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 MUNICIPALITY OF SOUTH BRUCE, ONTARIO

FINDINGS FROM PHASE ONE STUDIES

APM-REP-06144-0121

DECEMBER 2014

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 initiating the siting process in 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 South Bruce is one of 14 communities currently 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 South Bruce in the APM process began in January 2012 when the Mayor and Council approached the NWMO to learn more about the program. This request came to the NWMO in response to an open invitation to communities and groups to learn more about Canada's plan. Highlights of South Bruce's engagement to date in this Learn More process are provided below.

The Municipality has actively pursued learning opportunities to become better informed about the project and nuclear waste management in general. The costs associated with these learning activities were covered by the NWMO as part of a funding program provided to interested communities.

In March 2012, members of Council and Municipality staff received a briefing from the NWMO and toured the Western Waste Management Facility at the Bruce generating station.

The Municipality's Council passed a resolution that same month to request an initial screening of the community's potential suitability for the project. This request came to the NWMO in response to an open invitation to communities to learn more about APM with the understanding the community could end its involvement at any time. In early May 2012, the NWMO delivered a presentation to community officials in South Bruce to review the plan for conducting this initial screening and to confirm details of the work.

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
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project in the municipal office. Smaller document stands were also set up in local libraries. These were later moved to local community centres, to continue to reach more residents.

The Municipality of South Bruce also expressed interest, in March of 2012, in pursuing a strategic planning exercise. The NWMO was able to help support this work, by committing to funding per the Step 2 resource program assuming the successful completion of the initial screening.

In August 2012, representatives from the Municipality met with members of the Canadian Nuclear Safety Commission (CNSC) in Ottawa to continue their learning.

Upon completing the initial screening in August 2012, the NWMO and the contractor that conducted the work presented findings 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 South Bruce from further consideration in the site selection process.*"

At the invitation of Council, the NWMO convened a 2-day open house in South Bruce in September 2012 to review initial screening results and to share information about the project and site selection process. The open house was advertised via local newspapers, radio and online outlets. Individuals and groups who met with the NWMO during these events included members of town council and staff, students, representatives from the business community, seniors, farmers, conservation authority staff, and members of the general public.

On September 30 to October 2, the Mayor and CAO attended the International Conference on Geological Repositories to learn about how other countries are approaching site selection processes.

Following these activities, Council expressed an interest in learning more about preliminary assessments, the next step in the site selection process. Upon request, in November 2012 the NWMO provided a briefing to Council that outlined what would be involved should the Council wish to proceed to this step. After further consideration, Council passed a resolution later that month 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 within the community, Council established Terms of Reference for a South Bruce Nuclear Waste Community Liaison Committee (SBCLC) in February 2013. The SBCLC 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.

The community and Council members who volunteered for the committee were convened by May 2013 and SBCLC held its first meeting in June 2013; when the NWMO was invited to provide a briefing about its approach to the first phase of work in preliminary feasibility studies.

SBCLC 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 committee continued to work closely with the NWMO to plan

local dialogues and engagement, as well as early outreach to First Nation and Métis communities in the vicinity and surrounding communities.

The SBCLC made a visit to the OPG interim storage facility at the Western Waste Management Facility in December 2013, followed by a briefing with the NWMO.

To support engagement in the assessment process, the SBCLC established a monthly meeting schedule, with NWMO staff attending as requested to be part of the discussion and to work with the committee to complete preliminary assessment studies. Meetings were advertised in advance and open to the public. The committee also appointed a project coordinator, established a website and regular community newsletter, sought presentations from NWMO staff specialists about topics of interest to the committee, and helped organize multi-day open houses in both February and May of 2014. 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. SBCLC members attended to meet with the neighbours and explain the work of the committee and answer questions.

The May 2014 open house 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.

Working collaboratively, the Municipality, the SBCLC and the NWMO also undertook a wide range of outreach activities with local individuals and groups such as political leaders, first responders, municipal staff, community group members, agricultural organizations, business leaders, and potentially affected First Nation and Métis communities.

To support ongoing dialogue with the community, the NWMO opened a local office and Learn More Centre (LMC) in the community in June 2013. The South Bruce LMC was equipped with a permanent set of posters displays, videos, and printed material and NWMO staff working from the office several days each month were available to address questions, concerns and comments from community members dropping into the office. This office was first opened in Formosa and was relocated to Teeswater and Mildmay as well.

With SBCLC support, the NWMO also took part in the 2014 Mildmay Fall Fair, as a way to interact with residents and share information about the project. A broad range of community leaders were also engaged through individual briefings and conversations held as part of the study process.

In April 2014, CNSC staff made a presentation to the neighbouring Huron-Kinloss committee; and South Bruce CLC members travelled over to participate in the briefing. CNSC returned to Huron-Kinloss for an informational open house over 2 days in August 2014, and again SBCLC members attended.

The SBCLC was actively involved in the development of a community profile and guided the NMWO in its efforts to understand community priorities, objectives and interests with respect to the APM Project.

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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 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 potentially affected First Nation and Métis communities, and surrounding communities.

With 14 of the original 22 communities still engaged in exploring their interest and suitability for hosting the APM Project, the site selection process must provide a basis for progressively identifying a smaller number of communities for more detailed assessment. Through increasingly more detailed studies, communities with strong potential to meet the project's specific requirements will be identified to become the focus of further assessment.

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

TABLE OF CONTENTS

Page

1. INTRODUCTION 1

1.1 The Purpose of This Document 1
1.2 Towards Partnership 1
1.3 A Matter of Responsibility 2
1.4 The Foundation of Canada's Plan 2
1.5 The Site Selection Process 3
1.6 Initial Community Involvement 5
1.7 Approach to Preliminary Assessments 6
1.8 Next Steps 10
1.9 Moving Forward in Partnership 11
1.10 Organization of Report 11

2. INTRODUCTION TO THE Municipality of South Bruce 13

3. PRELIMINARY ASSESSMENT OF ENGINEERING 17

3.1 Engineering Assessment Approach 17
3.2 Characteristics of the Material to Be Managed: Used Nuclear Fuel 17
3.3 Conceptual Description of the APM Facility 18
3.4 APM Surface Facilities 19
3.4.1 Used Fuel Container 20
3.4.2 Used Fuel Packaging Plant 21
3.4.3 Sealing Materials Production Plants 22
3.4.4 Shafts and Hoists 23
3.5 Underground Facilities 24
3.6 Centre of Expertise 27
3.7 Engineering Feasibility in the South Bruce Area 27
3.8 Engineering Costs for South Bruce 28
3.9 Engineering Findings 30

4. PRELIMINARY ASSESSMENT OF GEOSCIENTIFIC SUITABILITY 31

4.1 Geoscientific Preliminary Assessment Approach 31
4.2 Geoscientific Site Evaluation Factors 32
4.3 Geoscientific Characteristics of the Communities 32
4.3.1 Physical Geography 32
4.3.2 Bedrock Geology 33
4.3.3 Quaternary Geology 36
4.3.4 Erosion 36
4.3.5 Seismicity and Neotectonics 36
4.3.5.1 Seismicity 36
4.3.5.2 Neotectonic Activity 37
4.3.6 Hydrogeology and Hydrogeochemistry 37
4.3.6.1 Overburden Aquifers 38
4.3.6.2 Bedrock Aquifers 39
4.3.6.3 Shallow Groundwater Regime 40
4.3.6.4 Formation Hydraulic Pressures 40
4.3.6.5 Hydrogeochemistry 41
4.3.7 Natural Resources 42
4.3.8 Geomechanical and Thermal Properties 43

4.4 Potential Geoscientific Suitability of the Communities ... 43
4.4.1 Potential for Finding General Potentially Suitable Areas ... 43
4.4.1.1 Town of Saugeen Shores ... 45
4.4.1.2 Municipality of Arran-Elderslie ... 46
4.4.1.3 Municipality of Brockton ... 47
4.4.1.4 Municipality of South Bruce ... 48
4.4.1.5 Township of Huron-Kinloss ... 49
4.4.2 Evaluation of General Potentially Suitable Areas in the Communities ... 50
4.4.2.1 Safe Containment and Isolation of Used Nuclear Fuel ... 50
4.4.2.2 Long-term Resilience to Future Geological Processes and Climate Change ... 51
4.4.2.3 Safe Construction, Operation and Closure of the Repository ... 53
4.4.2.4 Isolation of Used Fuel from Future Human Activities ... 53
4.4.2.5 Amenability to Site Characterization and Data Interpretation Activities ... 54
4.5 Geoscientific Preliminary Assessment Findings ... 54

5. PRELIMINARY ENVIRONMENT AND SAFETY ASSESSMENT ... 65

5.1 Environment and Safety Assessment Approach ... 65
5.2 Description of the Environment ... 66
5.2.1 Communities and Infrastructure ... 66
5.2.2 Natural Environment ... 67
5.2.3 Natural Hazards ... 69
5.2.4 Environment Summary ... 70
5.3 Potential Environmental Effects ... 71
5.3.1 Potential Effects during the Site Selection Process ... 71
5.3.2 Potential Effects during Construction ... 73
5.3.3 Potential Effects during Operation ... 75
5.3.4 Potential Effects during Decommissioning and Closure ... 78
5.3.5 Potential Effects during Monitoring ... 80
5.4 Postclosure Safety ... 80
5.4.1 Postclosure Performance ... 80
5.4.2 Postclosure Assessment ... 81
5.5 Climate Change Considerations ... 83
5.5.1 Near-Term Climate Change ... 83
5.5.2 Glaciation ... 83
5.6 Environment and Safety Findings ... 84

6. PRELIMINARY ASSESSMENT OF TRANSPORTATION ... 87

6.1 Introduction ... 87
6.2 Regulatory Framework ... 87
6.2.1 Canadian Nuclear Safety Commission ... 88
6.2.2 Transport Canada ... 88
6.2.3 Provincial and Local Safety Responsibilities ... 89
6.3 Transportation Safety ... 89
6.3.1 CANDU Used Nuclear Fuel ... 89
6.3.2 Used Fuel Transportation Package ... 90
6.3.3 Commercial Vehicle Safety ... 91
6.3.4 Radiological Safety ... 91
6.3.5 Radiological Dose ... 92
6.4 Used Fuel Quantities and Transport Frequency ... 93
6.5 Used Fuel Transportation Experience ... 93

6.6 Transportation Operations 94
6.6.1 Responsibility 94
6.6.2 Communications 94
6.6.3 Security 95
6.6.4 Emergency Response Planning 95
6.7 Transportation Logistics to South Bruce 95
6.7.1 Existing Transport Infrastructure 97
6.7.2 Road Transport from Interim Storage to a Repository 97
6.7.3 Railroad Transport from Interim Storage to a Repository 99
6.7.4 Weather 100
6.7.5 Carbon Footprint 100
6.7.6 Conventional Accidents 101
6.7.7 Transportation Costs to South Bruce 101
6.8 Transportation Findings 102

7. PRELIMINARY SOCIAL, ECONOMIC AND CULTURAL ASSESSMENT 105

7.1 Approach to Community Well-Being Assessment 105
7.1.1 Activities to Explore Community Well-Being 106
7.1.2 Assumptions of the APM Project – Drivers of Community Well-Being 106
7.2 Community Well-Being Assessment – Implications of the APM Project for South Bruce 108
7.2.1 Community Aspirations and Values 108
7.2.2 Implications for Human Assets 110
7.2.3 Implications for Economic Assets 111
7.2.4 Implications for Infrastructure 113
7.2.5 Implications for Social Assets 114
7.2.6 Implications for Natural Environment 115
7.2.7 Summary of APM and its Implications for South Bruce 116
7.3 Criteria to Assess Factors Beyond Safety – Summary in South Bruce 119
7.4 Overview of Engagement in South Bruce 123
7.4.1 Summary of Issues and Questions Raised 124
7.5 Community Well-Being Findings 124

8. REFLECTION ON POTENTIAL SUITABILITY 127

8.1 Early Findings 127
8.2 Preliminary Conclusions 127
8.3 Observations About Suitability 128
8.3.1 General Observations 128
8.3.2 Uncertainties and Challenges 129
8.4 Partnership 131
8.5 The Way Forward 131

9. REFERENCES 133

10. GLOSSARY 143

LIST OF TABLES

Page

Table 1-1: Steps in the Site Selection Process – At a Glance 4
Table 3-1: Estimated APM Facility Expenditures by Implementation Phase 29
Table 4-1: Stratigraphy of the Area of the Five Communities (after Armstrong and Carter, 2010) 34
Table 4-2: Water Well Record Summary for the Communities 38
Table 5-1: Summary of Environmental Features within Huron-Kinloss, Brockton and South Bruce 70
Table 5-2: Potential Interactions with the Biophysical Environment during Site Selection Process 72
Table 5-3: Potential Interactions with the Biophysical Environment during Construction 75
Table 5-4: Potential Interactions with the Biophysical Environment during Operation 77
Table 5-5: Potential Interactions with the Biophysical Environment during Decommissioning and Closure Activities 79
Table 6-1: Maximum Public Individual Dose due to Used Fuel Transported by Road 92
Table 6-2: Estimated Used Fuel Quantities by Owner 93
Table 6-3: Transport Summary from Interim Storage Sites to South Bruce, Ontario 97
Table 6-4: All Road Transport from Interim Storage Sites to South Bruce, Ontario 98
Table 6-5: Mostly Rail Transport from Interim Storage Sites to South Bruce, Ontario 99
Table 6-6: Used Fuel Transportation Program Costs – 4.6 million Bundles 101
Table 7-1: On-Site Workforce 107
Table 7-2: Overall Community Well-Being Implications – South Bruce 117
Table 7-3: Summary Table of Criteria to Assess Factors Beyond Safety – South Bruce 121

LIST OF FIGURES

Page

Figure 1-1: Communities Involved in the Site Selection Process 6
Figure 1-2: The Phase 1 Preliminary Assessment Studies 8
Figure 2-1: South Bruce and Surrounding Lands 14
Figure 3-1: CANDU Fuel Bundle 17
Figure 3-2: Illustration of an APM Facility 19
Figure 3-3: APM Surface Facilities 20
Figure 3-4: Example of a Used Fuel Container for a Deep Geological Repository 21
Figure 3-5: Conceptual Layout of a Used Fuel Packaging Plant 22
Figure 3-6: Example of a Large Press for the Sealing Material Compaction Plant 23
Figure 3-7: Horizontal In-room Placement of Used Fuel Containers 24
Figure 3-8: Example of an Underground Layout for a Deep Geological Repository 26
Figure 4-1: The Area of the Five Communities 57
Figure 4-2: Ground Surface Elevation of the Area of the Five Communities 58
Figure 4-3: Bedrock Geology, Oil and Gas Wells, and 2D Seismic Lines of the Area of the Five Communities 59
Figure 4-4: Regional Geological Cross Section of the Eastern Flank of the Michigan Basin 60
Figure 4-5: Surficial Geology and Groundwater Wells within the Area of the Five Communities 61
Figure 4-6: Historical Earthquake Records of Southern Ontario, 1985-2013 62
Figure 4-7: Petroleum, Mineral, and Deep Groundwater Resources in the Area of the Five Communities 63

Figure 4-8: Key Geoscientific Characteristics and Constraints in the Area of the Five Communities 64
Figure 5-1: Infrastructure and Land Use within Huron-Kinloss, Brockton and South Bruce 85
Figure 5-2: Natural Environment within Huron-Kinloss, Brockton and South Bruce 86
Figure 6-1: Used Fuel Transportation Package 91
Figure 6-2: Example Transport Processes for Used Nuclear Fuel 96
Figure 6-3: Highway 9 near Mildmay in South Bruce 96
Figure 7-1: Direct and Indirect Effects From the Project 108

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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. 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 South Bruce, 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 South Bruce, it is understood that a broader partnership involving potentially affected First Nation and Métis communities, and surrounding communities, would be needed in order for the project to proceed in this or any other area.

Through working with South Bruce and other communities involved in the site selection process in Phase 1 activities, and initial outreach with First Nation and Métis communities in the vicinity, and surrounding communities, 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, potentially affected First Nation and Métis communities, and other communities in the surrounding 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. Over 2.5 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.
	Phase 2: Field investigations and expanded regional engagement proceed with smaller number of communities.
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 potentially affected First Nation and Métis communities, and surrounding 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.

Twenty-two communities have entered the site selection process since it began in 2010. There are 14 communities involved in the site selection process (4 are in Phase 2 of Step 3; 10 are in Phase 1 of Step 3). Figure 1-1 maps the locations of these communities in Saskatchewan and Ontario.

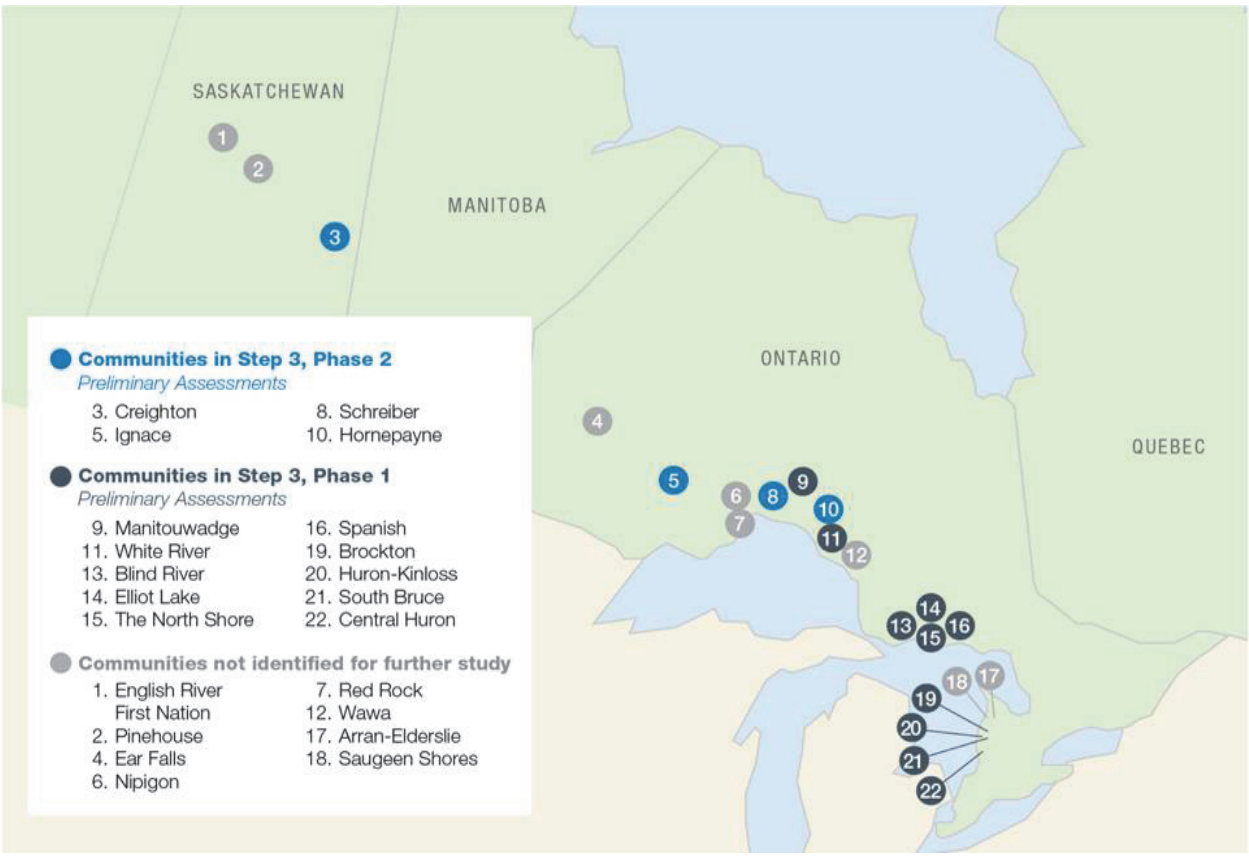

Figure 1-1: Communities Involved in the Site Selection Process

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 potentially affected First Nation and Métis communities, and surrounding communities 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 First Nation and Métis communities in the vicinity, and surrounding communities 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, potentially affected First Nation and Métis communities, and surrounding communities will reflect upon the suitability of the community and area to host the APM Project. Phase 2 Preliminary Assessments are expected to require a number of 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 Figure 1-2: The Phase 1 Preliminary Assessment Studies.

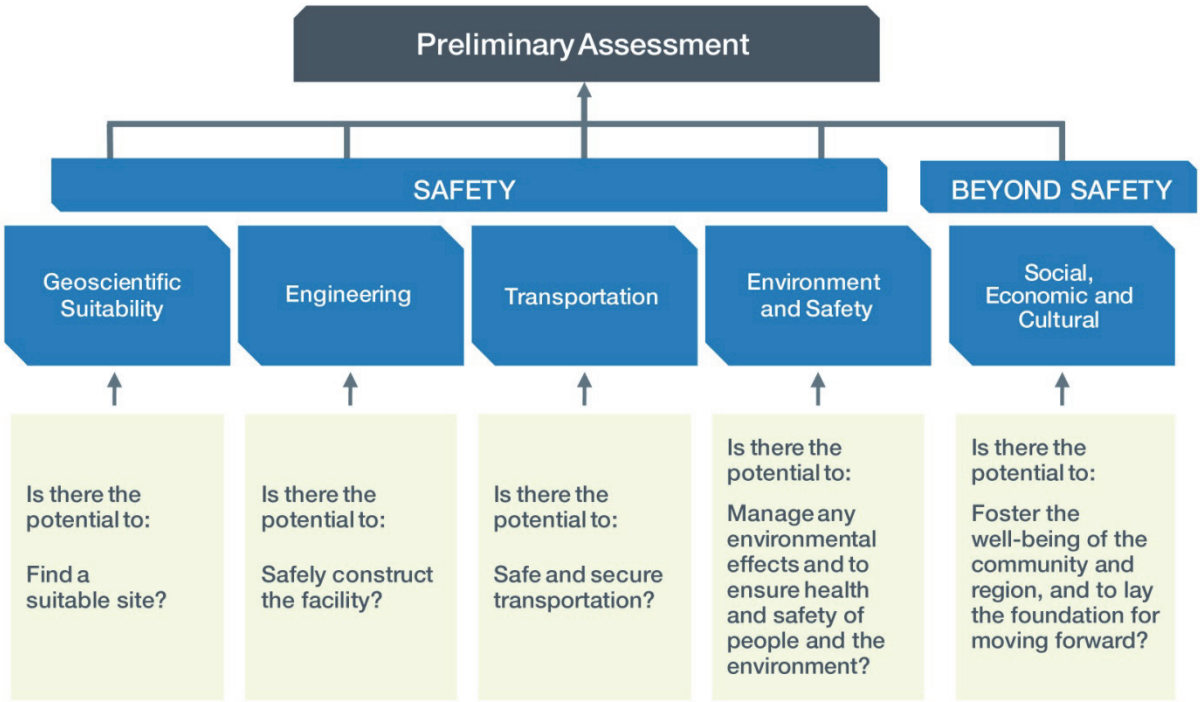

Figure 1-2: The Phase 1 Preliminary Assessment Studies

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 potentially affected First Nation and Métis communities and surrounding communities 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 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 processes 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?

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 First Nation and Métis communities in the vicinity and surrounding communities. 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 community, and identify opportunities to leverage the project to achieve other objectives important to people in the community and surrounding areas.

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, potentially affected First Nation and Métis communities, and surrounding communities before a preferred safe site for the project can be confirmed.

With 14 communities continuing to explore 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.

- In November 2013, the NWMO implemented 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). Four of these communities with strong overall potential to meet the site selection requirements were identified as warranting further study through Phase 2 assessments. These communities are Creighton, Ignace, Schreiber, and Hornepayne.

- In January 2014, the NWMO concluded siting studies in the Municipality of Arran-Elderslie and the Town of Saugeen Shores. Early findings indicate that the Town of Saugeen Shores has very limited potential to contain areas that would meet the geoscientific site evaluation factors outlined in the site selection process document. Similarly, the Municipality of Arran-Elderslie does not contain sufficient land areas that have the potential to meet these factors (Geofirma, 2014; NWMO, 2014a).

- In June, 2014 the Township of Nipigon passed a resolution to discontinue its involvement as a potential host community for Canada's plan for the safe, long-term management of used nuclear fuel. The decision followed review of an interim report (NWMO, 2014b; DPRA, 2014; Golder, 2014), which the NWMO prepared at the request of the Township to report on preliminary assessment work completed in the community so far.

- In 2015, 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 First Nation and Métis communities in the vicinity and surrounding communities 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 a number of 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 First Nation and Métis communities in the vicinity and surrounding communities, the NWMO is learning about the nature and shape of partnerships that will be required to implement the APM Project together. Involving potentially affected First Nation and Métis communities and surrounding communities 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, potentially affected First Nation and Métis communities, and other communities in the surrounding area 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 South Bruce 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 SOUTH BRUCE

The Municipality of South Bruce was created in 1999 with the amalgamation of the Village of Mildmay, Township of Carrick, Village of Teeswater and the Township of Culross. Teeswater is the seat of the Municipality. South Bruce is situated in the southeast corner of Bruce County and is located inland from Lake Huron. Figure 2-1 shows South Bruce in its regional context.

According to 2011 Census data, the total population of the Municipality is 5,685. South Bruce has a strong agricultural sector. It consists of a large rural area interspersed with smaller settlement areas. The three main population centres in South Bruce are Formosa, Mildmay and Teeswater, while the hamlet communities include Carlsruhe and Deemerton. South Bruce is predominantly an agricultural community The Teeswater River runs through the village bearing its name, and is the most noteworthy body of water in South Bruce. The Greenock Swamp is partly located in the municipality of South Bruce in the north western corner of the municipality.

There are a number of First Nation and Métis communities and organizations in the vicinity of South Bruce, including The Saugeen Ojibway Nations (Saugeen First Nation and Chippewas of Nawash Unceded First Nation). Métis Nation of Ontario community councils in the vicinity include Moon River Métis, Georgian Bay Métis, and Great Lakes Métis. The Historic Saugeen Métis are also located in the vicinity.

A more in-depth discussion of South Bruce and the surrounding area is contained in the Community Profile (AECOM, 2014) and is woven throughout the chapters of this report, including the geoscientific characteristics of the South Bruce area, the natural environment, transportation infrastructure, and the people and activities which contribute to the well-being of the community.

Figure 2-1: South Bruce 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, First Nation and Métis communities in the vicinity, and surrounding communities.

Throughout this work, the NWMO will look to First Nation and Métis communities in the vicinity 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.

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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 Municipality of South Bruce. The chapter also identifies infrastructure that would be required to safely construct and operate the facility in South Bruce. 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 additional 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 South Bruce 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 500 millimetre, a diameter of about 100 millimetre 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 average 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 over 2.5 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 assumed a reference used fuel inventory of 4.6 million used CANDU fuel bundles (Garamszeghy, 2013).

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

Conceptual reference designs have 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 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 nominally 600 metres by 550 metres for the main surface buildings and about 100 metres by 100 metres for the ventilation shaft area which can vary with actual site characteristics. In addition, the APM facility will need an excavated rock management storage area of about 700 metres by 700 metres for the rock excavated from the underground repository; its location would be determined in collaboration with the community.

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

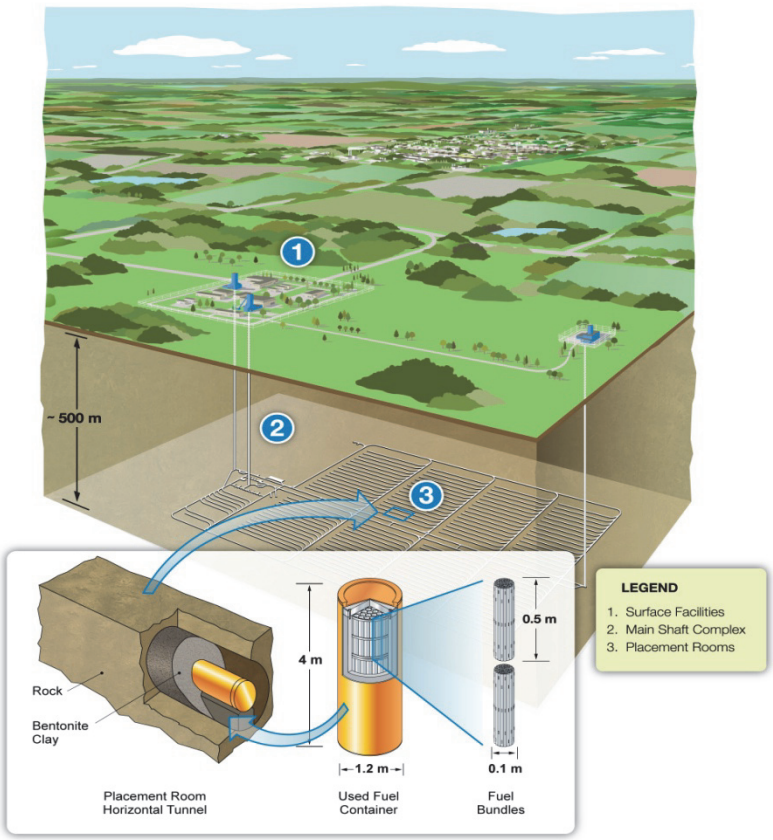


Figure 3-2: Illustration of an APM Facility

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

The layout of the underground repository has been developed for a projected reference inventory of 4.6 million used CANDU fuel bundles. It would require a subsurface area of about 2 kilometres by 3 kilometres at a depth of approximately 500 metres within a suitably thick and competent rock formation such as the Ordovician Cobourg Formation (limestone). 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 shaft buildings, auxiliary building, quality control offices, laboratory, active waste handling facilities, switch yard, and transformer area

The Balance of Site includes the administration building, fire hall, security monitoring room, cafeteria, water and sewage treatment plants, fuel storage tanks, water storage tanks, air compressor building, concrete batch plant and sealing materials compaction plant. An excavated rock management area for the excavated rock from the underground repository would also be required; its location would be determined in collaboration with the community.

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

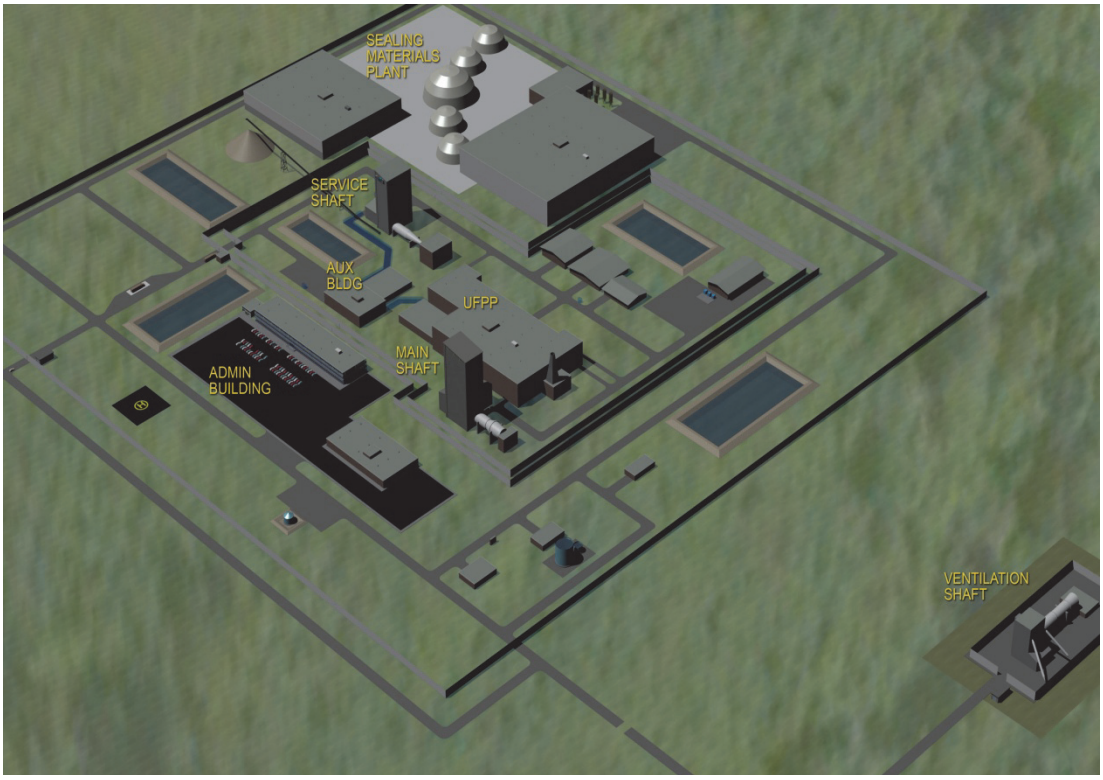


Figure 3-3: APM Surface Facilities

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

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

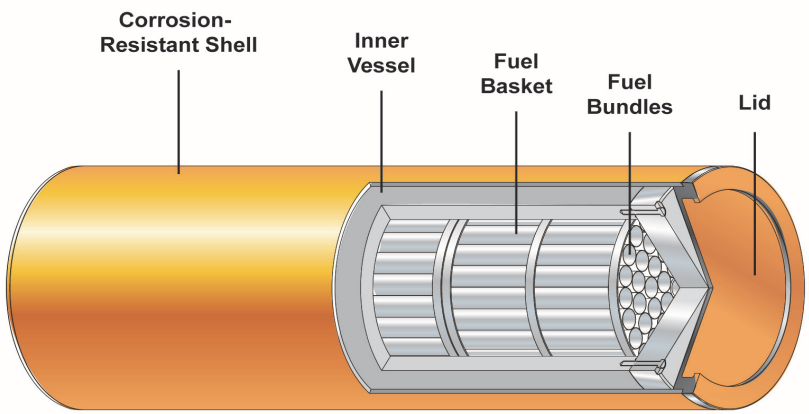


Figure 3-4: Example of a Used Fuel Container for a Deep Geological Repository

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.

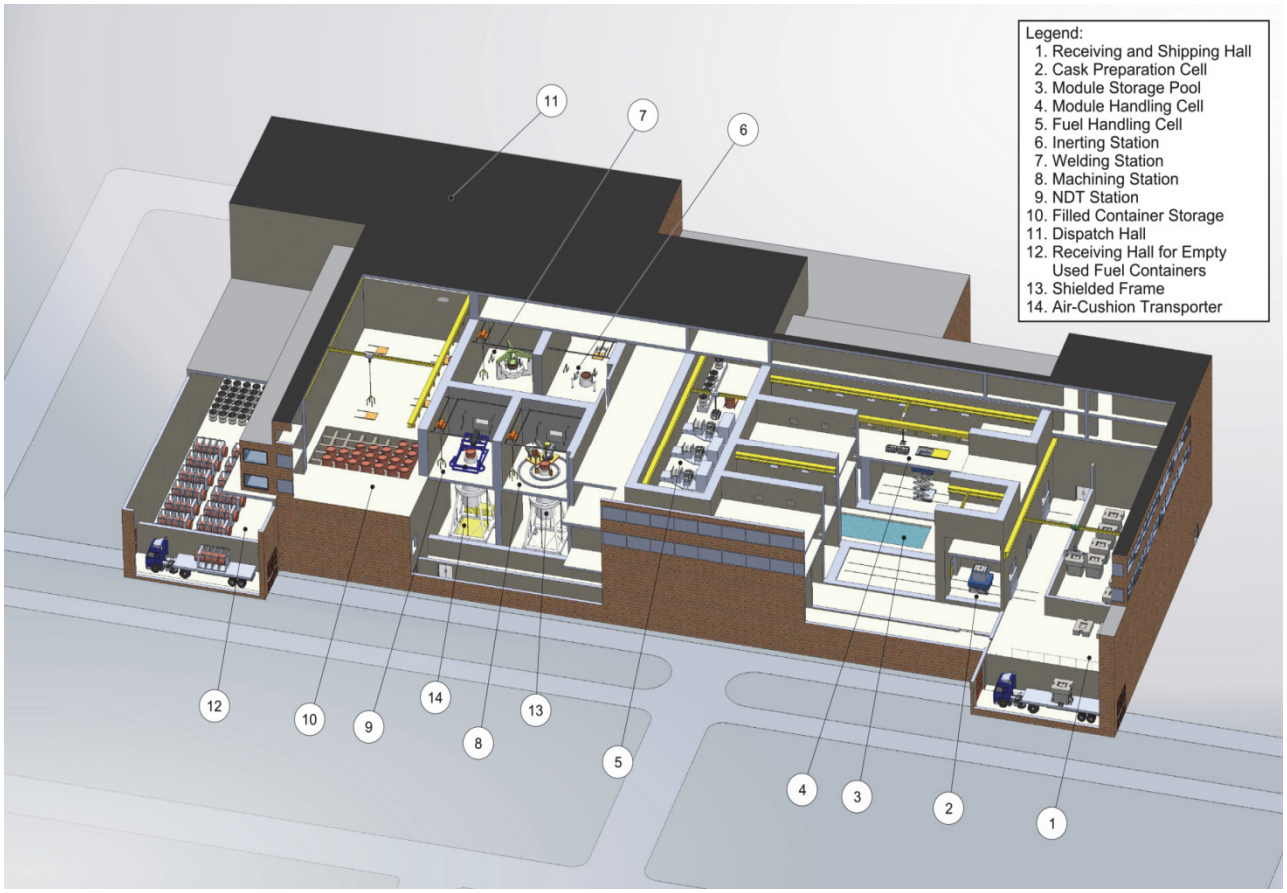


Figure 3-5: Conceptual Layout of a Used Fuel Packaging Plant

3.4.3 Sealing Materials Production Plants

The Sealing Material Production Plants provide materials for the clay-based and cement-based engineered barriers in the repository which backfill and seal excavation openings, and inhibit groundwater movement, microbial activity, and radionuclide transport in the region surrounding the used fuel containers.

The sealing materials prepared at the production plants include materials such as:

- Highly compacted bentonite blocks;
- Dense backfill composed of bentonite and aggregate;
- Light backfill composed of bentonite and sand;

- Gapfill composed of bentonite pellets;
- Shaft seal composed of bentonite and sand; and
- Low-heat high-performance concrete.

Crushed rock and sand for the backfill and concrete will be imported to the site and stockpiled for use in the compaction plant where presses will be used to prepare dense backfill blocks and gapfill material (see Figure 3-6). Aggregate will be brought to site for use in the Concrete Batch Plant.

Figure 3-6: Example of a Large Press for the Sealing Material 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: Conveys the used fuel containers within a shielded transfer cask;
- Service Shaft: Conveys personnel, equipment, waste rock and sealing materials; and
- Ventilation Shaft: Will handle the majority of the repository exhaust to the surface and will be equipped as an emergency egress hoist.

The headframes of the three shafts will be durable and easily maintainable structures that will provide a high level of protection against weather-related disturbances. All shafts will be concrete-lined as needed to help control the inflow of water and to provide a durable, easy-to-maintain surface.

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 and 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 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-room placement of used fuel containers is illustrated in Figure 3-7. This approach for container placement is consistent with reference repository design developed by the national radioactive waste management organization in Switzerland (NAGRA). Each placement room is designed to be 2.5 metres in diameter with a length of about 425 metres and a centre-to-centre room spacing of 20 metres. Within a placement room, the used fuel containers have a centre-to-centre spacing of 8 metres.

Each used fuel container is placed onto a pedestal that is made from highly compacted bentonite. The placement room around the used fuel container is filled with bentonite pellets. Each group of placement rooms, or a “placement panel,” would require about three to four years to develop and would be excavated in parallel with container placement operations in a previously completed panel in another area of the repository.

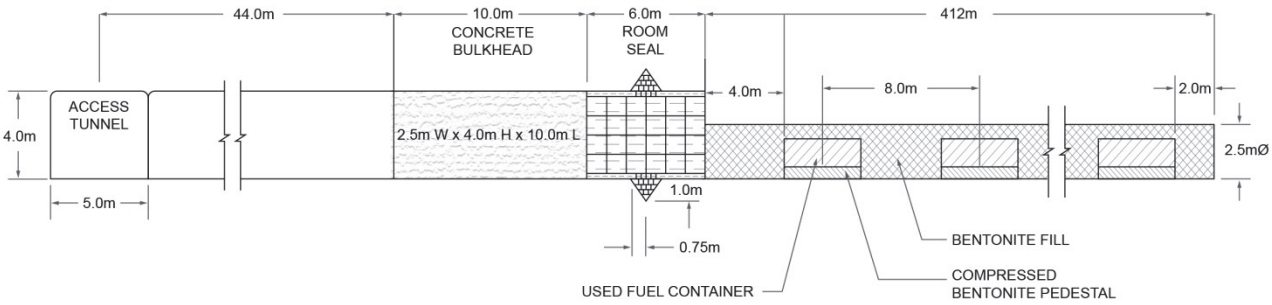


Figure 3-7: Horizontal In-room Placement of Used Fuel Containers

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 tunnels and two perimeter tunnels connected by perpendicular tunnels 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).

After used fuel container placement, a 6-metre-thick bentonite seal and a 10-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.

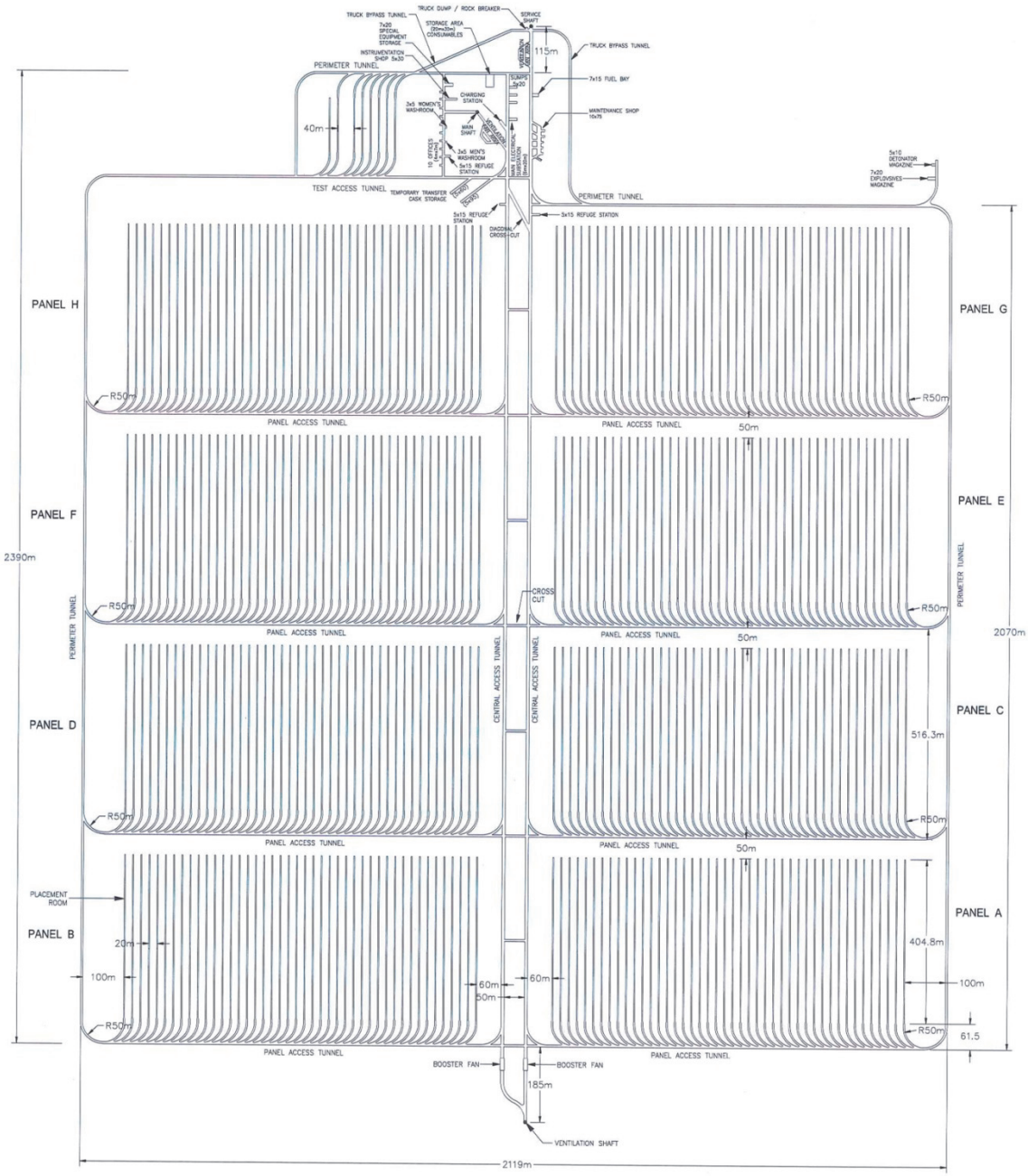


Figure 3-8: Example of an Underground Layout for a Deep Geological Repository

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 is illustrated in Figure 3-8.

3.6 Centre of Expertise

A Centre of Expertise will be established for the one or more communities in which a site has been selected for detailed evaluation (Step 4 of the siting process). The centre will be located in or near the community, as determined 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, socioeconomic and cultural impact assessment. The technologies and monitoring processes involved in the operation of a deep geological repository may be of interest and have applications in the community beyond the deep geological repository. This will be explored with the community. The design details of the Centre of Expertise would be developed with the community, potentially affected First Nation and Métis communities, and surrounding communities, with their preferences in mind. Discussion of the design details is also an important opportunity for involvement of youth. The Centre of Expertise could also 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 could be created as a small science centre, highlighting and demonstrating the science and technology being used to determine whether the site is suitable. It may be developed as a meeting place and learning centre for the community, and as a destination that welcomes interested visitors from the region and beyond.

Should the site ultimately be selected to host the deep geological repository, the Centre of Expertise would be expanded to include and support construction and operation of an underground facility designed to confirm the characteristics of the site. The centre would become a hub for knowledge sharing across Canada and internationally.

As with some other aspects of the project, the exterior design of facilities, and the way they are incorporated into the landscape of the area, will be a subject of discussion and shared planning with those living in the area.

3.7 Engineering Feasibility in the South Bruce Area

The Municipality of South Bruce and the surrounding region are underlain by a thick sequence of sedimentary rock (see Section 4). The surface land is characterized as flat-lying which is amenable for the construction of an APM facility. The Municipality of South Bruce contains existing infrastructure that could be used for the APM Project, including highways and high-voltage transmission lines. The closest rail line ends in Goderich which could be used as an

intermodal transfer point. Goods and materials would be transferred from rail to truck, and then travel by road to the repository site located in South Bruce.

In order to implement the APM Project at a particular site in the Municipality of South Bruce, 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 Production Plant
  - Administration Building, Fire Hall and Cafeteria
  - Quality Control Offices and Laboratory
  - Water Treatment Plant
  - Sewage Treatment Plant
  - Storage Areas and Commons Services
  - Stormwater run-off ponds
- Upgrade 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 from a surface water body (alternatively, source could be nearby drilled water wells);
- A Centre of Expertise;
- Provision for accommodation for temporary workers for the limited period of construction; and
- An excavation rock management 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 included for financial planning purposes.

3.8 Engineering Costs for South Bruce

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 (see Section 3.2)

The estimated cost for the APM facility in the Municipality of South Bruce – that is the deep geological repository and surface handling facilities, as well as the Centre of Expertise – is assumed to be bounded by the $20.1 billion (2010 $) cost estimate for an APM facility developed in crystalline rock. (The transportation costs from the interim storage facilities at the reactor sites to the central APM facility in South Bruce 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 for an illustrative implementation schedule 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 APM Facility Expenditures by Implementation Phase

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

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

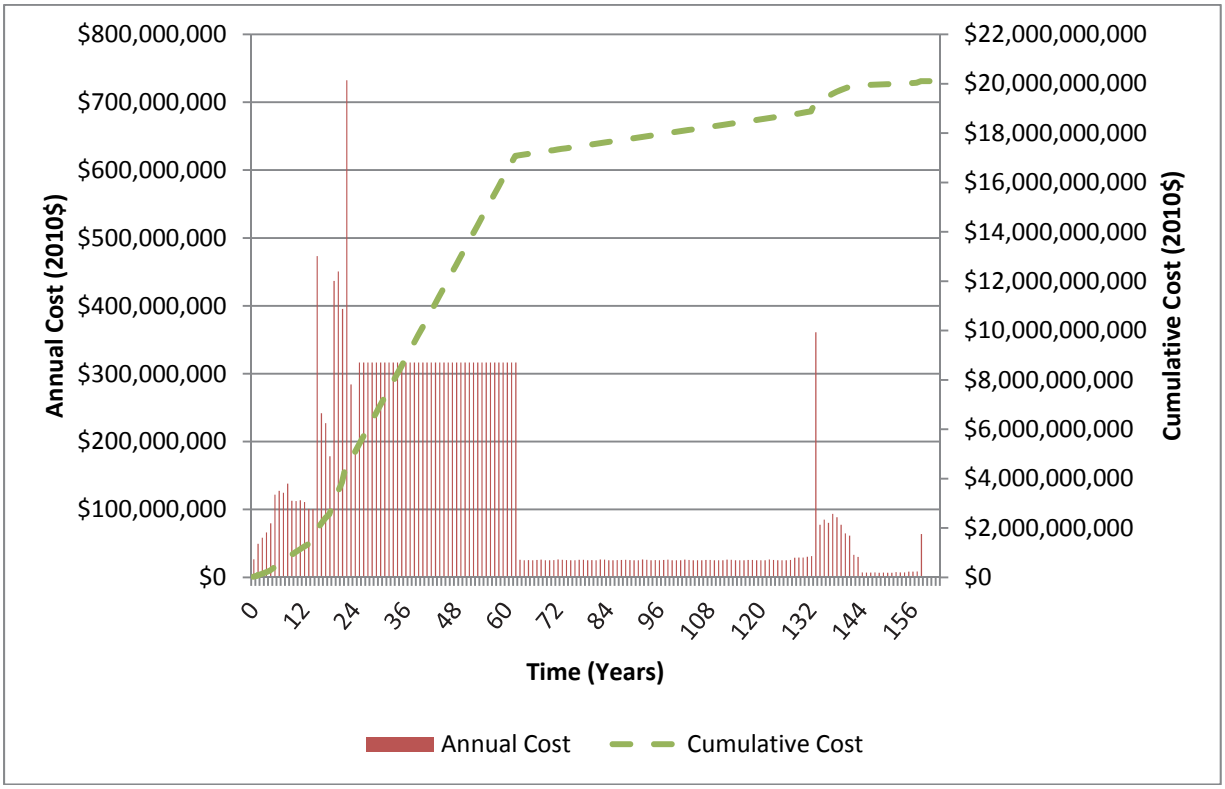


Figure 3-9: Estimated APM Facility Cash Flow

3.9 Engineering Findings

The engineering assessment of the Municipality of South Bruce found that the APM facility has the potential to be safely constructed and operated. The surface land is characterized as flat-lying, and sufficient space exists outside protected and built up areas to successfully locate the surface facilities. Additional information on the physical geography of the area is presented in Section 4.3. There are few surface topography features that would limit the construction and operation of the surface and underground facilities required by the APM Project. Further, the Municipality of South Bruce is located close to key infrastructure for the APM facility, including highways and high-voltage transmission lines (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, infrastructure, and engineering feasibility will be further refined.

4. PRELIMINARY ASSESSMENT OF GEOSCIENTIFIC SUITABILITY

4.1 Geoscientific Preliminary Assessment Approach

The Phase 1 geoscientific desktop preliminary assessment for the communities of Arran-Elderslie, Brockton, Huron-Kinloss, Saugeen Shores, andSouth Bruce, was conducted in an integrated manner considering the geoscientific characteristics of the five Bruce County communities that entered the site selection process. This chapter summarizes the geoscientific assessment of the Municipalities of Brockton and South Bruce, and the Township of Huron-Kinloss as part of the overall assessment of these five communities. Findings specific to the Municipalities of Brockton and South Bruce, and the Township of Huron-Kinloss are summarized in Section 4.4.1. The findings for the Municipality of Arran-Elderslie and the Town of Saugeen Shores are summarized in NWMO (2014a, b) and in Section 4.4.1. The geoscientific assessment was conducted by Geofirma Engineering Ltd. (Geofirma, 2014a).

The objective of the Phase 1 geoscientific desktop preliminary assessment was to assess whether the communities contain general areas that have the potential to satisfy the geoscientific evaluation factors outlined in the site selection process document (NWMO, 2010). The identification of potentially suitable areas focused on the area within the boundaries of the five communities [Municipalities of Arran-Elderslie, Brockton and South Bruce, Township of Huron-Kinloss, and Town of Saugeen Shores (shown in orange in Figure 3.1)]. Areas beyond the municipal boundaries of these five communities were not considered. However, for the purpose of the assessment, geoscientific information was collected and interpreted over a larger area comprising the five communities and their surroundings. The larger area is referred to in this chapter as the “Area of the Five Communities”, which is the entire area shown in Figure 3-1. The geoscientific desktop preliminary assessment built on the work previously conducted for the initial screenings (AECOM, 2012a; 2012b; 2012c; 2012d; 2012e) and included the following activities:

- Assembly and detailed review of available geoscientific information such as geology, structural geology, natural resources, hydrogeology and overburden deposits (surficial deposits);
- Interpretation of available geophysical surveys;
- Interpretation of available borehole geophysical data and selected 2-D seismic reflection surveys to provide information on the geometry and potential structural features of the subsurface bedrock geology;
- Terrain analysis studies to help assess overburden (surficial deposits) type and distribution, bedrock exposures, accessibility constraints, watershed and subwatershed boundaries, and groundwater discharge and recharge zones;
- Assessment of land use and protected areas including parks, conservation reserves, heritage sites and source water protection areas; and
- The identification and evaluation of general potentially suitable areas based on systematic assessment of key geoscientific characteristics and constraints that can be realistically assessed at this stage of the assessment.

The details of these various studies are documented in a main Geoscientific Suitability Report (Geofirma, 2014a) and three supporting documents: Terrain Analysis (JDMA, 2014); Geophysical Interpretation (PGW, 2014); and Borehole Geophysical Well Log and 2D Seismic Data Interpretation (Geofirma, 2014b).

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 processes 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 Communities 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 general 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 Area of the Five Communities (Section 4.3), followed by a summary of the geoscientific assessment of suitability (Section 4.4).

4.3 Geoscientific Characteristics of the Communities

The following sections provide a summary of available geoscientific information for the Area of the Five Communities 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 Area of the Five Communities is provided in the terrain analysis report (JDMA, 2014). There are six physiographic regions within the Area

of the Five Communities: Arran drumlin field, Horseshoe moraines, Huron fringe, Huron slope, Saugeen clay plain and Teeswater drumlin field.

The large-scale topography in the Area of the Five Communities is controlled by bedrock topography, whereas the detailed topography is often controlled by surficial deposits and erosional landforms cut into the surficial sediments. The pattern of elevation across the Area of the Five Communities (Figure 4-2) controls the overall pattern of drainage and is itself largely controlled by the bedrock topography. The elevation gradient in the Area of the Five Communities from southeast to northwest is from about 400 metres to 176 metres, with this elevation drop occurring over an approximate 70 kilometre lateral distance (Figure 4-2).

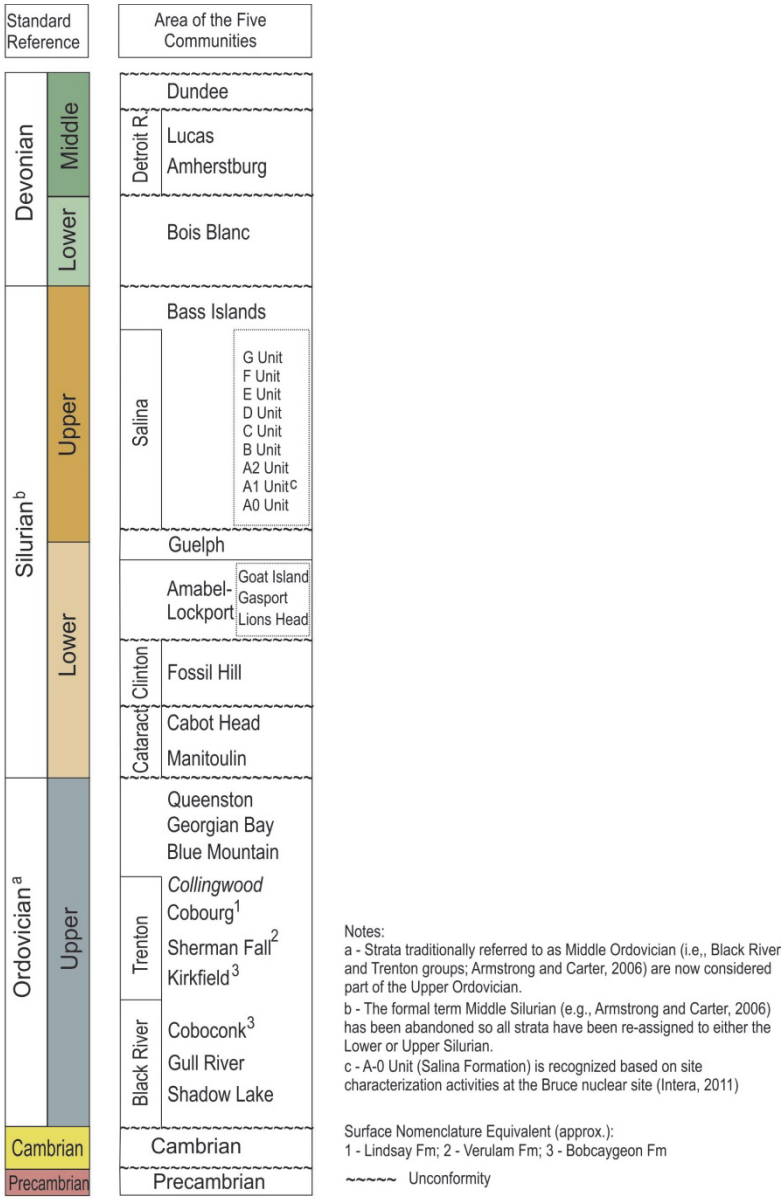
Overburden covers the bedrock surface throughout almost the entire area of the Communities, with overburden thicknesses ranging from zero up to about 104 metres, with the thickest overburden in the area associated with buried bedrock valleys (JDMA, 2014). Less than one percent of the Area of the Five Communities is occupied by water bodies of various sizes. The nine largest lakes in the area, aside from Lake Huron, cover from 0.4 to 3.9 square kilometres of the Area of the Five Communities.

4.3.2 Bedrock Geology

Information on the bedrock geology in the Area of the Five Communities was obtained from publically available reports and geologic maps, as well as from the interpretation of existing 2D seismic and borehole geophysical data (Geofirma, 2014b) and from the interpretation of existing airborne geophysical data (PGW, 2014) conducted as part of this preliminary assessment. The main geoscientific desktop preliminary assessment report (Geofirma, 2014a) provides a detailed description of the regional and local geology of the Area of the Five Communities. The bedrock geology and Quaternary geology are based on 1:250,000 scale geological maps from the Ontario Geological Survey (OGS, 2011) and 1:50,000 scale surficial Quaternary maps (OGS, 1997; 2010). 2D seismic interpretations were conducted by reinterpreting four historical 2D seismic reflection data lines (725937, 825938, A002800018, A003900020) that are available within the Area of the Five Communities (Figure 4-3). Detailed lithological and mineralogical information on the Paleozoic bedrock formations in the Area of the Five Communities is available from Armstrong and Carter (2010) and from studies completed as part of the work undertaken at the Bruce nuclear site for the proposed Low and Intermediate Level Waste Deep Geological Repository (AECOM Canada Ltd. and Itasca Consulting Canada Inc., 2011; Intera Engineering Ltd., 2011).

As shown on Figure 4-4, the Paleozoic sedimentary sequence of southern Ontario overlies the Precambrian crystalline basement of the Grenville Province of the Canadian Shield. In southern Ontario the lithology of the Paleozoic formations is generally similar over large distances, and therefore descriptions provided in Armstrong and Carter (2010) are indicative of what can be expected for the Area of the Five Communities. Table 4-1 illustrates the Paleozoic bedrock stratigraphy, which is 500 to 1000 metres thick, for the Area of the Five Communities.

Table 4-1: Stratigraphy of the Area of the Five Communities (after Armstrong and Carter, 2010)



The initial screenings (AECOM, 2012a; 2012b; 2012c; 2012d; 2012e) identified the Paleozoic Upper Ordovician shale and limestone sedimentary rock units as potentially suitable for hosting a deep geological repository for used nuclear fuel. These Upper Ordovician rocks comprise a thick sequence with a distinctly bimodal composition: a carbonate-rich lower unit and a shale-rich upper unit.

The lower carbonate-rich unit of the Upper Ordovician overlies the Cambrian unit, where present, or the Precambrian basement (Figure 4-4). It is a thick sequence (approximately 200 metre thick) predominated by limestone and argillaceous limestone formations, which include, from bottom to top: the Shadow Lake, Gull River and Coboconk formations of the Black River

Group; and the Kirkfield, Sherman Fall, and Cobourg (including the Collingwood Member) formations of the Trenton Group (Table 4-1). The Shadow Lake Formation, at the base of the Black River Group, is characterized by poorly sorted, red and green sandy shales, argillaceous and arkosic sandstones, minor sandy argillaceous dolostones and rare basal arkosic conglomerate. The lower part of the overlying Gull River Formation consists mainly of light grey to dark brown limestones and the upper part of the formation is very fine grained with thin shale beds and partings. The Coboconk Formation, at the top of the Black River Group, is composed of light grey-tan to brown-grey, medium to very thick bedded, fine to medium grained bioclastic limestones (Armstrong and Carter, 2010).

The Kirkfield Formation, at the base of the Trenton Group, is characterized by fossiliferous limestones with shaley partings and local, thin, shale interbeds. The overlying Sherman Fall Formation ranges in lithology from dark grey argillaceous limestones interbedded with calcareous shales, found lower in the formation, to grey to tan bioclastic, fossiliferous limestones that characterize the upper portions of the formation. The overlying Cobourg Formation is a grey, fine-grained limestone to argillaceous limestone with coarse-grained fossiliferous beds and a nodular texture. The Cobourg Formation is also subdivided to include an upper Collingwood Member that consists of dark grey to black, calcareous shales with increased organic content and distinctive fossiliferous limestone interbeds (Hamblin, 2003; Armstrong and Carter, 2010).

The upper unit of the Upper Ordovician succession is characterized by a thick sequence (approximately 200 metres) of predominantly shale sedimentary rocks, which comprise from base to top: the Blue Mountain, Georgian Bay and Queenston formations. The Blue Mountain Formation is characterized by uniform soft and laminated grey non-calcareous shale with minor siltstone and minor impure carbonate (Johnson et al., 1992; Hamblin, 1999). In the lower part of the Blue Mountain Formation there is downward gradation from grey to greenish-grey shales to a very dark grey to black shale (Armstrong and Carter, 2010). The overlying Georgian Bay Formation is composed of blue-grey shale with intermittent centimetre-scale siltstone and limestone interbeds. The Queenston Formation is characterized by maroon, and lesser green, shale and siltstone with varying minor amounts of carbonate. The top of the Queenston Formation is marked by a regional erosional unconformity (Table 4-1; Armstrong and Carter, 2010).

The Upper Ordovician shale and limestone packages exhibit relatively uniform thicknesses (i.e., about 200 metres each), and are known to dip uniformly to the southwest at between 0.23 degrees and 1degree in the Area of the Five Communities (e.g., Watts et al., 2009; Intera Engineering Ltd., 2011). The depth to the top of the Cobourg Formation ranges from about 350 metres below ground surface in the northern corner of the Municipality of Arran Elderslie to approximately 800 metres below ground surface at the southwestern boundary of the Township of Huron-Kinloss (Geofirma, 2014a). Erosion, pinnacle reef formation and salt bed dissolution introduce a certain degree of non-uniformity into the Paleozoic sequence in the Area of the Five Communities, mostly in relation to the thickness and presence/absence of certain Silurian formations (Geofirma, 2014a).

There are two mapped subsurface basement-seated faults within the Area of the Five Communities, one in the Municipality of Brockton and one that extends from the Municipality of South Bruce into the Township of Huron-Kinloss. Both are interpreted to be about 5 to 10 kilometres in length and strike east-northeast (Figure 4-3). The fault in the Municipality of Brockton is located at the west end of the Municipality, and it is interpreted to offset up to the Shadow Lake Formation/Precambrian units. The other mapped subsurface fault is in the

northwest corner of the Municipality of South Bruce, extending west into the Township of Huron-Kinloss, and is interpreted to extend upwards as shallow as the Trenton Group limestones. Given the sparse borehole data used to interpret these two faults, there is some uncertainty associated to their location, orientation and existence.

In addition, two sub-vertical faults were interpreted as part of the 2D seismic interpretation study conducted as part of this preliminary assessment (Geofirma, 2014b). One of these interpreted faults is in the Municipality of South Bruce, and is interpreted as a near vertical reverse fault extending from the Precambrian basement up to the base of the Silurian formations. This interpreted fault is in the same general location as the mapped subsurface fault identified in the Municipality of South Bruce (Figure 4-3). The second interpreted fault is located in the Township of Huron-Kinloss, and is thought to be a near vertical reverse fault that extends upwards from the Precambrian basement and into the Silurian Cabot Head Formation. The confidence in location, orientation and existence of these interpreted faults in the Municipality of South Bruce and the Township of Huron-Kinloss remains low.

4.3.3 Quaternary Geology

The terrain analysis report (JDMA, 2014) provides a detailed description of the Quaternary geology of the Area of the Five Communities. Glacial landforms and associated sediments within the Area of the Five Communities were deposited by the Huron and Georgian Bay lobes of the Laurentide Ice Sheet during the Late Wisconsinan 23,000 to 10,000 years ago (Karrow, 1993).

As shown on Figure 4-5, the Quaternary cover in the Area of the Five Communities comprises different types of glacial deposits. Overburden covers over 99 percent of the area, with thicknesses ranging from zero up to about 104 metres, with the thickest overburden in the area associated with buried bedrock valleys (Gao, 2011a; 2011b).

4.3.4 Erosion

Geofirma (2014a) summarizes the currently available information on glacial erosion in southern Ontario. 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 recent studies were aimed at assessing the impact of glaciations on erosion over sedimentary rocks. A recent literature review conducted by Hallet (2011) concluded that although uncertainties remain in ice sheet reconstructions and estimates of erosion by ice and melt water, all lines of evidence indicate that, in southern Ontario, glacial erosion would not exceed a few tens of metres in 100,000 years with a conservative estimate of 100 metres per 1 million years for the Bruce nuclear site (location of the Bruce nuclear site is shown on Figure 4-1).

4.3.5 Seismicity and Neotectonics

4.3.5.1 Seismicity

The Area of the Five Communities overlies the Grenville Province of the Canadian Shield and the interior of the North American continent, where large parts have remained tectonically stable for the last 970 million years (Percival and Easton, 2007). Figure 4-6 shows the location and magnitudes of seismic events recorded in the National Earthquake Database (NEDB) for the period between1985 to 2013 in southern Ontario (NRC, 2013a). Earthquake magnitude resolution in Figure 4-6 was improved to <1.0 for the Area of the Five Communities and

environs based on the 2007 installation of the microseismic monitoring network for the site characterization work at the Bruce nuclear site, and to magnitude 2.0 for the remainder of southern Ontario based on an expanded POLARIS (Portable Observatories for Lithospheric Analysis and Research Investigation Seismicity) network established in 2002. Over this time period, there are no recorded earthquakes located within any of the five Communities, with the closest recorded earthquakes located offshore in Lake Huron about 25-30 kilometres northwest of the Town of Saugeen Shores, and north of Owen Sound. The maximum magnitude of these events was of 2.5 Nuttli Magnitude. A 4.3 Nuttli Magnitude earthquake was recorded in 2005 northeast of Owen Sound within Georgian Bay at distances of 80 to 110 kilometres of the centres of the Communities (Hayek et al., 2011).

4.3.5.2 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 Area of the Five Communities is typical of many areas of southern Ontario, which have been subjected to nine glacial cycles during the last million years (Peltier, 2002). Post-glacial isostatic rebound is still occurring across most of Ontario. Vertical velocities show present-day uplift of about 10 millimetres per year near Hudson Bay, the site of thickest ice 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. The present day rebound rate in the Area of the Five Communities is about 1.5 millimetres per year (Peltier, 2011).

No neotectonic structural features are known to occur within the Area of the Five Communities. Slattery (2011) completed a remote-sensing and field-based study that analysed Quaternary landforms for the presence of seismically-induced soft-sediment deformation within 5 to 50 kilometres of the Bruce nuclear site. The investigation involved reviewing existing information sources (e.g., papers, reports, and maps), interpreting air photos and a LiDAR (Light Detection and Ranging) digital elevation model, and searching for liquefaction structures displayed in sediment exposures in the field. The review of existing information and interpretation of air photos was done for the entire area within 50 kilometres of the Bruce nuclear site, providing coverage of the entire Area of the Five Communities. No conclusive geomorphological or sedimentological evidence of post-glacial neotectonic activity was identified within the study area (Slattery, 2011).

4.3.6 Hydrogeology and Hydrogeochemistry

Information concerning groundwater use in the Communities was obtained principally from the Ontario Ministry of the Environment (MOE) Water Well Information System (WWIS) database (Ontario Ministry of the Environment, 2013a), as well as from regional groundwater studies and source water protection studies based on interpretation of these data. Water wells in the Area of the Five Communities obtain water from the overburden or the shallow bedrock.

The WWIS database contains a total of 12,442 water well records for the Area of the Five Communities. Not all of these water well records are complete and not all of these records provide useful hydrogeological information. A total of 10,374 water wells for the Area of the Five

Communities that have been reliably identified as overburden wells (1,337) and bedrock wells (9,037), and were plotted on Figure 3-5. The well type was uncertain for the remaining 2,068 wells which were not plotted. Most of the water well records (10,194) provide useful information on well depth, lithology, well yield, and static water level.

Table 3-2 summarizes the number and type of these water well records within the communities (3,785). The remaining 6,409 water wells are located outside of the municipal boundaries of the five communities.

Table 4-2: Water Well Record Summary for the Communities

Well Type	*No. of Well Records*	*Well Depth Range (mBGS)*		*Static Water Level Range (mBGS)*		*Well Yield (L/min)*		
		Min	*Max*	*Min*	*Max*	*Min*	*Max*	*Mean*
Municipality of Arran-Elderslie (Total 723 Well Records)								
Overburden	98	4.6	101.8	-0.3	36.3	4.5	450	47
Bedrock	625	6.1	218	-1.2	36.3	9.0	495	42
Municipality of Brockton (Total 1154 Well Records)								
Overburden	244	2.7	114.6	-1.8	50	4.5	360	52
Bedrock	910	5.0	134.1	-2.1	54.3	9.0	1,230	57
Municipality of South Bruce (Total 845 Well Records)								
Overburden	53	2.7	96.9	0.6	20.7	13.5	1,350	95
Bedrock	792	3.7	163.1	-12.2	48.8	9.0	1,125	60
Township of Huron-Kinloss (Total 861 Well Records)								
Overburden	78	2.5	93.3	1.5	27.4	9.0	1,125	88
Bedrock	603	15.2	111.3	-6.1	45.1	18.0	1,125	81
Town of Saugeen Shores (Total 382 Well Records)								
Overburden	156	2.6	157	-0.6	49.1	4.5	200	42
Bedrock	226	6.7	182.9	-9.1	48.8	9.0	1,350	29
Note: This table lists the 3785 wells within the boundaries of each of the five communities that can confidently assigned to overburden or bedrock aquifers. There are an additional 6,409 wells in the Area of the Five Communities, outside of the municipal boundaries of the five communities.								

4.3.6.1 Overburden Aquifers

There are 1,337 water well records in the Area of the Five Communities that can be confidently assigned to overburden aquifers. These wells are generally 10 to 100 metres deep and have mean well yields of 40 to 90 litres per minute. These well yields reflect the purpose of the wells (i.e. primarily residential use) and do not necessarily reflect the maximum sustained yield that might be available from the aquifers intersected by the wells.

Noteworthy overburden aquifers within the Communities include (Saugeen, Grey Sauble, Northern Bruce Peninsula Source Water Protection Region, 2011a; 2011b; Ausable Bayfield Maitland Valley Source Protection Region, 2011):

- the confined sand and gravel Chesley Aquifer found in proximity to and north of Chesley, Municipality of Arran-Elderslie;
- the partially confined sand and gravel Port Elgin-Southampton Aquifer found near and within the lower part of the Saugeen River, Town of Saugeen Shores;
- the confined sand and gravel Hanover Aquifer in the Municipality of Brockton which provides municipal water supply for Hanover;
- the partially confined sand and gravel Walkerton Aquifer situated in the vicinity of Walkerton, Municipality of Brockton;
- the unconfined sand Lake Warren Shoreline Aquifer located as a narrow north-south band of glaciolacustrine deposits within the Township of Huron-Kinloss;
- the unconfined sandy beach deposits of the Lake Huron Beach Aquifer found along the present day shoreline of Lake Huron in the Township of Huron-Kinloss and the Town of Saugeen Shores; and
- the unconfined sand and gravel Wawanosh Kame Moraine Aquifer located in the southeast part of the Township of Huron-Kinloss and the southwest part of the Municipality of South Bruce.

Source water protection assessment reports (Saugeen, Grey Sauble, Northern Bruce Peninsula Source Water Protection Region, 2011a; 2011b; Ausable Bayfield Maitland Valley Source Protection Region, 2011) provide the locations of significant groundwater recharge areas within the Area of the Five Communities, indicating areas where greater than average groundwater recharge likely occurs. These areas were mapped based on consideration of surficial geology, soils, land cover and topography. Significant groundwater recharge occurs in flat-lying/hummocky areas with sands and gravels at surface and limited land cover (Geofirma, 2014a).

4.3.6.2 Bedrock Aquifers

No water wells in the Area of the Five Communities were drilled to typical repository depths of approximately 500 metres below ground surface. There are 9,037 water well records in the Area of the Five Communities that can be confidently assigned to shallow bedrock aquifers. Shallow bedrock hydrogeological information is available primarily from surface to depths of 100 to 150 metres from the MOE well records (MOE, 2013a) based on regional use of this shallow bedrock aquifer as source of drinking water. Shallow bedrock is the most important source of drinking water in the Communities, and is the primary source of most of the municipal water supplies located inland from Lake Huron. Shallow bedrock aquifers within the Communities are composed of an aggregate of the upper few metres to over 100 metres of the different shallow bedrock formations present, which range from Middle Devonian Lucas Formation dolostone in the southwest (Township of Huron-Kinloss) to Upper Silurian Guelph Formation dolostone in the northeast (Municipality of Arran-Elderslie) (Figure 4-6). The municipalities of Brockton and South Bruce are underlain at shallow depths by Lucas Formation dolostones through to Salina Group dolostones, shales and evaporites. The Town of Saugeen Shores is underlain by the Salina Group and a thin band of Upper Silurian Bass Islands Formation dolostone along its southern boundary. Water quantity and quality within the shallow bedrock aquifer can vary dramatically across the Communities as a consequence of the different chemical and physical characteristics of the individual bedrock formations.

In many parts of the Area of the Five Communities, an overlying layer of clay and silt till confines the shallow bedrock aquifer. In these areas the low permeability silt and clay till is considered to represent an aquitard that protects the shallow bedrock aquifer.

4.3.6.3 Shallow Groundwater Regime

The shallow groundwater regime includes the overburden aquifers and aquitards, and shallow bedrock aquifers that provide drinking water supplies to both municipalities and residences. Within eastern parts of the municipalities of Brockton and South Bruce and within most of the Municipality of Arran-Elderslie and the Town of Saugeen Shores, the shallow groundwater regime will likely extend to depths of 150 metres or more within the Guelph Formation. Within the Township of Huron-Kinloss the shallow groundwater regime likely extends to somewhat shallower depths of about 100 metres.

Groundwater flow directions within shallow systems often mimic surface water flow directions with the groundwater table generally present as a subdued reflection of topography. Shallow groundwater flow will be directed from areas of higher hydraulic head, such as highlands and drainage divides to areas of lower hydraulic head such as low-lying areas of valleys, depressions, and surface waters. The extent of such shallow flow systems will be defined by local, topography-controlled, drainage divides across which groundwater flow will not readily occur. Generally, for such shallow systems, groundwater divides will coincide with surface water drainage divides.

4.3.6.4 Formation Hydraulic Pressures

There is limited readily available information on formation hydraulic pressures at typical repository depths in the Communities, however there is detailed information on hydraulic pressures within the Paleozoic bedrock sequence in the Area of the Five Communities from studies at the Bruce nuclear site.

Formation hydraulic pressures in bedrock to depths of about 850 metres below ground surface have been measured in-situ and reported for the entire Paleozoic bedrock sequence at the Bruce nuclear site using special multiple-port pressure monitoring instrumentation consisting of numerous packer-isolated test intervals installed in several deep boreholes (Intera Engineering Ltd., 2011). These ongoing hydraulic pressure measurements allow for determination of the presence of normally-pressured, overpressured or underpressured conditions within individual deep formations and estimation of groundwater flow directions within shallow and deep bedrock aquifers.

There is significant underpressuring of the deep aquiclude of the Ordovician shales and Trenton Group limestones of up to 250 to 300 metres below ground surface expressed as environmental water head at the Bruce nuclear site (Intera Engineering Ltd., 2011). These underpressures are an important hydrogeological characteristic of the Ordovician shales and Trenton Group limestones which indicate that these formations would act as barriers to groundwater migration. Possible explanations for the observed underpressures include: poroelastic response to glacial unloading and flexure; poroelastic response to Cenozoic erosional unburdening; capillary pressure effects due to the presence of a separate gas phase; and/or chemical osmosis (Intera Engineering Ltd., 2011). The occurrence and persistence of these underpressures are clearly indicative of very low formation permeability and provide confidence in the very low permeabilities reported from hydraulic testing at the Bruce nuclear site (NWMO, 2011). These

hydrogeological properties indicate aquiclude conditions with no advection of brine, and a system in which gas flow would also be diffusion controlled.

There is also significant overpressuring of up to 165 metres above ground surface expressed as environmental water head within the permeable Cambrian sandstone that propagates into some of the overlying Black River Group limestones and siltstones. There are also some moderate overpressures occurring within the Salina A1 and A0 Units, Goat Island, Gasport, Lions Head and Fossil Hill formations and within the middle of the Blue Mountain Formation. Possible explanations for the cause of these overpressures include: hydraulic connection to a remote elevated regional recharge area (e.g., Niagara Escarpment, Canadian Shield); remnant overpressure from deep basin glacial meltwater recharge and post-glacial basin isostatic rebound; and/or up-basin regional fluid (brine or gas) migration and pressurization (Intera Engineering Ltd., 2011).

Current pressure measurements within the Salina Upper A1 Unit aquifer at the Bruce nuclear site indicate groundwater flow directions to the northwest toward Lake Huron (Intera Engineering Ltd., 2011) consistent with groundwater flow directions in the overlying shallow groundwater regime at the Bruce nuclear site and in the Area of the Five Communities. Current pressure measurements for the slightly deeper Guelph Formation aquifer indicate that groundwater flows in an up-dip direction to the east-northeast towards the Guelph Formation subcrop (Geofirma, 2014a). The data from the Bruce nuclear site, along with the regional scale understanding, suggests that similar formation hydraulic pressures are present in the Paleozoic bedrock sequence beneath the Communities.

4.3.6.5 Hydrogeochemistry

Information on shallow overburden and bedrock groundwater geochemistry in southwestern Ontario, including the Area of the Five Communities, is presented by the Ontario Geological Survey (Hamilton, 2011) and by the Ontario Ministry of the Environment (2013b). Within the Area of the Five Communities, Hamilton (2011) summarizes the groundwater geochemistry of 101 wells (43 overburden, 58 bedrock) to a maximum depth of 148 m recently sampled in 2007 to 2010; and Ontario Ministry of the Environment (2013b) present water quality information for the 17 wells that are part of the Provincial Groundwater Monitoring Network.

There is no direct readily available information on hydrogeochemistry at typical repository depths in the Communities. Geofirma (2014a) summarizes the expected hydrogeochemical conditions of the shallow to deep Paleozoic and underlying Precambrian bedrock within the Area of the Five Communities based on a number of sources, including detailed porewater and groundwater testing completed at the Bruce nuclear site (Intera Engineering Ltd., 2011); regional compilations of oil, gas and salt well data completed as part the Bruce nuclear site DGR Geosynthesis (NWMO, 2011; Hobbs et al., 2011); and data from the Ontario Petroleum Institute (Carter and Fortner, 2011). Because the extremely low permeability of most of the Silurian and Ordovician formations precludes conventional groundwater sampling, significant reliance was placed on extraction and testing of porewaters for determination of bedrock hydrogeochemical parameters.

Based on information from the Bruce nuclear site, hydrogeochemical data shows highly saline, non-potable brines (salinities of approximately 200,000 to 300,000 milligrams per litre total dissolved solids in the Ordovician formations) exist at typical repository depths within the area. The current understanding of the origin of brines within the Michigan Basin indicates that they were formed by evaporation of sea water that was subsequently modified by: dilution of brines

by lower salinity water; dissolution of halite by lower salinity water; and diagenetic water-rock interactions, particularly dolomitization. The data from the Bruce nuclear site is consistent with the regional scale understanding, and suggests that similar brines are present in the Ordovician rocks beneath the Communities.

4.3.7 Natural Resources

The potential for natural resources in the Area of the Five Communities is shown on Figure 4-7 and discussed in detail in Geofirma (2014a). Natural resources assessed for the area include: petroleum resources (conventional and unconventional oil and gas), metallic mineral resources, non-metallic mineral resources (sand and gravel, bedrock resources and salt) and potable groundwater resources associated with the Guelph Formation.

Although the potential for petroleum resources is recognized in southern Ontario, most delineated oil and gas pools are located far to the south of the Area of the Five Communities. As shown on Figure 4-7, there are only three oil and gas pools, all of them located immediately south of the Township of Huron-Kinloss. There are no known oil and gas pools within the Communities and all the exploration wells drilled within the Communities resulted in dry holes.

Discretionary mineral occurrences of limestone, dolostone, and marl are present within the Communities, but the occurrences are associated with shallow depths (typically less than 20 metres) within the Area of the Five Communities. Sand and gravel pits are operating throughout the Area of the Five Communities. Most of these pits are shallow (<8 metres depth) and located within esker, glaciofluvial outwash, ice contact or glaciolacustrine beach deposits.

Salt beds of the Silurian Salina Group are known to be present beneath the Township of Huron-Kinloss, and the southwestern-most corner of the Municipality of South Bruce; however, these deposits are relatively thin and shallow compared to the depth of the Cobourg Formation in that area. The salt beds of the Silurian Salina group are not present beneath the Municipality of Arran-Elderslie, the Municipality of Brockton, or the Town of Saugeen Shores.

The Guelph Formation dolostone is a regionally important water supply aquifer, and is present over most of the Area of the Five Communities. Within the Communities, the top of the Guelph Formation is found at depths ranging from about 5 metres in the Municipality of Arran-Elderslie to a maximum of over 500 metres in the Township of Huron-Kinloss. Given the recognized potential of the Guelph Formation as a water supply aquifer, there is potential for its development as a fresh water source below depths typically assumed for shallow bedrock water supplies in the Area of the Five Communities (Geofirma, 2014a). However, in order for the Guelph Formation to be accessed as a water supply aquifer the groundwater must be potable. Figure 4-7 shows the inferred extent of the occurrence of fresh water within the Guelph Formation in the Area of the Five Communities. The northeastern extent of fresh water in the Guelph Formation shown in Figure 4-7 is the mapped outcrop limit of the Guelph Formation. The southwestern limit of fresh water occurrence within the Guelph Formation shown in Figure 4-7 is about 200 to 250 metres below ground surface. Potable water is likely to occur to the northeast above this depth horizon.

The communities are located in a sedimentary rock setting in southern Ontario, where the potential for metallic mineral resources is considered to be low.

4.3.8 Geomechanical and Thermal Properties

There are no data on geomechanical and thermal properties of the Paleozoic bedrock formations at typical repository depths within the Communities. However, geomechanical property data are available from detailed drilling and testing investigations at the nearby Bruce nuclear site (Intera Engineering Ltd., 2011, Golder Associates Ltd., 2013), and from regional compilations of geomechanical data (NWMO and AECOM Canada Ltd., 2011; Golder Associates Ltd., 2003a). Thermal property data are also available from additional detailed drilling and testing investigations at the nearby Bruce nuclear site (Atomic Energy of Canada Ltd., 2011), and from compilations of data available in the published literature (Clauser and Huenges, 1995; Sass et al., 1984; Cermak and Rybach, 1982). Based on the lateral traceability and predictability of the Paleozoic sequence in southern Ontario, geomechanical and thermal properties of the Paleozoic sequence in the Communities can be expected to be similar to those measured at the Bruce nuclear site and elsewhere in southern Ontario.

Argillaceous limestone of the Cobourg Formation has high strength, with an average Uniaxial Compressive Strength (UCS) value of 113 megapascals, thus indicating a high degree of stability for deep underground excavations (Intera Engineering Ltd., 2011; NMWO, 2011). The Upper Ordovician shale and limestone units at the Bruce nuclear site are very sparsely fractured and of excellent quality, with the Cobourg Formation having a rock mass designation of excellent and a rock quality designation generally ranging between 90 and 100 percent at the Bruce nuclear site (Intera Engineering Ltd., 2011). The measured fracture frequency is similar in all of the Ordovician formations and ranges from approximately 0 to 1.7 fractures per metre, with an average value of generally less than 0.3 fractures per metre. The mean measured thermal conductivity, thermal diffusivity and specific heat for Paleozoic formations measured on core samples collected at the Bruce nuclear site are generally consistent with thermal property data reported in the literature for sedimentary rocks. The Cobourg Formation has slightly higher thermal conductivity that the overlying Ordovician shales, and underlying Sherman Fall Formation.

Site-specific geomechanical and thermal data would need to be obtained during later stages of the site evaluation process.

4.4 Potential Geoscientific Suitability of the Communities

This section provides a summary of how key geoscientific characteristics and constraints were applied to the Five Communities to assess whether they 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 and constraints briefly described below.

- ***Geological Setting:*** The initial screenings of the five Bruce County communities involved in the site selection process (AECOM Canada Ltd., 2012a; 2012b; 2012c; 2012d; 2012e) identified the Upper Ordovician shale and limestone units as potentially

suitable host rock formations. As described in Section 4.3.2, the 500 to 1000 metre thick Paleozoic bedrock sequence within the Five Communities typically includes Devonian dolostones overlying Silurian dolostones, shales and evaporites, overlying Upper Ordovician shales and limestones, and occasionally Cambrian sandstone, overlying Precambrian basement. The Upper Ordovician Cobourg Formation argillaceous limestone is overlain by about 200 metres of Upper Ordovician shales and underlain by about 150 metres of deeper Upper Ordovician limestones (Figure 4-4).

Based on available information on the geoscientific characteristics of the sedimentary sequence beneath the Five Communities, the Ordovician Cobourg Formation (argillaceous limestone) would be the preferred host rock for a used nuclear fuel deep geological repository. The natural geological setting in this formation would provide the most favourable geoscientific characteristics for ensuring safety. As described in Section 4.3, the Cobourg Formation underlies the Bruce County area in sufficient thickness and volume, and has favourable geoscientific characteristics such as very low hydraulic conductivity and high geomechanical strength (Geofirma, 2014a).

While the other Trenton Group limestone formations (i.e. Sherman Fall and Kirkfield formations) and the Upper Ordovician shales (i.e. Queenston, Georgian Bay and Blue Mountain formations) also have very low hydraulic conductivities, they are less preferred than the Cobourg Formation from a geomechanical perspective (i.e. lower rock strength). The limestone formations of the Black River Group are also less preferred as they have uniformly higher hydraulic conductivity values than the Cobourg Formation. The favourable characteristics of the Cobourg Formation are complemented by the presence of approximately 200 metres of overlying very low permeability Ordovician shale formations, which act as an additional hydraulic barrier.

There are only two mapped subsurface faults within the communities, in the municipalities of Brockton and South Bruce and the Township of Huron-Kinloss. Two faults were also interpreted from the analysis of available 2D seismic data within the communities (Section 4.3). For the purpose of this preliminary assessment, these faults were not considered as key constraints in the identification of general potentially suitable areas as the possible faults are very localized and there is uncertainty at this stage regarding their location, orientation and existence. The potential for faults in the Paleozoic sequence within the communities would need to be further assessed during subsequent stages of the site selection process.

- ***Minimum Depth of Top of the Cobourg Formation:*** For the sedimentary sequence in the Area of the Five Communities, it was determined that a minimum depth of 500 metres below ground surface would be preferred in order to maintain the integrity of a repository within the Cobourg Formation. This preferred depth would also protect the 200 metre thick Ordovician shale barrier under the most conservative assumptions of future bedrock removal rates due to glacial erosion (Section 4.3.4; Hallet, 2011).

- ***Protected Areas :*** All known protected areas with the Communities were excluded from further consideration (Figure 4-8). These include exclusion areas identified by the Communities for future development, Conservation Areas and Reserves, First Nation Reserves, Provincial Parks, Provincially Significant Wetlands, and built-up areas.

- ***Source Water Protection Areas:*** Land-based water protection zones (IPZs, Intake Protection Zones) 1 and 2, and groundwater protection areas (WHPAs, Well Head

Protection Areas) A, B and C were excluded from further consideration, given that they provide the highest level of protection for municipal groundwater supplies through land use planning and controls. The consideration of WHPAs D and E would need to be further assessed in collaboration with the Communities in future studies.

- ***Natural Resources:*** The potential for natural resources in the Area of the Five Communities is shown on Figure 4-7. Discretionary mineral occurrences of limestone, dolostone, and marl present within the communities are not considered as siting constraints due to the shallow depth associated with these occurrences (typically less than 20 metres). While oil and gas pools exist immediately south of the Township of Huron-Kinloss, and potential for petroleum resources is recognized in southern Ontario, there are no known oil and gas pools within the communities and all the exploration wells drilled within them resulted in dry holes. Salt beds of the Silurian Salina Group are known to be present beneath the Township of Huron-Kinloss; these are also not considered as a siting constraint at this stage given the relatively thin nature of the deposits and their relatively shallow occurrence underneath the Township of Huron-Kinloss (approximately 350 to 400 metres below ground surface) compared to the depth of the Cobourg Formation (approximately 700 to 800 metres below ground surface).

- ***Surface Constraints:*** Surface features such as overburden, the limited extents of wetlands outside protected areas, the relatively flat topography and the ease of accessibility within the communities were not found to be significant siting constraints. Overburden cover is extensive and locally thick within the communities, and wetlands cover from 10 to 20 percent of each of the communities. However, these features were not considered as significant constraints to siting at this stage. Water bodies cover a relatively small area.

The consideration of the above key geoscientific characteristics and constraints revealed that the Area of the Five Communities has a number of favourable geoscientific characteristics for hosting a deep geological repository for used nuclear fuel. However, there are areas that have more potential than others.

Figure 4-8 illustrates the key geoscientific characteristics and constraints used to identify general potentially suitable areas. The application of these key characteristics and constraints revealed that the municipalities of Brockton and South Bruce, and the Township of Huron-Kinloss contain large areas that have the potential to satisfy NWMO's geoscientific evaluation factors. The assessment also revealed that the Municipality of Arran-Elderslie and the Town of Saugeen Shores have limited potential to satisfy the geoscientific evaluation factors outlined in NWMO's site selection process when the above geoscientific characteristics and constraints are coupled with land use constraints.

At this early stage of the assessment, the boundaries of the identified general potentially suitable areas in the Municipalities of Brockton and South Bruce, and the Township of Huron-Kinloss are not yet defined in detail. Their location and extent would be further refined during subsequent site evaluation stages, should any of these three communities continue in the site selection process.

4.4.1.1 Town of Saugeen Shores

The Town of Saugeen Shores contains several protected areas that occupy about 25 percent of the Town. These include the Saugeen Bluffs Conservation Area, MacGregor Point Provincial

Park, provincially significant wetlands, water intake protection zones at Southampton, and built-up areas at Port Elgin and Southampton. The land west of Highway 21 was excluded as it is preserved for future expansion.

There are no oil and gas pools or mineral occurrences recorded within the Town of Saugeen Shores. Two pinnacle reefs of the Guelph Formation are known to exist in the southern portion of the Town (Geofirma, 2014a). While pinnacle reefs of the Guelph Formation are known to host economically exploitable petroleum resources elsewhere in southern Ontario (e.g. approximately 50 kilometres south of the Town), exploration wells drilled through the pinnacle reefs in the Town of Saugeen Shores resulted in dry holes and did not encounter commercial hydrocarbon accumulations.

As described in Section 4.3.2, the bedrock geology in the Area of the Five Communities, including the Town of Saugeen Shores, is characterized by a laterally extensive and predictable sequence of Paleozoic formations. Based on borehole data, the cumulative thickness of the sedimentary sequence is estimated to be more than 700 metres in the southern portion of the Town. Contour mapping (Geofirma, 2014a) indicates that the depth to the top of the preferred Cobourg Formation decreases from approximately 584 metres below ground surface near the southern boundary of the Town to about 400 metres below ground surface in the northern part. The area where the depth to the top of the Cobourg Formation is greater than the preferred 500 metres below ground surface represents roughly 40 percent of the Town area, and is located in the southern portion of the Town (Figure 4-8). There are no faults mapped within the Paleozoic sequence beneath the Town of Saugeen Shores.

Although the Cobourg Formation is present at depths greater than the preferred 500 metres below ground surface over an area representing roughly 40 percent of the Town, this area contains a number of constraints that greatly reduce the prospect of finding areas that are large enough for hosting the repository's surface and underground facilities. These constraints include: the MacGregor Point Provincial Park along the shore of Lake Huron, the Saugeen Bluffs Conservation Area, a Surface Water Intake Protection Zone in Southampton, built-up areas at Port Elgin and Southampton, and the Saugeen River and its tributaries (Figure 4-8). In addition, the land west of Highway 21 was excluded from further consideration at the request of the community, as it is preserved for future expansion. When all these constraints are considered, limited area remains available for potentially hosting a deep geological repository.

In summary, the Town of Saugeen Shores has very limited potential to contain areas that would meet the geoscientific siting factors discussed above.

4.4.1.2 Municipality of Arran-Elderslie

There are six conservation reserves, four provincially significant wetlands and several earth science Areas of Natural Scientific Interest (ANSIs) within the Municipality, which combined account for approximately nine percent of the area of the Municipality (Figure 4-8). In addition there are also two wellhead protection areas; one associated with the Tara well supply, and one associated with part of the wellhead protection area for the Chesley well supply. Other surface constraints within the Municipality include the built-up areas of the settlement areas of Paisley, Chesley and Tara.

There are no oil and gas pools or mineral occurrences recorded within the Municipality of Arran-Elderslie, so there are no known natural resource constraints at this stage for identifying general

potentially suitable areas within the Municipality. There are no faults mapped within the Municipality.

There are no boreholes drilled within the Municipality of Arran-Elderslie to provide direct information on the subsurface bedrock geology. However, information on the bedrock geology beneath the Municipality can be obtained from wells surrounding the Municipality and from the regional understanding of the Paleozoic geology. The Municipality of Arran-Elderslie is underlain by a laterally extensive and uniform Paleozoic sequence, which is interpreted to have a cumulative thickness on the order of 700 metres. Contour mapping (Geofirma, 2014a) shows that the preferred Cobourg Formation is expected to be found at depths ranging from approximately 343 metres below ground surface in the northeastern portion of the Municipality to approximately 545 metres below ground surface towards its southwestern portion. The area within the Municipality where the top of the Cobourg Formation is at preferred depth of greater than 500 metres below ground surface represents only about five percent of the area of the Municipality, which is insufficient for hosting a deep geological repository. This area contains a number of surface constraints that further reduce land availability. These include: the McBeath Conservation Area, built-up areas associated with the settlement area of Paisley, railway infrastructure and the Teeswater River.

In summary, the Municipality of Arran-Elderslie does not contain sufficient land areas that have the potential to meet the geoscientific site evaluation factors discussed above.

4.4.1.3 Municipality of Brockton

The Municipality of Brockton is underlain by a predictable and laterally extensive Paleozoic sedimentary sequence. Based on information from well T004854 located near the western edge of the Municipality (Geofirma, 2014a), the thickness of the Paleozoic sequence in this area is approximately 890 metres.

Depth contour mapping (Geofirma, 2014a) shows that a large portion (about 70 percent) of the Municipality has the preferred Cobourg Formation at depths greater than the preferred depth (500 metres below ground surface). The top of the Cobourg Formation varies from about 404 metres below ground surface in the northeastern portion of the Municipality to approximately 691 metres below ground surface towards the western margin of the Municipality. The thickness of the overlying Upper Ordovician shale formations is estimated to be relatively uniform and more than 200 metres thick within the Municipality. There is one mapped subsurface fault within the Paleozoic sedimentary sequence in the Municipality, located at the west end of the Municipality and extending to the west beyond the municipal boundaries (Figure 4-3). The mapped subsurface fault is interpreted to offset the Shadow Lake Formation/Precambrian units.

Known potential for economically exploitable natural resources in the Municipality of Brockton is limited to a few shallow discretionary limestone and marl occurrences located mostly in the vicinity of Walkerton (Figure 3-7). There are no known oil and gas pools identified within the Municipality, and all six exploration wells drilled within the Municipality resulted in dry holes with no petroleum potential.

The only significant built-up area in the Municipality is that associated with the settlement area of Walkerton (Figure 4-8). The western portion of the Municipality of Brockton is covered by the Greenock Swamp Wetland Complex (68 square kilometres), which is designated as a Provincially Significant wetland complex. Part of this wetland complex is also designated as a conservation area. The wellhead protection area, zones A to C, associated with the Walkerton

well supply system cover approximately 6 square kilometres on the southern portion of the Municipality, just west of the settlement area of Walkerton (Figure 4-8). A wellhead protection area and a surface water protection zone are also present on the eastern edge of the Municipality, associated with water supply to the settlement area of Hanover. There are two very small earth science ANSIs located in the central and south-central parts of the Municipality.

The consideration of the above geoscientific characteristics and constraints indicates that the central portion of the Municipality of Brockton appears to have favourable geoscientific characteristics for hosting a deep geological repository. This general potentially suitable area is located north of the settlement area of Walkerton and east and north of the Greenock Swamp Wetland Complex (Figure 4-8). The top of the preferred Cobourg Formation beneath this area occurs at depth ranging from about 500 to 650 metres below ground surface, which is greater than the preferred minimum depth. This general potentially suitable area is mostly free of surface constraints and protected areas, with just a few localized provincially significant wetlands located along the banks of the Saugeen River, two small rectangular localized conservation areas/reserves (i.e., that are part of the Saugeen Conservation Area and Lands), a small earth science ANSI (Saugeen River Section), and a small well head protection area for the Chepstow Powers Subdivision well supply. The area is easily accessible via the existing road network (Figure 4-8).

Topography in the general potentially suitable area is relatively flat, although distinct topographic features are identified associated with the Saugeen and Teeswater rivers (Figure 4-2). The area also contains non-designated wetlands and extensive overburden deposits with thicknesses of up to approximately 100 metres locally. As discussed in Section 4.4.1, at this early stage of the assessment, topographic features, wetlands and overburden thickness are not considered as key constraints for the identification of general potentially suitable areas.

4.4.1.4 Municipality of South Bruce

The bedrock geology of the Municipality of South Bruce comprises a thick Paleozoic sequence that is laterally extensive and predictable. Data from two boreholes (F012062 and T004881) drilled through the entire Paleozoic sequence within the Municipality indicate that the estimated total thickness of the Paleozoic package is approximately 870 metres. Available borehole data within the Municipality confirm the presence of the preferred Cobourg Formation at depths ranging from about 433 metres below ground surface in the northeast corner of the Municipality to 717 metres below ground surface towards its southwestern portion (Geofirma, 2014a). The Cobourg Formation is overlain by a more than 200 metre thick shale package (i.e. Upper Ordovician shale units). There is only one subsurface fault mapped within the Paleozoic sequence in the northwest corner of the Municipality of South Bruce (Figure 4-3). This fault is interpreted to displace the Trenton Group limestones and deeper formations only, including the Precambrian basement. The reinterpretation of seismic line 725937, which crosses the mapped subsurface fault in the Municipality of South Bruce, identified a potential fault that extends upwards from the Precambrian basement into the base of the Silurian Cabot Head Formation. The coincidence between this interpreted seismic anomaly and the mapped subsurface fault provides a certain amount of confidence in the existence of a fault in the area crossed by the seismic line.

There are no known oil and gas pools within the Municipality of South Bruce, and the three exploration boreholes drilled within the Municipality resulted in dry holes with no petroleum potential. There are a number of discretionary limestone occurrences in the central portion of

the Municipality (Figure 4-7); the potential for limestone, however, is limited to very shallow depths and was not considered as a siting constraint.

Protected areas include the Provincially Significant Greenock Swamp and Teeswater wetland complexes in the western portion of the Municipality, and the Otter Creek Wetland Complex north of Mildmay. There is also the Saugeen Conservation Reserve south of Mildmay, and small parts of the wetland complexes are designated as conservation areas (Figure 4-8). Other potential siting constraints within the Municipality include built-up areas in Teeswater, Mildmay and Formosa and well head protection areas associated with the water supply systems in Teeswater and Mildmay, and the southern extension of the Walkerton well head protection area (Figure 4-8).

The consideration of the above geoscientific characteristics and constraints indicates that the Municipality of South Bruce contains large areas that have the potential to meet NWMO's geoscientific site evaluation factors. The potentially suitable area covers most of the Municipality with the exception of the westernmost portion and the northeast corner of the Municipality, as well as localized areas around Mildmay, Teeswater and Formosa (Figure 4-8). The top of the Cobourg Formation is interpreted to be at depths greater than the preferred 500 metres below ground surface beneath the entire the Municipality, except in small area in the northeastern corner. The potentially suitable area in the Municipality is easily accessible via the existing road network (Figure 4-8).

Non-designated wetlands are uniformly mapped throughout the potentially suitable area and overburden deposits are widespread, with mean thicknesses of about 20 metres. Topography in the identified general potentially suitable area is relatively flat. As discussed in Section 4.4.1, at this early stage of the assessment, topographic features, wetlands and overburden thickness are not considered as key constraints for the identification of potentially suitable areas.

4.4.1.5 Township of Huron-Kinloss

The bedrock geology beneath the Township of Huron-Kinloss consists of a laterally extensive and predictable Paleozoic sequence. Based on data from one well (F012061) drilled through to the Precambrian basement in the southern portion of the Township, the total thickness of the Paleozoic sequence in that area is approximately 1,000 metres. Based on contour mapping, the depth to the top of the preferred Cobourg Formation is interpreted to range from approximately 683 metres below ground surface in the northeastern portion of the Township to about 809 metres below ground surface towards its southern portion. Data from well F012061 confirms that the Cobourg Formation within the Township is overlain by about 200 metres of Upper Ordovician shale formations. One mapped subsurface fault extends into the eastern part of the Township of Huron-Kinloss (Figure 4-3). In addition, a possible fault was interpreted in a seismic line in the Township of Huron-Kinloss (Section 4.3.2).

While there are a number of pools that produce gas from pinnacle reefs of the Guelph Formation immediately south of the Township of Huron-Kinloss (Figure 4-7), there are no known oil and gas pools within the Township. All seven wells drilled within the Township resulted in dry holes and did not encounter economical accumulations of hydrocarbons, including wells drilled through three known pinnacle reefs. As described in Geofirma (2014a), salt beds of the Silurian Salina Group exist beneath the Township of Huron-Kinloss; the Salina B-Salt is interpreted to be approximately 75 metres thick towards the southwestern portion of the Township, thinning out towards its eastern part. Salt beds of the Salina Group extend beyond the Township boundaries to the south and are currently being exploited approximately 30 kilometres south of the

Township, at Goderich. Given that the Salina salt beds are relatively thin within the Township and occur approximately 400 metres above the Cobourg Formation, they are not considered a constraint from a siting perspective at this stage of the assessment. There are no other mineral occurrences within this community.

Protected areas within the Township of Huron-Kinloss include seven designated Provincially Significant Wetlands located in the eastern portion of the Township (Figure 4-8). The area west of Highway 21 was excluded from consideration at the request of the community. There is also one earth science ANSI northwest of Lucknow, seven well head protection areas, and one surface water protection zone. Built-up areas are associated with the settlement areas west of Highway 21, and with the settlement areas of Ripley and Lucknow (Figure 4-8).

The consideration of the above geoscientific characteristics and constraints indicates that the Township of Huron Kinloss contains large areas that have the potential to meet NWMO's geoscientific site evaluation factors. These include most of the area between the wetland complexes in the eastern portion of the Township and Highway 21, outside of protected areas and potential surface constraints discussed above. As discussed above, the top of the preferred Cobourg Formation is interpreted to be at depths greater than the preferred 500 metres below ground surface beneath the entire Township.

Topography in the general potentially suitable area is relatively flat, gradually decreasing from east to west (Figure 4-2). There are no significant topographic constraints and only a few non-designated wetlands are mapped within the central portion of the Township. Access to the general potentially suitable area is easy with the existing road network (Figure 4-8).

4.4.2 Evaluation of General Potentially Suitable Areas in the Communities

As discussed above, the assessment of the key geoscientific characteristics and constraints indicates that the Municipality of Arran-Elderslie and the Town of Saugeen Shores have limited potential to satisfy the geoscientific evaluation factors outlined in the site selection process (NWMO, 2014 a,b). This section focuses on the potentially suitable areas identified within the municipalities of Brockton and South Bruce and the Township of Huron-Kinloss. The 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 (NWMO 2010) 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 or more below ground surface, in a sufficient rock volume with characteristics that limit groundwater movement.

As discussed in the previous sections, the geology of the municipalities of Brockton and South Bruce, and the Township of Huron-Kinloss is consistent with the regional geological framework.

These three Communities are entirely underlain by a predictable and laterally extensive Paleozoic sedimentary sequence that was deposited approximately 460 to 385 million years ago.

The Cobourg Formation, which is considered as the preferred host rock in this assessment (Section 4.4.1), is interpreted to extend laterally beneath most of the three communities at depths greater than the preferred 500 metres below ground surface (see Section 4.4.1).

The thickness of the Cobourg Formation at the Bruce nuclear site is approximately 30 metres (Intera Engineering Ltd., 2011). Data from deep boreholes within the three communities indicate that the thickness of the Cobourg formation under the identified potentially suitable areas is expected to be similar. Given its thickness and lateral extent, the Upper Ordovician Cobourg Formation would provide a sufficient volume of rock to physically contain and isolate a deep geological repository for used nuclear fuel.

While there is limited site-specific information on the geoscientific characteristics of the Cobourg Formation beneath the three general potentially suitable areas, it is expected that they will be similar to the characteristics of the Cobourg Formation beneath the nearby Bruce nuclear site. As described in Geofirma (2014a) and Section 4.3.8, the Cobourg Formation is characterized by very low hydraulic conductivities and a very low frequency of fractures. These are favourable characteristics for the containment and isolation of used nuclear fuel. In addition, the Cobourg Formation in the potentially suitable areas is overlain by approximately 200 metres of very low permeability Upper Ordovician shale units, which would act as an additional barrier.

Given the regional predictability of the Paleozoic bedrock sequence, the hydrogeological and hydrogeochemical conditions beneath the potentially suitable areas in the municipalities of Brockton and South Bruce, and the Township of Huron-Kinloss are also expected to be relatively similar to those beneath the Bruce nuclear site (Section 4.3.6). The deep groundwater regime within the Upper Ordovician shale and limestone units beneath the Bruce nuclear site, including the Cobourg Formation, is described as diffusion dominated and isolated from the shallow groundwater which is generally limited to the upper 200 metres below ground surface. There are two mapped subsurface faults within the Area of the Five Communities, both of them outside of the identified potentially suitable areas. The isolated nature of the deep groundwater system is further supported by the regional hydrogeochemical setting (Section 4.3.6). Regional chemistries of the deep brines indicate that they were formed by evaporation of seawater, which was subsequently modified by fluid-rock interaction processes. Limited evidence for recent dilution by meteoric or glacial waters was found within the regional geochemical database. The nature of the deep brines, in particular their high salinities and distinct isotopic signatures, suggests long residence times and indicates that the deep system has remained isolated from the shallow groundwater system.

In summary, the review of available geoscientific information did not reveal any obvious conditions that would fail the three identified potentially suitable areas to satisfy the containment and isolation function. Potential suitability of these areas would need to be further assessed during subsequent stages of the site evaluation process.

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 desktop preliminary assessment 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 municipalities of Brockton and South Bruce, and the Township of Huron-Kinloss.

The Area of the Five Communities, including the three potentially suitable areas, is underlain by Precambrian crystalline basement of the Grenville Province, the southeastern-most subdivision of the Canadian Shield. The Precambrian Grenville Province is generally considered to have been relatively tectonically stable since approximately 970 million years ago (Section 4.3.5). There are two mapped subsurface faults within the Area of the Five Communities, both of them outside of the identified potentially suitable areas. The uppermost formations cut by these faults include the Shadow Lake Formation/Precambrian for one fault and the Cobourg Formation for the other fault. There is no evidence in the literature suggesting that these faults have been tectonically active within the past approximately 440 million years. Interpretation of an available 2D seismic line provides some indication that one of the subsurface mapped faults may have been active after the deposition of the lower Silurian-aged Cabot Head Formation (Geofirma, 2014b).

The geology of the Area of the Five Communities is typical of many areas of southern Ontario, which has been subjected to nine glacial cycles during the last million years. Glaciation is a significant past perturbation that could occur in the future. Findings from studies conducted in other areas of southern Ontario (NWMO, 2011) suggest that the deep subsurface Paleozoic sedimentary formations have remained largely unaffected by past perturbations such as glaciations (Sections 4.3.4 and 4.3.5).

As discussed in Section 4.3.5, land in the Area of the Five Communities is still experiencing isostatic rebound following the end of the Wisconsinan glaciations. The estimated rebound is fairly small (about 1.5 millimetres per year) and should not affect the long-term stability of a deep geological repository. As also mentioned in Section 4.3.5, a neotectonic study conducted by Slattery (2011) in the area concluded that the area has not likely experienced any post-glacial neotectonic activity. Hallet (2011) conducted a study on glacial erosion caused by the Laurentide Ice Sheet in southern Ontario, including the three potentially suitable areas identified. The study concluded that potential future glacial erosion rates in the area would be limited with a conservative estimate of erosion of only 100 metres per 1 million years, which would not affect the integrity of a deep geological repository located at a depth of 500 meters or more.

In summary, available information indicates that the identified general potentially suitable areas in the Area of the Five Communities 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 area would need to be further assessed during subsequent stages of the evaluation process 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 Area of the Five Communities. The potentially suitable areas are characterized by a relatively flat topography with limited obvious topographic features, and each contains enough surface land outside of protected areas and major water bodies to accommodate the required repository surface facilities.

From a constructability perspective, although no site-specific information on rock strength characteristics and in-situ stresses was found for the municipalities of Brockton and South Bruce, and the Township of Huron-Kinloss, there is abundant information from at other locations of southern Ontario that could provide insight into what would be expected for the area. Given the greater depth of the Cobourg Formation in the Township of Huron-Kinloss, there is potential for higher in-situ stresses for a proposed DGR in the Township of Huron-Kinloss. However, available information on strength and in-situ stresses suggests that the Upper Ordovician Cobourg Formation has favorable geomechanical characteristics and is amenable to the excavation of stable underground openings. As discussed in Section 4.3.8, the sedimentary sequence at repository depths in the Area of the Five Communities is expected to have favourable geomechanical characteristics based on available information from the Bruce nuclear site (Intera Engineering Ltd., 2011). This would need to be confirmed at later stages of the site evaluation process through collection of site-specific data.

Overburden cover in the three potentially suitable areas is extensive, with thicknesses ranging from less than 10 metres up to about 100 metres locally. At this early stage of the evaluation, it is anticipated that overburden cover is not a limiting factor for construction in any of the identified general areas.

In summary, the three identified general potentially suitable areas 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.

As discussed in Section 4.3.7, here are no known commercial oil and gas resources within the municipalities of Brockton and South Bruce or the Township of Huron-Kinloss. The potential for mineral resources in the three identified potentially suitable areas is limited to: discretionary occurrences of limestone and dolostone in the municipalities of Brockton and South Bruce; and salt occurrences in the Township of Huron-Kinloss (Figure 4-7). The potential for bedrock resources (i.e. limestone and dolostone) in the potentially suitable areas is limited to very shallow depths and would not affect a deep geological repository hosted in the Cobourg Formation at depths greater than 500 metres below ground surface. The presence of salt beds beneath the Township of Huron-Kinloss is not expected to compromise the containment and isolation functions of a potential repository in the area as they are relatively thin and occur about 400 metres above the Cobourg Formation which is the preferred host formation (Section 4.4.1). As discussed in Section 4.3.7, the potential for groundwater resources at typical repository depths (i.e. within the Cobourg Formation) in the Area of the Five Communities is extremely low.

In summary, the potential for the containment and isolation function of a repository in the three general potentially suitable areas 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.

As discussed in Geofirma (2014a), the Paleozoic sedimentary sequence beneath the Area of the Five Communities is consistent with the regional geological framework for southern Ontario. The Paleozoic bedrock stratigraphy has minimal structural complexity and a simple geometry, which makes it highly predictable. The review of available information on the bedrock geology for the Area of the Five Communities did not reveal any conditions that would make the rock mass difficult to characterize (Section 4.3.2).

Quaternary overburden deposits cover all three general potentially suitable areas identified in the municipalities of Brockton and South Bruce and the Township of Huron-Kinloss, with thicknesses ranging from less than 10 metres to up to about 100 metres locally (Section 4.3.3). Given the regional geological framework, the simple geometry and the predictability of the subsurface Paleozoic sequence, the thickness of the overburden cover is not likely to affect the ability to characterize the subsurface bedrock formations beneath the identified potentially suitable areas. The three general potentially suitable areas identified in the municipalities of Brockton and South Bruce, and the Township of Huron-Kinloss are all accessible using the existing road and rail network where it has been retained.

In summary, the review of available information did not indicate any obvious conditions which would make the subsurface Paleozoic bedrock geology beneath 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 Bruce County communities involved in the site selection process contain general areas that have the potential to satisfy the geoscientific site evaluation factors outlined in the NWMO's site selection document (NWMO, 2010).

The preliminary geoscientific assessment built on the work previously conducted for the initial screenings (AECOM, 2012a; 2012b; 2012c; 2012d; 2012e) and focused on the the Area of the Five Communities (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. These include: geology; structural geology; surface conditions; protected areas; and the potential for economically exploitable natural resources. Where information for the Area of the Five Communities was limited or not available, the assessment drew on information and experience from other areas with similar geological settings in southern Ontario. The geoscientific desktop preliminary assessment included the following review and interpretation activities:

- Assembly and detailed review of available geoscientific information such as geology, structural geology, natural resources, hydrogeology and overburden deposits (surficial deposits);

- Interpretation of available geophysical surveys;
- Interpretation of available borehole geophysical data and selected 2-D seismic reflection surveys to provide information on the geometry and potential structural features of the subsurface bedrock geology;
- Terrain analysis studies to help assess overburden (surficial deposits) type and distribution, bedrock exposures, accessibility constraints, watershed and subwatershed boundaries, and groundwater discharge and recharge zones;
- Assessment of land use and protected areas including parks, conservation reserves, heritage sites and source water protection areas; and
- The identification and evaluation of general potentially suitable areas based on systematic assessment of key geoscientific characteristics and constraints that can be realistically assessed at this stage of the assessment.

The geoscientific desktop preliminary assessment showed that the geological setting in the Area of the Five Communities has a number of favourable characteristics for hosting a deep geological repository for used nuclear fuel. However, the assessment revealed that there are areas that have more potential than others to satisfy NWMO's geoscientific site evaluation factors. The assessment identified the Ordovician Cobourg Formation (limestone) as the preferred host rock formation for a used nuclear fuel deep geological repository. It was determined that a minimum depth of 500 metres below ground surface (mBGS) would be preferred in order to maintain the integrity of a repository within the Cobourg Formation. Based on the key geoscientific characteristics and constraints considered in the assessment, it was concluded that:

- The Municipality of Brockton, the Municipality of South Bruce and the Township of Huron-Kinloss appear to contain large areas that have the potential to meet the geoscientific site evaluation factors outlined in the site selection process document.
- The Municipality of Arran-Elderslie does not contain sufficient land areas that have the potential to meet the geoscientific site evaluation factors outlined in the site selection process document.
- The Town of Saugeen Shores has very limited potential to contain areas that would meet the geoscientific site evaluation factors outlined in the site selection process document.

While the municipalities of Brockton and South Bruce, and the Township of Huron-Kinloss appear to contain large areas with favourable geoscientific characteristics, there are inherent uncertainties that would need to be addressed during subsequent stages of the site evaluation process. The assumption of transferability of geoscientific characteristics and understanding based on regional data and data from the Bruce nuclear site to the communities of Brockton, South Bruce and Huron-Kinloss would need to be confirmed. The potential for hydrocarbon resources and faults within the sedimentary sequence beneath the three communities would also need to be further assessed.

Should the municipalities of Brockton and South Bruce, and the Township of Huron-Kinloss be identified 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 they contain sites that can safely contain and isolate used nuclear fuel. This may include the acquisition and interpretation of higher resolution geophysical surveys, geological mapping, and the drilling of deep boreholes.

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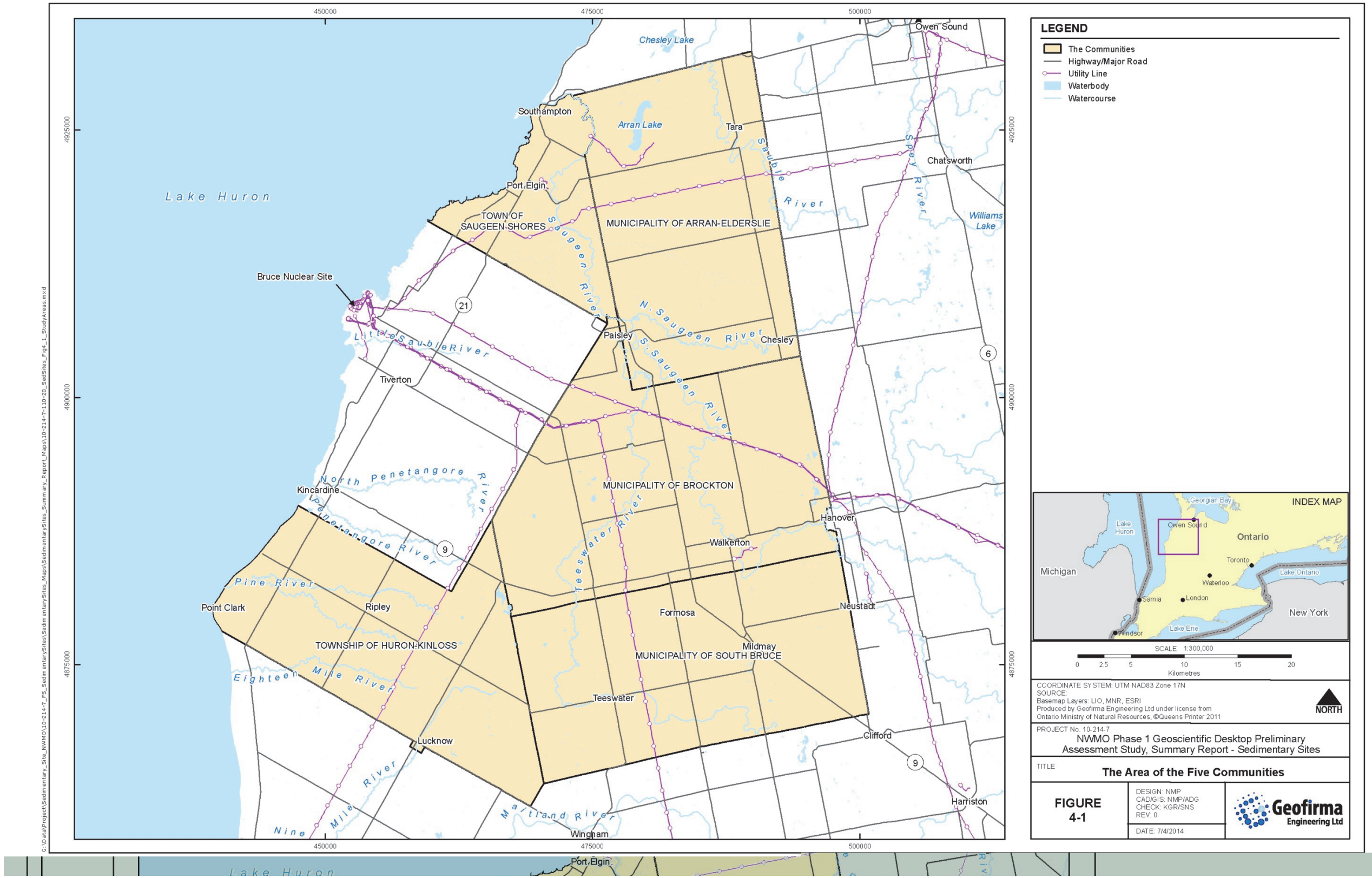


Figure 4-1: The Area of the Five Communities

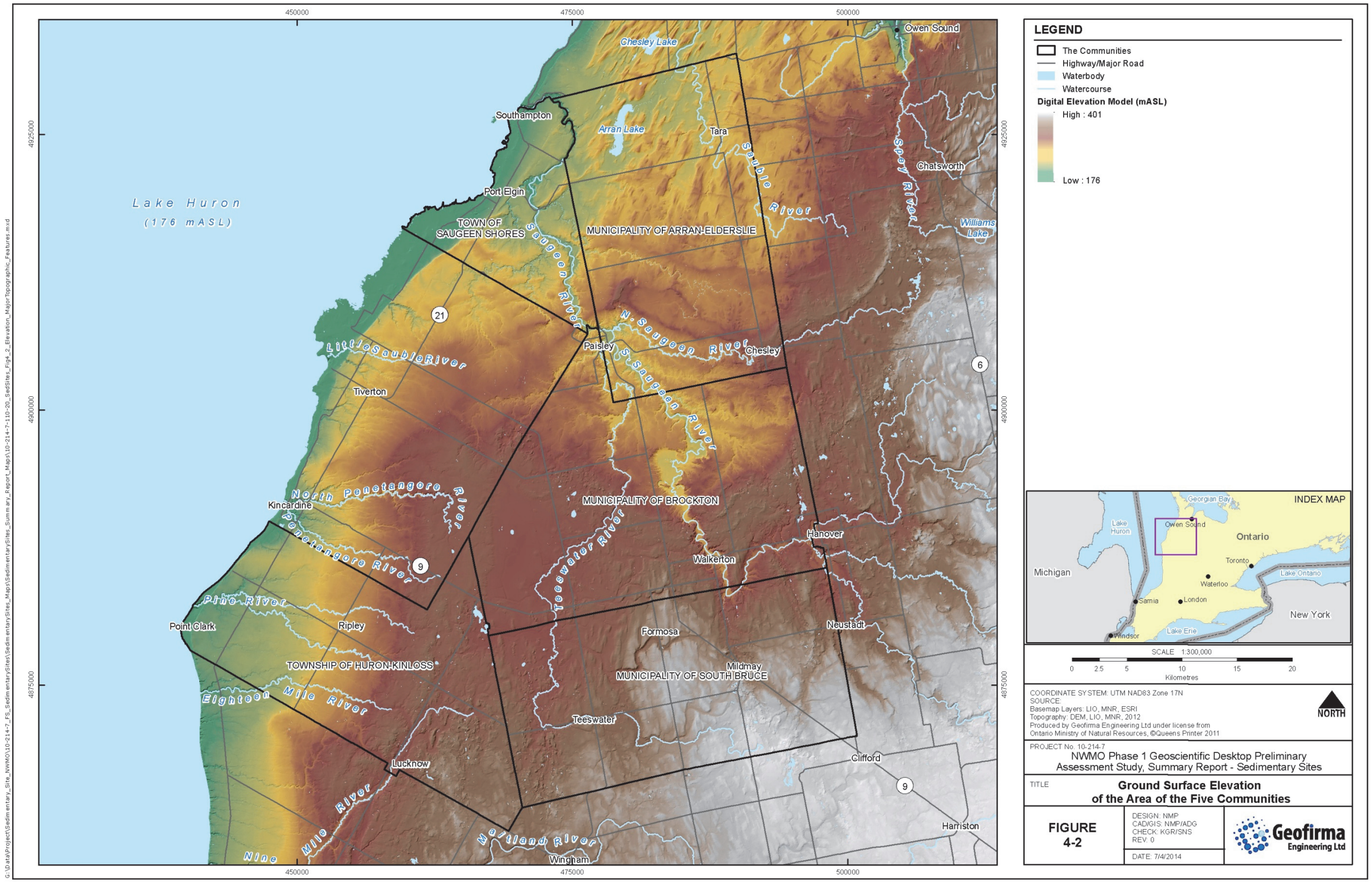


Figure 4-2: Ground Surface Elevation of the Area of the Five Communities

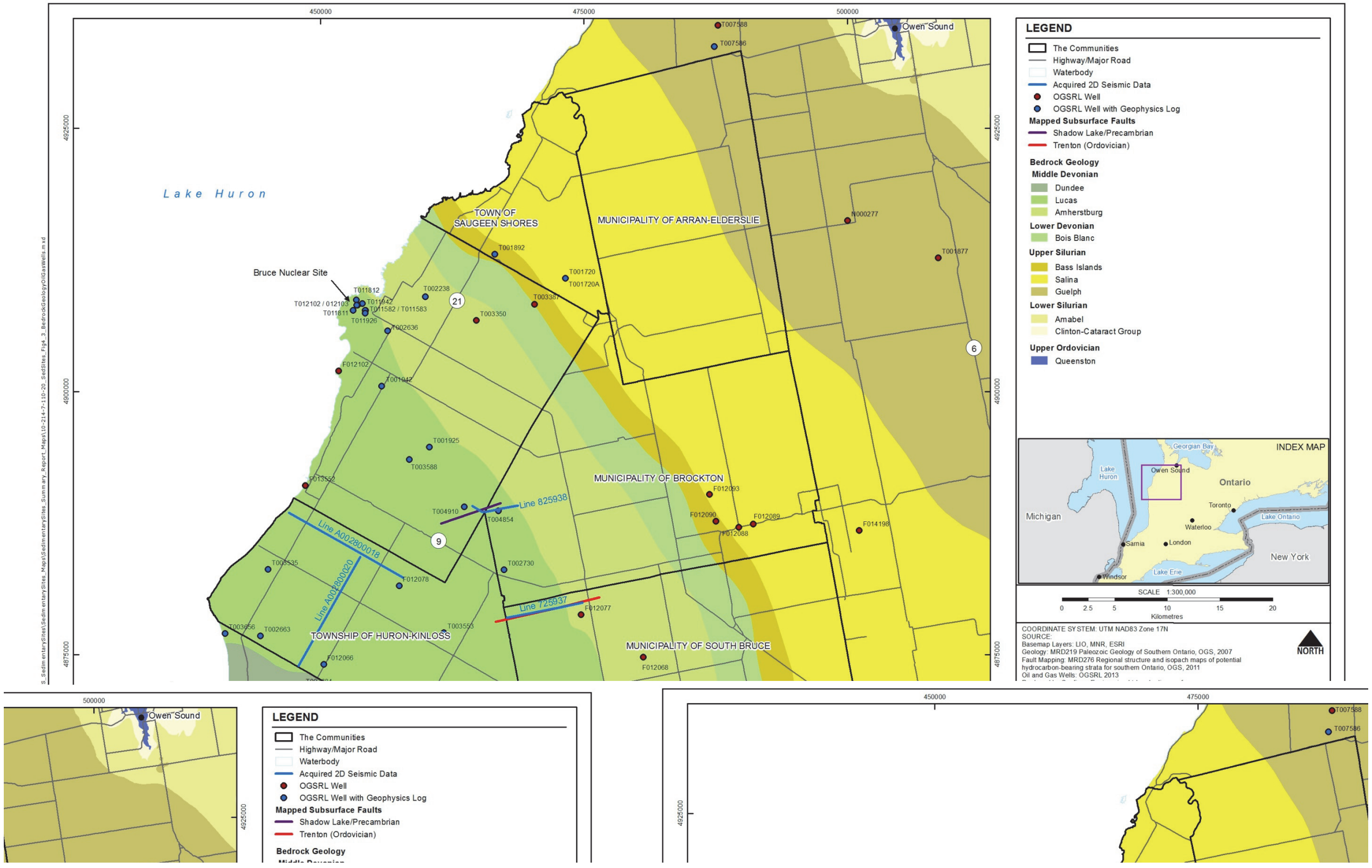
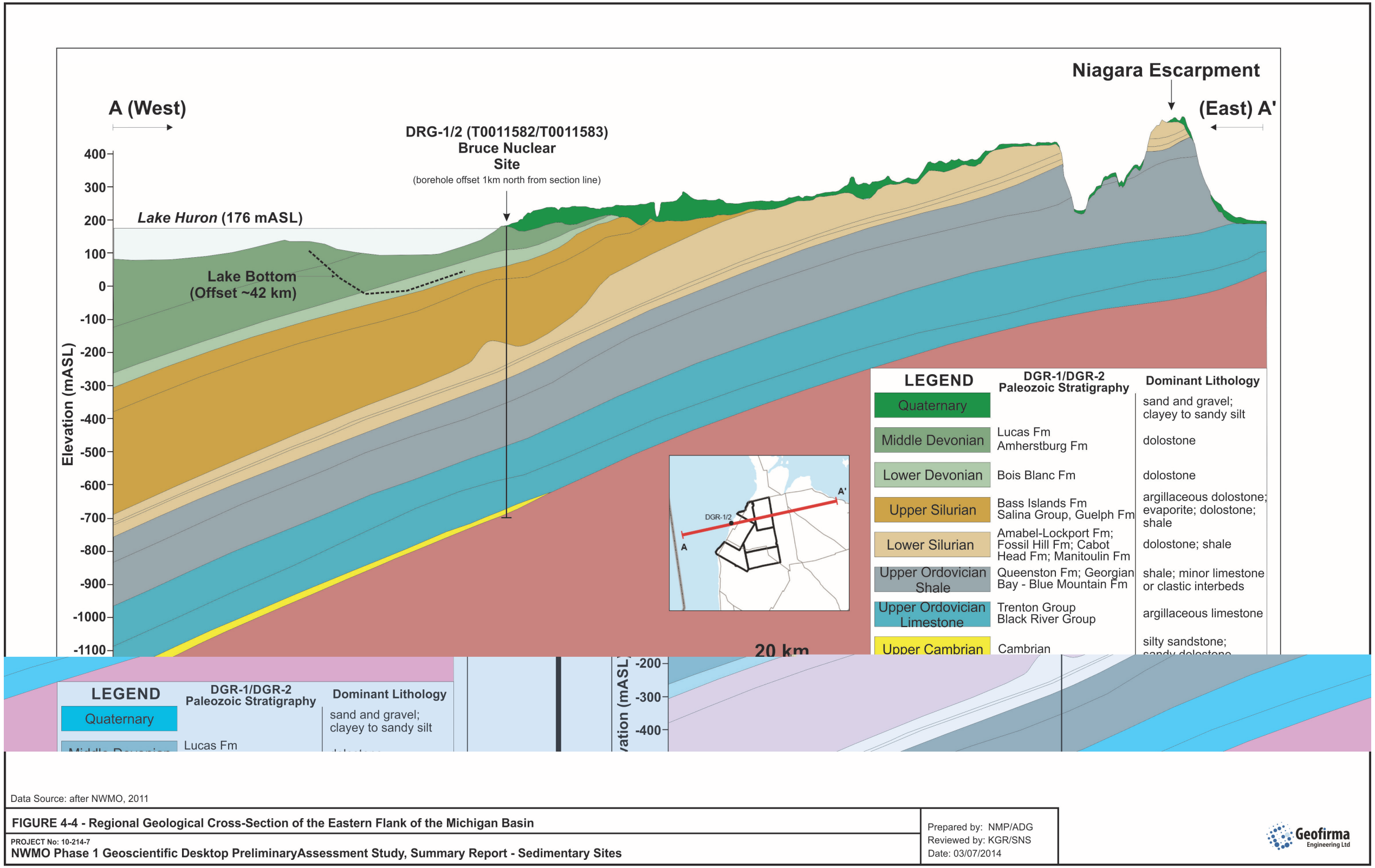


Figure 4-3: Bedrock Geology, Oil and Gas Wells, and 2D Seismic Lines of the Area of the Five Communities



Data Source: after NWMO, 2011

FIGURE 4-4 - Regional Geological Cross-Section of the Eastern Flank of the Michigan Basin	Prepared by: NMP/ADG Reviewed by: KGR/SNS Date: 03/07/2014
PROJECT No: 10-214-7 NWMO Phase 1 Geoscientific Desktop PreliminaryAssessment Study, Summary Report - Sedimentary Sites	

Geofirma Engineering Ltd

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Figure 4-4: Regional Geological Cross Section of the Eastern Flank of the Michigan Basin

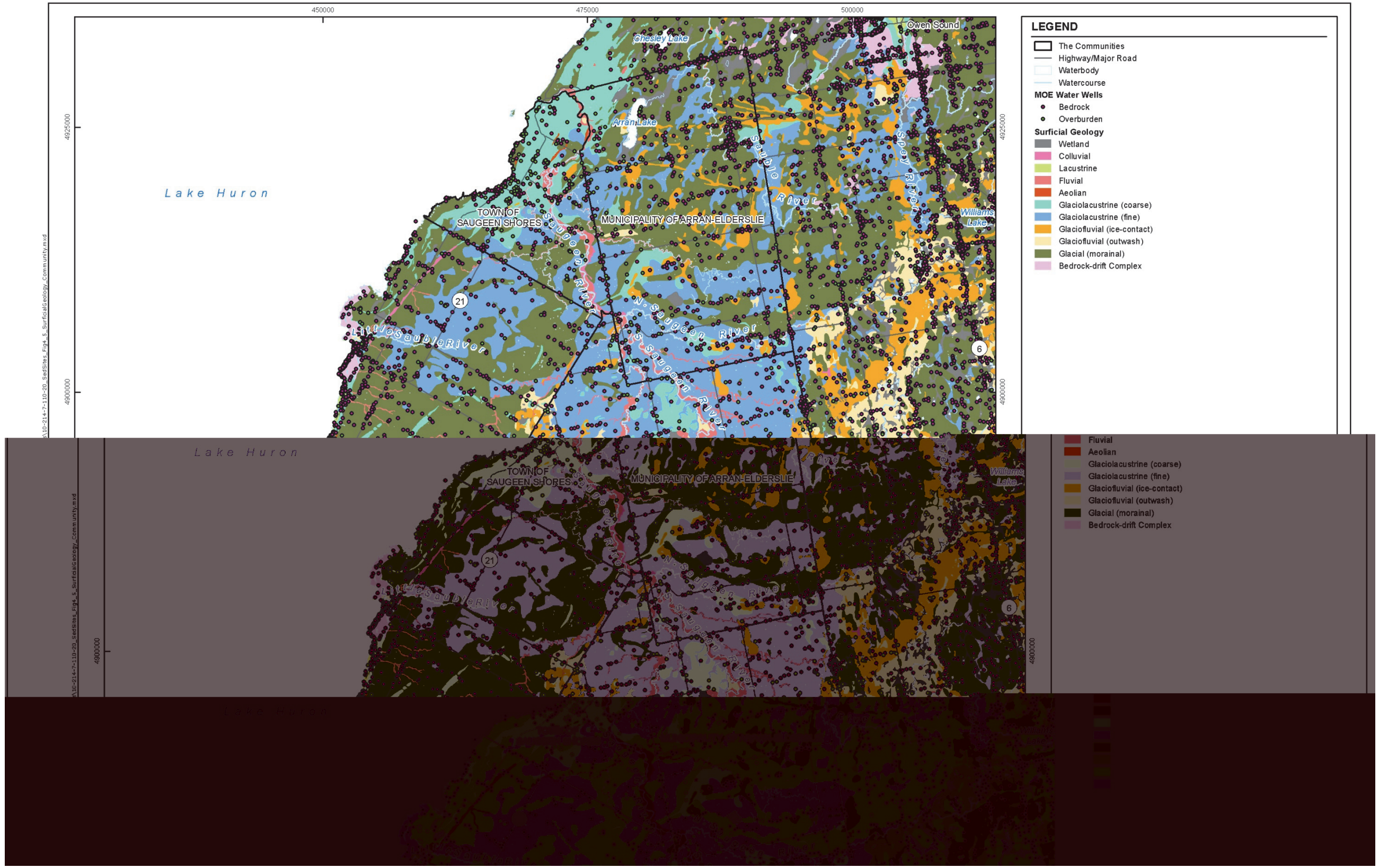

Figure 4-5: Surficial Geology and Groundwater Wells within the Area of the Five Communities

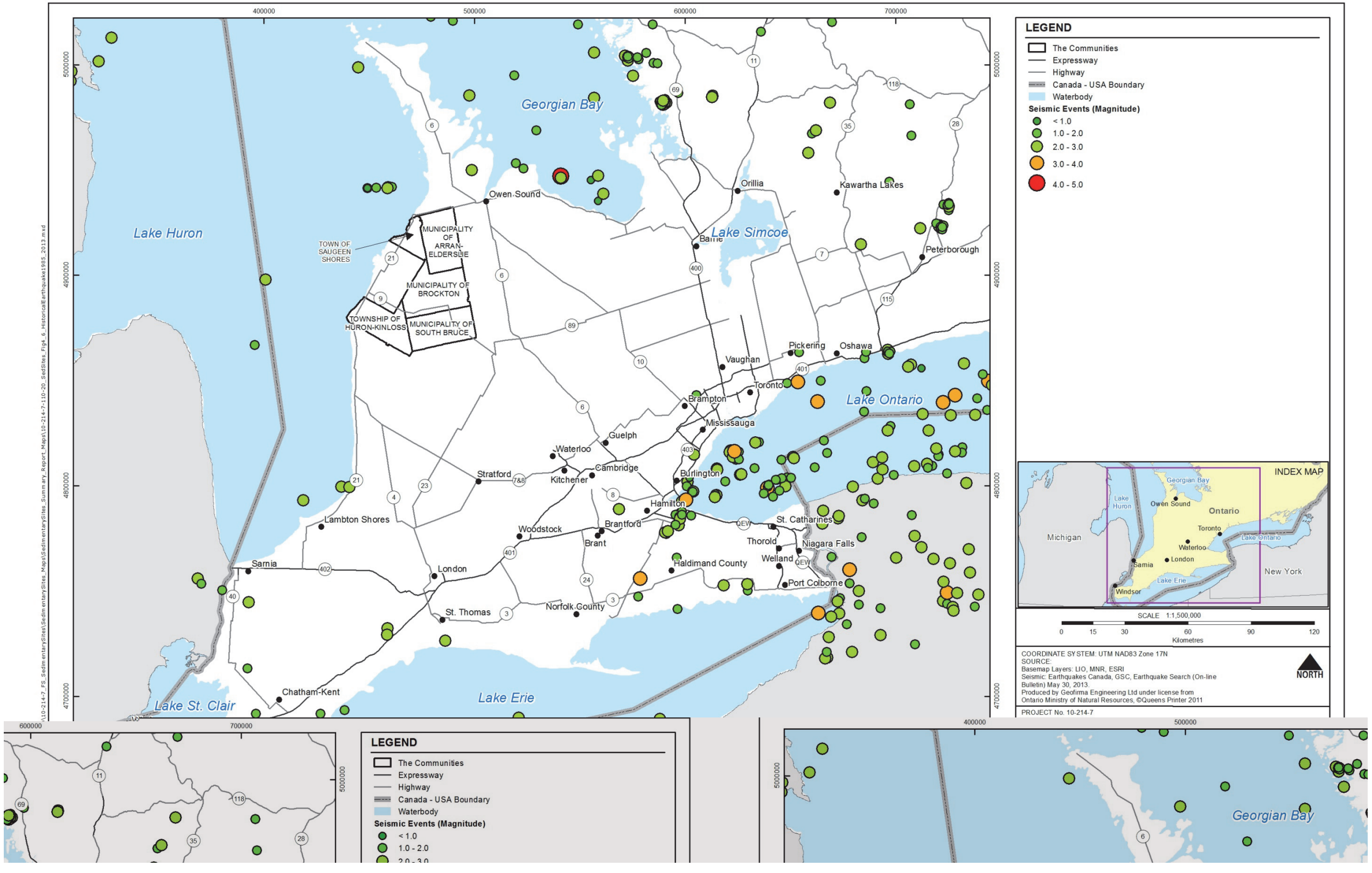

Figure 4-6: Historical Earthquake Records of Southern Ontario, 1985-2013

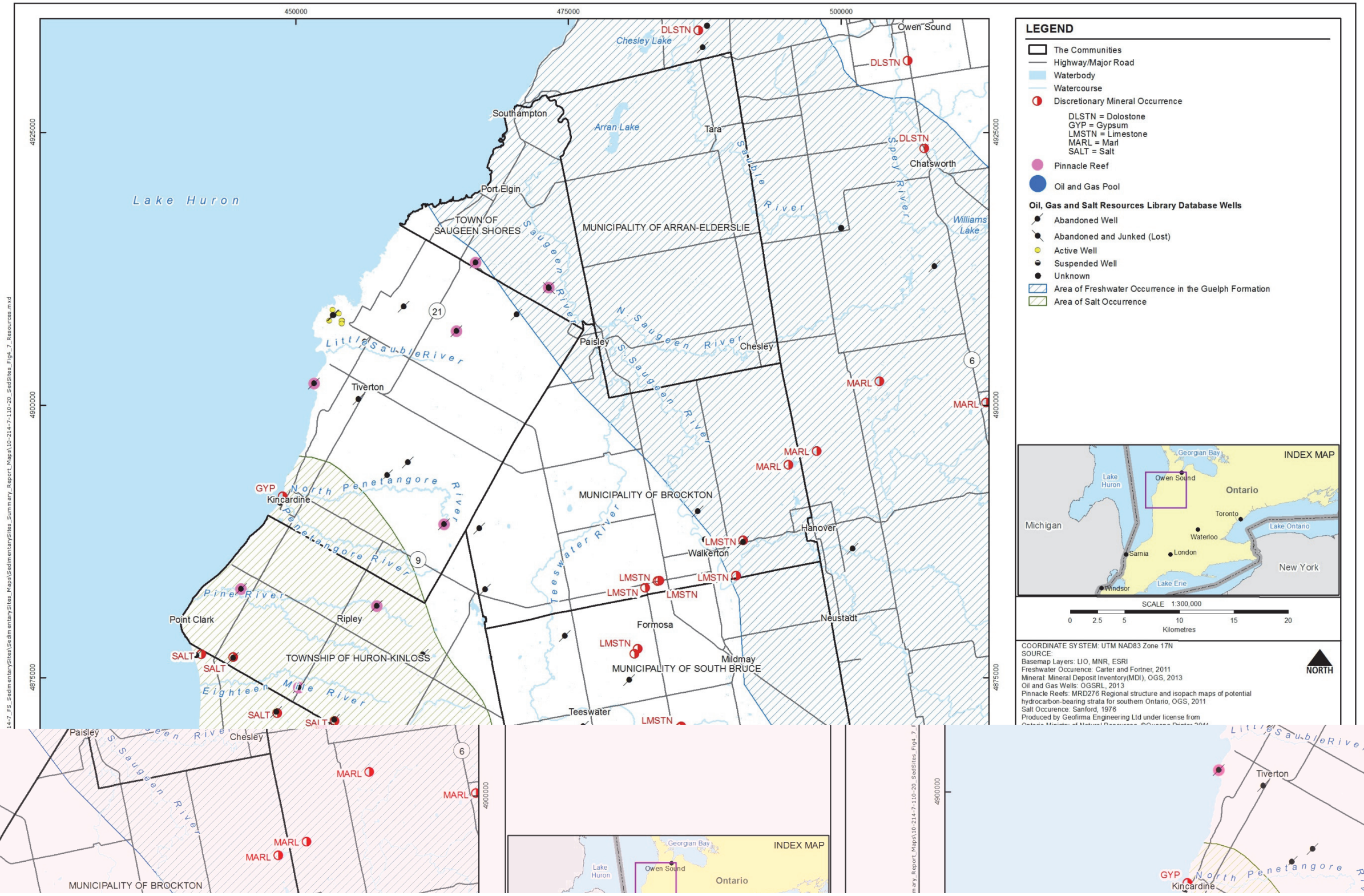

Figure 4-7: Petroleum, Mineral, and Deep Groundwater Resources in the Area of the Five Communities

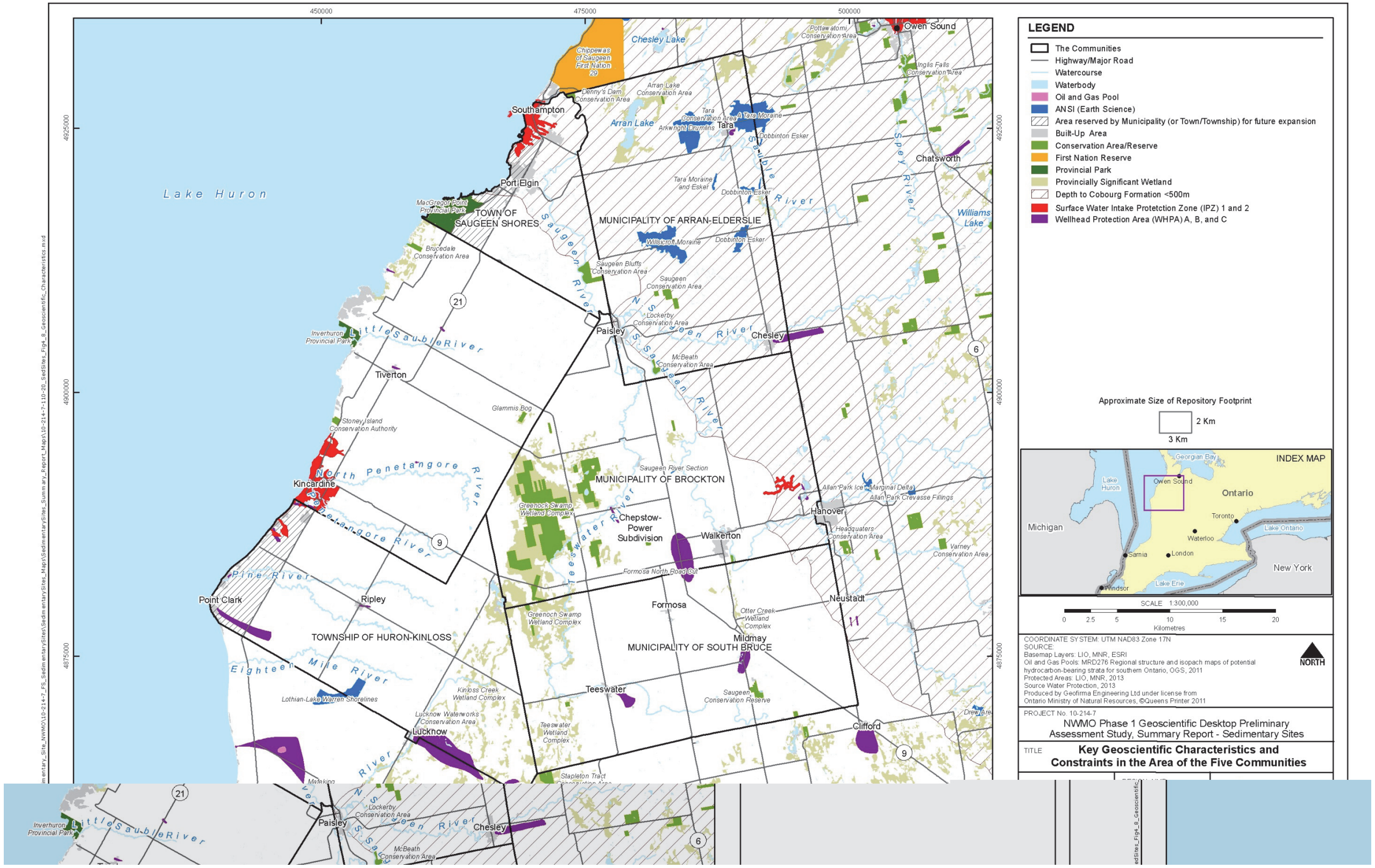

Figure 4-8: Key Geoscientific Characteristics and Constraints in the Area of the Five Communities

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 for the Township of Huron-Kinloss and the Municipalities of Brockton and South Bruce, collectively referred to as “the Area of the Three Communities”, and to explore the potential to manage any environmental effects that might result from the Adaptive Phased Management (APM) Project. This assessment was conducted in an integrated manner considering the environmental characteristics of the three Bruce communities that remain in the site selection process based on the initial findings from the geoscientific assessment (see Chapter 4). This environment and safety assessment considered the following questions:

1. Is there anything in the natural environment that would preclude siting the repository somewhere in Huron-Kinloss, Brockton and South Bruce?
2. If the repository is located somewhere in Huron-Kinloss, Brockton and South Bruce, 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 Huron-Kinloss, Brockton and South Bruce, 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 Area of the Three Communities, 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, First Nation and Métis communities in the vicinity, and surrounding communities, 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 Huron-Kinloss, Brockton and South Bruce 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. For the purpose of this preliminary assessment, the area considered encompasses three municipalities in Bruce County: the Township of Huron-Kinloss and the Municipalities of Brockton and South Bruce (referred to here as “Huron-Kinloss, Brockton and South Bruce” or the “Area of the Three Communities” as noted above).

A detailed description of the environment for Huron-Kinloss, Brockton and South Bruce is provided in Golder (2014). Summary information is presented here.

5.2.1 Communities and Infrastructure

Figure 5-1 shows the location of Huron-Kinloss, Brockton and South Bruce within the regional area. Figure 5-1 also shows the infrastructure and major land uses, including the locations of conservation areas, protected lands, source water protection wells and surface water intakes, and Crown lands.

Huron-Kinloss, Brockton and South Bruce encompass an area of 1,501 square kilometres (LIO, 2013), with a population of 21,907 (Statistics Canada, 2013). The largest settlement areas within Huron-Kinloss, Brockton and South Bruce include: Walkerton in the Municipality of Brockton; Teeswater, Mildmay and Formosa in the Municipality of South Bruce; and Ripley and Lucknow in the Township of Huron-Kinloss. More information on the Area of the Three Communities is provided in Chapter 7.

There are a number of First Nation and Métis communities and organizations in the vicinity of South Bruce, including The Saugeen Ojibway Nations (Saugeen First Nation and Chippewas of Nawash Unceded First Nation). Métis Nation of Ontario community councils in the vicinity include Moon River Métis, Georgian Bay Métis, and Great Lakes Métis. The Historic Saugeen Métis are also located in the vicinity.

The main transportation routes include Highway 21, which follows along the shore of Lake Huron in a southwest-northeast orientation and then crosses from west to east from Southampton towards Owen Sound. Highway 9 crosses through the Area of the Three Communities in a southeast-northwest orientation from Harriston through Mildmay and then westward to Kincardine. There are no active railway lines in Huron-Kinloss, Brockton or South Bruce or the surrounding area. In the past there was an extensive railroad network in the Area of the Three Communities, but most of the railways were abandoned in 1988 through 1995 (Zadro and Delamere, 2014). The nearest railway to the Area of the Three Communities is the Goderich-Exeter Railway, which runs from Stratford to Goderich.

A number of transmission lines cross through Huron-Kinloss, Brockton and South Bruce, including a 230 kilovolt transmission line running from west to east through the Municipality of Kincardine and then south through the Municipalities of Brockton and South Bruce and a 500 kilovolt transmission line branching off the 230 kilovolt line and running to the southwest,

approximately parallel to the Lake Huron shoreline. There is one municipal airport located in the Area of the Three Communities: the Saugeen Municipal Airport (northwest of Hanover), as well as several privately-owned airfields. There are seven operating landfills (MOE, 2013a) and two waste water treatment plants in Huron-Kinloss, Brockton and South Bruce.

Huron-Kinloss, Brockton and South Bruce are for the most part located within the Saugeen Valley Conservation Authority (SVCA) administrative area. The southern and eastern part of Huron-Kinloss and a small portion of South Bruce are located within the administrative area of the Maitland Valley Conservation Authority (MVCA). There is one conservation area (Lucknow Conservation Area) and several additional conservation lands within the Area of the Three Communities. There are also two provincial parks located along the shore of Lake Huron, just outside of the Area of the Three Communities. MacGregor Point Provincial Park is located in the Town of Saugeen Shores and Inverhuron Provincial Park, a historical park, is located in the Municipality of Kincardine. There are 11 conservation areas located close to but outside of Huron-Kinloss, Brockton and South Bruce.

The Ontario Archaeological Sites Database identifies 17 known archaeological sites in Huron-Kinloss, Brockton and South Bruce, including early (pre-contact) Aboriginal campsites, Early to Late Woodland Aboriginal sites and historic Euro-Canadian sites (von Bitter, 2013). There are 19 municipal or provincial designated heritage properties and one federally designated historic site (Point Clark Lighthouse) in the Area of the Three Communities (OHT, 2013; MTCS, 2013; Parks Canada, 2013). The presence of local heritage sites would need to be confirmed in discussion with the community and First Nation and Métis communities in the vicinity.

As discussed in Section 4.3.7, water wells in Huron-Kinloss, Brockton and South Bruce obtain water from the overburden or shallow bedrock. The Ontario Ministry of the Environment (MOE) Water Well Information System (WWIS) database contains 3,232 well records in the Area of the Three Communities, of which only 2,680 provide useful information on well depth, yield and other relevant parameters. These 2,680 water wells range from 2.5 to 163 metres in depth (MOE, 2013b). No potable water supply wells are known to exploit aquifers at typical repository depths in Huron-Kinloss, Brockton or South Bruce or anywhere else in southern Ontario.

There are eleven municipal wells with wellhead protection areas (WHPAs) and two surface water intakes with an intake protection zone (IPZ) within Huron-Kinloss, Brockton and South Bruce. There are additional WHPAs and IPZs outside of the Area of the Three Communities. The location of the wells with WHPAs and surface water intakes with IPZs are shown on Figure 5-1.

5.2.2 Natural Environment

As described in Chapter 4, the Area of the Three Communities is almost entirely covered by overburden, which includes glacial till, glaciofluvial outwash and ice-contact deposits, forming hummocky terrain. The western portion of Huron-Kinloss, Brockton and South Bruce is dominated by silty to clayey glacial till deposits with elongated patches of glaciolacustrine beach deposits. East of the till deposits is a northeast to southwest oriented moraine ridge of the Horseshoe moraine, characterized by glaciofluvial ice-contact and outwash sediments. Drumlins are pronounced in the eastern portion of the Municipality of South Bruce with axes trending north-south to northwest-southeast. Terraces of glaciolacustrine, outwash and kame deposits fill the valleys between the drumlins. In the northern part of Brockton is a clay plain characterized by varved silts and clays. The land surface in Huron-Kinloss, Brockton and South Bruce ranges from a maximum of 249 masl to a minimum of 176 masl along the shores of Lake

Huron. Relief within the Area of the Three Communities ranges from low relief along the Lake Huron shoreline to higher relief with undulating to hummocky in areas associated with the Horseshoe moraines and the Teeswater drumlin fields. A flat low-lying area associated with a wetland is also located in the southwest corner of the Municipality of Brockton. Formosa Creek and the Saugeen and Teeswater rivers flow westward through well-defined valleys in the Area of the Three Communities.

The bedrock geology in Huron-Kinloss, Brockton and South Bruce consists of a thick Paleozoic sedimentary sequence, deposited approximately 542 to 318 million years ago. The sedimentary stratigraphy includes shale, carbonate and evaporate units (Johnson et al., 1992; Walker and Geissman, 2009) which lie unconformably over the Precambrian crystalline basement, characterized by gneisses and metamorphic rocks of the Grenville Province of the Canadian Shield (Percival and Easton, 2007).

The communities of Huron-Kinloss, Brockton and South Bruce are located within a temperate and humid continental climate zone, with hot, humid summers and cold winters. In the summer, active weather such as showers and thunderstorms occur in June, July and August. The Area of the Three Communities is also prone to severe thunderstorms and even occasional tornadoes during the summer. Most precipitation falls from the late summer through the winter months due to snow squall activity. In winter, the proximity of Lake Huron results in lake effect snow squalls.

Figure 5-2 shows the significant natural features within the Area of the Three Communities, including watershed boundaries, significant valleys, deer wintering areas, spawning sites and nesting areas for known rare species. This information will be further developed in the future through discussions with interested communities and First Nation and Métis communities in the vicinity as well as field studies, should the community proceed in the site selection process.

Huron-Kinloss, Brockton and South Bruce are located within the St. Lawrence Drainage Area. Most of the eastern part of the Area of the Three Communities is within the Saugeen tertiary watershed while the western part along the Lake Huron shoreline lies within the Penetangore tertiary watershed. Drainage along the shoreline is generally from east to west into Lake Huron. The most prominent drainage features in the Area of the Three Communities are the Saugeen, Teeswater, South Pine River, Eighteen Mile and Nine Mile rivers. Water bodies occurring within the Area of the Three Communities are mostly streams and rivers that are warm water tolerant with some cool and cold water in the tributaries. The Area of the Three Communities supports recreational fishing, with species including brook, brown and rainbow trout, bass, pike and salmon (SVCA, 2013; MVCA, 2013). These rivers are actively managed and support provincial and federal biodiversity initiatives as well as supporting local sport fishing and tourism.

Huron-Kinloss, Brockton and South Bruce lie within the Deciduous Forest Region where woodlands consist primarily of American beech and sugar maple, together with basswood, red maple and oak on the northern limit of the Carolinian Forest (CCC, 2013). In areas where agriculture dominates, terrestrial features and areas are generally associated with valley lands along watercourses and within wetlands. There are no forest management units assigned by the Ontario government for this part of the province. Forests are managed jointly by the Ontario Ministry of Natural Resources (MNR), municipalities and Conservation Authorities; they contain important sustaining areas for wildlife such as feeding, wintering and calving sites for deer and concentration and nesting areas for raptors, herons and waterfowl. Hunting of white-tailed deer, waterfowl and wild turkey is common in permitted areas.

Although the Area of the Three Communities is primarily an agricultural landscape, it is located at the transition of Ontario forest zones and in line with known bird migration routes along the eastern shore of Lake Huron. The area has been subject to a large number of ecological studies designed to understand and describe its ecology and habitats. The Natural Heritage Information Centre (NHIC) database (NHIC, 2013) shows the occurrence of species that are listed as Endangered (END), Threatened (THR) or Special Concern (SC), either under the provincial *Endangered Species Act* (ESA) or the federal *Species at Risk Act* (SARA). The Royal Ontario Museum range maps (ROM, 2013) indicate the potential for Species at Risk (SAR) to exist within the Area of the Three Communities, based on the principles of range mapping. Habitats within the Area of the Three Communities could directly or indirectly support the needs of at least 70 designated SAR (NHIC, 2005; NHIC, 2013; ROM, 2013; Oldham and Weller, 2000; BSC, 2006; BCI, 2013a, b; Jones et al., 2013; Dobbyn, 1994 and CO, 2012). These species include: five mammals, 24 birds, ten herpetofauna, 11 fish and aquatic species, four invertebrates and 16 plants. Further data collection through site-specific surveys and potential discussions with interested communities and potentially affected First Nation and Métis communities 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 Huron-Kinloss, Brockton and South Bruce are described in the Environment Report (Golder, 2014). A preliminary qualitative assessment of natural hazards is summarized in this section. These identified natural hazards represent ways in which the natural environment could potentially affect the APM Project during the various phases of implementation (see Table 3-1). As with all large-scale construction projects, the design process will take into account the site-specific characteristics of the natural environment, and mitigate the risks associated with occurrence of these natural hazards, as appropriate.

- Earthquakes – Low risk – Located in a seismically stable region of the Michigan Basin in southwestern Ontario and has a low seismic hazard rating (NRCan, 2010) (see Chapter 4 for additional information).
- Tornadoes/Hurricanes – Possible risk – Located in an area with a low to moderate tornado frequency (less than 1.8 tornadoes per year per10,000 square kilometres), but where there is a potential for F2–F5 tornadoes (Sills et al., 2012) and is located outside the geographic area where hurricanes occur. It is noted that an F3 tornado struck the Town of Goderich to the south of the Area of the Three Communities on August 21, 2011, (The Weather Network, 2013).
- Flooding – Possible risk – Possible risk of flooding along the shore of Lake Huron. 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 – Moderate risk – Total average annual snowfall is moderate (390 centimetres), and extreme snowfall events are possible due to snow squall activity developing during the winter period.
- Fire – Low risk – Land use is largely agricultural with wooded areas covering approximately 8.5 percent of the land. Locations of historical forest fires are unknown. In wooded areas, fires could be initiated by lightning strikes or human activity.
- Landslide – Low risk – General risk of landslide is low topographic relief and low seismic hazard rating. Risk will vary based on specific location.

- Tsunami – Low risk – Low seismic hazard rating and low potential along immediate Lake Huron shoreline.

5.2.4 Environment Summary

Table 5-1 presents summary information for Huron-Kinloss, Brockton and South Bruce taken from the Environment Report (Golder, 2014).

Table 5-1: Summary of Environmental Features within Huron-Kinloss, Brockton and South Bruce

Environmental Feature	Summary
Protected Areas	
Known Heritage Sites (Including Archaeological Sites)	Yes
Provincial Parks, Conservation Areas and Conservation Lands	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	<1%/16%
Active Agriculture	Yes
Active Forestry	No
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), Earth or Life Science Sites and International Biological Program Sites	Yes
Natural Hazards	
Occurrence of Forest Fires	Low
Potential for Earthquakes	Low
Potential for Tornadoes or Hurricanes	Possible Tornado; Low Hurricane
Potential for Flooding, Drought, Extreme Snow and Ice	Possible Flooding;

Environmental Feature	Summary
	Low Drought; Moderate Snow/Ice
Potential for Landslides	Low

5.3 Potential Environmental Effects

This section presents the results of a high-level screening assessment performed to identify potential interactions between the APM 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 Area of the Three Communities 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*.

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 could involve field surveys to better characterize the site-specific environment, including the

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 and increased traffic. Site-specific project-environment interactions for Huron-Kinloss, Brockton and South Bruce 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 potentially affected First Nation and Métis communities, 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 Huron-Kinloss, Brockton and South Bruce.

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	Yes	Yes	No
Subsurface Environment	Change in groundwater quality and flow from site clearing	Yes	Yes	No
Aquatic Environment	Change in surface water quality and flow from site clearing, disturbance to aquatic habitat or biota from access construction	Yes	Yes	No
Terrestrial Environment	Clearing and disturbance to terrestrial habitat or biota from access construction, noise, 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* and after applicable permits have been obtained.

A sizable workforce would be expected. The substantial infrastructure available in Huron-Kinloss, Brockton and South Bruce and the surrounding area is likely sufficient to accommodate the temporary construction workers.

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) is 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 management area, whose location would be determined collaboratively with the community and area (Chapter 3). The excavated rock management 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. 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. If present,

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 Area of the Three Communities may be 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 Huron-Kinloss, Brockton and South Bruce, 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 Area of the Three Communities.

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 underground 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 underground blasting	Yes	Yes	No
Terrestrial Environment	Clearing and disturbance to terrestrial habitat or biota from infrastructure or rock pile placement, noise, vibration from underground 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, underground 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-storey 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 follow-up 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 Huron-Kinloss, Brockton and South Bruce.

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

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 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 underground 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 (if present); 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 be, in general, beneficial to the environment after completion.

Overall, no project-environment interactions are identified that would prevent decommissioning and closing the repository in Huron-Kinloss, Brockton and South Bruce.

Table 5-5: Potential Interactions with the Biophysical Environment during Decommissioning and Closure Activities

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

Environmental Component	Main Considerations	Is There Potential for an Effect?	Is Management and Mitigation Possible?	Are Significant Residual Effects Anticipated?
	residual radioactivity during infrastructure removal operations			
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 thousand 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 typically 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 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 Area of the Three Communities 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 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 processes 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?

At present, due to the limited site specific 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 the Ordovician Cobourg limestone formation would be the preferred host rock.

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.

Five major postclosure safety assessments for a deep geological repository for used CANDU fuel have been carried out over the last 20 years, with four assessments performed for hypothetical sites on the Canadian Shield and one assessment performed for a hypothetical site in the Michigan Basin (AECL, 1994; Goodwin et al., 1996; Gierszewski et al., 2004; NWMO, 2012; NWMO, 2013). Similar studies assessing repository concepts in sedimentary rock environments have also been published in other countries, notably France (Andra, 2005) and Switzerland (Nagra, 2002). 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 suitable formations of the sedimentary rock Michigan Basin 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 or millions 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 milliSievert per year).

The potential chemical toxicity hazard posed by a deep geological repository has also been examined (NWMO, 2012; NWMO, 2013). 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 Michigan Basin of southwestern Ontario 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.

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 geological repository have been assessed for a hypothetical site in the Michigan Basin (NWMO, 2013). The study shows that for a sufficiently deep repository with no nearby fractures, the net impact would not be significantly different from that associated with the assumption of a constant climate and the potential effects on people and the environment 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 Huron-Kinloss, Brockton and South Bruce. 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, First Nation and Métis communities in the vicinity, and surrounding communities, 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 site specific 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 the Ordovician Cobourg limestone formation would be the preferred host rock. Site-specific safety assessments would be created at later phases of the project when more information on the local geology becomes available.

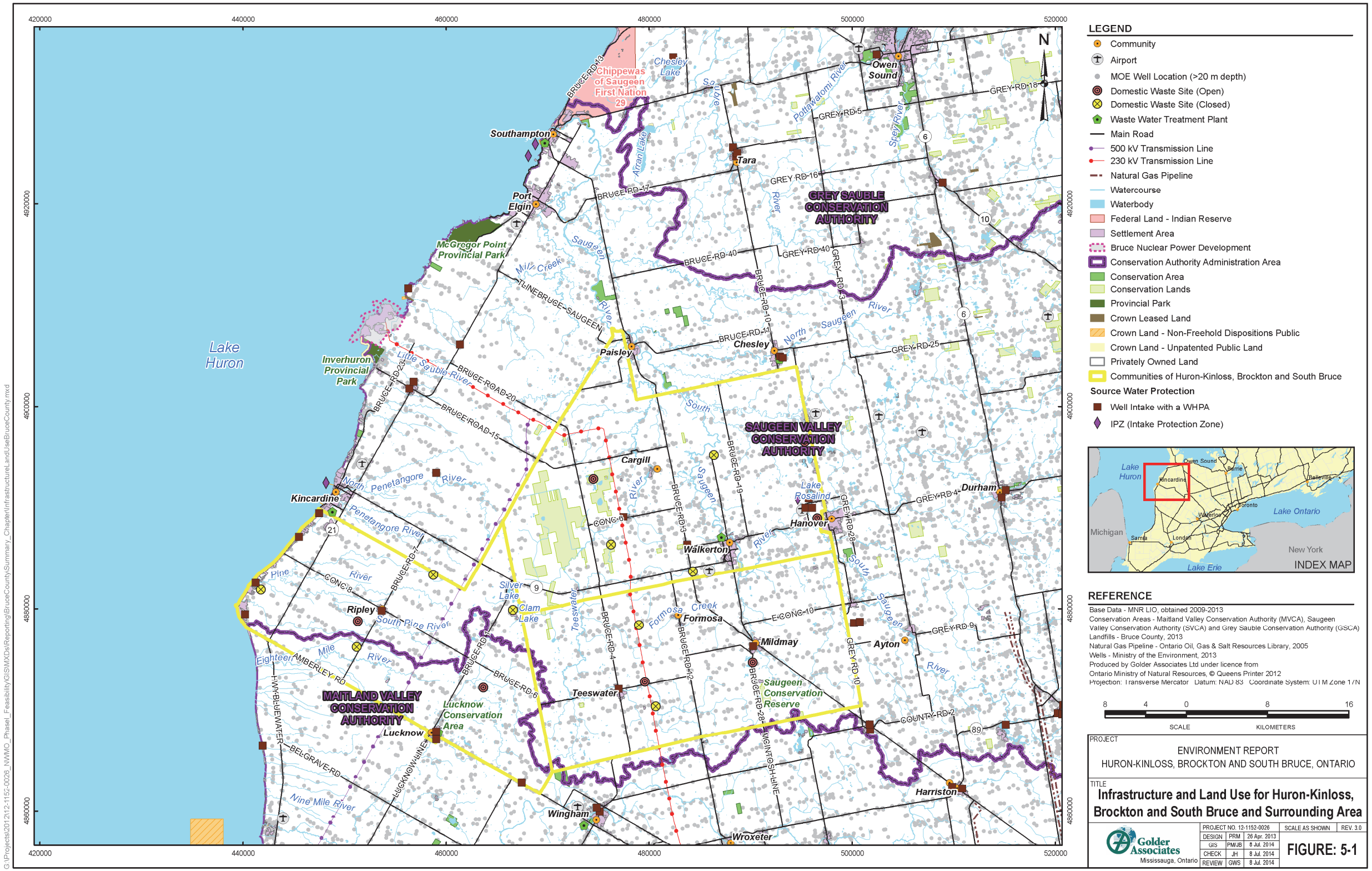

Figure 5-1: Infrastructure and Land Use within Huron-Kinloss, Brockton and South Bruce

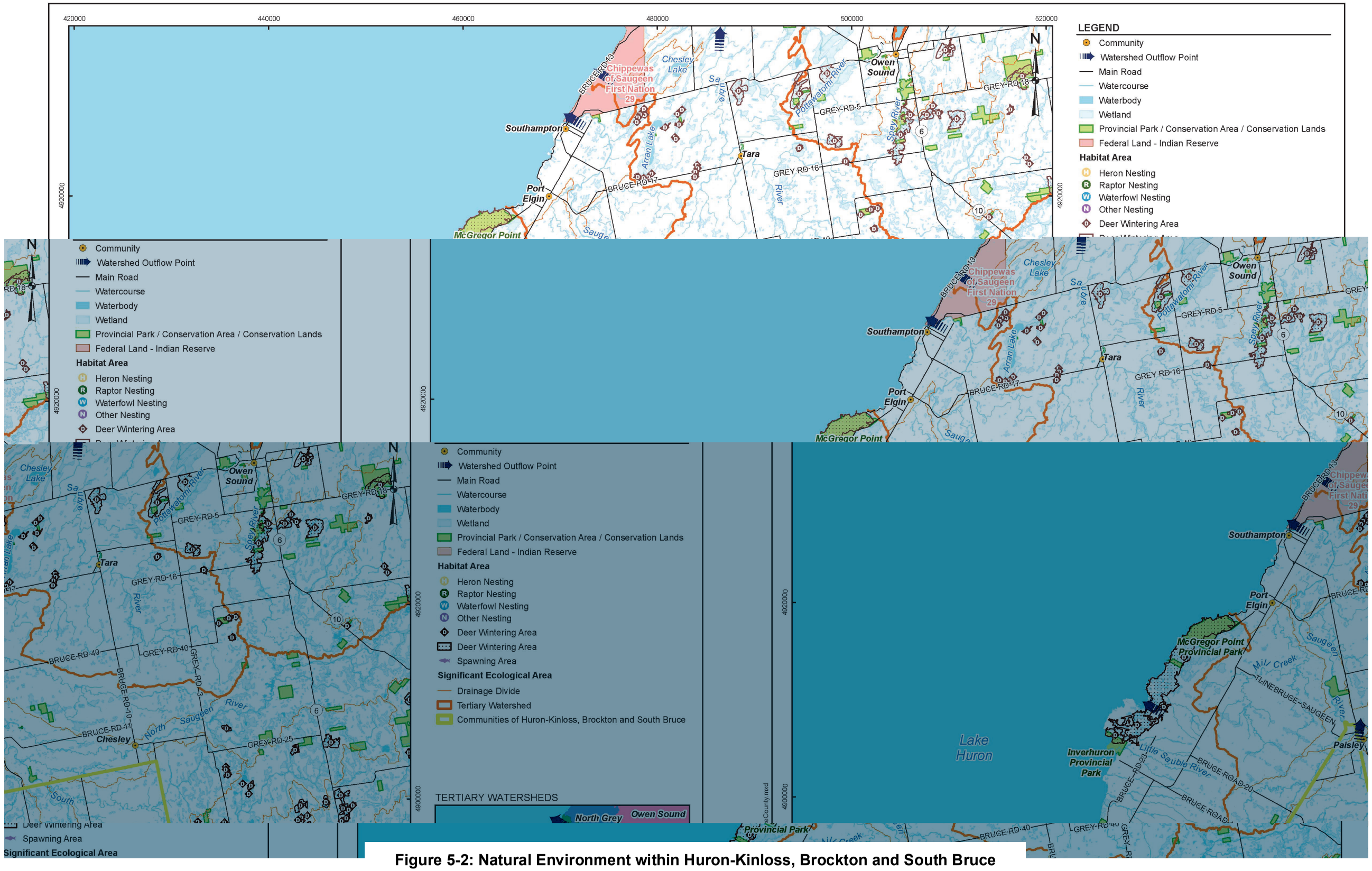

Figure 5-2: Natural Environment within Huron-Kinloss, Brockton and South Bruce

6. PRELIMINARY ASSESSMENT OF TRANSPORTATION

6.1 Introduction

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 in other countries.

The approach taken in preparing this chapter serves two functions. First, it describes the comprehensive transportation safety regulation and oversight processes which 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 publically 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 preliminary assessment 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 South Bruce 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 (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 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 cooperation between these agencies provides 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* 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 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 fire fighting 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 the 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 Agreements 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 CANDU Used 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-tin alloy. Typically, 37 of these tubes are mounted 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 to cool. Additional information on used nuclear fuel is provided in Section 3.2.

The radioactivity of used fuel initially drops quickly following removal from the reactor. After being out of the reactor for seven to 10 years the radioactivity has decayed by 99 percent 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. However, the reference design for a deep geological repository assumes an average out-of-reactor cooling period of 30 years.

6.3.2 Used Fuel Transportation Package

The NWMO will be transporting the used fuel bundles to the APM repository facility in the UFTP, which will be certified by the CNSC to the regulations in force at the time of shipment.

To be certified, the UFTP must, among other things 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 of the package are well below the regulatory dose limits.

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

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

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

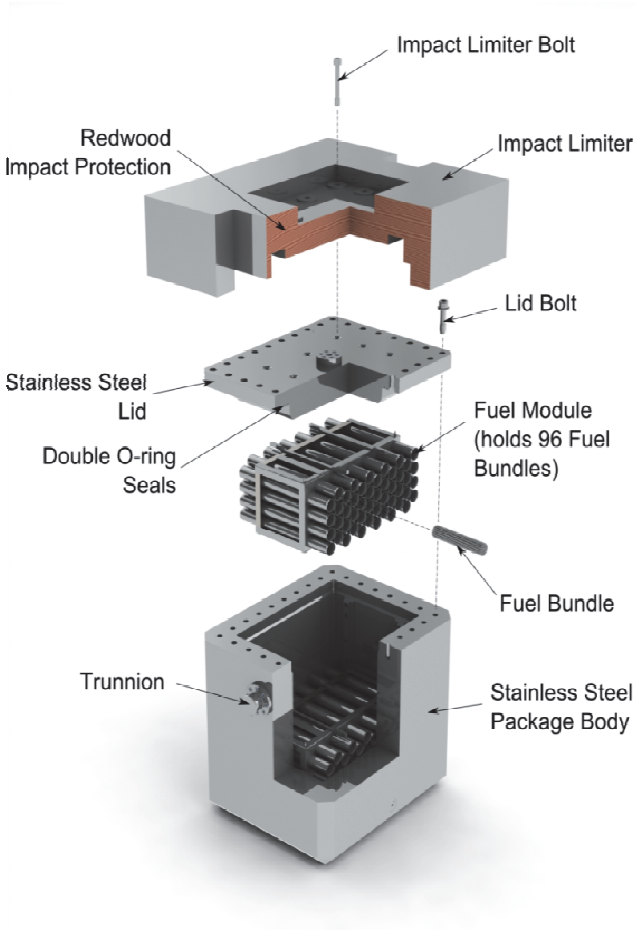

Figure 6-1: Used Fuel Transportation Package

6.3.3 Commercial Vehicle Safety

Commercial vehicle and driver safety are important to the NWMO. All commercial vehicles carrying dangerous goods are subject to Transport Canada safety requirements and inspection. 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 prescribed 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 one 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 milliSievart/year). For comparison, the typical dose received from one dental X-ray is approximately 0.01 milliSievert.

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 milliSievert 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 (milliSievert peryear)	Assumptions / Comments
During Transport				
Resident along Transport Route	30 metres	620 shipments	0.000 013	Person living 30 metres from route exposed to all 620 shipments (including one unplanned stop)
Public in Vehicle sharing Route	10 metres	2 shipments	0.000 22	Person in vehicle 10 metres from transport package for one hour twice per year
During ½ hour Rest Stop				
Public in Vicinity at Rest Stop	15 metres	31 shipments	0.000 12	Trucks alternate between 10 rest stops. Person present at given stop five per cent of time (i.e. five 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 reference used fuel inventory being used for the APM preliminary assessments is 4.6 million fuel bundles (Garamszeghy 2011). The distribution of the fuel bundles is provided in Table 6-2. Using the UFTP, the NWMO Transport Program anticipates it will require about 24,000 truck trips over 38 years to move the inventory to the repository site.

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

Table 6-2: Estimated Used Fuel Quantities by Owner

Owner	Number of Used Fuel Bundles
Ontario Power Generation	4,026,000
AECL	32,600
Hydro-Québec	268,000[a]
New Brunswick Power	260,000
TOTAL (rounded)	**4,600,000**

Note:
[a] The 268,000 fuel bundle inventory assumes refurbishment of the Gentilly 2 Nuclear Generating Station. In 2012, Hydro-Québec announced their decision to permanently shut down Gentilly 2. The actual fuel bundle inventory for Gentilly 2 is approximately 130,000 bundles.

6.5 Used Fuel Transportation Experience

Used nuclear fuel has been transported routinely in Canada since the 1960's, 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, health effects, fatalities, or environmental consequences attributable to the 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 (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 package safety during transport. The driver will ensure that all documentation, labeling and safety requirements have been met prior to departure and continue to be met en route. The shipments must have a security escort who is 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 as described in the Emergency Management Framework for Canada, local and provincial plans, and existing mutual aid agreements. The NWMO will co-ordinate its planning with the provinces and first responders along the designated routes to provide used fuel specific training and to conduct exercises. It is anticipated that the existing agreements between nuclear facilities in Ontario, Manitoba, Québec, and New Brunswick will be expanded to accommodate the requirements of NWMO shipments.

6.6.2 Communications

An 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 require review and approval by the CNSC.

The function of the transport command centre is anticipated to be similar 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 would 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; 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, fire fighting, 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 cooperative emergency response planning, and to identify and address training and exercise needs.

The NWMO will work with CNSC and local response agencies to coordinate planning and preparedness activities based on 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, and the provinces and local response agencies.

6.7 Transportation Logistics to South Bruce

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

The Municipality of South Bruce straddles Highway 9 (Elora Street South) just south of Walkerton and approximately 45 kilometres east of Kincardine. The Goderich-Exeter Railway, operated by Genesee and Wyoming Canada Inc., the Canadian subsidiary of Genesee and Wyoming, terminates in Goderich approximately 70 kilometres southwest of South Bruce. The short line railway interchanges with the cross-continental railroad, the Canadian National Railway (CNR), in London and Toronto.

If rail is a preferred mode, an intermodal facility could be constructed in Goderich with trucks used for the last stage of transport to the receiving facility at the repository.

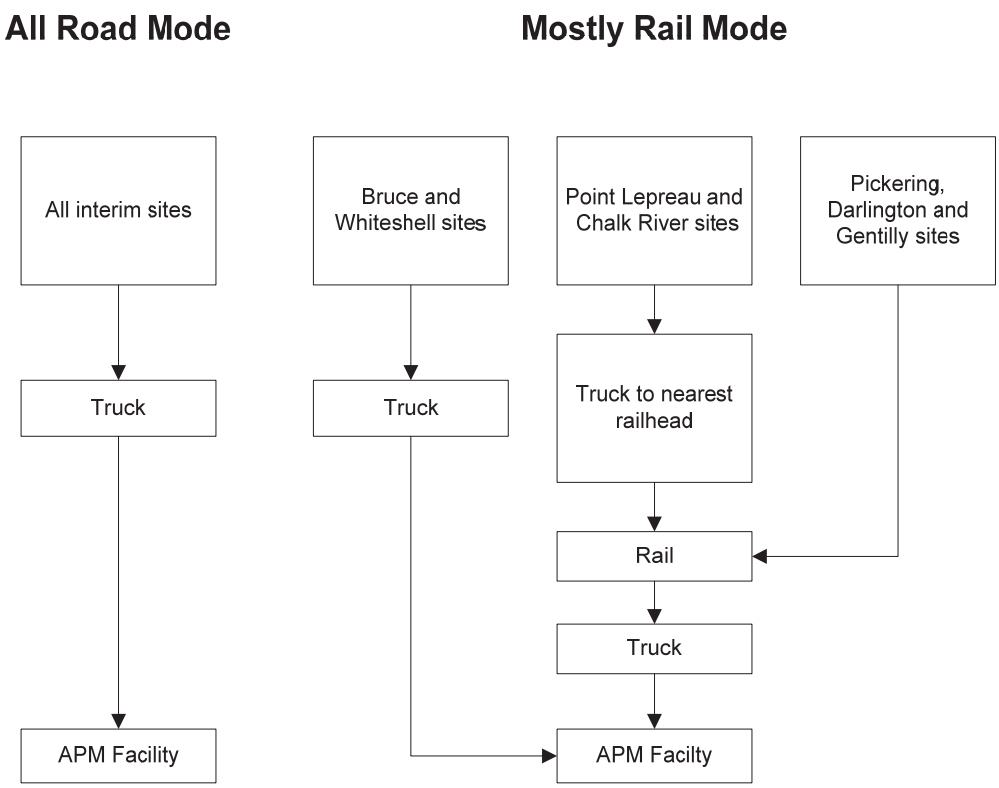

Figure 6-2: Example Transport Processes for Used Nuclear Fuel

Figure 6-3: Highway 9 near Mildmay in South Bruce

6.7.1 Existing Transport Infrastructure

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

Table 6-3: Transport Summary from Interim Storage Sites to South Bruce, Ontario

Transport Scenario	Transport Mode	Number of Shipments	Return Distance [kilometres]
All Road	Road	24,000	13,501,000
Mostly Rail	Road	25,600	2,850,000
	Rail	1,400	1,415,000

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 provincial highway system. The provincial highway system includes Highways 401, 10, and 9 which lead to South Bruce, Ontario. As planned, an existing local access road would be used or a new road constructed to provide access from Highway 9 or a local road 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 transportation tests were used:

1. Is there a continuous public road system connecting the interim storage facilities to the community capable of supporting an average of 2 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 Security Regulations*). 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 South Bruce, Ontario

Interim Storage Site	Distance Site to DGR [kilometres]	Number of Shipments	Return Distance [kilometres]
1 – Whiteshell	2,050	2	8,200
2 – Bruce	50	10,220	1,022,000
3 – Pickering	210	4,150	1,743,000
4 – Darlington	250	6,720	3,360,000
5 – Chalk River	550	30	33,000
6 – Gentilly	850	1,500	2,550,000
7 – Point Lepreau	1,660	1,450	4,785,000
Totals (rounded)		**24,000**	**13,501,000**

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 with the involvement of communities.

Truck access from the interim storage sites to South Bruce, Ontario can be accomplished entirely by existing road ways. Based on Ontario Ministry of Transportation records, there are no significant impediments to travel between the interim storage sites and South Bruce area. The average daily travel (vehicle) count for the South Bruce segment of Highway 9 is 4,600 vehicles per day (MTO, 2009). 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 Transportation Southern Highway Program (MTO, 2012) includes the resurfacing of Highway 21 from Tiverton to Port Elgin.

The local road system within South Bruce 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.

The network of roads in southwestern Ontario is well developed hence South Bruce is accessible via numerous alternative routes, although they involve additional mileage.

Emergency response resources are provided by the volunteer Fire Department (2 stations), the Bruce County Medical Services (EMS) and the Ontario Provincial Police. Although there are no hospitals in South Bruce, hospital services are offered nearby through the South Bruce Grey Health Centre, via their hospitals in Walkerton, and Durham, which provide a full range of level healthcare services including 24 hour emergency nursing coverage. Twenty-four hour emergency services are also offered at the Hanover and District Hospital and the Wingham and District Hospital.

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:

1. Is there a continuous rail system connecting the interim storage facilities to the community capable of supporting an average of one 15 car train per week for the duration of a long term shipping campaign?
2. 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 or steep grades)? If so, is there a plan in place to address these deficiencies?
3. Are there two or more serviceable routes providing access from the interim storage facilities to the community? (Required by the Nuclear *Security Regulations*). If not, is one planned?
4. Is there an operating intermodal facility near the interim sites or the community? If not, could one be developed?
5. Are there travel limitations regarding the use of the railway consisting of heavy cars due to reoccurring weather or seasonal conditions?

The Goderich-Exeter Railway operates a single track from Georgetown to Goderich, 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 Goderich is also feasible. The switch yard in Goderich offers an opportunity to construct an intermodal transfer facility providing truck access to the repository site.

Rail access to the Bruce Nuclear site has been dismantled since the facility was constructed. The used fuel inventory form the Bruce facility is assumed to be trucked to the repository site in South Bruce.

Table 6-5: Mostly Rail Transport from Interim Storage Sites to South Bruce, Ontario

Interim Storage Site	Distance Site to DGR [kilometres]	Number of Shipments	Return Distance [kilometres]
1 – Whiteshell	**2,050[a]**	**2**	**8,200**
2 – Bruce	**50[b]**	**10,220**	**1,022,000**
3 – Pickering	250	420	210,000
4 – Darlington	280	670	375,000
5 – Chalk River	**50[c]**	**30**	**3,000**
	720	3	4,300
6 – Gentilly	940	150	282,000
7 – Point Lepreau	**50[d]**	**1,450**	**145,000**
	1,810	150	543,000

Goderich	**60[e]**	**13,930**	**1,672,000**
Totals (Rounded)	**Road**	**25,600**	**2,850,000**
	Rail	1,400	1,415,000

Notes:
[a] Road mode from Whiteshell to repository site near South Bruce
[b] Road mode from Bruce to railhead near South Bruce
[c] Road mode from Chalk River to railhead near Mattawa
[d] Road mode from Point Lepreau to railhead near Saint John
[e] Road mode from Goderich to repository site near South Bruce

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 carrying 10 to 12 UFTPs (an estimated total car count of between 8 and 10 cars (including 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.

The Goderich Exeter Railway runs a single line from Georgetown through Stratford to Goderich. From Stratford west, there is no viable alternative rail routing. An intermodal facility could be constructed in Stratford to offer an alternate route by truck. This option adds mileage to the routing.

6.7.4 Weather

There are no vehicle weight restrictions on highways in Southern Ontario during the spring thaw months. Similarly, no weather or seasonal restrictions were identified for rail transport to South Bruce, 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 South Bruce, Ontario would produce approximately 420 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 16,200 tonnes of equivalent carbon dioxide emissions.

Transport by mostly rail mode would produce approximately 310 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 two 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 conventional traffic accidents. Incidents are controlled through the design of the transportation package and execution of operating procedures (see sections 6.3.4 and 6.3.5). Based on international experience, the design of the container, coupled with rigorous operating procedures, is sufficient to prevent any incident from occurring. Conventional 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 13.5 million kilometres, about 23 road collisions have been estimated over the 38-year operating period of the APM facility.

6.7.7 Transportation Costs to South Bruce

This section considers the used nuclear fuel transportation logistics from the existing interim storage sites to a hypothetical APM repository site located near South Bruce, Ontario to estimate transportation costs. Existing surface mode transport infrastructure, transport distances from the interim used fuel storage sites to South Bruce by road mode for a reference 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 South Bruce, Ontario for road and rail mode of transport is provided in Table 5-6. The cost of transporting used nuclear fuel from the seven interim storage sites to South Bruce is projected at $0.848 billion over the 38-year campaign (in constant 2010 $). The variance is $235 million under the base case estimate, or 21.7 percent lower.

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

Total Cost	Transportation to South Bruce	Variance to Reference Case	
Package Loading & Transportation	**$848,000,000**	**-$235,000,000**	**-21.7%**
Cost Breakdown			
Route and System Development	$19,000,000	$0	0%
Safety Assessment	$5,290,000	$0	0%
Capital Equipment and Facilities	$258,000,000	-$68,300,000	-21%
Operations	$398,000,000	-$156,000,000	-28%
Environmental Management	$8,400,000	$0	0%
Decommissioning	$32,000,000	-$10,800,000	-25%
Program Management	$127,000,000	$0	0%

Note:
[a] All costs are rounded to three significant digits

6.8 Transportation Findings

This transportation assessment includes two major components: a description of regulatory oversight, including how the requirements are being met by the NWMO transportation program; and a desktop analysis of transportation logistics assuming available transport infrastructure. If the APM Project were to be located in the South Bruce 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 transportation infrastructure to the repository. Improvements, if required, to the transportation and intermodal infrastructure would be reviewed in detail in Phase 2 studies, should the community continue in the site selection process.

The Municipality of South Bruce is located along Highway 9 south of Walkerton. Highway 9 serves provincial commerce in the region and is maintained by the Ontario Ministry of Transportation to the highest standards. The average vehicle travel on Highway 9 in South Bruce is about 4,600 vehicles per day. The Ontario Ministry of Transportation's current highway investment program includes the resurfacing of Highway 21 from Tiverton to Port Elgin. Given that these highways serve as major transportation routes in the region, it is anticipated that they will continue to be maintained to a high standard and would support repository construction, operations and closure.

If ancillary businesses and services locate near the repository (e.g., package manufacturing, testing labs, vehicle maintenance) the delivery of materials and shipment of finished goods would have access to the rest of Canada. The highways would also facilitate the safe and efficient commuting for workers from the surrounding region, as required.

South Bruce is 70 kilometres north of the Goderich Exeter Railway providing rail access to the region. The railway maintains a switch yard in Goderich. Minimal investment would be required to provide the infrastructure required by an NWMO facility to access a site via an intermodal facility. Transport of used fuel from the Bruce site is assumed to be shipped to the repository site by truck.

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 community and area in which it is implemented becomes an important consideration. The ability to benefit from the project, and the resources that would be required from the NWMO to support achievement of 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.

Preliminary Assessments begin with exploring the potential for the project to align with the vision and objectives of the community which expressed interest in the project and, in so doing, triggered studies in an area. The first phase of Preliminary Assessments (Phase 1) explores the potential for the project to help interested communities, such as South Bruce, 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. Through this initial work, the interested community and the NWMO may learn that the project is not a strong fit with the long-term vision and objectives of the community, and further studies may be concluded in the area.

Adaptive Phased Management involves a large project which has the potential to affect the broad area in which it is implemented. Should studies continue in an area, the next phase of work (Phase 2) is intended to explore the potential for the project to align with the vision and objectives of First Nation and Métis communities in the vicinity and surrounding municipalities, as well as their interest in implementing the project together. The project will only proceed with the involvement of the interested community, potentially affected First Nation and Métis communities and surrounding municipalities working in partnership.

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 well-being and sustainability of the community and area. Only through working together can the project be harnessed to maximize benefits to the community and 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 community and area consistent with their vision for the future.

Good decision-making will require that the project is understood from all perspectives and is informed by the best knowledge and expertise. The NWMO continues to work with and learn from communities to advance the siting process together. The NWMO also continues to look to First Nation and Métis communities in the vicinity 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 well-being and appropriately interweave Traditional Knowledge throughout the process.

Learning to date from preliminary studies, and engagement with the interested 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 APM Project to foster the well-being of the Municipality of South Bruce, Ontario if the project were to be implemented in the municipality. More detailed information can be found in the Municipality of South Bruce Community Profile (AECOM, 2014a) and Community Well-Being Assessment report (AECOM, 2014b). 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 South Bruce. It also discusses the relative fit of the APM Project for the community and the potential to create the foundation of confidence and support that would be 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 if the project were to be implemented in the community, and identify opportunities to leverage the project to achieve other objectives important to people in the community, potentially affected First Nation and Métis communities, and the surrounding 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 was to explore the potential to foster the well-being of the interested community. For this reason, the subset of factors and considerations related to the community are addressed at this time. Considerations related to First Nations and Métis communities in the vicinity and surrounding municipalities are noted where early insight is available; however, more detailed work would be conducted in Phase 2 should the area advance to the next phase 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. At this early phase of work, dialogue is focussed on the interested community.

In concert with the interested 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 review of community plans and/or 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, potentially affected First Nation and Métis communities, and surrounding communities, 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 communities to determine the nature and scope of how they wish 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 for the interested community and the broader area.

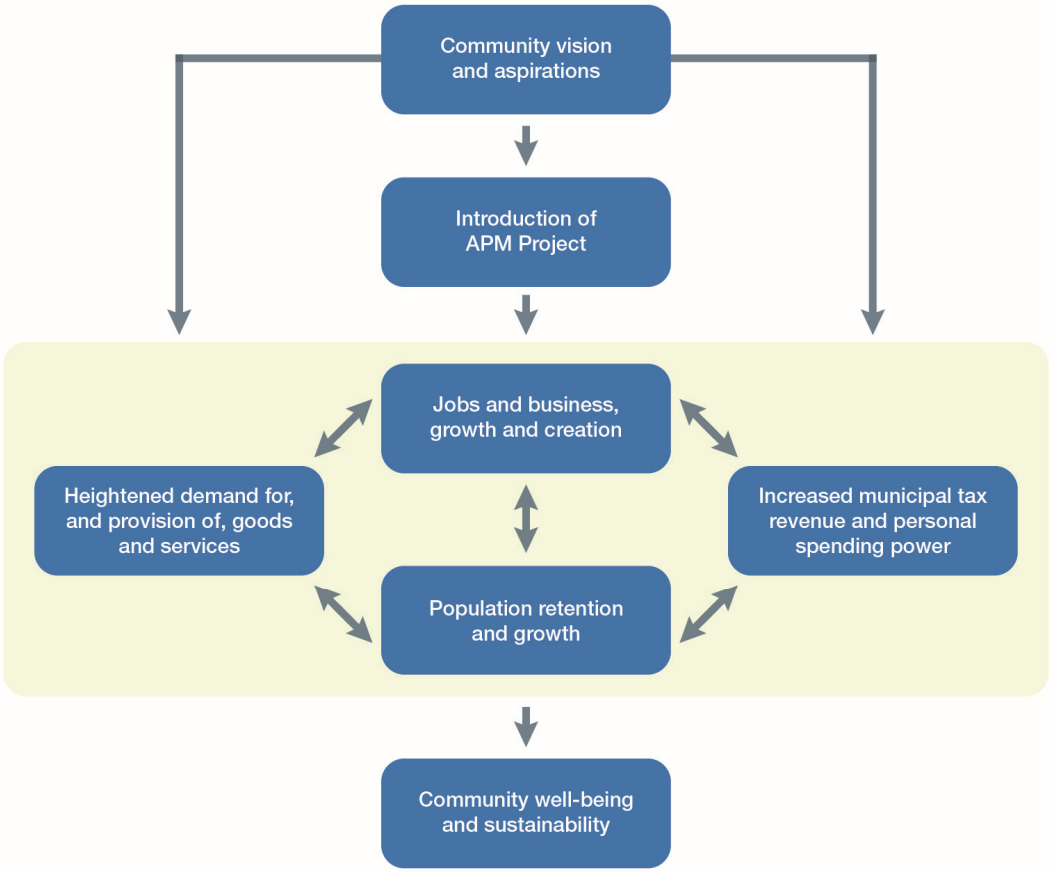

Figure 7-1: Direct and Indirect Effects From the Project

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

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

7.2.1 Community Aspirations and Values

The Municipality of South Bruce has expressed explicit values, aspirations and desires for its community. These have been documented in the Municipality of South Bruce Community Profile (AECOM, 2014a) and various other community reports, including the South Bruce Corporate Strategic Plan (Millier, Dickinson, Blais, 2014). Key themes are summarized below. The preliminary assessment is measured against these values and aspirations.

South Bruce aspires to grow and retain its younger population, attract investment, and diversify its economy. The municipality is seeking to maintain a strong agricultural sector and vibrant farm culture. It is also seeking to revitalize and energize its downtown urban centres, provide more senior housing and care programs and more generally encourage balanced residential development to ensure affordability, variety and choice. The community is mindful of its good agricultural land and the need to maintain and monitor provincial wetlands in order to ensure the natural environment is maintained.

The Municipality of South Bruce has identified five strategic goals and accompanying objectives (Millier, Dickinson, Blais, 2014])

GOAL #1: Create a Strong Corporate Climate that Supports Local Business Growth and Sustainability

Strategic Objective: Establish a supportive corporate culture that strengthens business retention, expansion and attraction, entrepreneurial activity, and new industry investment (including Adaptive Phased Management considerations).

GOAL #2: Create and Promote a Culture That Practices Clear Communication, Inclusiveness, Transparency and Accountability

Strategic Objective: Open and transparent communication between and among employees, the community and taxpayers through regular dissemination of relevant information that is shared in an accessible, timely and inclusive manner.

GOAL #3: Secure the Fiscal Capacity Necessary to Develop and Maintain Infrastructure Improvements that Address Bridge Replacements, Road Resurfacing, and Drainage Concerns

Strategic Objective: Develop and lead capital infrastructure initiatives that address community needs, reflect sustainable planning practices and future demand considerations, with a commitment to fiscal responsibility.

GOAL #4: Create a Strong Corporate Environment that Supports Retention and Succession Planning for Municipal Staff

Strategic Objective: A Corporate Succession Planning Strategy that includes a comprehensive market assessment and compensation review, municipal best practices study, and operational assessment for all levels of staff, establishing South Bruce as an "employer of choice".

GOAL #5: Support existing and new opportunities to attract new residents and retain young adults and senior populations

Strategic Objective: Establish and lead initiatives to position South Bruce as a community of choice among populations that tend to leave the community to access required services and opportunities.

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

The population of South Bruce was relatively stable between 2001 and 2006, before declining over 4% by the 2011 Census. South Bruce also has an increasingly aging population as the 45 to 65 years of age group has increased by 28% since 2001, while at the same time as other age groups have declined. South Bruce now has 46% of its population over 45 years of age. The declining population mixed with an aging demographic has economic and social implications which are reflected in the community today, creating challenges in areas such as retail and service businesses, seniors' housing, and community programming for residents. Rebalancing the demographic base as well as growing the overall population are aspirations of the community.

South Bruce has a diverse labour force led by the agriculture sector which accounts for 20% of the occupations. The most common occupation type is "sales and service," followed by "trades, transport, and equipment operators and related occupations" and "occupations unique to primary industry", which includes power generation at a nuclear site in region. The nuclear industry is acknowledged as a key employment driver for many households in South Bruce and the community population level is impacted by activity levels at the site. The importance of the connection to the nuclear industry in the area has been identified as a key driver for the community by community members in discussion with the NWMO and is also explicitly referred to the community's recent corporate strategy report (Millier, Dickinson, Blais, 2014).

Education in South Bruce is provided by elementary schools in the public and Catholic school systems. Secondary schools are located outside the community in nearby municipalities. Trades, apprenticeships and other post-secondary education require travel outside the community to Owen Sound or larger centres outside the region.

There are no hospitals within South Bruce. Residents must travel to facilities located nearby in Walkerton, Hanover and Wingham, while family health teams in these centres also cover residents of South Bruce. The Grey-Bruce Health Unit provides Public Health services regionally, while some nursing and rehabilitation home care is available through area agencies. The Ontario Provincial Police, Bruce County Emergency Medical Service (EMS), and the South Bruce fire department provide emergency services.

The APM Project has the potential to have a positive effect on the Human Assets of South Bruce. The project will bring direct, indirect and induced jobs which can provide the foundation for desired population growth and effective youth retention in the community. The APM Project is a long term project, which will help to diversify the economic base of the community over a sustained period of time. While it is expected that some people involved in the construction and operations of the project will choose to reside in other nearby communities, it is equally plausible that hundreds of jobs could be held by people residing in South Bruce. With additional community development and support provided by the NWMO it is possible that these job numbers could be further increased to match community aspirations. The increased population will be a boost to South Bruce socially and economically, and will be a catalyst for spin-off population growth and business development - priority aspirations for the Municipality.

Skills and labour supply would likely diversify and expand with the increased population, as well as the on-site and in-community job opportunities. Indirect and induced jobs will also create opportunities for skills diversification further attracting new residents with different levels of expertise while providing incentives for youth to remain in the community. The APM Project will capitalize on the existing labour force skills and expertise and attract other highly educated and

skilled workers, further expanding the demographic base of the community. This outcome aligns with the community's aspirations.

The project will also provide opportunities for ongoing training, as well as provide opportunities for following generations to pursue education paths to take advantage of careers associated with the APM Project. There are strong positive educational benefits from the APM Project, including an increased population driving expanded enrolment and educational programming opportunities and potential partnerships with post-secondary institutions. It is further expected that the APM Project will include an international centre of expertise that can attract attention from around the world to the community.

While the APM Project and the associated increase in population will place heightened demand on existing health and safety facilities and services, there is further potential to expand and improve the existing levels of service by attracting new specialized health care professionals to the area who could provide the resources to better serve and support all age groups in the community. In addition, the project may act as a catalyst to bring new local health services to the community itself. Proper planning would need to take place to ensure that potential increased social issues, many of which are generally associated with any large project that substantially increases local populations, are managed and that all age groups in the community are supported.

In summary, it can be expected that the APM Project would bring positive net benefits to the Human Assets of South Bruce were the project to be implemented in the area. The APM Project would help the municipality realize its aspirations and goals. It would drive development and expansion in other aspects of its community well-being.

7.2.3 Implications for Economic Assets

South Bruce has low unemployment of nearly 5% (2012 estimate) which is well below the Ontario average of over 7%, and it has a strong labour force participation level.

As is the case with many small communities in rural Ontario, the Municipality's business activity is focussed on the service, trade and retail sectors. The urban centres of Mildmay and Teeswater are the primary commercial centres in the Municipality, while surrounding areas have a strong agricultural presence. There are a few notable employers within South Bruce. Many residents, however, work beyond the community for public and private sector employers. Activities at a nuclear site in the region are an important source of employment for some South Bruce residents. For this reason, the community has a strong nuclear awareness and appreciation for the risks and benefits of such activities. One of the implications of this nuclear industry employment is income disparity in the community which causes some social friction.

An important focus of South Bruce is to help its retail businesses attract customers traveling through the Municipality to destinations along the shoreline. There are limited accommodation options in South Bruce which include three Bed and Breakfasts and no hotels. South Bruce also desires to increase recreational opportunities for residents and visitors. Many believe that a major project, like the APM Project, will become the impetus for desired changes in employment and new business opportunities including accommodations.

The South Bruce Community and Business Association leads economic development and recreation promotion locally, while The Bruce Community Futures Development Corporation and the Saugeen Economic Development Corporation support regional economic development.

Municipal finances have seen revenue growth since 2000, led by residential property tax revenues. In 2012, revenue was much higher than in recent years as the community received funding from Ontario and Federal grants related to wastewater collection and treatment. The community faces fiscal challenges over the longer term, however, as residential and agricultural properties form the bulk of the tax revenues due to the relative absence of large commercial and industrial operations found in other communities. This limits investment capability in infrastructure and services at the current time.

Should the APM Project locate in South Bruce, the net economic effects will be positive and match the aspirations of the community. A key attribute is the direct and indirect job creation it will bring to the community. 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 and help to grow and diversify its economic base. Out-migration of youth will decline as younger people will be able to find work locally. In-migration will also occur as South Bruce will become an employment centre with growing opportunities. This outcome will also serve to lessen existing income disparity tension in the community.

An increased number of residents with jobs and money mean that household incomes will climb and subsequently 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 which addresses community aspirations and goals.

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 balanced across industry, residential, farmland and commercial components. This is a key aspiration for the community as it seeks to diversify its tax base which is currently heavily reliant on the residential sector. A more diversified revenue base would enable investments in infrastructure and desired community services.

The APM Project is of a scope, scale and longevity that businesses will be attracted to the community to take advantage of the opportunities for the supply of goods and service to the project itself and the population it has brought into the community. South Bruce would need to be proactive in looking at where new businesses can locate and the support services they will require for long term operation.

Some have expressed the view that the APM Project may result in perceived effects on the quality of agricultural products, thereby affecting the viability of area agriculture. Concerns in this regard would need to be addressed, however it should be noted that despite decades of nuclear activities at existing nuclear sites in the region, there have been no such effects to agriculture documented in the region.

The effect of the APM Project on recreation has the potential to be both positive and negative. In the short term, initial concerns about the facility may make travellers less inclined to stop in the area until a greater understanding of the project has developed. Conversely, the population that migrates to the community to take advantage of jobs and the people who come to the community to study or visit the facility may present a whole new market for local recreation operations. Irrespective, it is important to note that recreational activities in the community or the

wider region do not appear to have been affected by the ongoing presence of the existing nuclear site operations in the region.

The APM Project appears to present South Bruce with the potential for a strong economic benefit through long term economic diversity and increased stability. However, this desired benefit will need to be carefully planned for and managed if the community is to realize its full potential. The community would need support to ensure that it is "*project ready*", many years into the future. In order for South Bruce to optimize project benefits, it would be helpful to support education and training of the labour force, municipality and residents, and provide advice to local businesses on project opportunities.

7.2.4 Implications for Infrastructure

The community has a stable, but aging housing stock as most homes in the municipality were built before 1986 and there is limited new housing growth, consistent with a declining and aging population. However, this has implications for infrastructure services like water, wastewater and roads, which cannot be easily updated without growth and its associated tax revenue base to maintain such services.

Municipal services vary between rural and urban areas. Municipal water and sewer service is available in Mildmay and Teeswater, while Formosa has sewer service only. Electricity is provided by either Hydro One or Westario Power, while some urban residents only have access to natural gas connections for home heating. The community offers waste collection and bi-weekly recycling for homes near built up areas using private operators. All together these services meet the needs of the existing population, but financing of future upgrades and maintenance is problematic.

South Bruce has reliable transportation infrastructure, including Highway 9 which passes through the Municipality. There are no local airports offering commercially scheduled passenger or cargo flights, while the closest commercial port is located in Goderich.

The APM Project will stimulate growth of the community (increasing population and a diverse economic base) and create the impetus for increased housing developments to accommodate ownership and rental needs. The development and absorption of new and existing homes will increase municipal tax revenues needed to maintain and upgrade current and future infrastructure.

Although there is a strong upside for housing with the APM Project, there is also a potential downside that must be managed. If demand strongly outstrips supply, price escalation will occur and the complement of affordable housing may be less. A further note of caution with respect to housing is that supply limitations particularly during the construction phase may see significant demand for rental units and visitor accommodations which will force most workers to look elsewhere due to the lack of availability in South Bruce. Additionally, these demands could displace tourists and travellers at a regional level. Attention will need to be carefully focused on maintaining an equitable housing supply/demand balance, as well as protecting regional tourist/traveler accommodations and other related services to prevent unwanted consequences in that industry.

The APM Project may stimulate the upgrading and expansion of infrastructure and services to accommodate new growth in the community. South Bruce has reliable and extensive transportation infrastructure and is well connected by road to nearby urban areas. It is also

serviced by air and marine transportation in nearby communities. The APM Project may provide impetus for further development and upgrading of local and regional roads as well as other nearby transportation infrastructure. This investment would help to diversify the economic base of the community by attracting transportation-sensitive business.

The community and the NWMO would need to work cooperatively to effectively plan, build, operate and manage each of the physical asset components were the project to be implemented in the area.

7.2.5 Implications for Social Assets

South Bruce is predominantly an agricultural community with rich agricultural lands interspersed with small towns and hamlets. There is also a small retirement population and a small Mennonite population.

South Bruce has a strong tradition of building culture through local festivals, service clubs, sports organizations and volunteer opportunities. The many clubs and organizations identified in the Municipality are indicative of a community that is interested in celebrating its past and nurturing social vitality for going forward. Amalgamation of lower tier communities into the Municipality of South Bruce had resulted in some frictions as old rivalries persisted, but more recently these are fading and the municipality is becoming more cohesive. The equitable distribution of services, facilities and programs across the municipality presents some challenges but the municipal administration is proactive in trying to ensure balance. The Corporate Strategy (Millier, Dickinson, Blais, 2014) addresses the whole municipality and sets out a common path forward that most community members support.

The APM Project will positively affect the Social Assets of the community if it is implemented in the area by stimulating community growth and providing revenue to pay for growth. The increased population associated with the APM Project would be expected to increase demand on community recreational facilities and programs, as well as social services and organizations. In addition, this increased population would also be expected to heighten participation rates, and create a larger volunteer base to ensure the culture and history of the community thrives. Increased funding, volunteerism and participation would allow South Bruce to upgrade and expand its recreational and social programs that would help to bond residents from different urban centres in a more cohesive community. This chain of events is what the community desires. It is cohesive in its vision and aspirations.

There are many social benefits that could be created by the APM Project. Based on engagement activities to date residents tend to support continuing to learn about the project and build their understanding and confidence in the safety case. Some individuals have personally indicated that they are opposed to the project in South Bruce, but the widely held view appears to strongly support learning more.

7.2.6 Implications for Natural Environment

Community well-being is enhanced when the natural environment is available to all residents for their enjoyment, and to support community goals for the sustainable use of resources. Initial studies on the potential environmental effects associated with the project suggest that with mitigation the APM Project is unlikely to have any significant negative effect on the natural environment within the Municipality.

During engagement activities a number of people expressed the view that when considering the environment on a broader scale (i.e. Bruce County and beyond) the project would enhance the natural environment by moving used fuel to a safer long-term place.

There are no provincial or national parks within South Bruce. There are however, four provincially designated protected areas that take up about 6% of the Municipality. The southern part of the Greenock Swamp occupies the northwest corner of the Municipality and in the vicinity of Formosa running northward there is a major groundwater recharge area. These environmentally sensitive areas within the community will need to be protected should the APM Project proceed in this community.

As would be the case with any large project, natural areas, might be affected during the construction, operation and decommissioning phases of the project. Effective mitigation and environmental protection measures will ensure that the overall environmental integrity of the area is maintained, as has been the case for other nuclear activities in the region.

Population growth associated with the APM Project may increase user demands on conservation lands. Off-setting this potential increase in usage however is the fact that the project may provide the community with increased resources and funding to manage and improve environmental attributes through proactive conservation initiatives such as reforestation, control of agricultural run-off and support for agricultural sustainability. Effective mitigation and environmental protection measures coupled with enabled investment will ensure that the overall environmental integrity of the area is maintained and where desired enhanced. South Bruce is seeking to ensure that desired economic and population growth is done in a balanced way to ensure sustainability of the environment, agriculture and the social values.

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 South Bruce

Based on the foregoing discussion, the APM Project has potential to be a good fit for the community of South Bruce. The APM Project has potential to enable the aspirations of the community, and through this, foster well-being, as South Bruce defines it.

The APM Project is in line with the values and objectives of the community as the NWMO has come to understand them through working with the community, including review of the recent Corporate Strategic Plan (Miller, Dickinson, Blais, 2014) and has the ability to enable many of the goals set out by the community. Based on discussions with community officials and residents, it is felt that the APM Project would generate population and economic growth and provide the Municipality with the human and fiscal resources to shape its future and well-being in keeping with its plan.

South Bruce has a strong desire to realize business diversification and growth and to secure the fiscal resources necessary to develop, maintain and improve infrastructure and services. South Bruce already has strong economic ties to an existing nuclear site in the region and as such many of its households are familiar with the nuclear industry. Moreover components of the labour force in the Municipality already have some of the skills that would be required for the implementation and operation of the APM Project while providing opportunity for others to aspire to. With respect to infrastructure, the existing transportation networks are suitable for the APM Project, with direct access to highway resources and access to air and marine resources within the broader region.

The project can be developed in a manner that would not compromise the environment. Effective mitigation would ensure the quality of the natural environment is maintained and where desired and as appropriate municipal revenues derived from the project could be directed to fund environmental initiatives such as reforestation and sustainable agriculture.

Based on engagement to date, some individuals have expressed opposition to the project. More often residents indicated they see positive implications for the community as result of project implementation and a few expressed a broader view and endorsed the project as a means of safeguarding the interests of society, as well as the local community, through the proper long term management of used nuclear fuel. For many, the project fits well with their aspirations and plans.

Table 7-2: Overall Community Well-Being Implications – South Bruce

Criteria / Measures	CWB is Enhanced When …	Current South Bruce Profile		Possible South Bruce 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 would enable population growth and the retention of youth. • Educational resources would be enhanced and new facilities could be developed.
Economic Assets	Employment opportunities are available and tax base increases to fund community services and facilities	Declining	⬅	Enhanced	➡	• There will be increased employment opportunities and a more diverse range of jobs would be available. • Increased funding through a wider tax base would provide the financial resources to fund infrastructure projects, educational developments, community and recreational facilities and programs and social services and organizations desired by the community. • The increased jobs from the APM Project would be the catalyst to enhance community well-being.
Infrastructure	Infrastructure is maintained or improved to meet the needs of the community	Neutral	▭	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	Neutral	▭	Enhanced	➡	• The community would see an overall benefit to its Social Assets through increased participation and funding to its recreational facilities and programs as well as its social services and organizations. • The community is cohesive in its desire to continue to learn about APM and how it benefits the community in a balanced and sustainable manner.
Natural Environment	Natural areas, parks and conservation reserves are preserved and maintained for use and enjoyment	Maintained	▭	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 juncture that no net negative environmental effects are likely during the construction, operation and decommissioning phases of the used fuel repository itself • Municipal revenues created by the project would enable investment in environmental initiatives such as reforestation and sustainable agriculture.

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

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7.3 Criteria to Assess Factors Beyond Safety – Summary in South Bruce

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 South Bruce 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. 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 potentially affected First Nation and Métis communities and neighbouring communities on transportation routes. The community also expressed a desire to better understand how to maintain small town quality of life. South Bruce realizes that it would be essential to develop or enhance relationships with all of the foregoing groups to support the implementation of the project. Noteworthy at this early stage is that four South Bruce community neighbours also expressed interest in learning more about the APM Project and have participated in the site selection process. The community also expressed a desire to better understand how to maintain small town quality of life, while attracting desired growth.

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

Factors that Address the Well-Being of a Community	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; however, the community is eager to learn more about safety and health considerations to enhance their confidence in the safety of the project. • Given the community's proximity to an operating nuclear facility, some local residents are well aware of safety measures related to nuclear facilities.
	Sustainable built environments	Enhanced	• Community infrastructure and built environment will be further enhanced through project activities and investments in the community.
	Sustainable natural environments	Maintained	• 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. • Municipal revenues created by the project would enable investment in environmental initiatives such as reforestation and sustainable agriculture.
	Local and regional economy and employment	Enhanced	• Significant employment and population growth will occur in South Bruce and surrounding communities – hundreds of new jobs might be created in the area. • With these jobs comes the potential to increase population and retain youth. • Opportunities would be created for current and new local businesses to serve the project and growing population.
	Community administration decision-making processes	Enhanced	• Local leadership, with community support, has demonstrated interest in the project and going forward it is expected that local leadership will ensure residents have opportunities to learn more and engage in community decision making
	Balanced growth and healthy, livable communities	Enhanced	• South Bruce has aspirations to improve its local businesses and grow its population and diversify its economy. • APM Project appears to be a strong fit with community objectives and aspirations in this regard. • Although concerns were expressed by some about the potential loss of agricultural land and nuclear stigma on outputs, agricultural land loss will be minimized and potential negative effects on outputs will be mitigated. To date no such effects have been documented with current nuclear industry activities in the region.
Potential for enhancement of the community's and region's long term sustainability through implementation of the project, including factors identified by Aboriginal Traditional Knowledge	Health and safety of residents and the community	Maintained	• There is a strong safety case as outlined in Chapter 5. Engagement of surrounding communities is required and further dialogue will be needed 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 by the project. • Effective mitigation and environmental protection measures will be required to ensure that the overall environmental integrity of the area is maintained.
	Local and regional economy and employment	Enhanced	• Substantial employment and economic development opportunities would extend to the surrounding region.
	Community administration and local and regional decision-making processes	Enhanced	• Engagement of nearby communities is underway. • Some surrounding community leaders have demonstrated interest in the project and going forward it is expected they will be able to make informed and effective decisions.
	Balanced growth and healthy, livable communities	Enhanced	• Surrounding area communities are collectively seeking economic development and growth in the region. • The APM Project appears to be in alignment with these aspirations, provided it does not compromise existing economic activities (i.e., agriculture and recreation).
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 area appears to contain many suitable sites for the project, thus providing flexibility in selecting specific sites that can avoid ecologically sensitive areas and local significant features.

Factors that Address the Well-Being of a Community	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 South Bruce or the surrounding region to impede project implementation. • South Bruce is located in-land which may limit the available modes of transportation. • Social and economic support services and capacity to absorb the anticipated growth in population and economic activity may increase. • Some infrastructure investments may be required to accommodate growth and special project needs.
	Potential for social infrastructure to be adapted to implement the project	Yes	• The community of South Bruce appears to have the necessary core of social infrastructure in place to plan and adapt to changes resulting from the project. • More investment may be required in recreation infrastructure such as hotels or amenities to increase visitor time within South Bruce.
	The NWMO resources required to put in place physical and social infrastructure needed to support the project	To be determined	• In all likelihood, South Bruce would require assistance in terms of planning, human and financial resources. • Further studies would be required to explore the specifics of these requirements.
Potential to avoid or minimize effects of the transportation of used nuclear fuel from existing storage facilities to the repository site	The availability of transportation routes (road and rail) 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, South Bruce is well situated and connected to major urban areas to the South. • Project transportation will need to address community, logistical and regulatory matters across multiple provinces and multiple jurisdictions including; Ontario, Quebec and New Brunswick. • Engagement of surrounding communities is at a preliminary stage and further dialogue will be required to understand 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 would be required to understand and address questions and concerns.
	The NWMO resources (fuel, people) and associated carbon footprint required to transport used fuel to the site	310 - 420 tonnes of equivalent carbon dioxide emissions 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 South Bruce, Ontario approximately 420 tonnes of equivalent carbon dioxide emissions is expected to be produced per year. • In a scenario of transport mostly by rail mode approximately 310 tonnes of equivalent carbon dioxide emissions is expected 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. • Engagement of surrounding communities and those on potential transportation routes is at a preliminary stage and further dialogue would be required to understand and address questions and concerns.

7.4 Overview of Engagement in South Bruce

The NWMO has engaged and supported learning with South Bruce leadership and community members, as well as initiated dialogue in surrounding communities, through a variety of means, including:

- Several community open houses;
- Regular attendance at the Community Liaison Committee meetings;
- Both informal and structured interviews with community members;
- Facilitating the Community Liaison Committee web page and newsletters;
- Preparation of written materials;
- Informal tours and visits with local residents;
- 'Ask the NWMO' columns in regional newspapers;
- Attendance at local meetings and events
- Storefront community office
- NWMO Mobile Transportation Exhibit; and
- Nuclear waste management facility tours.

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

- Local political leaders (e.g., Mayor and Councilors);
- Members of the Community Liaison Committee;
- Local farm operators and farming associations;
- Local business owners/operators;
- Local service providers (e.g. emergency services, social services, education);
- Community groups (e.g. clubs, associations); and
- Residents.

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

The community has taken initial steps to engage its neighbours to establish a foundation for broader area consideration of the project. Several neighbouring communities to South Bruce have expressed interest in learning and participating in the siting process.

7.4.1 Summary of Issues and Questions Raised

In South Bruce, many people engaged were interested in learning more, were supportive of their community being involved in the siting process and look forward to next steps.

Several key interests were recurring and identify the areas which the community, overall, is most interested in learning more about. The ***core*** key interests expressed include:

- Health, safety and environmental risk in and around the site and along the transportation route; and
- Economic benefit and opportunities for growth
    - Municipal Transparency and Confusion with the DGR Project;
    - Community Cohesiveness; and
    - Project Description Details

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

- The potential for concerns about nuclear image;
- APM Project process and APM Project description details; and
- Preservation of community character and environmental quality.

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 South Bruce.

The preceding discussion has looked at implementation of the APM Project in South Bruce and the implications this might have on community well-being. Additionally, key issues and concerns identified through engagement activities have been highlighted and discussed. Through desktop research, dialogue with community members and leaders, as well as on-going analysis, it is understood that South Bruce has an interest in learning about what it might mean to host the APM Project but also understands that benefits can be realized if the project were to locate in a neighbouring municipality.

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

There appears to be high potential for the APM Project to foster well-being in South Bruce. The project is understood to enable community priorities and aspirations, and is seen by leaders and many residents to be a potential catalyst for the socio-economic growth and development they desire.

There is high potential for sustained interest in the local community. This is evidenced through the strong, proactive commitment community leaders and residents have shown towards their continued participation in the site selection process. At this point in time, there is no indication that South Bruce will not remain interested in learning throughout the subsequent steps.

There is potential for the APM Project to foster well-being in surrounding communities. Preliminary discussions have revealed interest in the economic development potential offered by the project. Ongoing discussions will be required to further assess the implications of the project on the well-being of surrounding area communities.

There is high potential for sustained interest in the surrounding communities. The surrounding communities have experience with existing nuclear projects in the region, contributing to the foundation of knowledge for further constructive consideration of the APM Project and its opportunities. Several neighbouring municipalities also entered the siting process.

It is noteworthy that the municipalities which entered the site selection process in the area function as a region. They are politically autonomous but they are also tied to one another through their political, cultural, and administrative constituency as fellow neighbouring communities. Beyond their shared interest in learning about the APM Project, these communities are connected through government ties and shared planning. As well, there are a variety of other linkages that further speak to the broader connections between the municipalities. Many family ties crisscross community borders. Communities share facilities and services and share a common experience in proximity to a nuclear facility in the area. They come together for community events. They have a willingness to share common opportunities to benefit from the APM Project which has encouraged cohesion across the Bruce communities. Engagement of these communities would need to continue.

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

1. Among the potentially suitable land areas within the Municipality of South Bruce, smaller specific siting areas that are socially acceptable would need to be identified:
    a) Potential siting areas identified through scientific and technical studies must be the subject of community input to identify socially acceptable land areas.
    b) Further engagement with potentially affected First Nation and Métis 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, 2014).
    c) An appropriate process for securing land will need to be identified in collaboration with Municipalities, private land owners, and First Nation and Métis communities in the vicinity

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

a) An acceptable project implementation plan must be identified which aligns the ultimate project configuration with expectations of the community including potentially affected land owners.
b) Effective project planning at a broader level, involving the potentially affected First Nation and Métis communities, and surrounding communities, will be important for successful implementation of the project.

3. Interest in further learning about the project needs to be sustained:
    a) The site selection process spans several years and interest and conversation in the interested community needs to be sustained throughout this process, including multiple election cycles.
    b) The potential effects of the project on the interested community, First Nation and Métis communities in the vicinity and surrounding municipalities would be substantial and these communities 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 may actively seek to influence community decision-making and community leaders will need to respond to these pressures. South Bruce will require support to prepare for the next phases of the siting process if they are to proceed.

4. Transportation routes and mode(s) need to be designed and configured taking into account social values:
    a) Transportation considerations will need to be determined. 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 interested community input:
    a) This requires regard for input from the interested community and surrounding communities.
    b) This requires engagement by the NWMO and may require capacity building to enable community 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, First Nation and Métis communities in the vicinity and surrounding municipalities reflect upon the suitability of the area to host the Adaptive Phased Management (APM) Project. This initial phase of Preliminary Assessment has focused on supporting reflection of an interested community in the area participating in the siting process.

In order to fully understand and assess the potential of an 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 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. Across communities and 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 any community and area proceeding in the site selection process in order to support informed decision-making. Engagement activities within the interested community would need to continue to unfold. These activities would need to be broadened to involve potentially affected First Nation and Métis communities and surrounding municipalities in the learning and decision-making process, in order to fully understand the suitability of a an area and site to host this project.

At this early stage of work, the NWMO is able to make preliminary conclusions and observations about the potential to find a safe and secure site within the Municipality of South Bruce that will meet the robust scientific and technical requirements of the project. The NWMO is able to make preliminary conclusions and observations about the potential for the project to foster the well-being of the Municipality of South Bruce if the project were to be implemented there. The NWMO is also in a position to reflect on the uncertainties and challenges associated with proceeding with more detailed studies within the Municipality and 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 the Municipality of South Bruce 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 Municipality of South Bruce.
    - 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 the Municipality of South Bruce through the implementation of the project in the area.
3. There is potential for sustained interest in South Bruce to support further learning about the project.
4. There is potential to foster well-being in the surrounding area through the implementation of the project in South Bruce, as well as sustain interest to support further learning.

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

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

These Preliminary Assessment studies 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 support the overall conclusion that the geographic area explored in this assessment has potential to meet the robust scientific and technical requirements of the APM Project.

- The APM Project has potential to be safely located in a suitable site within the municipality, 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 valued activities identified to date such as economic development, farming and recreation. In other words, there exists potential 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 general area.

Based on this preliminary information, there are a number of observations that support the overall conclusion that there is potential to foster the well-being of the Municipality of South Bruce through the implementation of the project, and there is potential to sustain interest.

- There appears to be high potential for the APM Project to foster well-being in South Bruce as the community has defined it. The project is understood to enable community priorities and aspirations, and is seen to be a potential catalyst for the socio-economic growth and development they desire.

- There is high potential for sustained interest in the local community. This is evidenced through the strong, proactive interest community leaders and residents have shown toward continued participation in the site selection process. At this point in time, there is no indication that South Bruce will not remain committed to learning throughout the subsequent steps.
- There is potential for the APM Project to foster well-being in the surrounding communities. Preliminary discussions have revealed interest in the economic development potential offered by the project. Ongoing discussions will be required to further assess the implications of the project on the well-being of surrounding area communities.
- At this point in time, there is high potential for sustained interest in the surrounding communities. The surrounding communities have experience with nuclear projects in the region, contributing to the foundation of knowledge for further constructive consideration of the APM Project and its opportunities. Several neighbouring municipalities also entered the siting process. Further discussions will be required to gain a full understanding of the potential interest in surrounding communities.

8.3.2 Uncertainties and Challenges

Based on this preliminary information, there are uncertainties and challenges that would need to be addressed if the Municipality continues in the site selection process. These uncertainties and challenges are important to understanding the potential to meet the requirements of the project in the Municipality. Some uncertainties and challenges are a result of being at an early phase of study with limited information available. Other uncertainties and challenges have been identified from the conduct of the studies themselves and may be unique to better understanding the potential suitability of a particular area. The difficulty and the level of resources required to successfully address the challenges and uncertainties may vary across the interested communities and areas.

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

1. Geoscience studies suggest that while the municipalities of Brockton and South Bruce, and the Township of Huron-Kinloss appear to contain large areas with favourable geoscientific characteristics, there are inherent uncertainties that would need to be addressed during subsequent stages of the site evaluation process. The assumption of transferability of geoscientific characteristics and understanding based on regional data and data from the Bruce nuclear site to the communities of Brockton, South Bruce and Huron-Kinloss would need to be confirmed. The potential for hydrocarbon resources and faults within the sedimentary sequence beneath the three communities would also need to be further assessed.

2. Environment and safety studies suggest there is potential to implement the project safely and with respect for the environment in the Brockton, South Bruce and Huron-Kinloss 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 further 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, potentially affected First Nation and Métis communities and surrounding communities, as well as field studies, would be needed to fully characterize the environmental conditions in these smaller potential siting areas.

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

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

    - Potential siting areas identified through scientific and technical studies must be the subject of community input to identify socially acceptable land areas.
    - Further engagement with potentially affected First Nation and Métis communities is required, including Aboriginal Traditional Knowledge holders in the area. This may also expand the framework for assessment through, for instance, insight from Indigenous science, ways of life, and spiritual considerations.
    - An appropriate process for securing land will need to be identified, in collaboration with
        - Municipalities
        - Private land owners
        - First Nation and Métis communities in the vicinity.

5. Project implementation (including engineering, logistics and/or community well-being) must align with specific community aspirations.
    - An acceptable project implementation plan must be identified, which aligns project configuration with expectations of the community.
    - Effective project planning at a broader level, involving potentially affected First Nation and Métis communities and surrounding communities will be important in the successful implementation of the project.

6. Interest in further learning about the project needs to be sustained:
    - The site selection process spans several years and interest and conversation in the interested community needs to be sustained throughout this process, including multiple election cycles.
    - The potential effects of the project on the interested community, First Nation and Métis communities in the vicinity and surrounding municipalities would be substantial and these communities will to need support to further explore their interest and take an active role in discussions of how the project should be implemented.
    - Opposition groups may actively seek to influence decision-making and community leaders will need to respond to these pressures. South Bruce 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 considerations will need to be determined. 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. Environmental and safety evaluations need to be aligned with community input:
    - This requires regard for input from the interested community and surrounding communities.
    - This requires engagement by the NWMO and input from the interested 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, First Nation and Métis communities in the vicinity and surrounding municipalities reflect upon the suitability of the area to host the APM Project.

The implementation of the project will have an effect on the broad area in which it is sited. Potentially affected First Nation and Métis communities and surrounding municipalities also need to be involved in decision-making about the project and planning for its implementation should it proceed in the community. Only through working together can the project be harnessed to maximize benefits to the community and 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 community and area consistent with their vision for the future. This project will only proceed with the involvement of interested communities, potentially affected First Nation and Métis communities and surrounding municipalities working in partnership.

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, 2014), 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

Through a multi-year sequence of engagement and assessments, the NWMO will lead a gradual narrowing down of communities and areas in the process to eventually arrive at a single preferred site with an informed and willing host.

The outcome of Phase 1 Preliminary Assessments will guide an initial phase of narrowing down of communities and areas engaged in site selection studies. The NWMO will identify a smaller number of communities and areas with strong potential to meet the requirements of 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 that continue on in the process, a broad network of relationships would also need to be established in the area, involving the interested community, potentially affected First Nation and Métis communities and surrounding municipalities to reflect upon the suitability of the 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 – 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.

Aquiclude – A medium with very low values of hydraulic conductivity (permeability) which, although it may be saturated with groundwater, is almost impermeable with respect to groundwater flow. Such geologic media will act as boundaries to aquifers and may form confining strata.

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.

Aquitard – A confining bed and/or formation composed of rock or sediment that retards but does not prevent the flow of water to or from an adjacent aquifer. It does not readily yield water to wells or springs, but stores groundwater.

Argillaceous – Largely composed of, or containing, clay-size particles (less than 4 microns) or clay minerals.

Basement (rock) – The crust of the Earth (Precambrian igneous and metamorphic complex) underlying the sedimentary deposits.

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

Brine – Water with a salinity greater than 100,000 milligrams per litre (greater than 100 grams per litre) total dissolved solids.

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.

Dolostone – Also named dolomite, it is a sedimentary rock of which more than 50 percent by weight consists of the mineral dolomite (magnesium carbonate). Dolostone is generally thought to form when magnesium ions replace some of the calcium ions in limestone by the process of dolomitization. Warm migrating fluids along some faults and fractures may locally dolomitize limestone, and the resulting rock, being more porous, may become a host for oil and gas deposits in an appropriate sedimentary setting and physical/chemical environment.

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.

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.

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

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).

Hydraulic Head – Fluid mechanical energy per unit weight of fluid, which correlates to the elevation that water will rise to in a well.

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.

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

Karst – A type of topography that is formed in limestone, gypsum or other soluble rocks primarily by dissolution. It is typically characterized by the formation of sinkholes, caves and underground drainage.

Limestone – A sedimentary rock composed of the mineral calcite (calcium carbonate). Where it contains appreciable magnesium carbonate, it is called dolomitic limestone. Typically, the primary sources of this calcite are the shells of marine organisms.

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

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.

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

Nuttli Magnitude – Magnitude is a measure of the amount of energy released at the source of an earthquake. It is commonly described using the Richter scale (ML). However, this scale does not apply to Eastern North America where the seismic waves attenuate differently. As a result, a different scale, namely the Nuttli magnitude scale (Mn or mN), was adapted to better measure the seismic events in Eastern North America.

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

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

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

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

Permeability – Is a measure of the relative ease of fluid flow under a hydraulic gradient, and is a function only of the medium through which the fluid is moving.

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

Sandstone – A medium-grained clastic sedimentary rock that may be deposited by water or wind, and is composed of abundant sand size particles, with or without a fine-grained matrix (clay or silt), and cemented (commonly silica, iron oxide or calcium carbonate); i.e., the consolidated equivalent of sand.
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.

Shale – A fine-grained detrital sedimentary rock, formed by the compaction and cementation of clay, silt, or mud. It may have a fine laminated structure which gives it fissility; i.e., preferred plane(s) along which the rock splits readily.

Stratigraphy – The study of the age relation of rock strata, including the original succession (order of placement), form, distribution, composition, fossil content, geophysical and geochemical properties, and the environment of origin and geologic history of a rock mass. The science primarily involves the description of rock bodies, and their organization into distinctive, mappable units based on their properties and features.

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).

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

PRELIMINARY ASSESSMENT OF ENVIRONMENT AND SAFETY

masl – metres above sea level.

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

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

Crown land – **Non-Freehold Dispositions Public** – Crown land that is a tenure holding, usually for a set term and a specific purpose (e.g., Lease, Licence of Occupation, Land

Use Permit, Beach Management Agreement and Easement), excluding permanent disposition in the form of a patent.

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

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

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

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

PRELIMINARY ASSESSMENT OF TRANSPORTATION

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

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

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

PRELIMINARY SOCIAL, ECONOMIC AND CULTURAL ASSESSMENT

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