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 Municipality of Wawa, Ontario

FINDINGS FROM PHASE ONE STUDIES

APM-REP-06144-0025

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. This 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 Municipality of Wawa 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 to support the Municipality 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 Municipality of Wawa in the APM process began in February 2011 when the Chief Administrative Officer approached the NWMO on behalf of Council 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 Wawa's engagement to date in this Learn More process are provided below.

In May 2011, the Wawa Council requested an initial screening of the community's potential suitability for the project. In July 2011, the NWMO provided briefing at a Council meeting to review the plan for conducting the initial screening and to confirm details of the work. The Mayor, members of Council and community members also attended a briefing in Toronto in August 2011, followed by a briefing with the Canadian Nuclear Safety Commission (CNSC) in Ottawa. Community representatives met with the 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. Community representatives also attended meetings in the community in July 2011 convened by environmental groups to hear alternative perspectives.

In September 2011, representatives from Wawa 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.
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Upon completing the initial screening in October 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 Municipality of Wawa from further consideration in the site selection process.*"

At the invitation of Council, in October 2011 the NWMO convened an open house in Wawa to review initial screening results and share information about the project and site selection process. Individuals and groups who met with the NWMO during this event included Municipal Council and staff, students, representatives from the business community, seniors, camp operators, hunters and anglers, health-care and emergency first responders, and representatives of First Nations communities.

The Municipality 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 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 Municipality 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, and the committee's inaugural meeting was held in March 2012. 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 the surrounding communities and Aboriginal peoples.

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 open 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 Municipality, 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, and community group 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, including presentations to the Michipicoten High School students and the Algoma District Mutual Aid first responders group, as a way to interact with residents and share information about the project. A broad range of community leaders was also engaged through individual briefings and conversations held as part of the study process.

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 made a visit to an OPG interim storage facility at Darlington in October 2012 and met with the CNSC in March 2013. Community representatives also attended meetings held in the community by environmental groups to hear alternative perspectives.

The CLC actively involved the community in the development of a community profile and community well-being assessment report. Community open houses were organized to share progress 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 of 2012 to report on findings of work to date.

Led by the CLC, engagement activities in 2013 also 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.

Recognizing the importance of engaging surrounding communities and Aboriginal people in discussion about this project, the Municipality 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 and the Algoma District Mutual Aid first responders 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.
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This process of stepwise reflection and decision-making will be supported by a sequence of assessments and engagement that 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 Municipality of Wawa, 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 Municipality of Wawa, 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 Wawa 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.

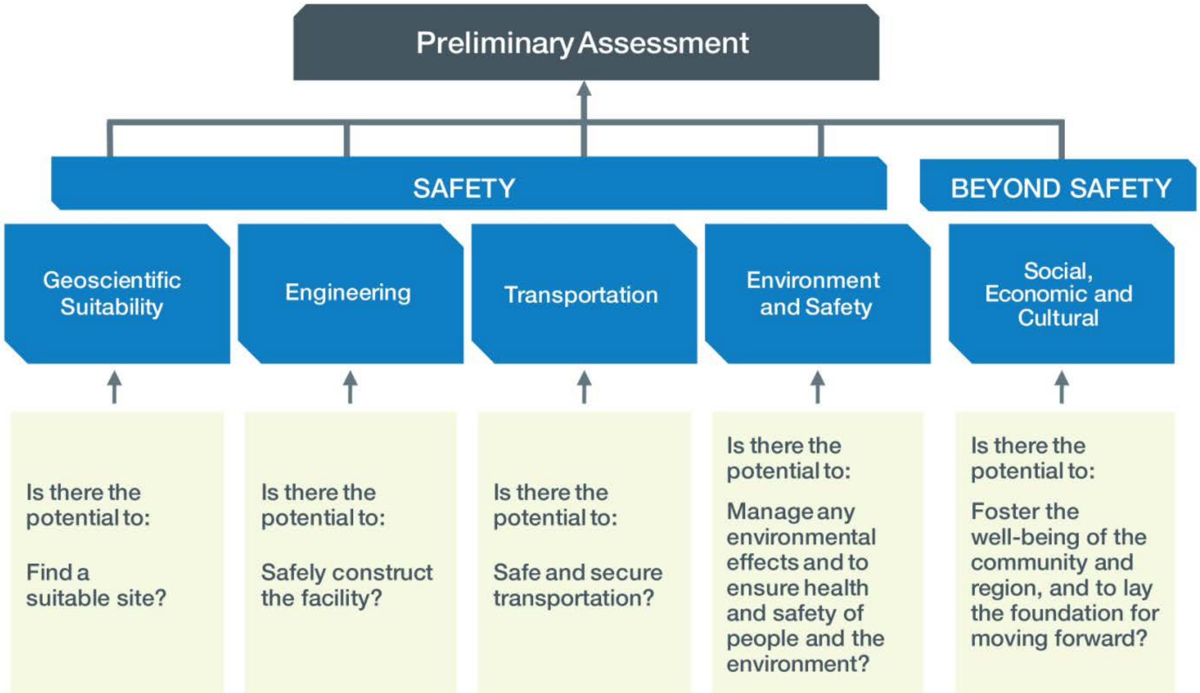

Figure 1-2: The Phase 1 Preliminary Assessment Studies

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 Municipality of Wawa 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 MUNICIPALITY OF WAWA

The Municipality of Wawa is a community located approximately 225 kilometres north of Sault Ste. Marie at the intersection of the Trans-Canada Highway (Highway 17) and Highway 101. It is also located on the shores of Lake Superior and Lake Wawa.

Wawa has a long history dating to 1725 when the French established a fur-trading post in the area. The area was surveyed and registered as Wawa City in 1899, and became the Municipality of Wawa in 2007. In 2011, the population was reported to be 2,975 residents. Wawa residents have historically been employed in the mining and forestry industries, as well as being the regional centre for health and social services.

The bulk of municipal development is situated along the shore of Lake Wawa, located approximately 7 kilometres from Lake Superior. The community is surrounded by the Boreal Forest of the Canadian Shield.

Figure 2-1 shows Wawa and the surrounding area. There are a number of Aboriginal communities and organizations in the Wawa area, including the Brunswick House First Nation, Chapleau Cree First Nation, Chapleau Ojibway First Nation, Michipicoten First Nation and Missanabie Cree First Nation. Métis Councils in the area include Greenstone Métis Council, Superior North Shore Métis Council and Thunder Bay Métis Council 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 Wawa 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 Wawa area, the natural environment, transportation infrastructure, and the people and activities which contribute to the well-being of the community.

Figure 2-1: Wawa 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 that 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 Wawa area. The chapter also identifies infrastructure that would be required to safely construct and operate the facility in Wawa. 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 Wawa 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 Municipality of Wawa and surrounding region.

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

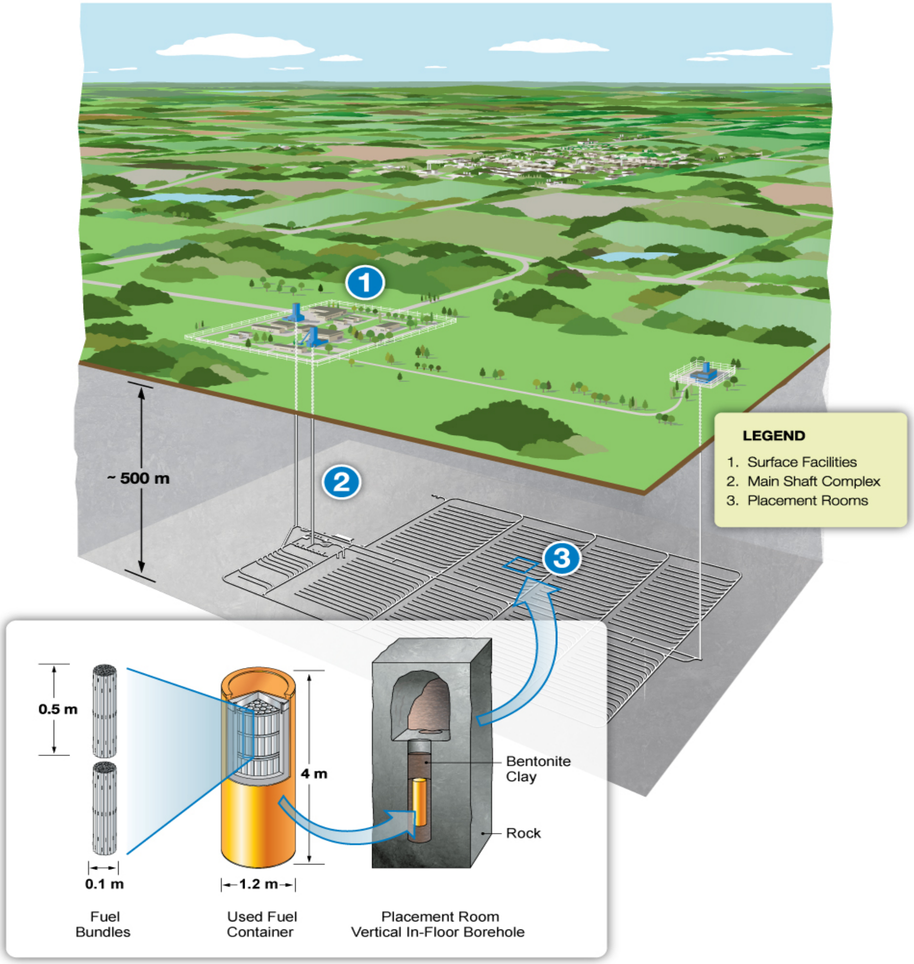

Figure 3-2: Illustration of an APM Facility

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.

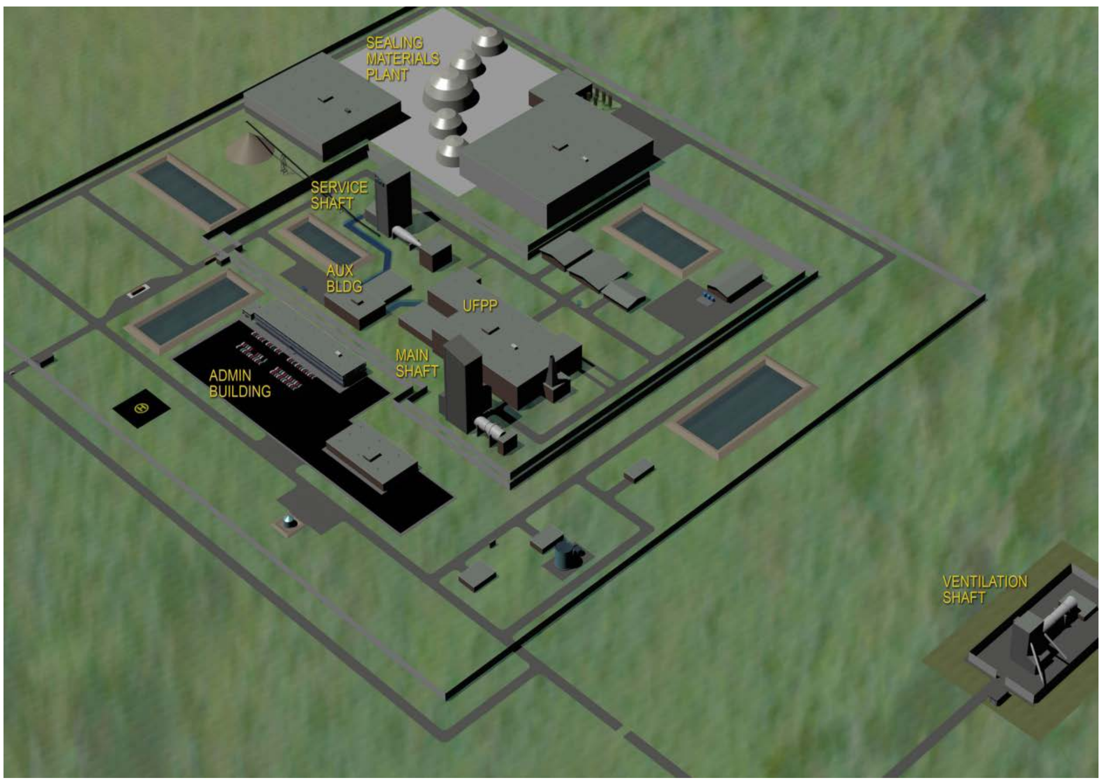

Figure 3-3: APM Surface Facilities

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 number 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.

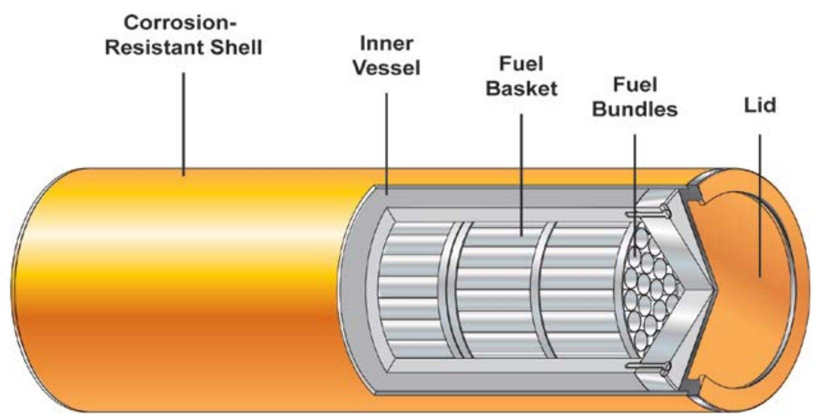

Figure 3-4: Used Fuel Container for a Deep Geological Repository

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.

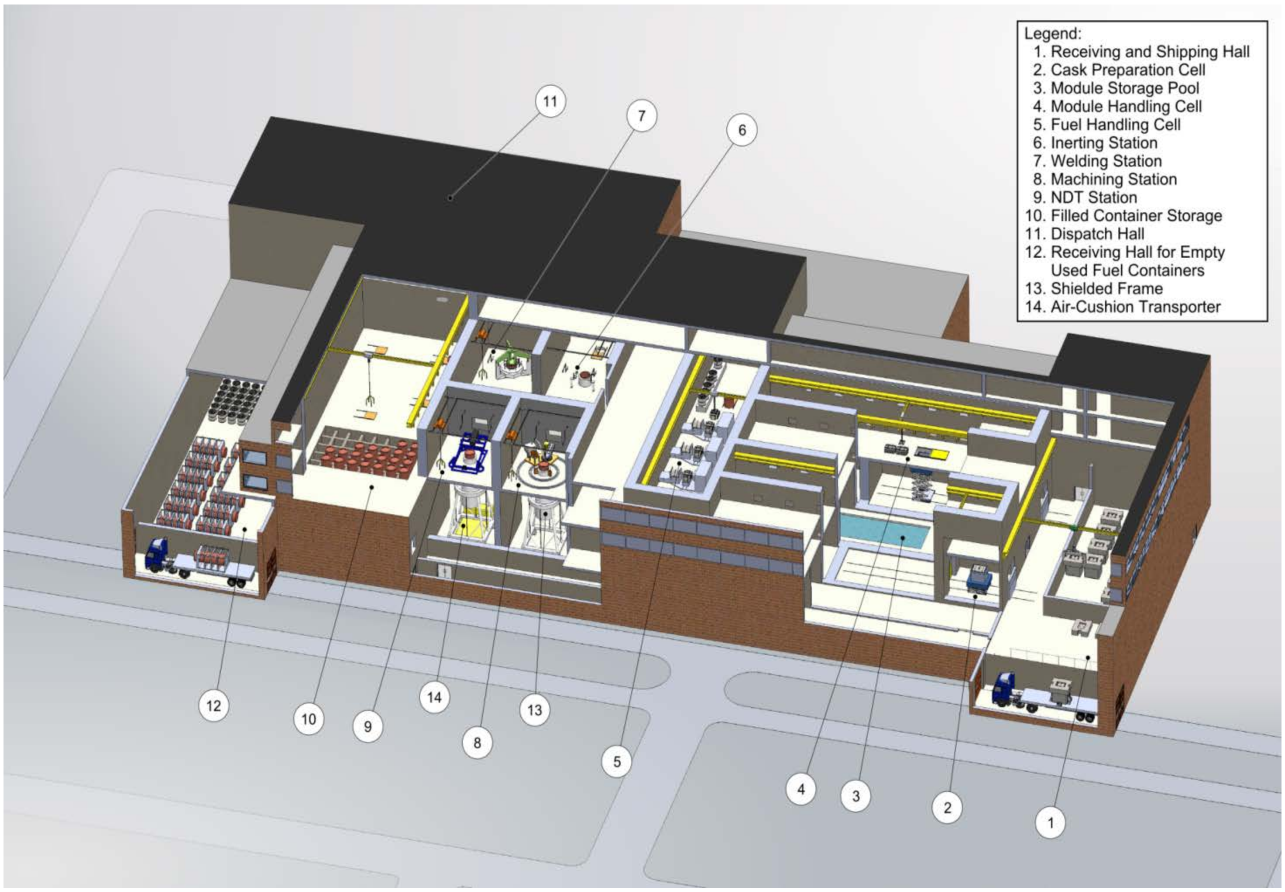

Figure 3-5: Conceptual Layout of a Used Fuel Packaging Plant

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.

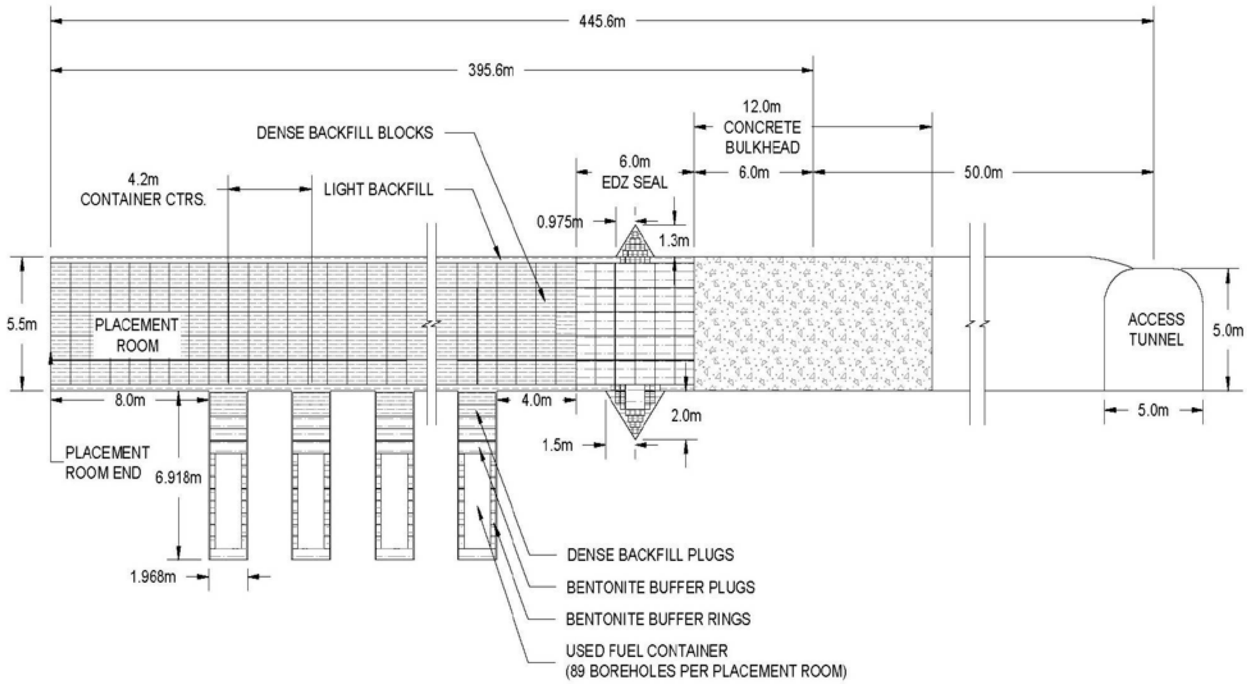

Figure 3-7: In-Floor Borehole Placement of Used Fuel Containers

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.

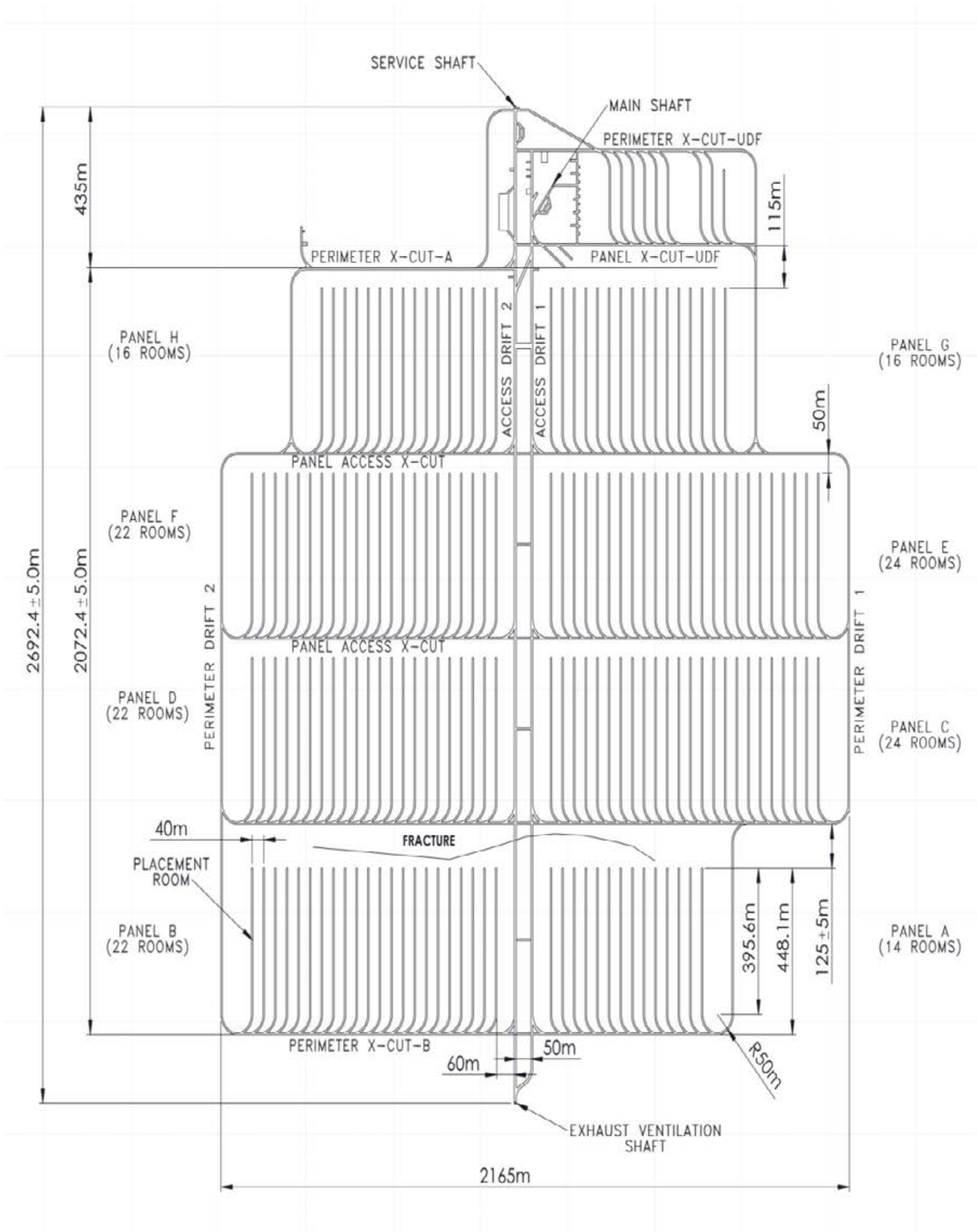

Figure 3-8: Example Underground Layout for a Deep Geological Repository

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 Wawa Area

The Municipality of Wawa and the surrounding region is located on the Canadian Shield in an area that is characterized by fairly rugged terrain which can be suitable for the construction of an APM facility. The Wawa area contains existing infrastructure that could be used for the APM Project, including a highway and a high-voltage transmission line. In addition, Wawa has a major rail line that passes within 25 kilometres of 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 Wawa 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 Wawa

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 Wawa – 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 Wawa 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.

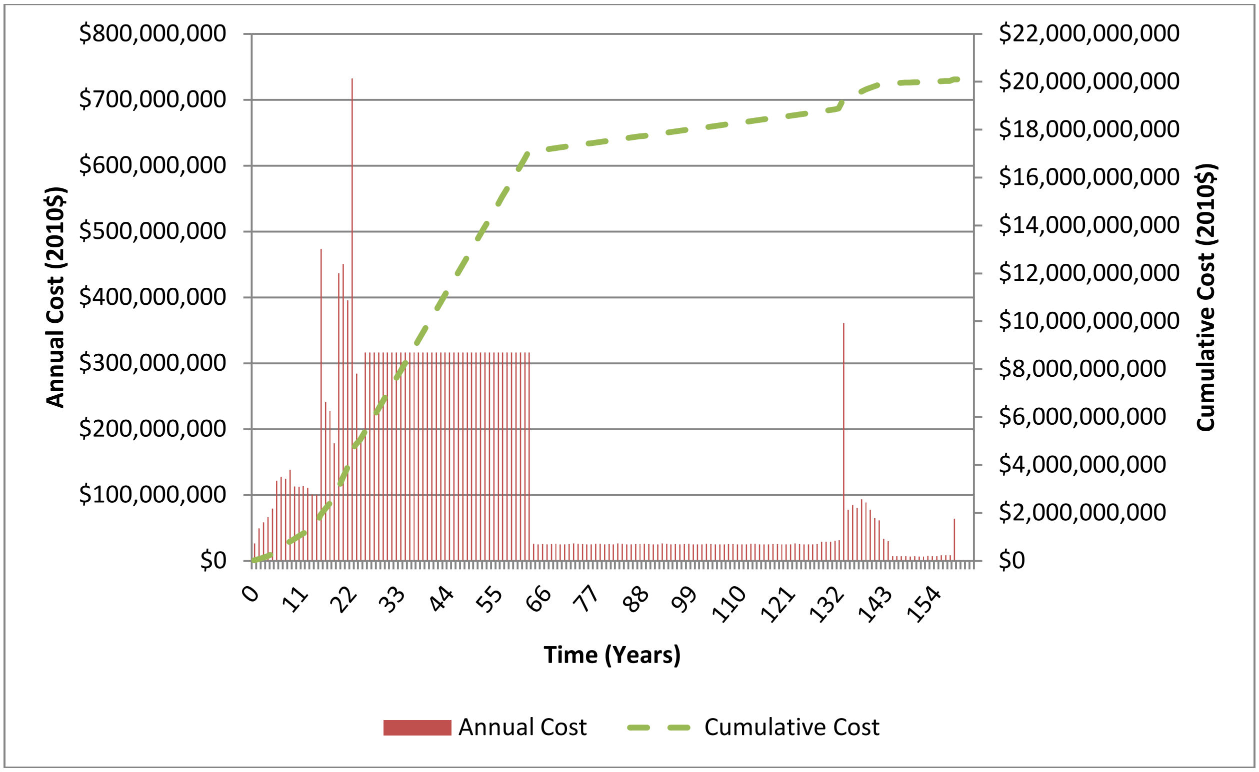

Figure 3-9: APM Cost Estimate for a Deep Geological Repository in Wawa

3.9 Engineering Findings

The engineering assessment of the Wawa area found that the APM facility has the potential to be safely constructed and operated. The surface land is characterized by fairly rugged terrain, 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 4.3.1. There are some surface topography features that would limit the construction and operation of the surface and underground facilities required by the APM Project, and the prevalence of steep slopes and changes in elevation would need to be accommodated. Further, Wawa is located close to key infrastructure for the APM facility, including highways and high-voltage transmission lines. As well, an existing rail mainline located approximately 25 kilometres northeast of Wawa 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 Wawa 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 Municipality of Wawa and its periphery, which are referred to as the “Wawa area” (Figure 4-1). The boundaries of the Wawa area shown on Figure 4-1 have been defined to encompass the main geological features within the Municipality and its surroundings.

The desktop geoscientific preliminary assessment built on the work previously conducted for the initial screening (Geofirma, 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 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 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?

The assessment was conducted in two steps. The first step assessed the potential to find general potentially suitable areas within the Wawa 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 Wawa area (Section 4.3), followed by a summary of the geoscientific assessment of suitability (Section 4.4).

4.3 Geoscientific Characteristics of the Wawa Area

The following sections provide a summary of available geoscientific information for the Wawa 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 Wawa area is provided in the terrain analysis report (JDMA, 2013). The Wawa 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 Wawa area is fairly rugged, with elevation ranging from about 183 metres at Lake Superior to as much as 607 metres within the bordering highlands (Figure 4-2). Very steep slopes are common, including near-vertical cliffs which predominate along the shores of Lake Superior. The most extensive uplands are identified in the northwestern and southeastern corners of the Wawa area, associated with the Western batholith and the Wawa Gneiss domain, respectively. The northwestern highland associated with the Western batholith is broken into three north-trending ridges. Four large ridges are also identified within the Whitefish Lake batholith, with dimensions of about 4 kilometres by 8 kilometres and heights of 200 metres above the surrounding trenches (Figure 4-2).

The vast majority of lakes in the Wawa area are small in size (less than 1–2 square kilometres), and many of them are positioned outside the major river valleys. Excluding Lake Superior, there are three lakes greater than 10 square kilometres, including Anjigami Lake, Whitefish Lake and

Manitowik Lake. All the lakes, excluding Lake Superior, cover only about 7 per cent of the Wawa area (Figure 4-2).

4.3.2 Bedrock Geology

Information on the bedrock geology of the Wawa 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 Wawa area. The entire Wawa area is covered by 1:250,000 scale bedrock geology mapping. More detailed mapping is available for portions of the Wawa area, including the greenstone belts and parts of the Western batholith. Low-resolution magnetic data (805 metres flight line spacing) provide coverage for the entire Wawa area. High-resolution aeromagnetic surveys (200 metres flight line spacing) are available for the greenstone belts in the Wawa area, and cover the margins of the Western batholith, Whitefish Lake/Brulé Bay batholith, and the Wawa Gneiss domain (Geofirma, 2013a).

As shown on Figure 4-3, the bedrock geology in the Wawa area is dominated by two large granitic intrusions, the Western batholith and the Wawa Gneiss domain, which includes the Whitefish Lake/Brulé Bay batholith. These intrusions were emplaced into the older rocks of the Michipicoten, Mishibishu and Gamitagama greenstone belts.

The initial screening (Geofirma, 2011) identified the Western batholith and the rocks of the Wawa Gneiss domain, including the Whitefish Lake/Brulé Bay batholith, as potentially suitable for hosting a deep geological repository. Rocks of the greenstone belts in the Wawa area were deemed not suitable due to their lithological heterogeneity, structural complexity and potential for mineral resources.

The Wawa Gneiss domain is a 1,205-square-kilometre intrusive complex that extends over the eastern half of the Wawa area. It comprises multiple phases of variable composition, age and deformation. It is predominantly composed of tonalitic gneiss (approximately 2.71 billion years old) and younger massive granitic rocks (Jackson and Sutcliffe, 1990; Moser, 1994). Migmatized rocks (i.e., rocks that underwent partial melting) are also mapped within this intrusive complex, reflecting the high degree of metamorphism that affected these rocks. The thickness of the Wawa Gneiss domain is estimated to be approximately 10 to 15 kilometres (Jackson and Sutcliffe, 1990; Percival, 1990; Moser, 1994).

The distinct Whitefish Lake/Brulé Bay batholith, within the Wawa Gneiss domain, is a 2.694 billion years old intrusion that covers an area of 62 by 15 kilometres (Turek et al., 1984). The thickness of this batholith is expected to exceed several kilometres in thickness (Percival, 1990). The interpretation of available geophysical data in the Wawa Gneiss domain did not identify lithological variations beyond what is published in the available geologic maps. This may be due to the low resolution of available geophysical data, and to the interference from the strong magnetic responses associated with dykes in the area (PGW, 2013).

The Western batholith is a large multi-phase intrusion that is mostly composed of tonalite and massive granitic rocks and extends over 631 square kilometres within the Wawa area (Figure 4-3). The gneissic tonalite phase of this batholith is estimated to be 2.698 billion years old (Turek et al., 1984). The thickness of the batholith is expected to exceed several kilometres (Percival, 1990). The interpretation of available geophysical data (PGW, 2013) suggests that rocks from the surrounding Michipicoten greenstone belt may be mixed with granitic rocks of the Western batholith along the margin of the intrusion. The interpretation did not identify distinct phases within the batholith beyond what is published in the available geologic maps.

The Wawa 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; Geofirma, 2013b) show that abundant northwest- and northeast-trending dykes crosscut all the geologic units within the Wawa area (Figures 4-3 and 4-6). Dykes in the Wawa area have been reported to belong to different dyke swarms (e.g., Matachewan, Abitibi, Biscotasing, and Marathon swarms) with ages ranging from 2.473 to as young as 1.142 billion years old.

4.3.3 Quaternary Geology

The terrain analysis report (JDMA, 2013) provides a detailed description of the Quaternary geology of the Wawa area. The Quaternary cover in the Wawa area is composed of 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, approximately 75 per cent of the Wawa area is mapped as bedrock terrain, which comprises exposed bedrock and discontinuous drift deposits generally less than 1 metre thick. Quaternary deposits are limited and predominantly located in bedrock-controlled valleys.

Information on measured overburden thickness is limited to a small number of water wells and to diamond drill holes concentrated mostly in the greenstone belts (Figure 4-4). A detailed accounting of recorded overburden thickness in the Wawa is provided by JDMA (2013). Recorded depths to bedrock in the Wawa area generally range from 0 to 15 metres, although greater thicknesses have been recorded in a few locations. These observations provide an indication of the typical values and variability in overburden thicknesses that can be expected in the Wawa area.

4.3.4 Structural Geology

4.3.4.1 Mapped Faults

Faults are a common feature of the bedrock in the Wawa area, with numerous mapped faults extending for tens of kilometres (Figure 4-3). Some of these mapped faults have been interpreted to be associated with the Kapuskasing structural zone, east of the Wawa area. Other faults are associated with the Midcontinent Rift, southwest of the Wawa area.

As shown on Figure 4-3, some of the longest faults mapped in the Wawa area include the northwest-trending Trembley, Mildred Lake and Marsden faults (12 to 55 kilometres long); the combined northeast-trending Wawa-Hawk-Manitowik Lake fault; and the north-trending Agawa Canyon and McEwan Lake faults. The latter is not shown on Figure 4-3.

The Kapuskasing structural zone, east of the Wawa area, is a major regional structure that is interpreted to have been active approximately 1.9 billion years ago (Sage, 1994; Manson and Halls, 1997) and had a clear influence on the structural character of the Wawa area. In general, all northeast-trending faults in the Wawa area experienced movement during uplift of the Kapuskasing structural zone. The zone of influence of the Midcontinent Rift, located to the southwest, may extend into the Wawa area. However, the complexity introduced by the Kapuskasing structural zone makes this distinction unclear.

As mentioned in Section 4.3.2, rocks in the Wawa 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 from 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 Investigation

A detailed lineament study was conducted for the Wawa 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 Wawa area. The observed density and distribution of surficial lineaments is influenced by overburden cover, which masks surface expressions of potential fractures. Surficial lineament density in the potentially suitable geologic units (i.e., Western batholith, Wawa Gneiss domain, Whitefish Lake/Brulé Bay batholith) is generally moderate to high, with only small patches of lower surficial lineament density observed. Given the limited overburden cover in the Wawa area, interpreted surficial lineament densities are considered a fair representation of the extent of potential bedrock structures in the Wawa area.

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 Wawa area are shown on Figure 4-6. The figure shows that the density of geophysical lineaments is higher in the northeastern portion of the Wawa area where high-resolution magnetic data are available. This higher density of geophysical lineaments may be representative of the lineament density that would be observed across the Wawa area if higher-resolution data were available.

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.

Approximately 45 per cent of the geophysical lineaments identified in the Wawa area are interpreted as dykes, which show well-defined orientations trending northwest and northeast (Figure 4-6). There is an apparent spatial variation in the distribution of dykes in the Wawa area, with an increased occurrence of dykes in its eastern half. Given that the resolution of geophysical data is the same for both of these areas, this spatial variability may be related to actual differences in geological structures and to the relative proximity to the Kapuskasing structural zone to the east (Geofirma, 2013a). There are also some uncertainties regarding the distribution 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 Wawa 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 Wawa 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 Wawa area lies within the Canadian Shield, where large parts have remained tectonically stable for the last 2.5 billion years (Percival and Easton, 2007). The location and magnitudes of seismic events are recorded in the National Earthquake Database (NRCan, 2012). As shown on Figure 4-7, for the period between 1985 and 2011, the closest recorded earthquake to the Wawa area was a 2.2-magnitude (Nuttli Magnitude, m_N) event recorded approximately 87 kilometres northwest of the settlement area of Wawa.

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 Wawa 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 Wawa area should be well below 10 millimetres per year, likely between 2 and 4 millimetres.

No neotectonic structural features are known to occur within the Wawa 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 Wawa area was obtained from the Ontario Ministry of the Environment (MOE) Water Well Record (WWR) database (MOE, 2012). Water wells in the Wawa area obtain water from the overburden or the shallow bedrock, and are mostly located near the settlement area of Wawa, and east of the Municipality of Wawa along Highway 101 (Figure 4-4). The MOE water well database contains 71 water well records in the Wawa area, of which only 41 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 Wawa Area

Water Well Type	Number of Wells	Total Well Depth (Metres)	Static Water Level (Metres Below Ground Surface)	Tested Well Yield (Litres Per Minute)	Depth to Top of Bedrock (Metres)
Overburden	31	3.3–101	0.9–28	4–227	Not Applicable
Bedrock	10	38–117	1–113	4–68	0–86

4.3.7.1 Overburden Aquifers

There are 31 water well records in the Wawa area that can be confidently assigned to the overburden aquifer, ranging in depth from 3.3 to 101 metres. These wells are completed in overburden materials within the bedrock valleys of the Magpie, Michipicoten and Doré rivers, as they approach Lake Superior. Well yields are variable with recorded values of 4 to 227 litres per minute, with the range being explained by the diversity of materials encountered during drilling: from clay to gravel. 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 review of the water well information indicates that competent overburden aquifers exist where thick overburden deposits occur, and within bedrock valleys particularly in proximity to Lake Superior (Morris, 2001a; 2001b). It is notable that overburden is thin to non-existent over much of the Wawa area.

4.3.7.2 Bedrock Aquifers

No information was found on deep bedrock groundwater conditions in the Wawa area at a typical repository depth of approximately 500 metres. In the Wawa area, there are 10 well records that can be confidently assigned to the shallow bedrock aquifer, ranging from 38 to 117 metres in depth. 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 Wawa area or anywhere else in northern Ontario (MOE, 2012).

4.3.7.3 Regional Groundwater Flow

There is little known about the hydrogeologic properties of the deep bedrock in the Wawa 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 Wawa area. Information from mines in the Canadian Shield (Raven and Gale, 1986) and other geological settings show 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, the 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 Wawa 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 Wawa 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 Wawa 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 (OGS, 2004).

There are currently no operating mines in the Wawa area. However, production of iron and gold occurred in the past at a number of mines within the Michipicoten and Mishibishu greenstone belts (Figure 4-8). Occurrences of diamonds have also been reported in these greenstone belts which are subject to ongoing exploration activities for metallic minerals and diamonds (Wilson, 2006).

Figure 4-8 shows that a limited number of mineral occurrences have been recorded in the Wawa Gneiss domain and in the Whitefish Lake and Western batholith. Two kimberlite intrusions have also been recorded in the eastern part of the Whitefish Lake/Brulé Bay batholith (Kaminsky et al., 2002). However, the economic viability of these occurrences and kimberlites has not been proven to date.

The potential for an economically viable building stone industry in the Wawa area is poor to fair (Wilson, 1990). The Wawa 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 rocks in the Wawa 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 Wawa area (Geofirma, 2013a).

There are also no site-specific thermal conductivity values or detailed quantitative mineral compositions for the Wawa 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 Wawa area would need to be investigated during subsequent field evaluations stages.

4.4 Potential Geoscientific Suitability of the Wawa area

This section provides a summary of how key geoscientific characteristics were applied to the Wawa 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 (Geofirma, 2011) were not considered. Such areas include rocks of the Michipicoten, Gamitagama, and Mishibishu greenstone belts. These units were considered not suitable due to their lithological heterogeneity, structural complexity and potential for mineral resources. Potentially suitable geological units in the Wawa area include the Western batholith, and the Wawa Gneiss domain, including the Whitefish Lake/Brulé Bay batholith. The geological setting associated with each general potentially suitable area identified is further discussed in Sections 4.4.1.1 and 4.4.1.2.

- ***Structural Geology:*** Faults are a common feature of the bedrock in the Wawa area, with numerous mapped faults extending for tens of kilometres (Figure 4-3). Some of these faults are interpreted as being associated with the Kapuskasing structural zone. Other faults, such as the Agawa Canyon fault, are associated with the Midcontinent Rift (Section 3.3.3.1). Areas within or immediately adjacent to large mapped faults (e.g., Agawa Canyon fault) and shear zones were considered unfavourable. The thickness of potentially suitable units was also considered when identifying potentially suitable areas. The Wawa Gneiss domain is estimated to be 10 to 15 kilometres thick. The Western and Whitefish Lake/Brulé Bay batholiths are expected to exceed several kilometres in thickness based on their regional extent. These thicknesses are sufficient for the purpose of developing a repository.

- ***Lineament Analysis:*** In the search for general 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 exposure. The extent of bedrock exposure in the Wawa 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:*** All provincial parks and conservation reserves, including the recommended Lake Superior Highlands conservation reserve, were excluded from consideration in the selection of general potentially suitable areas. The largest protected areas in the Wawa area include the Lake Superior Provincial Park (550 square kilometres) covering part of the Whitefish Lake/Brulé Bay batholith and the Wawa Gneiss domain, and the Magpie River Terraces Conservation Reserve

(210 square kilometres) within the Michipicoten greenstone belt. The recommended Lake Superior Highlands conservation reserve covers part of the southern portion of the Western batholith. Other smaller protected areas in the Wawa area include the Nimoosh Provincial Park, which overlies a portion of the Western batholith and the Potholes Provincial Park, which covers part of Wawa Gneiss domain (Figure 4-1).

- ***Natural Resources:*** The potential for natural resources in the Wawa area is shown on Figure 4-8. Areas with known potential for exploitable natural resources were excluded from further consideration. These include the rocks of the Mishibishu, Michipicoten, and Gamitagama greenstone belts. The mineral potential of the Western batholith, the Wawa Gneiss domain and the Whitefish Lake/Brulé Bay batholith 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, all other factors being equal. Lake cover in the Wawa area is generally uniform, with most lakes being less than 10 square kilometres in extent. Larger water bodies, such as Whitefish Lake and Anjigami Lake cover parts of the Whitefish Lake/Brulé Bay batholith. Topography is generally rugged in the Wawa area, where very steep slopes are common (Figure 4-2). The majority of the Wawa area is accessible via Highway 17 and Highway 101, and a number of existing logging roads, with the exception of some portions of the northern area of the Western batholith and northern parts of the Whitefish Lake/Brulé Bay batholith (Figure 4-1).

The consideration of the above key geoscientific characteristics and constraints revealed that the Wawa area contains three general areas that have the potential to satisfy the NWMO's geoscientific site evaluation factors. One of the areas is located within the granitic rocks of the Western batholith, and the two others are located within the Wawa Gneiss domain, which includes also the Whitefish Lake/Brulé Bay batholith. 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 Western Batholith

As discussed in Section 4.3.2, the Western batholith is a large multi-phase intrusion that is expected to exceed several kilometres in thickness and extends over 631 square kilometres within the Wawa area. Three long mapped faults crosscut the Western batholith: the northwest-trending Black Trout Lake and Trembley faults, and an unnamed northeast-trending fault. There are also numerous dykes mapped within the Western batholith (Figures 4-3 and 4-9).

Within the Wawa area, the Western batholith has low potential for natural resources, extensive bedrock exposure and is mostly free of surface constraints (i.e., topography and large bodies of water). Only a small portion of the intrusion is covered by protected areas (Figure 4-9).

Therefore, the differentiating factors for selecting potentially suitable areas within the Western batholith were considered to be geology, lineament density, and structural geology.

The general potentially suitable area identified within the Western batholith is located in the northeastern portion of the intrusion, between the Trembley fault and the Jimmy Kash River, and north of Molybdenite Lake (Figure 4-9). This area lies within a sector where lineament density is lower compared to other parts of the Wawa area.

Figure 4-6 shows that geophysical lineaments in the potentially suitable area are mostly interpreted as fracture lineaments longer than 5 kilometres, with only a small number of lineaments interpreted as dykes. The spacing between these long geophysical lineaments varies from less than 1 to about 3 kilometres. As mentioned in Section 4.3.4.2, it is anticipated that the density of geophysical lineaments in this area to be higher, as interpreted lineaments are based on low-resolution data. Figure 4-5 shows the surficial lineament density to be generally high throughout most of the Western batholith, likely due to the extensive bedrock exposure, which makes surficial lineaments readily mappable. The spacing between interpreted surficial lineaments longer than 5 kilometres in the identified general area ranges from less than 1 to about 2.5 kilometres.

Interpreted geophysical and surficial lineaments suggest that there is some potential to find suitable rock volumes between long lineaments. This would need to be further assessed during subsequent stages of the site evaluation process, as the structural characteristics of the Wawa area are fairly complex due to its close proximity to the Kapuskasing structural zone and the Midcontinent Rift.

Although the density of dykes seems to be lower over the Western batholith compared to the remainder of the Wawa area, there still remain some uncertainties regarding the distribution, density and structural impact of the dykes in the Wawa area. The main uncertainties are related to: the potential for smaller-scale dykes to be present between interpreted dykes; the potential underestimation of geophysical lineaments due to the predominance and masking effect of the dyke signal in the geophysical dataset; and the potential damage that may have been caused to the host rock during dyke emplacement.

The potentially suitable area in the Western batholith comprises predominantly private land and is free of active mining claims (Figure 4-9). Although the area does not contain any protected areas, Nimoosh Provincial Park lies in close proximity to the southwest (Figure 4-9). Access to the identified potentially suitable area is limited via the existing road network. The area is of moderate relief and contains a generally low percentage of lake/wetland cover.

4.4.1.2 General Potentially Suitable Areas Within the Wawa Gneiss Domain

As discussed in Section 4.3.2, the Wawa Gneiss domain is a vast intrusive complex that extends for 1,205 square kilometres within the Wawa area and has an estimated thickness of approximately 10 to 15 kilometres. The distinct Whitefish Lake/Brulé Bay batholith is within the Wawa Gneiss domain, covering an approximate elongated area of 62 kilometres by 15 kilometres. This batholith is expected to exceed several kilometres in thickness. The long north-trending Agawa Canyon fault crosscuts the Wawa Gneiss domain, bisecting the Whitefish Lake/Brulé Bay batholith. There are numerous mapped dykes crosscutting the Wawa Gneiss domain (Figures 4-3 and 4-9).

The Wawa Gneiss domain and Whitefish Lake/Brulé Bay batholith have extensive bedrock exposure, generally have a low potential for natural resources and are free of significant surface constraints (i.e., topography and large water bodies). The largest protected area over these units is the Lake Superior Provincial Park, which covers part of the western portion of the Wawa Gneiss domain (Figure 4-9). Therefore, the differentiating factors for identifying potentially suitable areas were considered to be mostly lineament density and structural geology.

Two general potentially suitable areas were identified in the Wawa Gneiss domain. The first area is located west of the Agawa Canyon fault, south of Anjigami Lake, and north of the Lake Superior Provincial Park. The second potentially suitable area is in the eastern part of the Whitefish Lake/Brulé Bay batholith, to the east of the Agawa Canyon fault, between Whitefish Lake and the northeastern margin of the intrusion (Figure 4-9). Both of these general areas lie fairly close to the Agawa Canyon fault. It is uncertain to what extent this long structure affects their potential suitability.

The two potentially suitable areas within the Wawa Gneiss domain were identified to capture areas with lower lineament density. As shown on Figure 4-6, the spacing of geophysical lineaments ranges from 1 to about 4 kilometres in the area within the Whitefish Lake/Brulé Bay batholith, and from less than 1 to about 2 kilometres in the area west of the Agawa Canyon fault. The area within the Whitefish Lake/Brulé Bay batholith contains numerous mapped and interpreted dykes (Figures 4-6 and 4-9). No dykes were interpreted in the other area. As discussed above in Section 4.4.1.1, density of geophysical lineaments in the Wawa Gneiss domain is expected to be higher given the low resolution of available geophysical data.

Figure 4-5 shows the surficial lineament density to be generally moderate to high throughout the Wawa Gneiss domain. The interpreted spacing between surficial lineaments longer than 5 kilometres in the two identified potentially suitable areas ranges from less than 1 to about 3 kilometres.

As noted above for the Western batholith, while there is some potential to find suitable rock volumes between long lineaments, the uncertainties related to presence of dykes, and the proximity of the Wawa area to the Kapuskasing structural zone and the Midcontinent Rift would need to be further assessed.

The two general potentially suitable areas identified in the Wawa Gneiss domain comprise mostly private land and do not contain any protected areas (Figure 4-9). Mineral resource potential is considered low throughout both areas, with no active mining claims recorded (Figure 4-9). The area in the Whitefish Lake/Brulé Bay batholith lies in close proximity to rocks with potential for mineral resources (i.e., greenstone belt) and contains two documented kimberlite occurrences. However, the economical potential of these occurrences has not been proven. Access is limited to recreational/collector roads that either run through or nearby the general areas.

Topographic relief in the general areas of the Wawa Gneiss domain is moderate (Figure 4-2). Total lake/wetland cover in the two areas is generally low, although part of the Whitefish Lake covers a portion of the general area in the Whitefish Lake/Brulé Bay batholith.

In summary, the three general potentially suitable areas within the Western batholith and Wawa Gneiss domain were identified based mostly on geology, lineament density and structural geology. Bedrock in all three areas has low potential for economically exploitable natural resources, good bedrock exposure and lower lineament density. The areas are also outside protected areas and are accessible to some extent via the existing road network. Inherent uncertainties remain in relation to the proximity to major regional faults, the occurrence of numerous dykes, and the low resolution of available geophysical data over the three identified potentially suitable areas.

4.4.1.3 Other Areas

Given the large geographic extent of the Wawa 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 Wawa 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 thicknesses of the Wawa Gneiss domain is of approximately 10 to 15 kilometres, and that of the Whitefish Lake/Brulé Bay and Western batholiths is expected to be in the order of several kilometres. Therefore, the rock in the three general potentially suitable areas identified within these geologic units are 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 potentially suitable areas have a relatively lower density of lineaments and some potential to contain structurally bounded rock volumes to host a deep geological repository (Geofirma, 2013b). The classification of lineaments by length shows that the spacing between lineaments increases and becomes more favourable as shorter lineaments are filtered out. Longer lineaments are more likely to extend to greater depth than shorter lineaments. All three identified areas lie fairly close to mapped long faults. The extent to which these long structures would affect potential 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 Wawa 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 Wawa area are often sealed by infilling materials, which results in a much reduced potential for groundwater flow at depth. The Wawa 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.

There is limited 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, and the thermal and geomechanical properties of the rock. 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 granitic rocks underlying the three general potentially suitable areas identified within the Wawa area (Geofirma, 2013a).

In summary, the review of available geoscientific information, including completion of a lineament analysis of the Wawa 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 Wawa area.

The Wawa 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 Wawa area lies within a low seismicity area.

The geology of the Wawa 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 remained largely unaffected by past perturbations such as glacial cylces. 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 Wawa area.

In summary, available information indicates that the identified general potentially suitable areas in the Wawa 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 Wawa 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 Wawa 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 the potentially suitable formations in the Wawa area. However, as discussed in Section 4.3.10, there is a fair amount of information at other locations of the Canadian Shield that could provide insight into what might be expected for the Wawa area in general. Available information suggests that granitic and gneissic crystalline rocks 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 potentially suitable areas are situated in areas having extensive bedrock exposure (Figure 4-9). 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 potentially suitable areas.

In summary, the three identified potentially suitable areas in the Wawa 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.

The mineral potential in the Wawa area is limited to the greenstone belts, and no known economic mineralization has been identified to date within the Western batholith, the Wawa Gneiss domain and the Whitefish Lake/Brulé Bay batholith in the Wawa area. Also, the review of available information did not identify any groundwater resources at repository depth for the Wawa 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 Wawa 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 Wawa 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 geology in the three potentially suitable areas is mapped as relatively homogeneous and is expected to be fairly easy to characterize. At this stage of the assessment, it is uncertain if multiple intrusive phases exist within the three identified areas. Such uncertainties, however, are not expected to greatly affect site characterization.

Interpreted surficial and geophysical dyke lineaments in the Wawa area exhibit well-defined orientations (i.e., northwest, northeast and east), which would facilitate 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 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 Wawa area contains general areas that have the potential to satisfy the geoscientific site evaluation factors outlined in the NWMO's site selection process document (NWMO, 2010).

The preliminary geoscientific assessment built on the work previously conducted for the initial screening (Geofirma, 2011) and focused on the Municipality of Wawa and its periphery, which are referred to as the "Wawa 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 Wawa 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);
- Lineament studies using available satellite imagery, topography and geophysical surveys to provide information on 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 Wawa area contains at least three general areas that have the potential to satisfy the NWMO's geoscientific site evaluation factors. These general areas are located within the Wawa Gneiss domain and the Western batholith.

These two geological units 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 in the three potentially suitable areas is mostly exposed. All three areas have low potential for natural resources, although one of the areas within the Wawa Gneiss domain lies in close proximity to rocks with known economically exploitable mineral resources (i.e., greenstone belt). The identified potentially suitable areas contain limited surface constraints and are accessible via recreational roads.

While the three potentially suitable areas appear to have favourable geoscientific characteristics, 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 presence of major regional faults, the occurrence of numerous dykes, and the low resolution of available geophysical data over most of the Wawa area.

Interpreted lineaments suggest that the three identified general areas may contain sufficient rock volumes that are favourable for hosting a deep geological repository. However, the structural characteristics of the Wawa area are fairly complex due to its close proximity to the Kapuskasing structural zone to the east and the Midcontinent Rift to the southwest. The Wawa area includes a number of long mapped faults in the vicinity of the three identified potentially suitable areas. Also, the Wawa area contains numerous dykes as it lies within major regional dyke swarms. The low resolution of geophysical data available for the Wawa area and the occurrence of numerous dykes could be masking the presence of both smaller-scale dykes and fractures not readily identifiable from available data.

Should the community of Wawa 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 Wawa area contains sites that can safely contain and isolate used nuclear fuel. This would initially include the acquisition and interpretation of higher-resolution airborne geophysical surveys, detailed geological mapping and the drilling of deep boreholes.

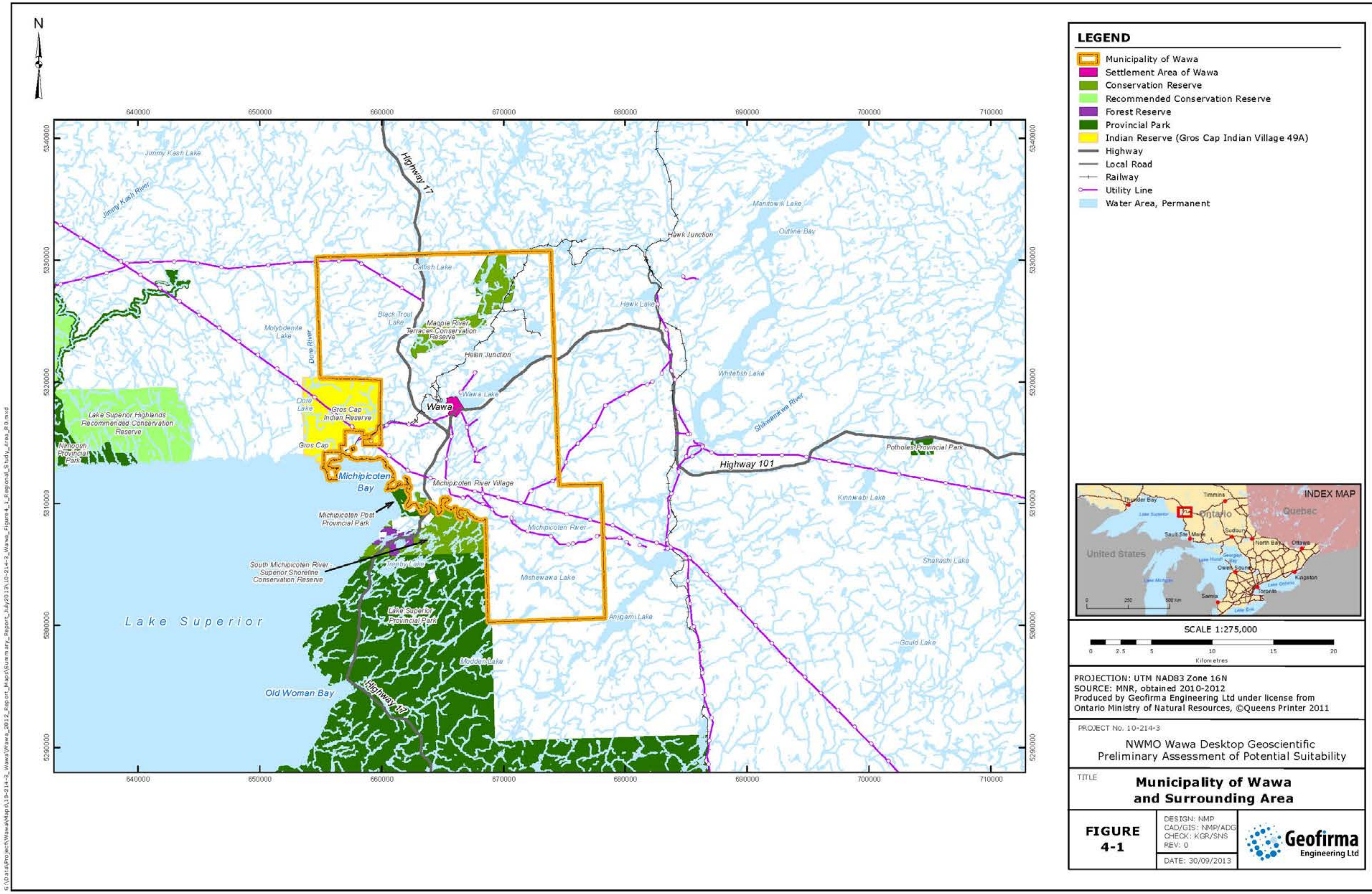

Figure 4-1: Municipality of Wawa and Surrounding Area

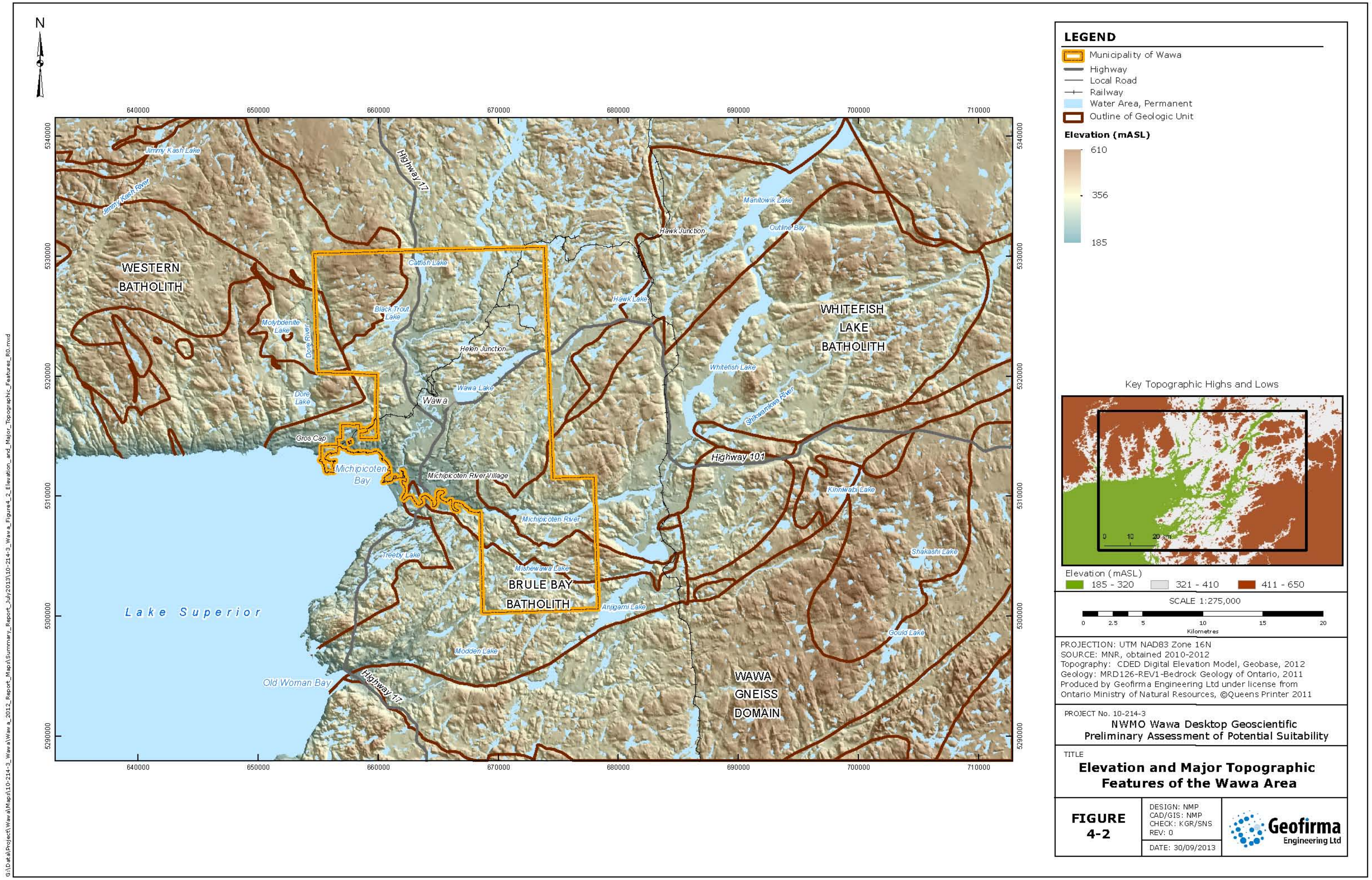

Figure 4-2: Elevation and Major Topographic Features of the Wawa Area

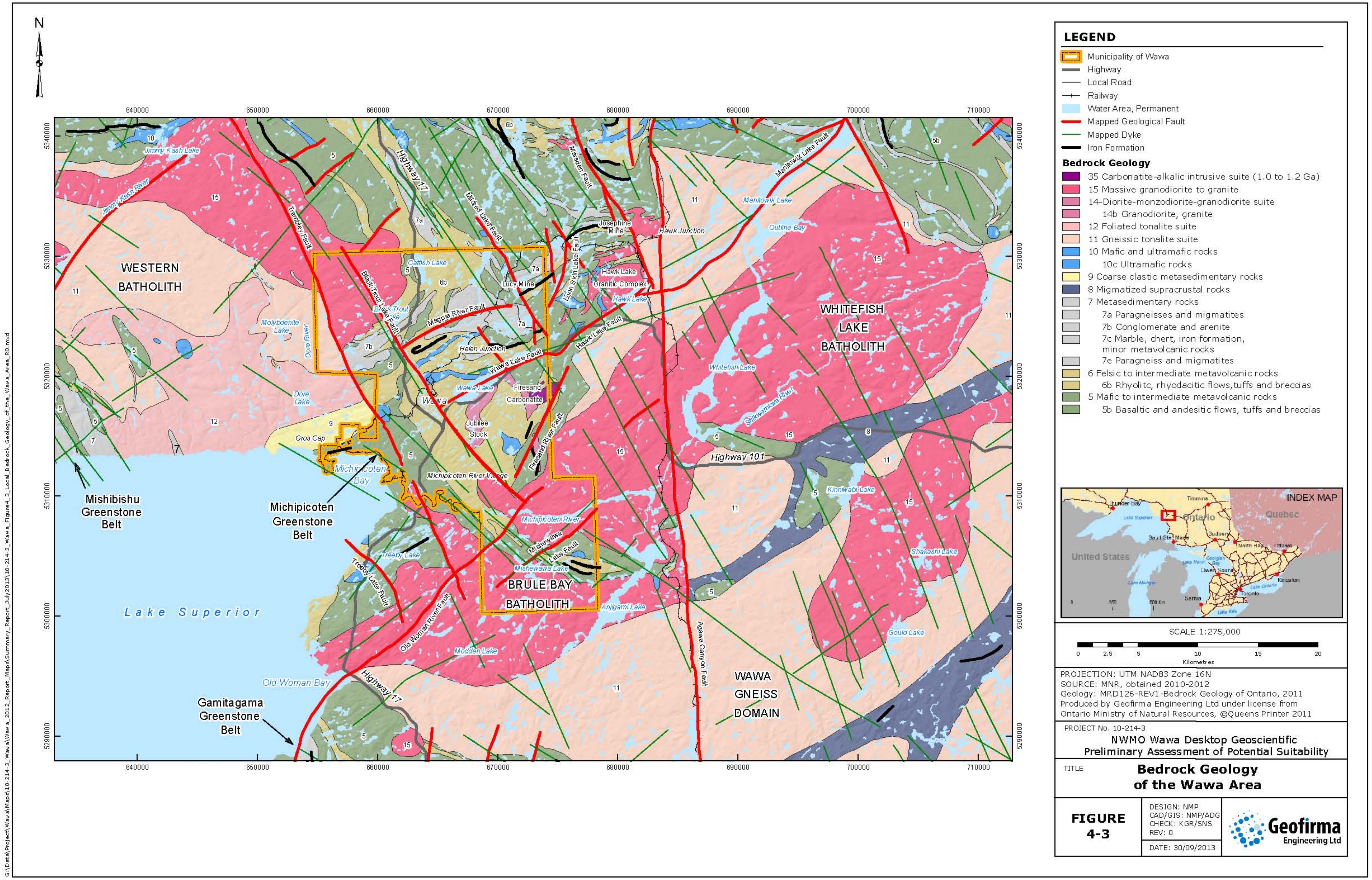

Figure 4-3: Bedrock Geology of the Wawa Area

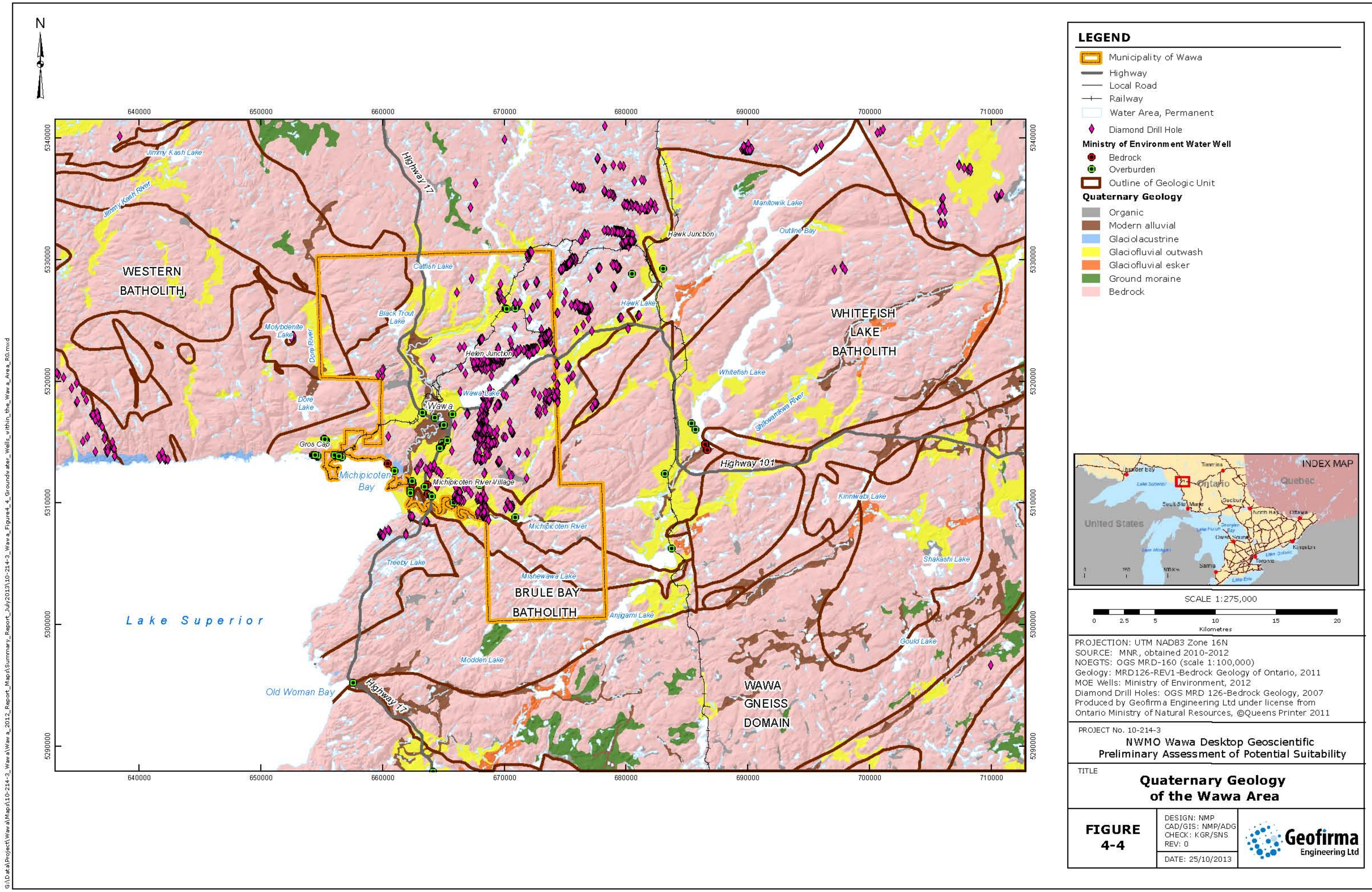

Figure 4-4: Quaternary Geology of the Wawa Area

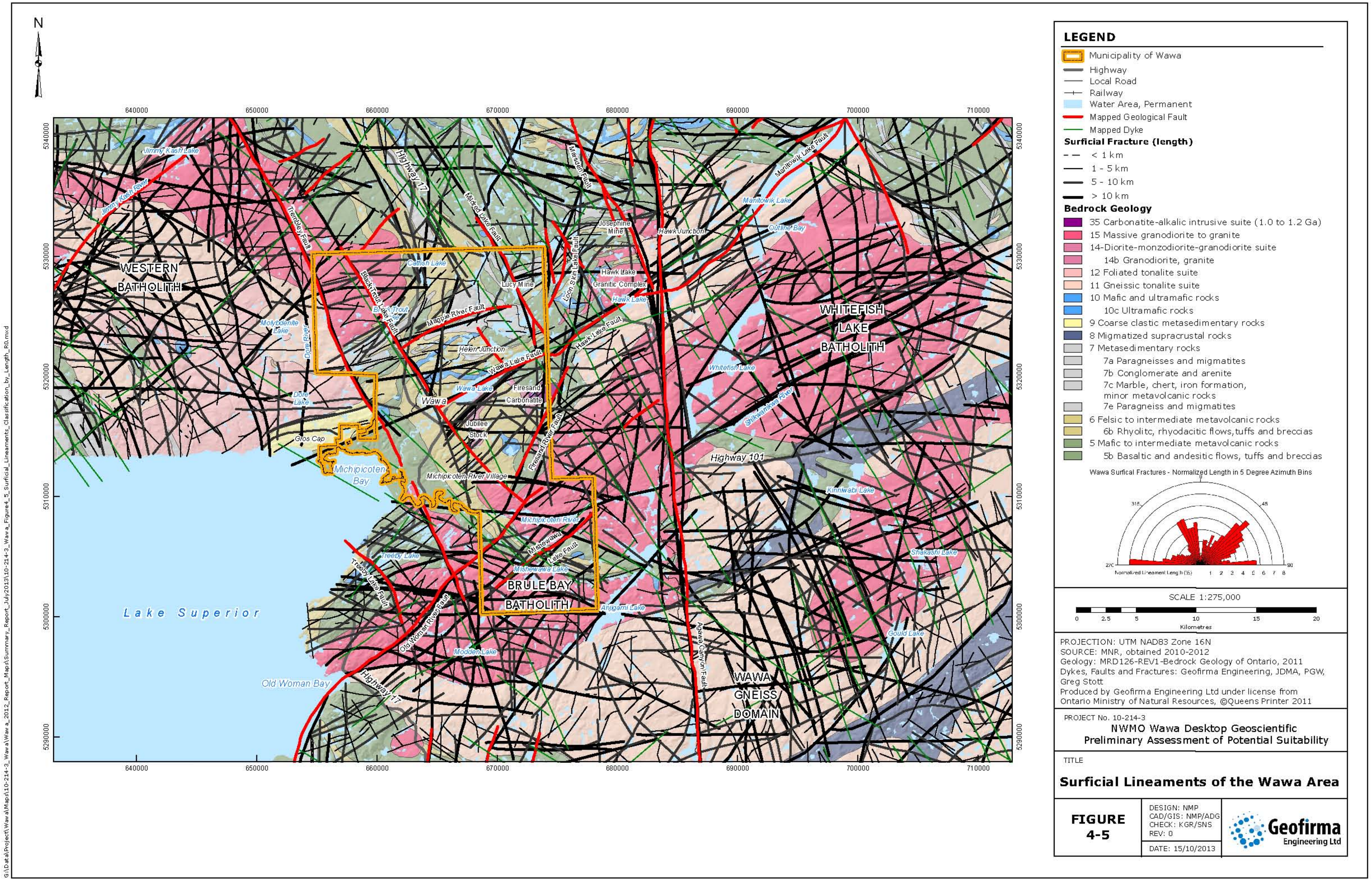

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Figure 4-5: Surficial Lineaments of the Wawa Area

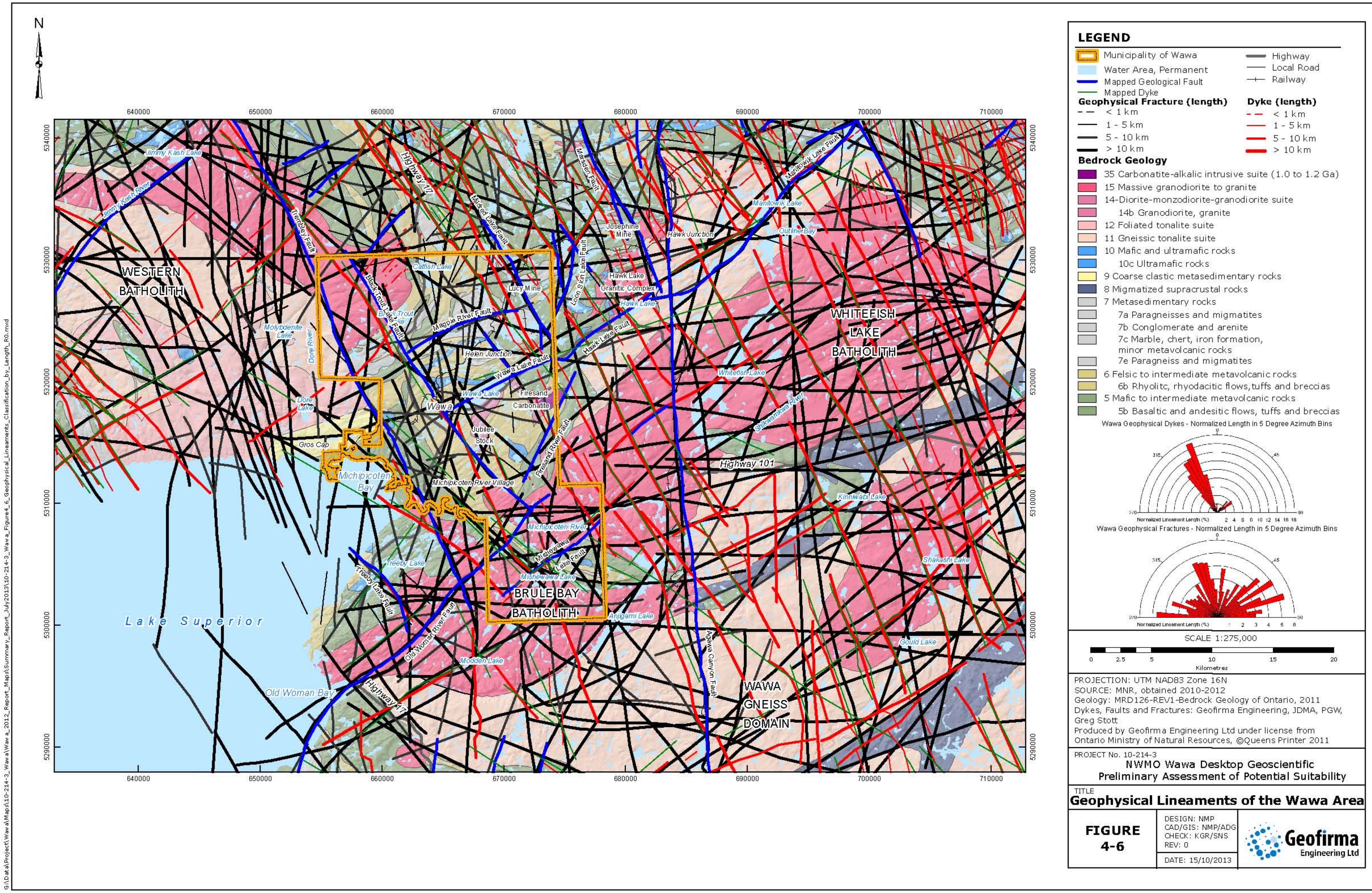

Figure 4-6: Geophysical Lineaments of the Wawa Area

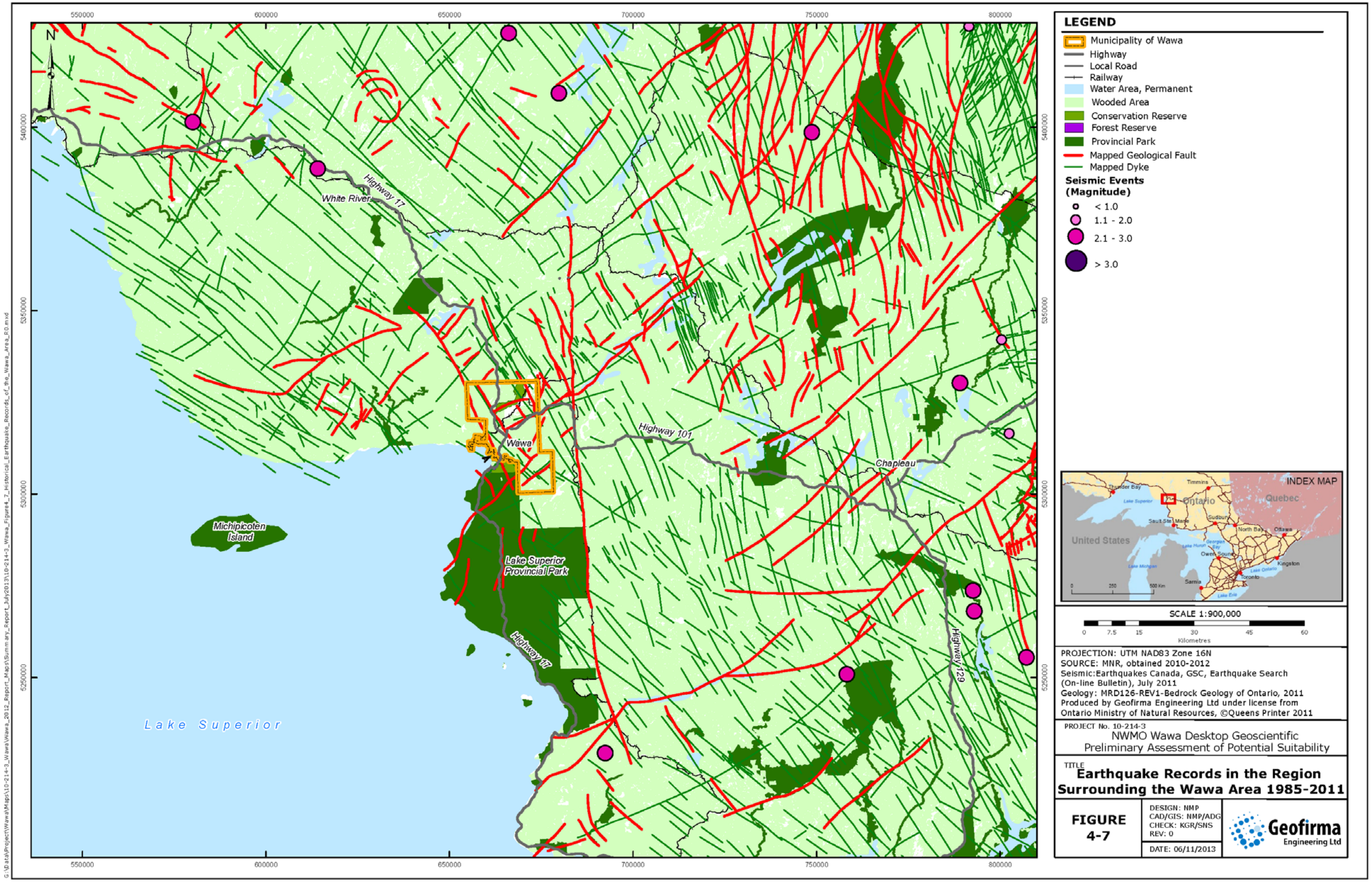

Figure 4-7: Earthquake Records in the Region Surrounding the Wawa Area 1985–2011

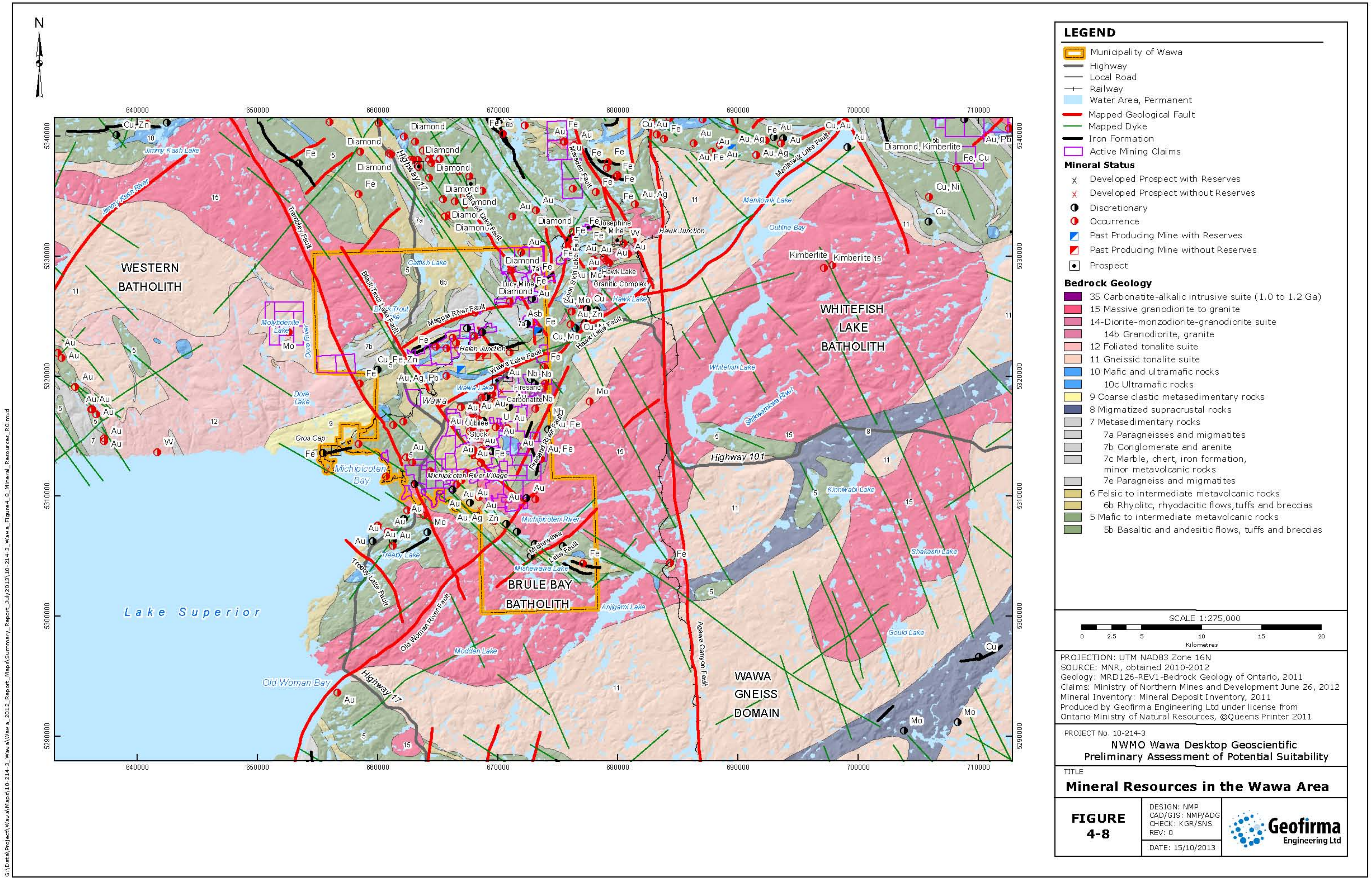

Figure 4-8: Mineral Resources in the Wawa Area

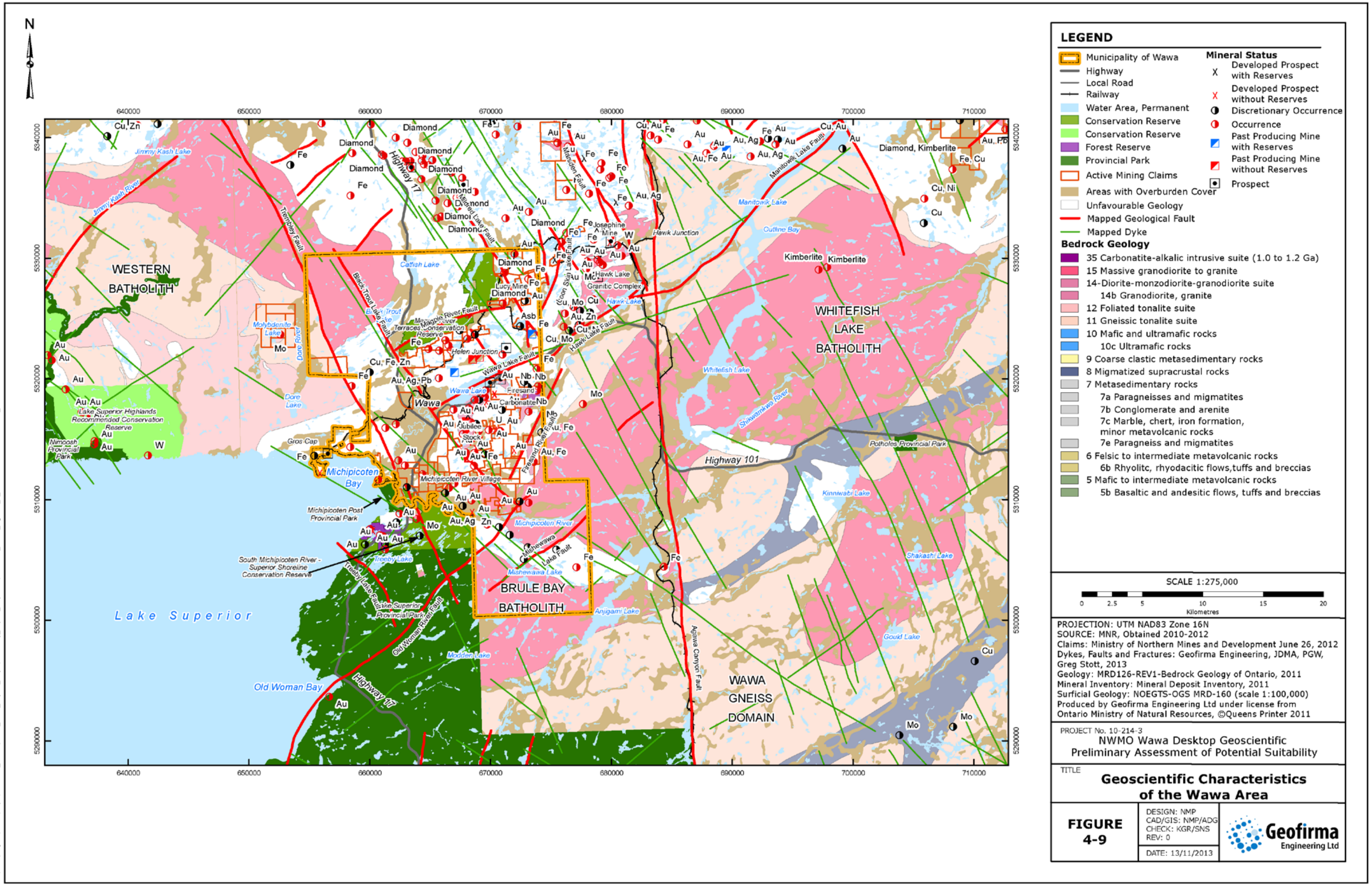

Figure 4-9: Geoscientific Characteristics of the Wawa Area

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 Wawa 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 Wawa area?
2. If the repository is located somewhere in the Wawa 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 Wawa 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 Wawa 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 Wawa 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 Wawa, referred to as the "Wawa area." For the purpose of this preliminary assessment, the area considered is the same as that selected for geoscientific assessment shown on Figure 4-1.

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

5.2.1 Communities and Infrastructure

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

The Municipality of Wawa is approximately 420 square kilometres in size (LIO, 2012), with a population of 2,975 (Statistics Canada, 2012). The settlement area of Wawa is situated at the south end of Wawa Lake, approximately 7 kilometres northeast of the Lake Superior shoreline. More information on the Municipality of Wawa is provided in Chapter 7.

There are a number of Aboriginal communities and organizations in the Wawa area, including the Brunswick House First Nation, Chapleau Cree First Nation, Chapleau Ojibway First Nation, Michipicoten First Nation and Missanabie Cree First Nation. Métis Councils in the area include Greenstone Métis Council, Superior North Shore Métis Council and Thunder Bay Métis Council 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 Trans-Canada Highway (Highway 17) passes north-south through the Wawa area, and Highway 101 passes through the Municipality of Wawa from the east and then travels south through the centre of the municipality. The railway in the Wawa area is owned by the Canadian National (CN) Railway. This includes the north-south line from Sault Ste. Marie to Hearst, and the now-removed branch from Michipicoten Harbour past Wawa to Hawk Junction. Two 230-kilovolt electrical transmission lines meet at the Wawa Transformer Station from the south. One 230-kilovolt line, the East-West Tie, heads northwest through the Wawa area from the Wawa Transformer Station. As well, a 115-kilovolt transmission line heads north, then east from Anjigami. The Wawa airport is located just south of the town. There are no gas pipelines recorded in the Wawa area. There are two operating landfills and a waste water treatment plant within the Wawa area.

Four provincial parks (Lake Superior, Potholes, Michipicoten Post and Nimoosh Provincial Parks), three conservation reserves and a forest reserve are located in the Wawa area.

The Ontario Archaeological Sites Database identifies 37 known archaeological sites in the Wawa area. Of the 37 sites, 11 are historical sites with seven identified as Euro-Canadian, four as historical Aboriginal and nine as pre-contact Aboriginal. There are also 30 municipally designated heritage sites, but no national or provincial heritage sites in the Wawa area.

Trapline Licence Areas are located over much of the Wawa area, outside Provincial Parks, Conservation Reserves, communities and Indian Reserves.

As discussed in Section 4.3.7, water wells in the Wawa 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 Wawa area, of which only 41 provided useful information on depth to bedrock, yield, and other relevant parameters. These 41 water wells ranged from 3.3 to 117 metres in depth (MOE, 2012). No potable water supply wells are known to exploit aquifers at typical repository depths in the Wawa area or anywhere else in northern Ontario. The Municipality of Wawa obtains its municipal water supply from Wawa Lake.

5.2.2 Natural Environment

As described in Chapter 4, the Wawa area lies in the Abitibi Upland, a broadly rolling surface of the Canadian Shield that occupies most of north-central Ontario. Topography in most of the Wawa area is fairly rugged, with elevation ranging from about 183 metres at Lake Superior to as much as 607 metres within the bordering highlands. Very steep slopes are common, including near-vertical cliffs which predominate along the shores of Lake Superior. The vast majority of lakes in the area are small in size, with all the lakes, excluding Lake Superior, covering only about 7 per cent of the Wawa area.

Geologically, the Municipality of Wawa is situated in the Wawa Subprovince, which is part of the Superior Province of the Canadian Shield. The bedrock geology in the Wawa area is dominated by two large granitic intrusions, the Western batholith and the Wawa Gneiss domain, which includes the Whitefish Lake/Brulé Bay batholith. These intrusions were emplaced into the older rocks of the Michipicoten, Mishibishu and Gamitagama greenstone belts.

The Wawa area has a typical boreal climate, with long cold winters and cool to mild summers with most precipitation falling in the form of summer showers and thunderstorms. Although winter snowfall amounts are moderate, the Wawa area receives most of its yearly precipitation between May and October.

Figure 5-2 shows the significant natural features within the Wawa area, including watershed boundaries, significant ecological areas, wintering areas, migration routes, 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 Wawa area is located within the Lake Superior Drainage Area which drains into the Michipicoten River, and eventually into Lake Superior. Surface water generally flows to the southeast. Wawa, Black Trout, Deep and Reed Lakes are all considered “lake trout” lakes and are identified by the Ontario Ministry of Natural Resources (MNR) as sensitive. Wawa Lake is the largest inland coldwater lake within the Wawa area. The Wawa area supports recreational and commercial fishing, with species including walleye, northern pike, brook trout and lake trout (MNR, 2012).

Wawa lies in the southern portion of the Boreal Forest Region where it meets the Great Lakes-St. Lawrence Forest (Hoffman, 2011). The Municipality of Wawa largely lies within the Algoma Forest Management Unit (FMU 350) managed by Clergue Forest Management Inc. (CFMI). Forestry is a major industry in the area (CFMI, 2005).

The region’s forests provide habitat for wildlife, including game, fur-bearing mammals and birds. Management of featured species populations (e.g., moose), and concentration and nesting areas for raptors, herons and waterfowl are a focus of Ontario Ministry of Natural Resources

(MNR) forest management planning in this area. The Natural Heritage Information Centre (NHIC, 2012) identified six species observed within the Wawa area that are listed as Endangered (END), Threatened (THR) or Special Concern (SC) either under the Ontario *Endangered Species Act* (ESA), 2007, or the Federal *Species at Risk Act* (SARA), 2012. These are the woodland caribou, bald eagle, peregrine falcon, kiyi, shortjaw cisco and flooded jellyskin.

Using habitat range mapping, an additional 15 END, THR or SC species are identified to have a range that overlaps the Wawa area (ROM, 2012; Oldham and Weller, 2000; Cadman et al., 2007; Holmes et al., 1991). In particular, eastern cougar (provincially END) and eastern wolf (SC provincially and federally) each have a current range that reaches the Wawa area. The range for provincially END golden eagle also extends to the region, as does provincially THR lake sturgeon (northwestern Ontario population). 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 Wawa area are described in the Environment Report (Golder, 2013). A preliminary qualitative assessment of 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 – Possible risk – Possible risk of flash flooding in some areas due to moderate-sized catchments and very 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 (320 centimetres), and extreme snowfall events are uncommon.
- Fire – Possible risk – Forest fires occur in the area, although historically they have been less than 25 square kilometres in size and have affected only less than 1 per cent of the area over a 35-year period.
- Landslide – Possible risk – Some landslide risk in areas of high topographic gradients. Risk will vary based on specific location.
- Tsunami – Low risk – Low seismic hazard rating and low potential along immediate Lake Superior shoreline.

5.2.4 Environment Summary

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

Table 5-1: Summary of Environmental Features Within the Wawa 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	7%/4%
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
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	Possible
Potential for Landslides	Possible

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 Wawa 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 Wawa 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 Wawa 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
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 Municipality of Wawa 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 Wawa 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 or 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 Wawa 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 Wawa 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
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 used 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 Wawa 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 site preparation and 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 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 Wawa 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

Environmental Component	Main Considerations	Is There Potential for an Effect?	Is Management and Mitigation Possible?	Are Significant Residual Effects Anticipated?
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 Wawa 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 Wawa 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 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 Wawa 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 Wawa 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.

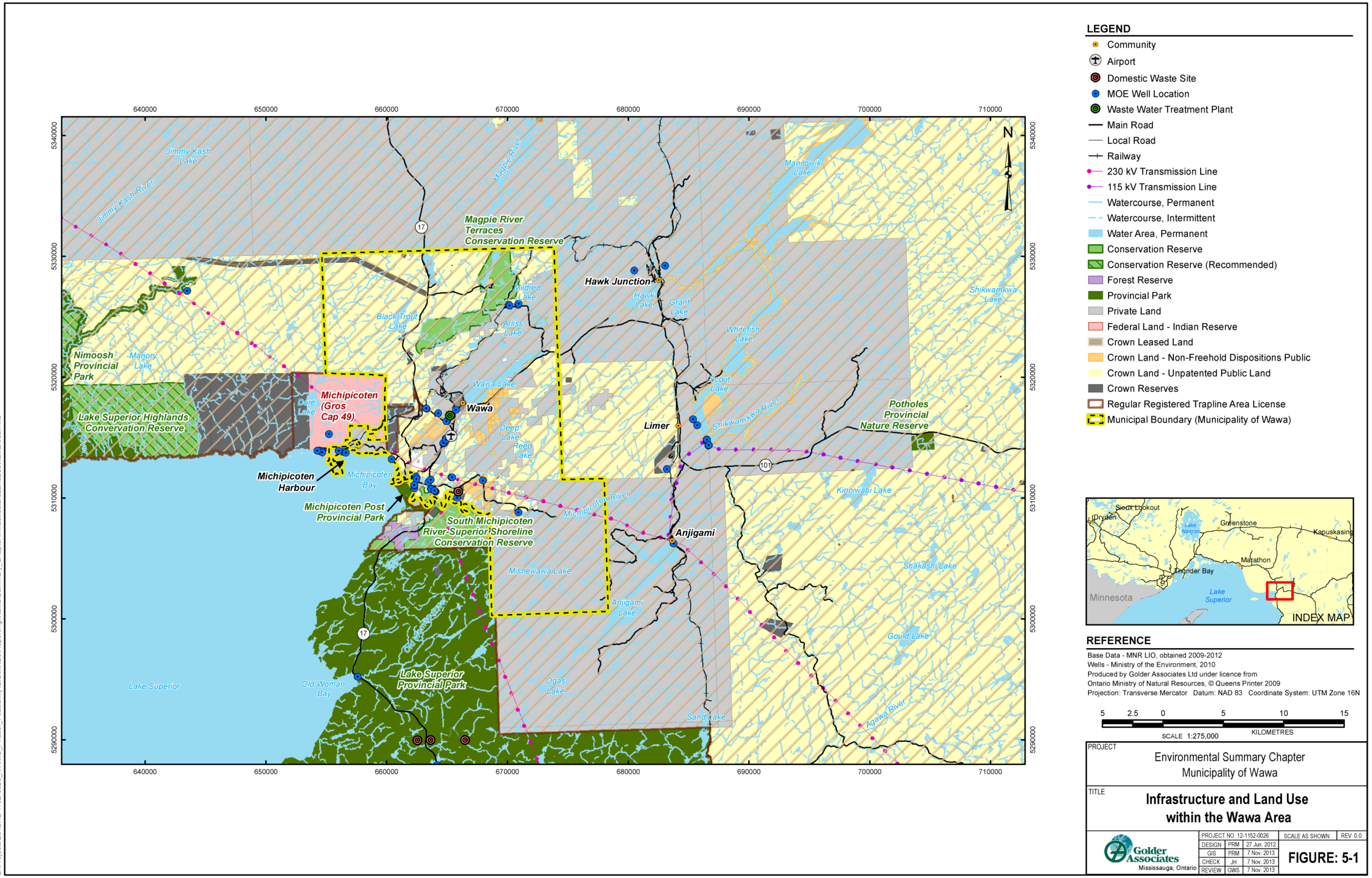

Figure 5-1: Infrastructure and Land Use Within the Wawa Area

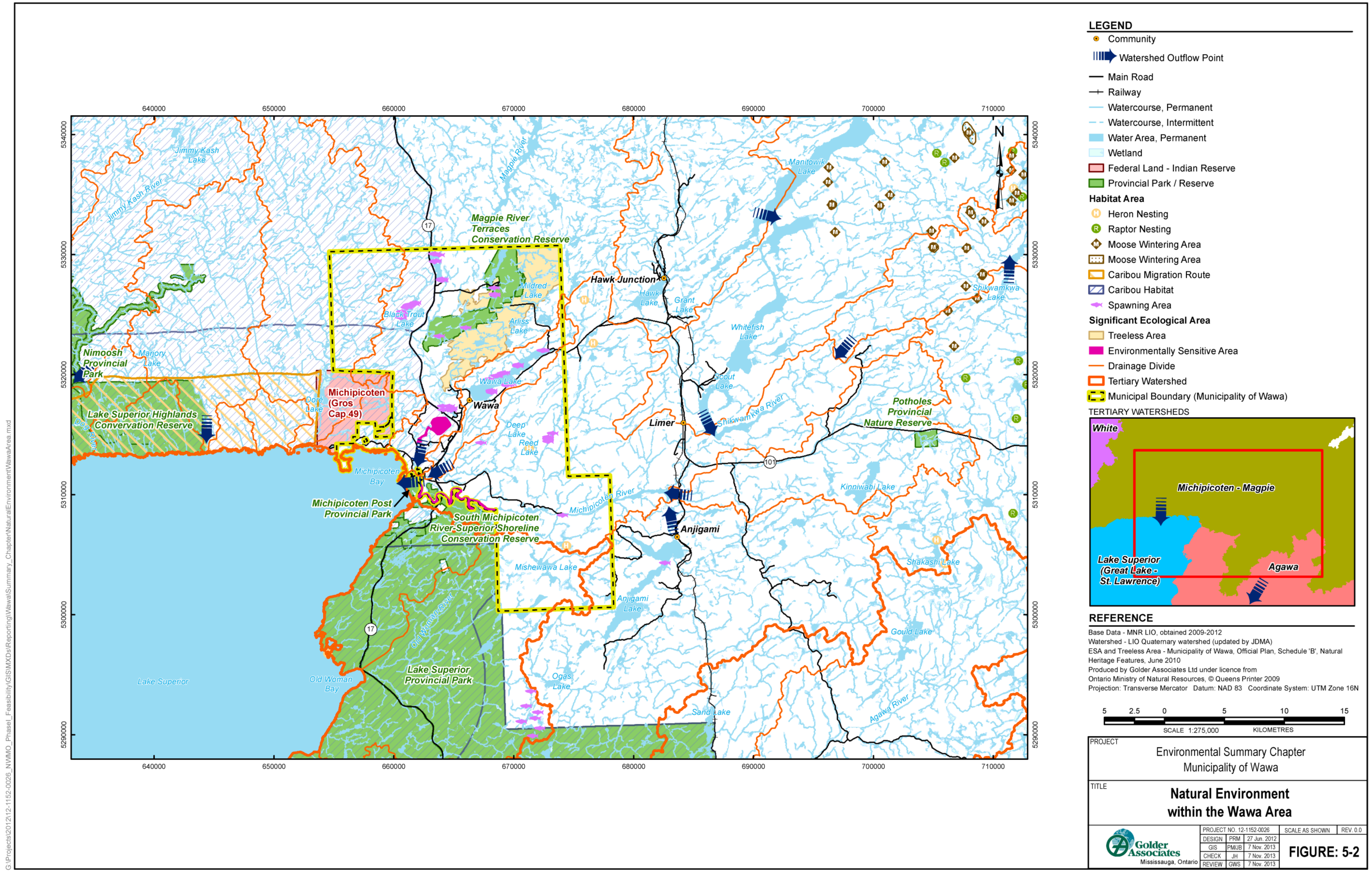

Figure 5-2: Natural Environment Within the Wawa Area

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 Wawa 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 on 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.

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

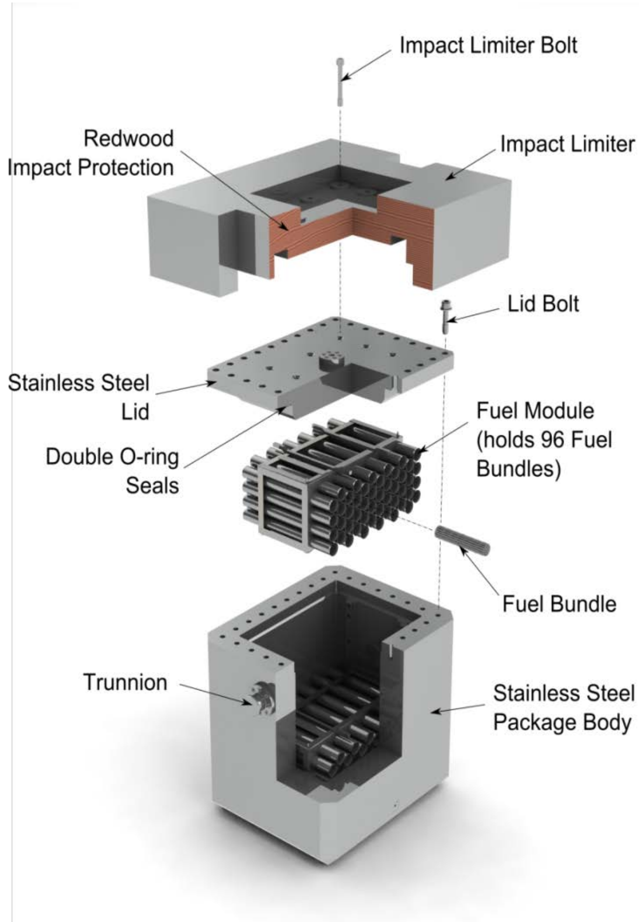

Figure 6-1: Used Fuel Transportation Package

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. 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 package, 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 fuel owner. The NWMO will certify that the packages are loaded in accordance with 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 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*. 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 Wawa

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 Wawa would be accessible by truck via existing roadways and a service road to the receiving facilities.

Wawa straddles Highway 101 (Mission Road) just off Highway 17, the Trans-Canada Highway (see Figure 6-3), and is located near the cross-continental railroad operated by the Canadian National (CN) Railway. Both systems are maintained to the highest standards and are important to the interprovincial movement of goods and services.

If rail is a preferred mode, rail service could be extended from Hawk Junction (see Figure 6-4), an existing junction about 25 kilometres northeast of Wawa to a service spur leading directly to the receiving facility at the repository. In the past, a spur line extended from Hawk Junction, past Wawa to Michipicoten Harbour on Lake Superior. The rails along this abandoned line have been removed.

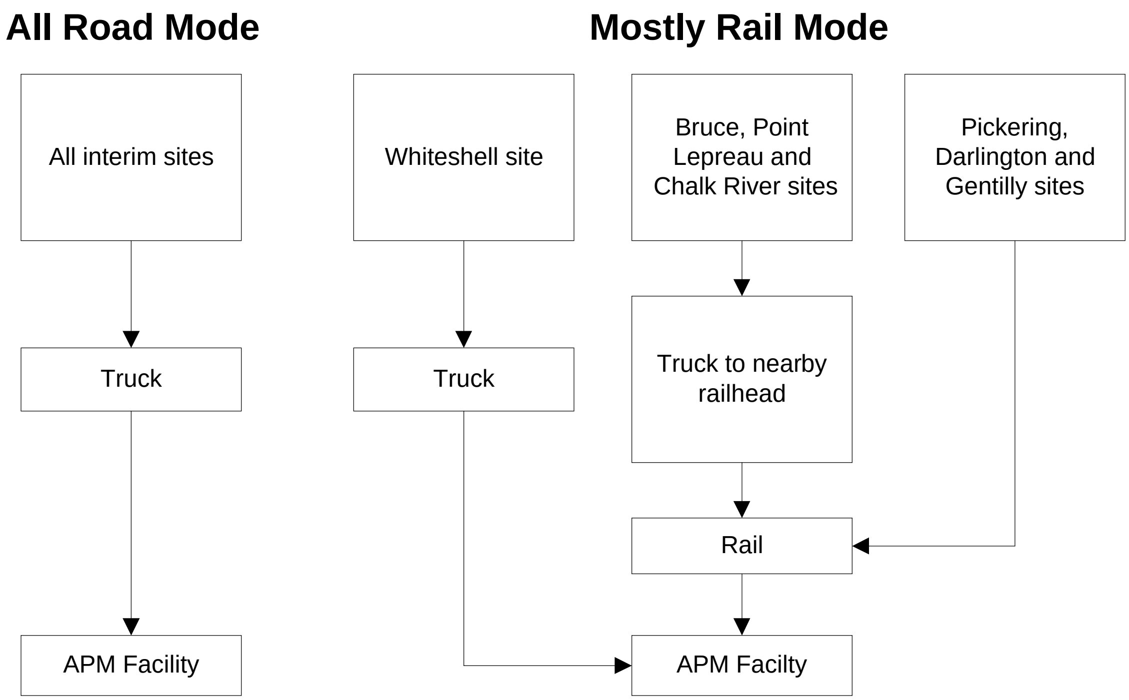

Figure 6-2: Example Transport Processes for Used Nuclear Fuel

Figure 6-3: Highway 17 Near Wawa

Figure 6-4: Hawk Junction Near Wawa

6.7.1 Existing Transport Infrastructure

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

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

Transport Scenario	Transport Mode	Number of Shipments	Return Distance (Kilometres)
All Road	Road	24,000	48,200,000
Mostly Rail	Road	11,700	1,790,000
	Rail	2,400	5,300,000

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 national highway system includes Highway 17 of the Trans-Canada Highway, which passes by Wawa on Highway 101, Ontario. As planned, an existing local access road would be used or a new road constructed to provide access from Highway 17 or Highway 101 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 Wawa, Ontario

Interim Storage Site	Distance Site to Repository (Kilometres)	Number of Shipments	Return Distance (Kilometres)
1 – Whiteshell	1,100	2	4,400
2 – Bruce	970	10,220	19,830,000
3 – Pickering	930	4,150	7,719,000
4 – Darlington	750	6,720	10,080,000
5 – Chalk River	750	30	46,800
6 – Gentilly	1,300	1,500	3,900,000
7 – Point Lepreau	2,300	1,450	6,670,000
	Totals (rounded)	**24,000**	**48,200,000**

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 Wawa, 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 Wawa area. The average daily travel (vehicle) count for the Wawa segment of Highway 17 is 2,300 vehicles per day (MTO, 2009), and the Wawa segment of Highway 101 is 4,200 vehicles per day. Two trucks a day more to the existing traffic count would be a small addition (less than 0.1 per cent).

The Ontario Ministry of Northern Development and Mines Northern Highways Program (MNDM, 2012) includes the resurfacing of Highway 101 west of Missanabie. The program also includes the rehabilitation of bridges.

The local road system within Wawa 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.

Wawa is accessible via an alternative route, although it involves additional mileage. The alternative route is Highway 11, north to Highway 101, through Timmins, entering Wawa on Highway 101 from the east.

Emergency response resources are provided by a volunteer 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 Hornepayne. The Lady Dunn Health Centre 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?

Canadian National (CN) Railway operates a single track from Sault Ste. Marie through Hawk Junction located 25 kilometres from Wawa across the CN mainline to Hearst, Ontario. 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 Hawk Junction is also feasible. The switch yard in Hawk Junction offers an opportunity to construct either an intermodal transfer facility or to construct a switch for a local line providing service directly to the repository site.

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

Interim Storage Site	Distance Site to Repository (Kilometres)	Number of Shipments	Return Distance (Kilometres)
1 – Whiteshell	**1,000**[a]	**2**	**4,400**
2 – Bruce	**80**[b]	**10,220**	**1,635,000**
	1,070	1,020	2,183,000
3 – Pickering	880	420	739,000
4 – Darlington	910	670	1,219,000
5 – Chalk River	**120**[c]	**30**	**7,200**
	660	3	4,000
6 – Gentilly	1,590	150	477,000
7 – Point Lepreau	**50**[d]	**1,450**	**145,000**
	2,250	150	675,000
Totals (rounded)	**Road**	**11,700**	**1,790,000**
	Rail	2,400	5,300,000

Notes:
[a] Road mode from Whiteshell to repository site near Wawa
[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.

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 National Railway operates a trans-Canada rail line north of Wawa. Trains could use the northern route and transfer the transportation packages to trucks at Hearst for the trip to a repository. This option does add mileage to the routing.

6.7.4 Weather

There are no vehicle weight restrictions on Highway 17 during the spring thaw months. Similarly, no weather or seasonal restrictions were identified for rail transport to Wawa, 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 Wawa, Ontario, would produce approximately 1,510 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 57,800 tonnes of equivalent carbon dioxide emissions.

Transport by mostly rail mode would produce approximately 875 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 48.2 million kilometres, about 82 road collisions have been estimated over the 38-year operating period of the APM facility.

6.7.7 Transportation Costs to Wawa

This section considers the used nuclear fuel transportation logistics from the existing interim storage sites to a hypothetical APM repository site located near Wawa, Ontario, to estimate transportation costs. Existing surface mode transport infrastructure and transport distances from the interim used fuel storage sites to Wawa 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 Wawa, 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 Wawa is projected at $1.06 billion over the 38-year campaign (in constant 2010 $). The variance is $27.1 million under the reference case estimate, or 2.5 per cent lower.

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

Total Cost	Transportation to Wawa	Variance to Reference Case	
Package Loading and Transportation	**$1,060,000,000**	**-$27,100,000**	**-2.5%**
Cost Breakdown			
Route and System Development	$19,000,000	$0	0%
Safety Assessment	$5,290,000	$0	0%
Capital Equipment and Facilities	$320,000,000	-$6,210,000	-2%
Operations	$534,000,000	-$19,900,000	-4%
Environmental Management	$8,400,000	$0	0%
Decommissioning	$41,800,000	-$977,000	-2%
Program Management	$127,000,000	$0	0%

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 Wawa 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.

Wawa is located on Highway 101 about a kilometre off Trans-Canada Highway 17 and nearly 225 kilometres north of Sault Ste. Marie. Trans-Canada Highway 17 is one of two transcontinental highways serving interprovincial commerce. It is maintained by the Ontario Ministry of Transportation to the highest standards.

Highway 101 is a two-lane paved regional highway serving Wawa, and provides access to wood product and recreational uses to the east. Since Highway 101 passes through the business district, improvements would be needed to reduce conflicts between local traffic and NWMO-generated traffic going east.

The Canadian National Railway runs from Franz Junction south to Sault Ste. Marie. In 1998, when Algoma Steel closed its iron ore mine in Wawa, the branch line between Michipicoten Harbour near Wawa and Hawk Junction on the Algoma line was abandoned, and the tracks removed.

The status of the right-of-way ownership for this line is unclear from published sources. If Algoma/CN owns the right-of-way, a moderate investment would be required to return the line to service, given most of the grade and drainage control is still in place. A local service line would be needed to access the repository if it is not located along the existing right-of-way. Hawk Junction has sufficient space if an intermodal transfer facility were needed, and the roads appear to be adequate to move the UFTP via Highway 101 to Wawa.

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 Municipality of Wawa, Ontario. More detailed information can be found in the Wawa 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 Wawa. 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 were the project to 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.

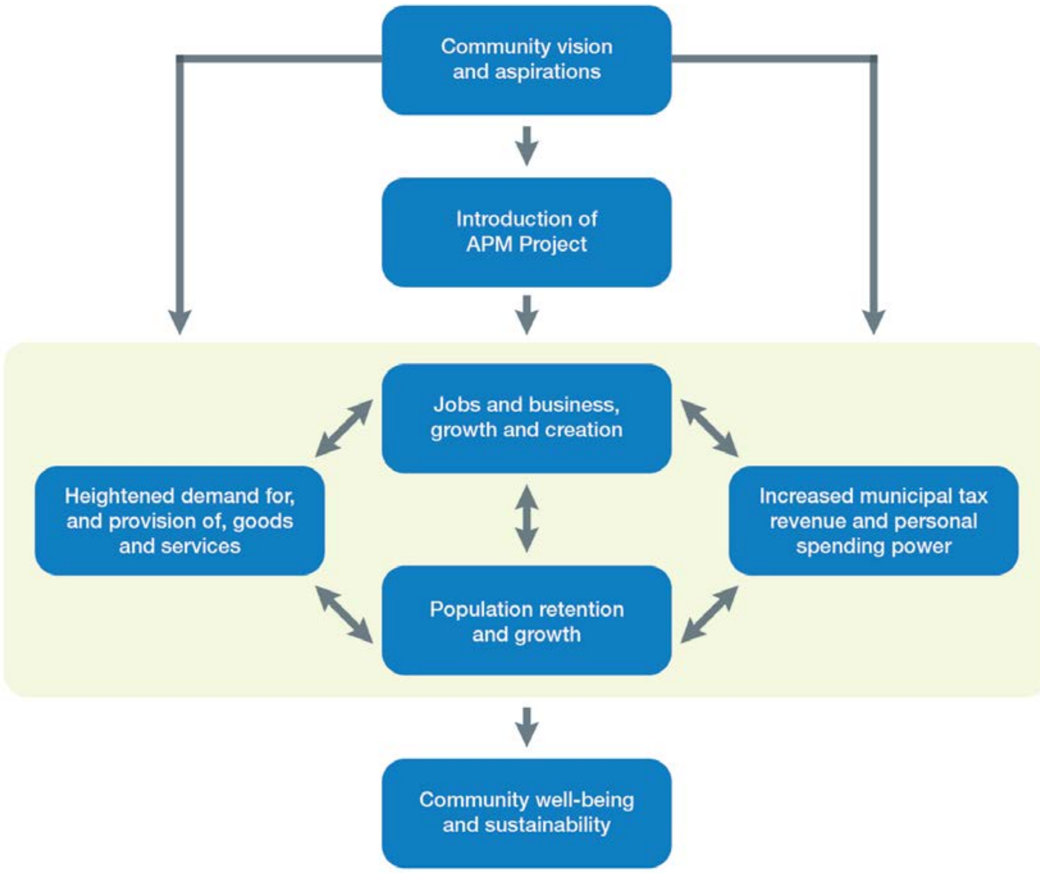

Figure 7-1: Direct and Indirect Effects From the Project

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

The potential effect of the project, should it be implemented in the Wawa area, on the people, economics, infrastructure, social assets and natural environment of Wawa is discussed below. The discussion starts with an overview of the aspirations and values of Wawa, 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 Municipality of Wawa is a resilient community, having faced significant social, cultural and economic change due to the various "boom and bust" cycles associated with the community's natural resource-based economy. Perhaps the greatest changes in Wawa have occurred since the closure of the community's largest employers, including Algoma Ore Division and Weyerhaeuser. The community now faces an aging population and an aging infrastructure network with surplus capacity.

The Municipality of Wawa is currently conducting a strategic planning process. However, the community is currently guided by multiple vision statements: the *Municipality of Wawa Official Plan* (Meridian, 2010), *Wawa 2015: Building Our Future* (Wawa Community Adjustment Committee, 2010) and *New Beginnings: The Municipality of Wawa Sustainability Plan, Final Draft* (Municipality of Wawa, 2010). Each vision statement differs in scope. For example, the Official Plan vision contains a comprehensive statement of how to develop and prosper going forward, while the *Wawa 2015* and *New Beginnings* vision statements are more specific and action-oriented in nature. Nevertheless, each vision has a role in guiding the future development of the Municipality.

The vision statement from *New Beginnings: The Municipality of Wawa Sustainability Plan, Final Draft* is reproduced here:

> *To provide the best possible municipal services through an environment which focuses on an attainable quality of life for the Residents of the Municipality of Wawa.*

This vision has been woven into other community documents which identify a focus on environmental, economic and social sustainability by providing specific goals addressing:

- The natural environment;
- Growth and settlement;
- Rural lands; and
- Economic development.

The strategies noted above have been drafted to assist Wawa in realizing new opportunities and community aspirations. Each of them identifies the challenges Wawa has and continues to face as a natural resource-based community. However, they also identify potential opportunities which utilize the community's existing resources and assets.

Continued support for natural resource-based industries will help to stabilize the community. However, additional opportunities to support Wawa include:

- Greater incorporation of technological advancements to support new and existing businesses;
- Promotion of partnerships with neighbouring municipalities and organizations to realize economic development opportunities, particularly those communities and organizations located west along Highway 17 from Wawa;
- Pursue public-private partnerships;
- Promotion of a responsible attitude and use of the natural environment (i.e., use of Wawa Lake for recreation, tourism and educational opportunities);
- Growth of the Wawa and surrounding area ecotourism sector;
- Development of strong partnerships in the forestry and mining industries; and
- Encouragement of a diverse local economy with employment opportunities across sectors.

In addition to the identified opportunities above, increased economic activity and employment opportunities will stabilize existing services and may encourage expanded retail.

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

Wawa and many northern Ontario communities have experienced declines in population. Wawa has experienced significant population loss in the past two decades with the resulting effects on loss of retail and other services. Since 1986, the population has declined by more than 30 per cent. Wawa has historically been dependent on natural resource-based industries and has been susceptible to many “boom and bust” cycles. Specific events such as the 1998 closure of Algoma Ore Division, 2007 closure of Domtar Forest Products and 2007 closure of Weyerhaeuser strand board mill significantly reduced employment opportunities. As a result, the community has been experiencing out-migration as youth and predominantly young families seek other employment opportunities. As a result, there are limited local employment opportunities to attract a diverse and growing workforce.

Population decline is a primary concern for the people of Wawa, and there is a strong desire to grow – the community has said it would like to see its population at least double. The APM Project has the potential to reverse the decline, achieve its population goal, and stimulate growth in Wawa and other nearby communities. This growth will rejuvenate the schools, retail options, and community facilities and services. The APM Project would likely utilize the existing skilled labour force and attract a new skilled and diverse workforce, as well as attract new families. The APM Project will also provide local residents with employment options. The project offers the opportunity for local residents to obtain opportunities in direct, indirect and induced jobs and thereby retain population.

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 Wawa (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 Wawa could increase significantly, which is a community aspiration. The increased population will be a boost to Wawa and a catalyst for spinoff growth and development.

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.

With respect to education, Wawa 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. As well, the school system will stabilize, and potentially, a broader range of programming (education and training) will be provided.

Basic health care is available in the community; however, specialty health-care services require travel outside the community. Emergency services are also adequate for the community at this time. Because the regional health facilities are located in Wawa, any growth will reinforce Wawa as the regional centre, and so one can anticipate a degree of stability. There is the potential for increased social risks associated with population growth and project activity. Conversely, growth may stimulate planning and expansion of health and safety facilities and services.

The APM Project has the potential to bring positive net benefits to the Human Assets of Wawa should the project be implemented in the area. It would help the town 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

The economy of Wawa is one of decline with many closed businesses. Employment in the resource sectors has been declining until recently. Many residents left the community to find work elsewhere in northern Ontario and beyond. This was particularly prevalent amongst the younger generation. While participation rates and employment rates have been decreasing over time, so too have unemployment rates because of out-migration and people leaving the labour force.

Mining exploration activities have recently created local employment opportunities. It is expected that these and the APM Project will provide desired stable employment and career opportunities for community residents, and stimulate business activity in the community. Wawa may require assistance to plan for economic development and ensure local residents realize direct and indirect project employment opportunities.

The community is working hard at enhancing its destination tourism, but is being handicapped by the struggling US economy.

Even within this set of circumstances, property values appear to be stable. Community prosperity and household incomes in Wawa are improving and rising back to former levels. The APM Project will further create local jobs and stimulate growth in household income and wealth creation.

Natural areas in and surrounding Wawa are very important to the community for conservation, residents' use and tourism. The tourism industry in Wawa is partially dependent on the American market, which is in decline. Tourism has long been an important economic activity for the community of Wawa. Going forward, the community has expressed a strong desire to pursue new tourism opportunities and grow the industry, including the promotion of ecotourism and nature-based programming. There is concern among some in the community that the APM Project may not be well-aligned with aspirations of the community regarding tourism, as some people may be less likely to visit the area. Conversely, there is also potential for new tourist visitors to come to the area to learn more about the project.

Municipal fiscal circumstances are currently challenging. Business closures, out-migration, loss of tax revenue 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 to accommodate project-related demands for services and infrastructure. Optimizing benefits may require assistance from the NWMO in terms of planning.

A key attribute is the direct and indirect job creation the project 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 Wawa 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.

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 covered by the strong municipal revenue base. 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 services to the project itself and the population it has brought into the community. Were the APM Project to be located in the area, Wawa 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 Wawa, the net economic effects are expected to be positive, although there is some concern that the APM Project may require specific implementation and mitigation measures in order to be compatible with the tourist industry in the community. For the most part, however, 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 Wawa 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

Wawa is well-positioned to handle population and housing growth in the coming years. The existing municipal infrastructure is more than sufficient to handle population growth anticipated from the APM Project and the rejuvenation of retail businesses. The APM Project may place increased demands on existing infrastructure ad may necessitate facility replacement or upgrading in some cases.

New housing is being developed, and property values have been increasing in recent years. Vacant zoned serviced lots are available for future residential, commercial and industrial development.

The APM Project would see the in-migration of individuals and families who will absorb the available housing stock. As vacancy rates fall and housing supply becomes constricted, housing prices might increase. The APM Project would create a demand for a mix of housing types and tenure arrangements. A supply/demand balance of housing would need to be maintained and ensure there is a strong supply of affordable housing.

Although there is a 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.

The APM Project would generate municipal revenues directly and indirectly that can be applied to facility operation and maintenance, upgrading and replacement.

Wawa has strong transportation linkages, particularly for road (Trans-Canada Highway). The community has a municipal airport and privately owned deep-water marine port. Freight rail is also available near the community. The APM Project would increase road, rail, and airport usage.

Overall, the changes in community well-being related to the physical assets of Wawa 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 the means to pay 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

Recreational facilities and recreational and social programs are generally a major source of pride for many communities and serve as a social hub and focal point. They also provide opportunities to foster young talent in sports and recreation, and have other benefits for the social, physical and emotional well-being of the population. Wawa currently has a number of recreational facilities and programs; however, the decline in population has led to program reductions in recent years. Fluctuating financial circumstances of the Municipality do not permit major capital investments in infrastructure; therefore, new facilities cannot be constructed or existing facilities upgraded. The APM Project will bring an increased population to the community, thereby boosting participation and involvement. It will also enable new facility construction and upgrading. This transition may require planning assistance.

Wawa also has the usual complement of social services and organizations and has the benefit of local media (paper and radio) outlets.

Wawa is a safe and quiet community for families. The community has a strong sense of identify that is rooted in its location and the related natural environmental features. This underscores the tourism base and potential. Wawa has a strong community recreation focus which is rooted in its natural environment. There is some concern that the APM Project may affect perceptions of the area with respect to the natural environment and that this might not align with the aspirations and visions of all community members. Some community members are uncertain about the potential for a major development such as the APM Project to coexist with an ecotourism focus of the community's vision; whereas, others see potential for coexistence of ecotourism objectives with such a development. The potential effect this may have on the character of the community and cohesion within the community is, at this point, uncertain. Although the APM Project could double the existing population, there is a desire to preserve the community character, and ensure community pride is maintained and the project aligns with community visions.

The APM Project will bring additional demands on the community and social services which will result in beneficial changes and may revitalize some of the community organizations.

The APM Project would likely 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 Wawa to upgrade and expand its recreational and social programs. Based on discussions with the community, the project could 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. However, there is some uncertainty regarding the compatibility of the APM Project and the community's values and vision for its surrounding natural environment.

7.2.6 Implications for Natural Environment

The natural environment, including inland and shoreline areas, are a source of pride for the community of Wawa and its residents. Wawa and area residents regularly use the surrounding area for recreational activities. In addition to the community's location on Lake Superior and Wawa Lake, recreational opportunities are provided by the numerous Provincial Parks (both operational and non-operational), a National Park, conservation reserves and the Chapleau Crown Game Preserve which are located in the area surrounding Wawa. A number of tourism operators and fly-in lodges are present in the area surrounding Wawa. Fishing, hunting and other shoreline activities are important to the community as are the snowmobile and ATV trails. These natural features will likely be attractive to many of the new residents and workers, thereby increasing demand.

In addition, there is a proposal for the Lake Superior Highlands Conservation Reserve. Natural heritage features have been recognized by residents and are protected under the *Municipality of Wawa Official Plan* (2010). Increased population will result in increased visitor numbers and also heightened pressure on natural areas. Growth of nature base and ecotourism is highly desired by the community.

Wawa prides itself on being at the centre of many natural environmental features. These features are central to the Municipality's image and focus on tourism growth and development.

The APM Project will attract employees and families, but their effect on the natural environmental features will be minimal. Of greater concern among some in the community is that the project may create a "negative image" effect that will diminish Wawa in terms of the public perception of the area being a relatively pristine natural environment. The NWMO will need to work with the community to ensure that the natural environment and its opportunities for residents and visitors are maintained.

Further environmental studies would be needed to understand any environmental effects. With proper planning and dialogue, resources would remain protected, and increased demand 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 the mitigation that will be applied. There is the potential that visitation at the Provincial Parks may experience some decline with the presence of the facility as some may be less likely to visit the area. However, there are many examples of Provincial Parks that are situated close to or nearby to nuclear facilities (i.e., Darlington, MacGregor Point and Inverhuron Provincial Park) where visitation has not been affected. It is expected that through working with park managers and clearly communicating with the public, any potential effects 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 the 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 Wawa

Based on the foregoing discussion, the APM Project has some potential to be a fit for the community of Wawa. The project is understood to be compatible with many community aspirations, including the desire to see growth and stability. 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 Wawa will create significant change. Positive changes could include:

- Employment and business opportunities (direct and indirect)
- Population growth due to in-migration of workers will result in greater utilization and growth of local community assets (infrastructure, housing, facilities and services)
- Utilization of available, serviced land
- Ability to retain and attract 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 members of the community are concerned about the effect of the APM Project. This is particularly the case with respect to potential and perceived effects on the natural environment and tourism in the area. Some see the APM Project as being in conflict with the ecotourism goal of the community. There are those that 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 Wawa Profile		Possible Wawa 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 Wawa 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 Wawa 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	▭	Uncertain	△	• The community would see benefit to its Social Assets through increased participation and funding to its recreational facilities and programs, as well as its social services and organizations. • Interest in the project is positive for many residents. • Some potential for APM Project to diminish community pride and image for some residents if there is perceived negative effects on the valued natural assets which may affect community character and cohesion.
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 environmental effects are likely during the construction, operation and decommissioning phases of the used fuel repository itself

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

7.3 Criteria to Assess Factors Beyond Safety – Summary in Wawa

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 Wawa 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. Wawa 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	Potential Effect of APM Project	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 wants to learn more about safety and health considerations in order to strengthen 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 itself.
	Local and surrounding area economy and employment	Enhanced	• Significant employment and population growth would occur in Wawa and surrounding communities – hundreds of new jobs could be created in Wawa. • With these jobs comes the potential to significantly increase the current population of Wawa. • New opportunities would be created for local businesses to serve the project and growing population.
	Community administration and decision-making processes	Uncertain	• Some local leadership has demonstrated interest in the project, while for others within the community, there are uncertainties surrounding the suitability of the project. • Going forward, it is expected that local leadership will engage the community in decision-making with respect to the APM Project.
	Balanced growth and healthy, livable communities	Uncertain	• Wawa 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. • There is some uncertainty as to the alignment of the APM Project with the community's vision and values for the natural environment with a particular concern around the nearby wilderness areas and the related ecotourism industry.
Potential for enhancement of the community's and surrounding area'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 negatively influenced during the construction, operation and decommissioning phases of 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 surrounding area 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 some 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. • 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 potentially suitable sites for the project, thus providing flexibility in selecting specific sites that can avoid ecologically sensitive areas and local significant features.

Factors Beyond Safety	Evaluation Factors to Be Considered	Potential Effect of APM Project	Discussion Based on Preliminary Assessment
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 Wawa or the surrounding area to impede project implementation. • Wawa and the surrounding areas are highway accessible, have social and economic support services, and have capacity to absorb the anticipated growth in population and economic activity. • Some investments would be required to accommodate identified specific infrastructure deficiencies.
	Potential for social infrastructure to be adapted to implement the project	Yes	• The community of Wawa appears to have the necessary core of social infrastructure in place to plan and adapt to changes resulting from the project.
	The NWMO resources required to put in place physical and social infrastructure needed to support the project	To be determined	• In all likelihood, Wawa would require assistance in terms of planning, and human and financial resources. • Further studies will 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 from a social perspective	To be determined	• As outlined in Chapter 6, Wawa is well-situated along the Trans-Canada Highway and is near rail transportation. • The community and surrounding area have access to multiple modes of transportation. • Project transportation will need to address community, logistical and regulatory matters across multiple provinces and multiple jurisdictions, including Ontario, Quebec and New Brunswick. • However, engagement of surrounding communities will 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 from a social perspective	To be determined	Engagement of surrounding communities and those on potential transportation routes is at a preliminary stage, and further dialogue will 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	875–1,510 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 Wawa, approximately 1,510 tonnes of equivalent carbon dioxide emissions are expected to be produced per year. • In a scenario of transport mostly by rail mode, approximately 875 tonnes of equivalent carbon dioxide emissions are expected to be produced per year.
	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 is at a preliminary stage, and further dialogue will be required to help build understanding and address questions and concerns.

7.4 Overview of Engagement in Wawa

The NWMO has engaged with Wawa 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 Nuclear Waste Community Advisory Committee meetings;
- Both informal and structured interviews with community members;
- Facilitating the Nuclear Waste Community Advisory Committee website and newsletters;
- Preparation of written materials;
- Informal tours and visits with local residents;
- "Ask the NWMO" columns in regional newspapers;
- Meetings with nearby First Nations and Métis;
- Attendance at regional meetings, conferences (e.g., with Northeast Superior Regional Chiefs' Forum, Northeast Superior Mayors' Group, 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 members, and conversations with residents during open houses suggest there is some 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 Advisory Committee;
3. Local business owners/operators;
4. Local service providers (e.g., emergency services, social services, education);
5. Community groups (e.g., clubs, associations);
6. Surrounding community leaders;
7. Residents; and
8. First Nation and Métis communities in the vicinity, including elders.

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

Through engagement with organizations such as the Northeast Superior Mayors' Group and others, Wawa has taken steps to engage its neighbours, including Aboriginal peoples. These steps have elicited positive interest from some surrounding communities.

7.4.1 Summary of Issues and Questions Raised

In Wawa, most of the persons engaged were neutral to supportive about the APM Project. Many were also interested in learning more. Some persons engaged were initially in opposition to the APM Project; however, once questions were addressed through the "Learn More" process, their positions shifted. In some cases, persons were still opposed. The core key interests expressed include:

- Environmental risk in and around the site;
- Public health and safety in and around the site; and
- Economic benefit and opportunities for growth.

In addition to these core interests, a number of secondary key interests were also expressed and include:

- The potential for negative perceptions in the area due to the project;
- Transportation;
- NWMO process and project description details (e.g., what is the NWMO exit strategy if a community leaves the process?); and
- Consultation (e.g., how will "willing host" actually be decided?).

Going forward, engagement with surrounding communities will need to continue.

7.5 Community Well-Being 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 Wawa.

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

There appears to be potential for the APM Project to foster the well-being of Wawa. The project is understood to be compatible with many community aspirations, including the desire to see growth and stability. The APM Project has potential to assist Wawa in achieving some of its goals, and is seen by some residents and leaders as a potential opportunity for sustainable growth and the development they desire. However, the community's ecotourism focus may conflict with the APM Project from the perspective of some community members. The potential for the APM Project to create negative perceptions was a concern expressed by some community members, particularly among those associated with the tourism industry. Concerns centred on the possibility of the project negatively affecting tourism in the area due to negative perceptions. Other concerns expressed included a questioning of whether the facility would be contradictory to the community's nature-based and/or ecotourism focus.

The community of Wawa 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 decide whether or not they are interested in continuing to the next phase of studies.

There is some potential for sustained interest in the local community. This is evidenced by support from some community leadership to continue participation in the site selection process. There is also a potential interest in moving forward. However, there is some potential that the APM Project may not be aligned with community aspirations particularly with respect to the natural environment and the community's ecotourism objectives.

There is potential for the APM Project to foster well-being in the communities surrounding Wawa. 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 potential for sustained interest in the surrounding communities. Through engagement with organizations such as the Northeast Superior Mayors' Group and others, Wawa has taken steps to engage its neighbours although some communities in the area have expressed concern. 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. Some areas (in proximity to the waterfront and the proposed Lake Superior Highlands Conservation Reserve) have already been identified by the community as unsuitable for the APM Project.

    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 and area need to be sustained throughout this process, including multiple election cycles.

    b. The potential effects of the project on the community 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. Wawa 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 would 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. 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 site for the APM Project.

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 Wawa 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 Wawa 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 Wawa through the implementation of the project.

3. There is some potential for sustained interest in Wawa 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 Wawa to be suitable for the project from the multiple perspectives of:

- Engineering logistics;
- Geoscientific suitability;
- Environment 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 Wawa area has some potential to host the APM Project.

- The APM Project has the potential to be safely located in a suitable site within or near Wawa 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 Wawa 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 Wawa area.

- There appears to be potential for the APM Project to foster well-being in Wawa. The project is understood to be compatible with many community aspirations, including the desire to see growth and stability. The APM Project has potential to assist Wawa in achieving some of its goals, and is seen by some residents and leaders as a potential opportunity for sustainable growth and the development they desire. However, from the perspective of some community members, the APM Project may conflict with the community's nature-based and/or ecotourism focus.

- There is some potential for sustained interest in the local community. This is evidenced by support from some community leadership to continue participation in the site selection process. However, for some in the community, the APM Project may not be aligned with community aspirations and values, particularly with respect to the natural environment and the community's ecotourism objectives. This will pose a challenge to sustaining interest in learning about the project.

- There is potential for the APM Project to foster well-being in the communities surrounding Wawa. 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 potential for sustained interest in the surrounding communities as Wawa has engaged its neighbours, including members of the Northeast Superior Mayors' Group, although some surrounding communities have expressed concern. 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 begin 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 Wawa 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 presence of major regional faults, the occurrence of numerous dykes, and the low resolution of available geophysical data over most of the Wawa area.

2. Environment and safety studies suggest there is potential to implement the project safely and with respect for the environment in the Wawa 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. Once smaller potential siting areas have been identified in the Wawa area, 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. Some areas (in proximity to the waterfront and in the proposed Conservation Reserve) have already been identified by the community as unsuitable for the APM Project.

    - 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. Wawa 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 Wawa 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 Wawa 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 Municipality of Wawa 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 relatively stronger 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.

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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*.)

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.

Ductile – Deformation without fracturing of the internal structure of a rock in response to stress. Ductile deformation usually occurs at several kilometres deep in the ground where high pressures are combined with high temperatures and low strain rates.

Ductile lineament – An interpreted curvilinear trace on remote sensing and geophysical data where the bedrock has undergone ductile deformation.

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.

Gravity data – Data gathered by measuring variations in the Earth's gravitational field caused by differences in the density of subsurface rocks.

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).

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

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

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.

Iron formation – A thin-bedded, chemical sedimentary rock containing at least 15 per cent iron of sedimentary origin.

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-coloured minerals.

Magnetic data – See Aeromagnetic Data definition.

Massive (rock) – A durable rock that is considered to be essentially isotropic, homogeneous, and free of fractures, bedding, foliation and other planar discontinuities.

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.

Migmatization – Partial melting of rock resulting in a high-grade metamorphic rock known as migmatite.

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).

Outwash – Stratified detritus (i.e., sand and gravel) removed or "washed out" from a glacier by meltwater streams, and deposited in front of or beyond the end moraine or the margin of an active glacier.

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.

Shear zone – A zone of strong deformation that may exhibit brittle and/or ductile characteristics, surrounded by rocks that are less deformed.

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

Supracrustal – Rocks that overlie the basement.

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.

Ultramafic – Term to describe an igneous rock composed of > 90 per cent mafic minerals.

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.