors' Group. There are three other communities (White River, Wawa, Manitouwadge) in the immediate region (Northeast Superior Mayors' Group) involved in the siting process. Hornepayne has also taken steps to set the foundation for further constructive consideration of the project and its opportunities with communities in the surrounding area, including Aboriginal peoples. Further discussions will be required to gain an understanding of the potential interest in surrounding communities.

There are some uncertainties associated with the preceding analysis due to the preliminary nature of the work at this stage. These uncertainties and challenges include:

1. Specific land areas that are socially acceptable would need to be identified.

    a. Community input is required to identify areas which should be reserved for other uses or preservation. The remaining areas must overlap with potentially suitable siting areas identified through scientific and technical studies.

    b. Further engagement with potentially affected Aboriginal communities is required, including Aboriginal Traditional Knowledge holders in the area. The NWMO acknowledges, respects and honours that Aboriginal peoples – Indian, Inuit and Métis peoples of Canada – have unique status and rights as recognized and affirmed in s.35 of the *Constitution Act*, 1982. The NWMO is committed to respecting the Aboriginal rights and treaties of Aboriginal peoples (NWMO, 2010b).

2. Project implementation (including engineering, logistics and/or community well-being) must align with specific community aspirations.

    a. An acceptable area and regional project implementation plan must be identified, which aligns ultimate project configuration with area expectations.

    b. Effective implementation of project planning at a broader level, involving the surrounding communities and potentially affected Aboriginal peoples, will be important in the successful implementation of the project.

3. Interest in the community for further learning about the project needs to be sustained.

    a. The site selection process spans several years, and interest and conversation in the community need to be sustained throughout this process, including multiple election cycles

    b. The potential effects of the project on the community and area would be substantial, and the community and area will need support to further explore their interest and take an active role in discussions of how the project should be implemented.

    c. Opposition groups, largely from outside the area, may actively seek to influence community decision-making, and community leaders will need to respond to these pressures. Hornepayne will require support to prepare for the next phases of the siting process if it is to proceed.

4. Transportation routes and mode(s) need to be designed and configured taking into account social values.

    a. Transportation will be spatially extensive from current interim storage sites to the repository. Regulatory matters along routes in several provinces, including New Brunswick, Quebec and Ontario, would need to be addressed. Social questions and concerns would also need to be heard and taken into account.

5. Environment and safety evaluations need to be aligned with community input.

    a. This requires regard for input from the community and surrounding communities.

    b. This requires engagement by the NWMO and input from the community and surrounding communities. This may require capacity building to enable this input, which could include Aboriginal Traditional Knowledge.

    c. Input from transportation route communities will also need to be incorporated.

8. REFLECTION ON POTENTIAL SUITABILITY

8.1 Early Findings

The site selection process outlines a road map for decision-making, which involves many steps completed over a number of years. Over the course of these steps, the NWMO and potentially interested communities reflect upon the suitability of the community to host the Adaptive Phased Management (APM) Project. Progressively detailed scientific and technical studies are completed, and surrounding communities and potentially affected Aboriginal peoples are drawn into the process and engaged, before any decision is made on a preferred safe site for the APM Project in an informed willing community.

In order to fully understand and assess the potential of a community and area to host the APM Project, detailed scientific and technical studies are required over many years. At this preliminary assessment phase of work, initial studies have been completed. However, more detailed study is still required in order to assess suitability and ensure the conditions are there for the safe and secure containment and isolation of used fuel over the very long term.

The decisions that people will make in the future about learning more about the project, exploring the potential to foster well-being of the community and area, and ultimately whether they are willing to host the project in the area and are prepared to support its implementation, are also key determinants of suitability. At this early point in the site selection process, the NWMO cannot anticipate with certainty the outcome of a dialogue which would need to continue into the future in order to support informed decision-making. This dialogue would need to continue to unfold. Engagement activities within the community would need to continue, and these activities would need to be broadened to involve surrounding communities and potentially affected Aboriginal communities in the learning and decision-making process, to fully understand the suitability of a community and area to host this project.

At this early stage of work, the NWMO is able to make preliminary conclusions and observations about the potential suitability of the community and area to host the project, as well as reflect on the uncertainties and challenges associated with the community and area, ultimately satisfying the conditions for successful implementation of the project.

8.2 Preliminary Conclusions

The preceding sections of this report have examined, in a preliminary way, the potential for Hornepayne to meet the broad range of siting conditions set for the project. Four overriding research questions have guided this preliminary assessment. In all cases, these questions can be answered affirmatively.

1. There is potential to find a safe site in the Hornepayne area.
    - There is the potential to find a site with suitable geology.
    - There is the potential to safely construct the facility at the potential site.
    - There is the potential for safe and secure transportation to the potential site.There is the potential to manage any environmental effects and to ensure safety of people and the environment.
2. There is potential to foster community well-being in Hornepayne through the implementation of the project.

3. There is potential for sustained interest in Hornepayne to support further learning about the project.
4. There is potential to foster community well-being in the surrounding area through the implementation of the project, as well as sustain interest in the surrounding communities to support further learning.

Preliminary assessment studies conducted to date suggest that there is the potential for Hornepayne to be suitable for the project from the multiple perspectives of:

- Engineering logistics;
- Geoscientific suitability;
- Environmental health and safety;
- Transportation safety; and
- Social, economic and cultural effects within the community and surrounding areas.

Studies in each of these areas addressed criteria that were set out in the siting process description as was feasible in this initial phase of work.

8.3 Observations About Suitability

8.3.1 General Observations

Based on this preliminary information, there are a number of observations that can be made that support the overall conclusion that the Hornepayne area has potential to host the APM Project.

- The APM Project has the potential to be safely located in a suitable site within or near Hornepayne in a manner that will protect people and the environment now and in the future.

- There is potential to find a site that does not adversely affect future options for other activities valued by the community and area such as mining and recreation. In other words, if the Hornepayne area was selected for the APM Project, it is likely that a geologically and environmentally suitable site can be found that does not jeopardize future uses of the land and resources as the NWMO understands them today.

- From a technical perspective, there is potential to safely transport used nuclear fuel from existing storage facility sites to the Hornepayne area.

- There appears to be high potential for the APM Project to foster the well-being of Hornepayne. The project is understood to be compatible with community aspirations, including the desire to see growth and stability. There is also an expectation that the APM Project will assist Hornepayne in achieving its goals. In addition, the project is seen by residents and leaders as an opportunity for sustainable growth and the development they desire.

- There is a high potential for sustained interest in the local community. This is evidenced by strong community leadership to continue participation in the site selection process. There is also a strong commitment to moving forward as there is no indication at this time that Hornepayne could not remain committed throughout the subsequent steps.

- There is potential for the APM Project to foster well-being in the communities surrounding Hornepayne. Preliminary discussions with residents and officials of the surrounding communities have revealed an interest in the potential economic development benefits offered by the project. However, further discussions will be required to assess the implications of the project for surrounding area communities.

- There is high potential for sustained interest in the surrounding communities as Hornepayne has demonstrated a proactive approach to engaging its neighbours, including members of the Northeast Superior Mayors' Group. There are three other communities (White River, Wawa, Manitouwadge) in the immediate region (Northeast Superior Mayors' Group) involved in the siting process. Hornepayne has also taken steps to set the foundation for further constructive consideration of the project and its opportunities with communities in the surrounding area, including Aboriginal peoples. Further discussions will be required to gain an understanding of the potential interest in surrounding communities.

8.3.2 Uncertainties and Challenges

Based on this preliminary information, there are uncertainties and challenges which these studies have not been able to address and are important to understanding the potential for the community and area to meet the requirements for hosting the project.

Some uncertainties and challenges are a result of being at an early phase of study with limited information available. Other uncertainties and challenges have arisen from the conduct of the studies themselves and may be unique to better understanding the potential suitability of the particular area. Other communities in the site selection process may share many of these challenges and uncertainties, although the difficulty and the level of resources required to successfully address them vary by community.

The reader is encouraged to review the full report and supporting documents, for a better understanding of the challenges and uncertainties associated with this community and area. Examples of the range and type of uncertainties and challenges which would need to be considered in planning and resourcing any further studies in this community and area include the following:

1. Geoscientific studies suggest that while the Hornepayne area appears to contain general land areas with favourable geoscientific characteristics for hosting a deep geological repository, there are inherent uncertainties that would need to be addressed. The main uncertainties are associated with the influence of the geological subprovince boundary that crosscuts the Hornepayne area, the presence of numerous dykes, the low resolution of available geophysical data over most of the Hornepayne area, and the variable degree of metamorphism that the sedimentary rocks experience in the geological past.

2. Environment and safety studies suggest there is potential to implement the project safely and with respect for the environment in the Hornepayne area. Although the assessment has identified some specific areas that would be excluded as they contain parks and protected areas, a more definitive environmental evaluation would be required once smaller potential siting areas have been identified. These studies could result in the exclusion of additional areas based on such factors as, for example, the presence of migration routes, the proximity to important habitats and cultural sensitivity. Discussions with interested communities, surrounding communities and Aboriginal peoples, as well as field studies, would be needed to fully characterize the environmental conditions in these smaller potential siting areas.

3. Environment and safety studies suggest that effects of the project on the environment can be managed or mitigated through a combination of in-design features, operating procedures, and implementation of a sound environmental management plan. As smaller potential siting areas are identified, these mitigating measures would need to be identified and their effectiveness confirmed.

4. Among these potentially suitable land areas, specific smaller siting areas that are socially acceptable would need to be identified.

    - Community input is required to identify areas which should be reserved for other uses or preservation. The remaining areas must overlap with potentially suitable land areas identified through scientific and technical studies.

    - Further engagement with potentially affected Aboriginal communities is required, including Aboriginal Traditional Knowledge holders in the area. This may expand the framework for assessment through, for instance, insight from Indigenous science, ways of life, and spiritual considerations.

5. Project implementation (including engineering, logistics and/or community well-being) must align with specific community aspirations.

    - An acceptable area and regional project implementation plan must be identified, which aligns ultimate project configuration with area expectations.

    - Effective implementation of project planning at a broader level, involving the surrounding communities and potentially affected Aboriginal peoples, will be important in the successful implementation of the project.

6. Interest in the community for further learning about the project needs to be sustained.

    - The site selection process spans several years, and interest and conversation in the community and area need to be sustained throughout this process, including multiple election cycles.

    - The potential effects of the project on the community and area would be substantial, and the community and area will need support to further explore their interest and take an active role in discussions of how the project should be implemented.

- Opposition groups, largely from outside the area, may actively seek to influence community decision-making, and community leaders will need to respond to these pressures. Hornepayne will require support to prepare for the next phases of the siting process if they are to proceed.

7. Transportation routes and mode(s) need to be designed and configured taking into account social values.

    - Transportation will be spatially extensive from current interim storage sites to the repository. Regulatory matters along routes in several provinces, including New Brunswick, Quebec and Ontario, would need to be addressed. Social questions and concerns would also need to be heard and taken into account.

8. Environment and safety evaluations need to be aligned with community input.

    - This requires regard for input from the community and surrounding communities.

    - This requires engagement by the NWMO and input from the community and surrounding communities. This may require capacity building to enable this input, which could include Aboriginal Traditional Knowledge.

    - Input from transportation route communities will also need to be incorporated.

8.4 Partnership

The site selection process outlines a road map for decision-making, which involves many steps. Over the course of these steps, the NWMO, potentially interested communities, and surrounding communities and Aboriginal peoples reflect upon the suitability of the community and area to host the APM Project.

At this preliminary assessment phase of work, initial studies have been completed. However, more detailed studies would be required before confidence could be established that project requirements could be met in the Hornepayne area. A broad network of relationships would also need to be established in the area, involving the interested community, surrounding communities and Aboriginal peoples.

Through working with communities that have come forward to participate in the site selection process, and through initial outreach with surrounding communities and Aboriginal peoples, the nature and shape of the partnerships required to implement the APM Project is beginning to emerge. This project will only proceed with the involvement of the interested community, surrounding communities and potentially affected Aboriginal peoples.

The implementation of the project will not only have an effect on the local area in which it is sited, it will also have an effect on those in the surrounding area. Surrounding communities and Aboriginal peoples need to be involved in decision-making about the project and planning for its implementation were it to proceed in the area. Only through working together can the project be harnessed to maximize benefits to the area, manage any pressures which may come from the project, and ensure that the project fosters the long-term well-being and sustainability of the area consistent with the area's vision for the future.

These initial studies have demonstrated it is possible to find land areas in the vicinity of Hornepayne that have the potential to satisfy the geoscientific factors outlined in the NWMO site selection process description and enable the project to be implemented in a way that is respectful of people and the natural environment. These potentially suitable areas include areas in the vicinity of the community on Crown land, and in territory for which Aboriginal peoples have a claim. As identified in the site selection process description (NWMO, 2010a), the NWMO has committed to respect Aboriginal rights and treaties in the siting decision, and take into account that there may be unresolved claims between Aboriginal peoples and the Crown. Furthermore, as outlined in the NWMO Aboriginal Policy (NWMO, 2010b), the NWMO acknowledges, respects and honours that Aboriginal peoples – Indian, Inuit and Métis peoples of Canada – have unique status and rights as recognized and affirmed in s.35 of the *Constitution Act*, 1982. The NWMO is committed to respecting the Aboriginal rights and treaties of Aboriginal peoples.

8.5 The Way Forward

The Township of Hornepayne is one of 21 communities engaged in the site selection process to explore potential interest and suitability for hosting Canada's APM Project. Through a multi-year sequence of engagement and assessments, the NWMO will lead a gradual narrowing down of communities in the process to eventually arrive at a single preferred safe site in an informed, willing community.

The outcome of Phase 1 Preliminary Assessments will guide an initial phase of narrowing down of communities engaged in site selection studies. The NWMO will identify a smaller number of communities with strong potential to be suitable for the project to be the focus of Phase 2 Assessments for detailed field studies and broadened dialogue.

Several more years of detailed studies would be required before confidence could be established that project requirements could be met in any potential siting area. For those selected to continue on in the process, a broad network of relationships would also need to be established in the area, involving the interested community, surrounding communities and Aboriginal peoples. Together, the NWMO, interested communities, surrounding communities and Aboriginal peoples will reflect upon the suitability of the community and area to host the APM Project.

9. REFERENCES

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10. GLOSSARY

PRELIMINARY ASSESSMENT OF ENGINEERING

Backfill – The material used to refill excavated portions of a repository (drifts, disposal rooms or boreholes) during and after waste has been emplaced.

Barrier – A physical obstruction that prevents or delays the movement of radionuclides or other material between components in a system, for example a waste repository. In general, a barrier can be an engineered barrier which is constructed or a natural (or geological) barrier.

Bentonite – Soft light-coloured clay formed by chemical alteration of volcanic ash. It is composed essentially of montmorillonite and related minerals of the smectite group. Bentonite is used as backfill and buffer material in repositories.

Borehole – A cylindrical excavation, made by a drilling device. Boreholes are drilled during site investigation and testing and are also used for waste emplacement in repositories and monitoring.

CANDU – Canada deuterium uranium.

Limited access area – A designated area containing a nuclear facility and nuclear material to which access is limited and controlled for physical protection purposes.

Lithostatic pressure – A pressure due to the weight of overlying rock and/or soil and water.

Nuclear security protected area – A designated area within a nuclear facility to which access is restricted, controlled and guarded for security and physical protection purposes (i.e., an area that contains the used nuclear fuel).

Protected area – An area inside a limited access area containing Category I or II nuclear material and/or sabotage targets surrounded by a physical barrier with additional physical protection measures.

Repository – A nuclear facility where waste is emplaced for disposal.

Repository, geological – A facility for disposal of radioactive waste located underground (usually several hundred metres or more below the surface) in a geological formation to provide long-term isolation of radionuclides from the biosphere.

Used fuel – Irradiated fuel bundles removed from a commercial or research nuclear fission reactor. (Adapted from the *Nuclear Fuel Waste Act*.)

PRELIMINARY ASSESSMENT OF GEOSCIENTIFIC SUITABILITY

Aeromagnetic data – Data gathered by measuring the Earth's magnetic field using an airborne magnetometer.

Aquifer – A geological unit or structure that is sufficiently porous and permeable to store, transmit, and yield significant or economic quantities of groundwater to wells and springs. A confined aquifer is bound by low permeability formations such that it is under pressure. An unconfined aquifer is one whose upper groundwater surface (water table) is at atmospheric pressure.

Archean – Of or belonging to the earlier of the two divisions of Precambrian time, from approximately 4 to 2.5 billion years ago.

Basement – All deformed crystalline (igneous and metamorphic) rocks underlying variably deformed rocks of volcanic and metasedimentary origin in an area.

Batholith – A large intrusive body having an areal extent of 100 square kilometres or more.

Bedrock – Consolidated rock that underlies soil or other unconsolidated material.

Brittle – The physical response in which a rock breaks along a surface under an applied stress at relatively low pressure and temperature, and usually results in formation of fractures and joints.

Brittle lineament – An interpreted linear trace on remote sensing and geophysical data where the bedrock has undergone brittle deformation. These features are inferred to represent fractures, faults and brittle-ductile shear zones.

Canadian Shield – A large plateau that occupies most of eastern and central Canada and consists of exposed Precambrian basement rocks in a stable craton. It is surrounded by younger sedimentary rocks.

Craton – A large portion of a continental plate that has remained relatively tectonically stable since the Precambrian Era.

Crystalline rock – A rock of igneous or metamorphic origin consisting wholly of mineral crystals.

Deformation – Any process of folding, faulting, shearing, or fabric development undergone by a rock as a result of Earth stresses; or the change in geometry of a body of rock as a consequence of Earth stresses.

Diffusion – Random movement of both ions and molecules in water from areas of higher concentration to areas of lower concentration.

Discretionary occurrence – An occurrence that does not meet any of the defined criteria of an occurrence as established by Ontario Mineral Deposit Inventory (MDI) database.

Dyke – A planar injection of magmatic or sedimentary material that cuts across the pre-existing fabric of a rock. Dykes can be formed by the filling of a crack/fissure from above, below, or laterally by forcible injection, or intrusion.

Dyke lineament – An interpreted linear feature on geophysical data inferred to be a dyke.

Dyke swarm – A concentration of vertical to subvertical dykes radiating around a central intrusion, or aligned parallel to subparallel over a large region of land.

Erosion – The process by which the surface of the Earth is worn away by the action of water, wind, or ice movement. The erosive process operates by the combined action of weathering and transportation, where first rocks are broken down (weathering), and then the smaller pieces are carried away (transportation).

Fault – A fracture or a zone of fractures that occurs as a result of brittle deformation and within which there is relative displacement of the fracture surfaces.

Felsic – Term to describe an igneous or metamorphic rock having abundant light-coloured minerals, including, for example, quartz and feldspar.

Foliation – Parallel alignment of minerals or structural features arranged in planes.

Fracture – A break in the rock mass, including cracks, joints, faults, and bedding partings.

Geomechanics – A branch of Geology that embraces the fundamentals of structural geology and knowledge of the response of natural materials to deformation.

Gneiss – A banded rock formed by regional metamorphism, in which bands result from the separation of dark-coloured minerals (e.g., biotite, hornblende, pyroxenes) and the light-coloured minerals (e.g., quartz, feldspars).

Granite – A plutonic rock in which quartz constitutes 20 to 60 per cent of the felsic component, and in which the alkali feldspar/total feldspar ratio is restricted to the range of 35 to 90 per cent.

Granodiorite – Plutonic rock in which quartz constitutes 20 to 60 per cent of the felsic component, and in which the alkali feldspar/total feldspar ratio is restricted to the range of 10 to 35 per cent.

Greenstone belt – Group of mainly Archean aged metavolcanic rocks with lesser amounts of metasedimentary rocks, that are intruded by large granitic intrusions. Many mineral deposits of copper, nickel, iron, chrome, and gold, among others, occur in greenstone belts.

Heterogeneous – A volume of rock that exhibits spatial variability of its physical properties (e.g., lithology, porosity).

Homogenous – A volume of rock that exhibits spatial uniformity of its physical properties (e.g., lithology, porosity).

Hydraulic conductivity – Ease with which water can move through a volume of rock, and is measured in unit length (e.g., metres) per unit time (e.g., seconds).

Hydrogeology – Branch of Geology that studies the movement and characteristics of subsurface waters.

Hydrogeochemistry – Branch of Geochemistry that studies the chemical characteristics of ground and surface waters and their interaction with the rock environment of an area.

Igneous rock – A rock that solidified from molten or partly molten material (i.e., from magma).

In-situ stress – The current state of stresses in a rock mass/region, representing the magnitude of, and direction in which, the rock is being compressed due to crustal movement.

Intrusion – Igneous rock emplaced as magma in a pre-existing rock volume.

Isostatic rebound – Rise of land masses that were depressed by the huge weight of ice sheets.

Lineament – An interpreted linear trace that can be observed on remote sensing and geophysical data and that may represent geological structures (e.g., fractures). Lineaments were classified as brittle, dyke or ductile.

Lithology – Set of physical characteristics of a rock, including colour, grain size, and mineralogy.

Mafic – General term for igneous or metamorphic rocks composed primarily of ferromagnesian (iron- and magnesium-rich) and other associated dark-colored minerals.

Metamorphic rock – A rock derived from pre-existing rocks by mineralogical, chemical or structural changes in response to marked changes in temperature, pressure, shearing stress, or chemical environment.

Metasedimentary (rock) – Sedimentary rock that has been subjected to metamorphic processes, which resulted in alterations to the original mineral composition of the rock.

Metavolcanic (rock) – Volcanic rock that has been subjected to metamorphic processes, which resulted in alterations to the original mineral composition of the rock.

Migmatite – High-grade metamorphic rock that has undergone partial melting.

Neotectonics – Neotectonics refers to deformations, stresses and displacements in the Earth's crust of recent age or which are still occurring.

Occurrence – Evidence of mineralization present within a surface rock sample (channel or grab) and/or isolated diamond-drill intersection(s) that may or may not have the potential to be exploited. At least one sample must meet the minimum requirements for a mineral occurrence. This definition forms the basis of an occurrence used in the Mineral Deposit Inventory database maintained by the Ontario Geological Survey (OGS).

Overburden – The silt, sand, gravel, or other unconsolidated material overlying the bedrock surface, either by having been transported or formed in place.

Paleo- – Prefix used when referring to something “ancient” or “old.”

Paleohydrogeology – Branch of Hydrogeology concerned with the study of ancient hydrologic processes, regimes and associated hydrologic features preserved in the rock.

Pluton – A deep-seated igneous intrusion of small surface area.

Plutonic – Pertaining to an igneous rock or an intrusion formed at great depth.

Quaternary – Period of time of the Earth extending from approximately 2.6 million years ago until present time.

Sedimentary rock – Rock formed by the accumulation of layers of clastic and organic material or precipitated salts.

Seismology – The study of seismic waves from earthquakes to investigate the structure and processes within the Earth.

Subprovince (geologic) – A fault-bounded, medium- to large-scale region characterized by similar rock types, structural style, isotopic age, metamorphic grade, and mineral deposits.

Tectonics – The study of the interplay between the plates that make up the outer part of the Earth, which usually results in earthquakes, creation of mountains, and fault movement, among others.

Terrain – An area of ground with a particular physical character.

Thermal conductivity – Ease with which heat can move through a volume of rock, and is measured in unit energy (e.g., Watt) per unit distance (metre) and unit temperature (Kelvin).

Tonalite – Plutonic rock in which quartz constitutes 20 to 60 per cent of the felsic component, and in which the alkali feldspar/total feldspar ratio is restricted to the range of 0 to 10 per cent.

Total Dissolved Solids – The quantity of dissolved material in a sample of water.

PRELIMINARY ASSESSMENT OF ENVIRONMENT AND SAFETY

masl – metres above sea level.

ANSI – Area of Natural and Scientific Interest – An official designation by the Province of Ontario applied to areas of land and water that represent significant geological (earth science) and biological (life science) features.

Crown leased land – Crown land acquired by the Ministry of Natural Resources for reasons based on ecological sustainability, including ecosystem health, the protection of natural and cultural assets, recreation, and/or the protection of people and property.

Crown land – **Non-Freehold Dispositions Public** – Crown land that is a tenure holding, usually for a set term and a specific purpose (e.g., Lease, Licence of Occupation, Land Use Permit, Beach Management Agreement and Easement), excluding permanent disposition in the form of a patent.

Crown land – **Unpatented Public Land** – Crown land that has never been granted or sold by the Crown to people or organizations for their private use and is under the mandate or management of the Ministry of Natural Resources.

Crown reserves – Crown lands that have been withdrawn from dispositioning under Section 21 of the *Crown Minerals Act*.

Safety case – An integrated collection of arguments and evidence to demonstrate the safety of a facility. It includes a Safety Assessment, complemented by additional arguments and evidence in order to provide confidence in the long-term safety of the facility.

Postclosure – The period of time following closure of a repository, after the shafts have been sealed and surface facilities have been decommissioned.

PRELIMINARY ASSESSMENT OF TRANSPORTATION

Designated Licensing Authority – The position designated as being accountable to manage the regulatory interface with the Canadian Nuclear Safety Commission (CNSC) (any verbal or written exchange of information with a representative of the CNSC).

Role – A set of duties, responsibilities and accountabilities, usually associated with a particular job. Roles generally define who does what.

Testing – Performed to demonstrate that a structure, system, equipment, component or software meets specified requirements, or to substantiate the predicted performance.

PRELIMINARY SOCIAL, ECONOMIC AND CULTURAL ASSESSMENT

Community well-being – In the NWMO site selection process, community *well-being* is defined by the community to reflect its long-term vision, goals and objectives. Although there is no single definition, communities often include in their consideration elements relating to such things as economic health, the environment, safety and security, spiritual dimensions, social conditions, and enhancing opportunities for people and communities. The NWMO has adopted a Sustainable Livelihoods framework to encourage broad reflection and discussion by the community, inclusion of multiple perspectives, community leadership in the discussion, and establishment of a broad foundation for the assessment. The framework is expected to evolve over time as dialogue and reflection continue.