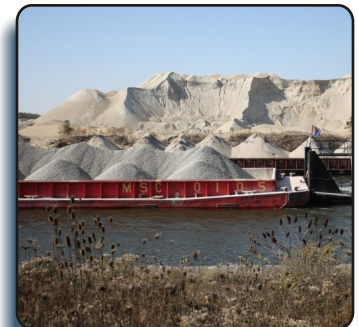
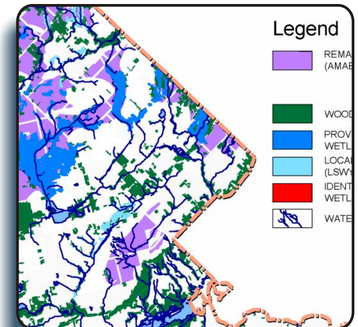
SAROS Paper 2

Future Aggregate Availability & Alternatives Analysis





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In conjunction with: iTRANS transportation planning and traffic consultants, Golder Associates, LVM JEGEL

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SAROS Paper 2 –

Future Aggregate Availability and Alternatives Analysis

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Oversight Statement

The deliverables for this Paper, with respect to the Terms of Reference provided by the Ministry of Natural Resources, have been overseen by members in good standing of the Association of Professional Geoscientists of Ontario - Wayne Caston (#0025), David Hanratty (#1091) and/or John Petrie (#0035).

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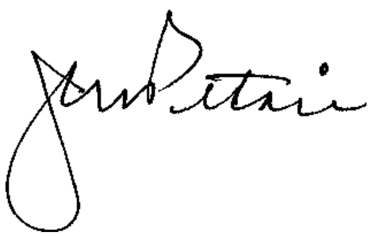

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EXECUTIVE SUMMARY

Mineral aggregates are the cornerstone on which a modern and developed society is built. Mineral aggregates, also known as construction or structural minerals, include naturally-occurring, select deposits of consolidated bedrock and unconsolidated sand and gravel. Aggregates are characterized as non-renewable, fixed location resources and are termed a high bulk, low unit cost commodity.

In order to gain a better understanding of the current status and future issues facing the Province with respect to aggregate resources, the Ontario Ministry of Natural Resources (MNR) has proceeded with the State of the Aggregate Resources of Ontario Study (SAROS), which is composed of six individual Papers.

MHBC Planning is the lead consultant on Paper 2: Future Aggregate Availability and Alternatives Analysis. The main elements of this Paper are:

- a review of other jurisdictions to determine their use of close to market aggregate supply policies;
- a planning constraint analysis for selected bedrock areas in southern Ontario;
- determining the feasibility of alternative sources of aggregate;
- reviewing the feasibility of long-distance aggregate transportation modes;
- calculating the greenhouse gas emissions efficiency associated with the long-distance transportation modes; and
- comparing the impacts of close to market supply and impacts from the use of alternatives.

Based on the research completed, this Paper has led to the following findings:

<u>Aggregate Resource Management and Supply:</u>

Mineral aggregates, similar to agriculture and forestry, are an essential resource. They are a basic element of our daily lives, touching most aspects of our housing, services and mobility.

It is a mandate of the Province to ensure that aggregate resources are protected for long-term use. The Province has declared a Provincial interest in maintaining close to market supply in order to minimize transportation costs and impacts including air quality, greenhouse gas emissions and fossil fuel consumption. Over the past four decades and following numerous background studies and policy reviews, the Provincial interest in aggregate resource management has remained strong. This underlines the importance of aggregate resources to the economic well-being of the Province.

Local concerns regarding environmental effects and opposition to proposals for new and expanded pits and quarries remains strong. There has been increasing pressure to evaluate alternative sources of aggregate, and the need for extraction of close to market resources.

A review of existing provincial policy was undertaken and mineral aggregates are a matter of provincial interest however these plans also include environmental policies that protect some of the more significant environmental areas in Southern Ontario. For example, 70% of the Niagara Escarpment Plan Area and over 50% of the high potential aggregate areas in the Oak Ridges Moraine Plan Area cannot be considered for new or expanded mineral aggregate operations.

Aggregate resources are required in large quantities in economically active regions and in growth centres. Their high bulk, low per unit value places constraints on the distance over which they are transported. Extracting the resource close to where it is being utilized avoids unnecessarily transferring impacts to other jurisdictions.

Close to Market Research:

A literature review was conducted to evaluate policies for mineral aggregate planning in other jurisdictions and identify examples of jurisdictions that utilize a close to market policy approach. Fifteen jurisdictions were identified for further review based on the availability of information and studies. Further, five jurisdictions were selected for an in-depth review of aggregate resource policies.

Historically, the most common factor for incorporating close to market policies has been to ensure aggregate materials were available as economically as possible to the demand areas. Several jurisdictions were identified that support the close to market policy approach similar to Ontario in terms of policy and rationale.

Where jurisdictions did not have general policies that guide the location of aggregate extraction, market forces primarily prevailed. Despite the lack of a consistent policy framework, traditional industry practices and market forces cause operators to locate close to market where such deposits exist. Some jurisdictions support long distance transportation when local availability/supply is limited or does not exist or based on other factors (e.g. tourism, preservation of natural features).

Planning, Environmental and Agricultural Constraints Analysis:

Mineral aggregate deposits are fixed in location and must be extracted where they naturally occur. Mineral aggregate deposits by their very nature, are found in rivervalleys, outwash plains, limestone plains, eskers, kame and moraines. These landforms also contain wetlands, woodlands, agriculture and water features.

A planning, environmental and agricultural constraints analysis was completed for all of Southern Ontario assessing overlapping impacts of constraints on selected bedrock resource areas. In total, 20 constraints were applied and 93% of the selected bedrock resource had overlapping constraints. Of the remaining 7% that did not have overlapping constraints, 91% of this area is located within Study Area 5 and 6 (Eastern Ontario). Overall, based on the constraints analysis, it was concluded that there is a high degree of overlap between prime agricultural land, woodlands and wetlands and selected bedrock resource areas.

In addition to the 20 constraints that were applied to the selected bedrock resource areas, there are numerous other factors that have to be considered in determining whether the deposit area can be assembled and made available to supply mineral aggregate needs. Without an integrated and balanced approach, it is unlikely that an aggregate deposit could be assembled and made available since there is a high probability of on-site and adjacent natural features, agriculture, water resources and social factors to consider.

The constraints analysis also identified that the majority of other rural resources are located outside of the selected bedrock resource area. For example, 95% of ANSI, 91% of significant woodlands, 93% of all wetlands and 96% of prime agricultural lands are located outside of selected bedrock resource areas.

<u>Alternative Sources of Aggregates:</u>

This component of the Paper considers alternative sources of aggregate and the feasibility of each source to meet Ontario's long-term availability and supply objectives. The feasibility of five sources of aggregate alternatives to the current supply from surface pit and quarry sources was considered. The five alternative sources were mine tailings, river or lake dredged sand/gravel, manufactured sands, underground bedrock mining and mega-quarries. Of these, underground mining and mega-quarries were found to have a stronger feasibility than dredging, mine tailings and manufactured sands.

Environmental concerns and questions of quality/quantity have historically limited dredging production to a small percentage of total aggregate production in the Province. There have been no active dredging operations in Ontario for several years.

Mine tailings tend to be located in remote areas well outside economically feasible distances to urban areas. It is unlikely that mine tailings will be significantly used until favourable transportation costs to Southern Ontario are available. The use of mine tailings could also pose problems due to issues of contamination.

Manufactured sand from bedrock quarries can be considered as a possible alternative source of aggregate in geographic areas where natural sands do not exist. In areas where natural sands exist, manufactured sand is not an economically feasible alternative due to high production costs.

Underground mining of limestone aggregates has been explored for over 30 years in Ontario. While investigations to assess the feasibility of underground mining have occurred, no underground limestone mining operations have been developed in Ontario. However, there are 86 active underground mines in the United States (2007). Underground mining appears feasible, however, the cost of aggregate may be 2 to 3 times higher than that of the surface mine. Underground mining does reduce surface disruption but will not eliminate social/environmental concerns since processing and shipping still occur at surface and dewatering can influence water wells and surface water features.

A mega-quarry, which is defined as having 150 million tonnes of reserves and an annual production capacity of at least 10 million tonnes, appears to be a feasible alternative. Mega-quarries are similar to today's surface quarries but are at a larger scale. To have 150 million tonnes of reserves, a mega-quarry would require an extraction area of approximately 280 hectares. A mega-quarry would result in a greater level of activity onsite and result in a larger area of influence requiring greater mitigation to minimize social and environmental impacts.

<u>Feasibility of Alternative Transportation Systems:</u>

This component of the Paper evaluates the feasibility of alternative transportation systems to supply aggregate to the Greater Toronto Area from long distance sources compared to the existing close to market strategy. The three alternative transportation modes considered were marine, rail and long distance trucking.

The transportation analysis confirms that there would be significant economic, environmental and social implications of shifting away from the close to market policy in favour of importation from long distance sources for the Greater Toronto Area market.

The delivery cost of aggregate would more than double compared to the existing close to market scenario. Delivery from close to market pits and quarries is by far the most economical scenario given the much smaller distances traveled and the opportunity for direct delivery from source to job site. Replacing close to market supply with imports from remote sources would also significantly increase greenhouse gas emissions. For example, the rail, marine and long distance trucking scenarios were all more than double the greenhouse gas emissions when compared to the close to market scenario.

Previous studies assessing transportation alternatives have noted that there is no identifiable environmental benefit of extracting aggregate from a pit and quarry located further from market. There are however, additional negative environmental impacts associated with long distance haul alternatives. In addition to greenhouse gases, there are environmental consequences associated with consumption of resources and manufacturing processes necessary to produce and maintain transportation vessels, facilities and infrastructure.

The social impacts of alternative delivery systems from long distance sources would be greater than the continued delivery from dispersed close to market sites. At the extraction site, there would likely be lower social impacts because there is a strong possibility that fewer people are affected at remote extraction locations. However, due to the long distances traveled for the alternative scenarios, social impacts would be higher because of the number of people affected along the increased transportation routes. The redistribution terminals associated with the alternative scenarios would also create social impacts.

In addition, significant government intervention would be required in order to shift away from close to market sources. This would include market interventions and compensation, expropriation and overriding municipal land use controls. Implementing an alternative far from market supply strategy would require significant capital investment and construction for new infrastructure, vehicles and facilities. This would take years to achieve and close to market sources would continue to be required in the interim and phase-in periods.

1.0 INTRODUCTION

A Request for Proposals (RFP) was issued on March 25, 2009 by the Ontario Ministry of Natural Resources (MNR) with respect to a landmark aggregates study entitled the State of the Aggregate Resource in Ontario Study (SAROS). The current SAROS builds on and updates a study done in 1992 for the MNR entitled "Aggregate Resources of Southern Ontario, A State of the Resource Study". SAROS is focused on researching and analyzing information on the consumption, demand, availability, feasibility of alternative sources, current reserves, rehabilitation, transportation, recycling/re-use and the value of aggregates to the Province.

Given the amount and complexity of work to be undertaken, the overall Study was divided into six separate Papers. On April 30, 2009, the MNR selected MacNaughton Hermsen Britton Clarkson Planning Limited (MHBC), lead consultant, in association with Golder Associates Ltd. (Golder), iTRANS Consulting Inc. (iTRANS), and LVM-JEGEL to complete Paper 2, entitled Future Aggregate Availability and Alternatives Analysis.

The requirements of the RFP, which have been summarized below, are addressed in the following sections of this Paper.

1.1 OBJECTIVES

The general objectives for SAROS, as summarized from the RFP, are to:

- Provide updated base information about current licenced aggregate resources in Ontario;
- Provide information to support provincial, regional and municipal strategic planning for aggregate supply to meet long term demand;
- Provide a more definitive understanding of current supply and future aggregate resource constraints that may affect long term supply; and,
-
- Provide a credible source book of information on aggregate resources available to the general public online.

1.2 SCOPE OF WORK

The detailed scope of work for Paper 2, as stated in the RFP, is comprised of the following tasks:

- *Review other jurisdictions for application of close to market aggregate utilization concept.*
  - *The benefit of the utilization of close to market resources is noted in many planning documents from other jurisdictions around the world.*
  - *Provide a list of references and review.*
- *Undertake a planning constraint analysis using identified aggregate resource mapping (e.g. aggregate resource inventory papers) and all provincial planning constraints by selected*

geographic regions (Canadian Portland Cement Association of Canada Areas 1 to 6) and selected commodity.

- *As a base layer use the bedrock resources (ARIP) mapping for limestone/dolostone resources only.*
- *Using Provincial Policy Statement 2005 determine the planning policies that prohibit or limit the establishment of an aggregate operation.*
- *Access GIS data layers from provincial ministries.*
- *Map the information in a GIS Arcinfo format.*
- *Apply and/or explain additional constraints that would impede the establishment of a quarry (e.g. size of deposit, parcel size, rural development etc.).*

▪ *Determine the feasibility of alternative sources of aggregates such as mine tailings, underground mining, lake dredging and single source extraction (mega quarry, greater than 10 million tonnes/year with 150 million tonnes reserve).*

- *Review past feasibility studies and reports and determine the opportunities and barriers that may exist in the current planning and economic climate for alternative sources.*
- *Include discussion on the costs, environmental and social implications.*

▪ *Review the feasibility of increased transportation of aggregates by rail including additional associated facility requirements, costs, opportunities and barriers to implementation.*

- *Develop a general model - use North Bay as the starting point and the final destination is Vaughan Corporate Centre (Urban Growth Centre for Growth Plan). Include all steps to move aggregates from quarry to rail depot to market depot to delivery site. Describe additional infrastructure needed to make this system work.*

▪ *Determine the greenhouse gas emission efficiency (GHG emissions per 1000 tonnes of aggregates) from source to project site for rail transport of aggregates.*

- *Emissions efficiency of systems is a way to measure in environmental terms the most effective method of supplying aggregates.*
- *Consider this as full cost accounting or life cycle assessment for emissions. All new development and equipment has an emission cost and all steps of loading and unloading resources also has emission costs.*

▪ *Feasibility of increased transportation of aggregates by ship including additional facility requirements, associated costs, opportunities and barriers to implementation.*

- *Develop a general model - use Manitoulin Island as the starting point and the final* *destination is Vaughan Corporate Centre (Urban Growth Centre for Growth Plan). Include all steps to move aggregates from quarry to ship to dockyard depot to delivery site. Describe additional infrastructure needed to make this system work.*

- *Calculate the greenhouse gas emission efficiency for trucking aggregates by road from a northern Ontario source as comparison to rail and ship transport.*

  - *Develop a general model - use North Bay as the starting point and the final destination is Vaughan Corporate Centre (Urban Growth Centre for Growth Plan). Include all steps to move aggregates from quarry to delivery site. Describe additional infrastructure or equipment needed to make this system work.*

- *Compare the impacts of close to market aggregate utilization vs. impacts of using alternatives.*

1.3 OVERVIEW

Paper 2 examines future aggregate availability and alternatives. Its purpose is to provide background information to inform policy discussions related to Ontario's future aggregate supply.

Section 2 of this Paper examines other jurisdictions and their approach to mineral aggregate resource policies. The purpose of this research is to determine if other developed countries have adopted comparable policy approaches to Ontario and require a close to market supply of aggregate. This section will provide a preliminary framework for evaluating Ontario's aggregate resource policies in the context of other jurisdictions.

Section 3 of this Paper is the planning, environmental and agricultural constraints analysis. This analysis examines limestone/dolostone resources in selected areas and the extent of the overlap of environmental, agricultural and social constraints. A Geographic Information System-based (GIS) mapping analysis was completed and 20 constraints were identified and applied cumulatively to the selected bedrock resource area. Additional constraints were identified but were not included in the analysis due to factors described in Section 3.

Section 4 of this Paper is an assessment on the feasibility of alternative sources of aggregates. The alternatives that were examined were mine tailings, underground mining (bedrock only), lake dredging (sand/gravel only), manufactured sand and mega-quarries (bedrock only). Past feasibility and evaluation studies have been examined and the economic, social and environmental implications were analyzed for each alternative source. A more detailed analysis was undertaken for underground mining and mega-quarries since these two alternative sources had the strongest feasibility for future aggregate extraction scenarios.

Section 5 of this Paper is an evaluation of the feasibility of alternative transportation modes, including rail, marine and long distance trucking to the major market area of Ontario, being the Greater Toronto Area (GTA)[1]. These alternatives will be used as a comparison to the existing close to market (CTM) strategy (short haul trucking) in terms of economic, social and environmental impacts.

The final section of this Paper provides a review of the preceding sections and a summary of overall conclusions that can be drawn.

[1] The Greater Toronto Area includes the City of Toronto, Region of Durham, Region of York, Region of Peel and Region of Halton.

1.4 CURRENT POLICY FRAMEWORK

Mineral aggregate, which includes gravel, sand, clay, earth, shale, stone, limestone, dolostone, sandstone, marble, granite and rock, is one of the more essential commodities for our economic, environmental and social well-being. It is used to construct homes, schools, hospitals, offices, sewers, bridges and highways, with public infrastructure consuming the largest proportion. It is also used as an additive in the production of a wide variety of everyday materials. Aggregates are non-renewable and have few viable substitutes.

It is a mandate of the Province to ensure that aggregate resources are protected for long-term use and made available as close to market (CTM) as possible. This reflects the Provincial interest in ensuring abundant and competitive CTM supply for the full range of products. The current policy framework is an evolution of 40 years of Provincial policy development and studies (see Section 1.5).

The Provincial land use interest in aggregates is reflected in the Provincial Policy Statement, 2005, (PPS) issued under Section 3 of the *Planning Act*. The PPS is a key part of Ontario's policy-led planning system and recognizes the complex inter-relationship among environmental, economic and social factors in land use planning. It supports a comprehensive, integrated and long-term approach to planning and recognizes linkages among policy areas (Part III: How to Read the Provincial Policy Statement).

The PPS is more than a set of individual policies. The PPS should be read in its entirety and the relevant policies should be applied to each situation (Part III: How to Read the Provincial Policy Statement). The PPS recognizes the Province's natural heritage resources, water, agricultural lands, mineral resources, cultural heritage and archaeological resources provide important environmental, economic and social benefits. The wise use and management of these resources over the long term is a key Provincial interest (Part IV: Vision for Ontario's Land Use Planning System).

The current PPS (2005) includes the following policies for mineral aggregates (Section 2.5):

> *2.5.1 Mineral aggregate resources shall be protected for long-term use.*
>
> *2.5.2 Protection of Long-Term Resource Supply*
>
>> *2.5.2.1 As much of the mineral aggregate resources as is realistically possible shall be made available as close to markets as possible.*
>>
>> *Demonstration of need for mineral aggregate resources, including any type of supply/demand analysis, shall not be required, notwithstanding the availability, designation or licensing for extraction of mineral aggregate resources locally or elsewhere.*
>>
>> *2.5.2.2 Extraction shall be undertaken in a manner which minimizes social and environmental impacts.*
>>
>> *2.5.2.3 The conservation of mineral aggregate resources should be promoted by making provision for the recovery of these resources, wherever feasible.*

2.5.2.4 Mineral aggregate operations shall be protected from development and activities that would preclude or hinder their expansion or continued use or which would be incompatible for reasons of public health, public safety or environmental impact. Existing mineral aggregate operations shall be permitted to continue without the need for official plan amendment, rezoning or development permit under the Planning Act. When a license for extraction or operation ceases to exist, policy 2.5.2.5 continues to apply.

2.5.2.5 In areas adjacent to or in known deposits of mineral aggregate resources, development and activities which would preclude or hinder the establishment of new operations or access to the resources shall only be permitted if:

a. resource use would not be feasible; or

b. the proposed land use or development serves a greater long-term public interest; and

c. issues of public health, public safety and environmental impact are addressed.

2.5.3 Rehabilitation

2.5.3.1 Progressive and final rehabilitation shall be required to accommodate subsequent land uses, to promote land use compatibility, and to recognize the interim nature of extraction. Final rehabilitation shall take surrounding land use and approved land use designations into consideration.

2.5.3.2 In parts of the Province not designated under the Aggregate Resources Act, rehabilitation standards that are compatible with those under the Act should be adopted for extraction operations on private lands.

2.5.4 Extraction in Prime Agricultural Areas

2.5.4.1 In prime agricultural areas, on prime agricultural land, extraction of mineral aggregate resources is permitted as an interim use provided that rehabilitation of the site will be carried out so that substantially the same areas and same average soil quality for agriculture are restored.

On these prime agricultural lands, complete agricultural rehabilitation is not required if:

a. there is a substantial quantity of mineral aggregate resources below the water table warranting extraction, or the depth of planned extraction in a quarry makes restoration of pre-extraction agricultural capability unfeasible;

b. other alternatives have been considered by the applicant and found unsuitable. The consideration of other alternatives shall include resources in areas of Canada Land Inventory Class 4 to 7 soils, resources on lands identified as designated growth areas, and resources on prime agricultural lands where rehabilitation is feasible. Where no other alternatives are found, prime agricultural lands shall be protected in this order of priority: specialty crop areas, Canada Land Inventory Classes 1, 2 and 3; and

c. agricultural rehabilitation in remaining areas is maximized.

There are also a number of Provincial Plans, issued under Section 3 of the *Planning Act*, that guide land use planning for specific areas in Southern Ontario and these plans contain policies relating to mineral aggregates. These plans include:

- Niagara Escarpment Plan (1985 and 2005);
- Oak Ridges Moraine Conservation Plan (2002);
- Greenbelt Plan (2005);
- Growth Plan for the Greater Golden Horseshoe (2006); and
- Lake Simcoe Protection Plan (2009).

The following is a brief overview of the objectives of these plans and the general approach to mineral aggregate resources:

Niagara Escarpment Plan (2005)

The Niagara Escarpment Plan is a Provincial Plan that governs land use within the Niagara Escarpment Plan Area. The Niagara Escarpment Plan serves as a framework of objectives and policies to strike a balance between development, preservation and the enjoyment of this important resource.

The purpose of the Niagara Escarpment Plan is to provide for the maintenance of the Niagara Escarpment and lands in its vicinity substantially as a continuous natural environment and to ensure only such development occurs as is compatible with the natural environment.

The principle as to whether new aggregate operations should be permitted in the Niagara Escarpment Plan Area has been thoroughly reviewed. The Niagara Escarpment Plan prohibits aggregate extraction in the Escarpment Natural and Protection Areas to protect the most significant features of the Escarpment. The Plan permits new mineral aggregate operations in the Escarpment Rural Area subject to an amendment and satisfying the relevant policies of the Niagara Escarpment Plan.

During the 1990-1994 Plan Review Hearing, it was determined that only 30% of the total Plan area was designated Escarpment Rural Area and could be considered for extraction. A further analysis of this area identified that only 17% of the Rural Area contains “high priority aggregate areas”. Therefore, only 5% of the Plan area is realistically available for consideration of new aggregate operations.

Oak Ridges Moraine Conservation Plan (2002)

The Oak Ridges Moraine Conservation Plan is a Provincial Plan that governs land uses within the Oak Ridges Moraine Plan Area. The purpose of the Oak Ridges Moraine Conservation Plan is to provide land use and resource management planning direction on how to protect the Moraine’s ecological and hydrological features and functions.

The Oak Ridges Moraine Conservation Plan prohibits aggregate extraction in the Natural Core Area. As a result, over 50% of the selected aggregate resource area within the Oak Ridges Plan Area is sterilized (precluded from extraction). The Oak Ridges Moraine Conservation Plan permits above water aggregate operations within the Natural Linkage Area and above / below water aggregate operations within the Countryside area. New aggregate operations within the designation still need to address the applicable environmental / water resources policies.

Greenbelt Plan (2005)

The Greenbelt Plan is a Provincial Plan that governs land use within the Greenbelt Plan Area and includes the Niagara Escarpment Plan Area and Oak Ridges Moraine Conservation Plan Area. The Greenbelt is a broad band of permanently protected land which provides for a diverse range of economic and social activities associated with rural communities, agriculture, tourism, recreation and resource uses (Section 1.2.1).

The Greenbelt Plan permits new or expanded mineral aggregate operations in the Protected Countryside and Natural Heritage System subject to the relevant policies of the plan and supports the availability of close to market aggregates for economic and environmental reasons (Section 4.2.3). The Greenbelt Plan recognizes the benefits of protecting renewable and non-renewable natural resources and has provision for the availability and sustainable use of those resources critical to the region's social, environmental, economic and growth needs (Section 1.2.2.5).

Within the Natural Heritage System, the Greenbelt Plan makes a distinction between new aggregate operations and expansions to existing operations. For expansions, the policies are more permissive and extraction may be permitted in key natural heritage features and key hydrologic features if the decision is consistent with the Provincial Policy Statement (Section 4.3.2.3.d). In contrast, within the Natural Heritage System, new aggregate operations are prohibited in significant wetlands; significant habitat of endangered species and threatened species; and significant woodlands unless the woodland is occupied by young plantation or early successional habitat (Section 4.3.2.3.a).

Within specialty crop areas, the Greenbelt Plan prohibits new mineral aggregate operations between Lake Ontario and the Niagara Escarpment Plan Area. In other specialty crop areas (e.g. Fonthill Kame) new mineral aggregate operations may be permitted if the physical characteristics of the site allow for rehabilitation back to an agricultural condition which allows for the same range and productivity of specialty crops (Section 4.3.2.8).

Growth Plan for the Greater Golden Horseshoe (2006)

The Growth Plan for the Greater Golden Horseshoe has been prepared to implement the Province's vision for building stronger, prosperous communities by better managing growth in the Greater Golden Horseshoe (GGH). The Plan will guide decisions on a wide range of issues, such as transportation, infrastructure planning, land use planning, urban form, housing, natural heritage and resource protection in the interest of promoting economic prosperity. The Growth Plan is intended to create a clear environment for investment decisions and to secure the future prosperity of the GGH. Section 1.1 states:

> *"Decades of neglect and lack of sufficient investment have resulted in the current*

infrastructure deficit. Tens of billions of dollars beyond current levels of investment will be required before the situation is back in balance. All levels of government are under pressure to meet public infrastructure needs. Additional support from federal partners; innovative, alternative partnership arrangements that protect the public interest; and the strategic staging of infrastructure investments are all required to respond to these challenges. Ultimately, better investment in our cities will help to mitigate sprawl. Enhancing infrastructure, integrating and improving transit systems, protecting valuable natural resources and strengthening local government will all go far towards the implementation of this Plan...The GGH is one of the fastest growing regions in North America. By 2031, the population of this area is forecasted to grow by an additional 3.7 million (from 2001) to 11.5 million people, accounting for over 80 percent of Ontario's population growth. The magnitude and pace of this growth necessitates a plan for building healthy and balanced communities and maintaining and improving our quality of life."

Section 4.1 states:

"The GGH is blessed with a broad array of unique natural heritage features and areas, irreplaceable cultural heritage sites, and valuable renewable and non-renewable resources that are essential for the long-term economic prosperity, quality of life, and environmental health of the region. These valuable assets must be wisely protected and managed as part of planning for future growth… A balanced approach to the wise use and management of all resources, including heritage, agriculture, and mineral aggregates, will be implemented."

The mineral aggregate policy of the Growth Plan states (Section 4.2.3.1):

"Through sub-area assessment, the Ministers of Public Infrastructure Renewal and Natural Resources will work with municipalities, producers of mineral aggregate resources, and other stakeholders to identify significant mineral aggregate resources for the GGH, and to develop a long-term strategy for ensuring the wise use, conservation, availability and management of mineral aggregate resources in the GGH, as well as identifying opportunities for resource recovery and for co-ordinated approaches to rehabilitation where feasible."

<u>Lake Simcoe Protection Plan (2009)</u>

The Lake Simcoe Protection Plan is a Provincial Plan that provides land use policies within the Lake Simcoe watershed. The purpose of the Lake Simcoe Protection Plan is to protect, improve or restore the elements that contribute to the ecological health of the Lake Simcoe watershed. One of the primary objectives of the Plan is to reduce phosphorous loadings in the watershed.

Policies limiting areas where new mineral aggregate operations may occur are similar to the Greenbelt Plan Natural Heritage System. Section 6.42-DP of the Plan states that extraction is not permitted in significant wetlands, significant habitat of endangered species and threatened species and significant woodlands unless the woodland is occupied by young plantation or early successional habitat.

Municipal Official Plans

In accordance with the requirement to implement policies in various provincial plans, and to be consistent with the Provincial Policy Statement, 2005, local and upper-tier municipal governments include policies in their Official Plans related to mineral aggregate resources. Typically, a new mineral aggregate operation is required to obtain an Official Plan and Zoning By-law amendment to permit the use. Prior to an *Aggregate Resource Act* licence being issued, the site must be zoned as a permitted use in the municipality's zoning by-law (*Aggregate Resources Act*, Section 12.1(1)).

1.5 THE DEVELOPMENT OF AGGREGATE RESOURCE MANAGEMENT POLICY

The evolution of aggregate resource policies in Ontario has been evident over the past 40 years. The Province, through policy development and implementation, has demonstrated the management of aggregate resources as a matter of Provincial interest.

In 1969, the Minister of Mines established a technical committee for the purposes of considering the designation of lands for pit and quarry use and introducing legislation that would regulate aggregate operations. The *Pits and Quarries Control Act* was subsequently enacted in 1971. It applied only in selected municipal jurisdictions, with extraction only permitted under Provincial licence in accordance with approved operations and rehabilitation site plans.

In 1974, an Interministerial Committee on Mineral Aggregate Policy was established and responsible for recommending alternative mineral aggregate policy options.

In 1975, Cabinet directed that a senior Interministerial group should be established to formulate and implement a mineral aggregate policy for Ontario based upon consideration of the following:

a) *Provincial intervention to ensure continued availability of mineral aggregates.*

b) *Whether the cost of aggregate should include some form of remuneration to the municipalities to compensate them for costs imposed by the industry.*

c) *Examination of the longer run aggregate supply situation with specific reference to alternate sources, underground mining, substitutes, etc.*

d) *A continued emphasis on the responsibility which the industry itself must bear to become more acceptable to municipalities and the general public.*

A Working Party was then appointed by the Province consisting of municipal, public and industry representatives. It issued the 1976 Report of the Ontario Mineral Aggregate Working Party to the Minister of Natural Resources. The Working Party recommendations had an important bearing on the subsequent development of policy and legislations in the 1980's and 1990's. Several of the points addressed by the Working Party 30 years ago continue to be debated in current policy discussions.

In 1978, the *Mineral Aggregate Policy for Official Plans* (Ten Point Policy for Aggregates) was approved by Cabinet as one of the first Provincial statements regarding planning for availability of aggregate resources. It became an important statement for the Province in the contested 1979 Ontario Municipal Board hearing on the first Durham Region Official Plan. The purpose of the Ten Point Policy was to provide direction for municipalities on Official Plan aggregate resource policies. Some of the general themes included a shared responsibility for supply, identifying high potential mineral resource areas, protecting resource areas from incompatible land uses and a requirement to make aggregates available at a reasonable cost including environmental, transportation and energy costs.

In December 1982, the *Mineral Aggregate Resources Planning Policy* (MARPP) was approved by Cabinet and replaced the Ten Point Policy. MARPP was a formal declaration of Provincial policy on planning for mineral aggregate resources. The MARPP stated that municipalities should identify and protect as much as of its aggregate resources as is practicable.

In May 1986, the *Mineral Aggregate Resources Policy Statement* (MARPS) was approved by the Lieutenant Governor in Council. It superseded MARPP although it was very similar in its terms. MARPS was the first policy statement issued under Section 3 of the *Planning Act* and it contemplated improvements to the *Pits and Quarries Control Act* in terms of operating standards, rehabilitation and evaluation / approval procedures for creating new operations.

A basic premise of MARPS was that it did not supersede or take priority over other policy statements or other policy for specific areas of the Province. MARPS included specific policies to ensure regard to the importance of mineral aggregates was taken into account in any related planning action. Its background statement included:

> *Mineral aggregates are vital to Ontario's economy. In 1980, for example, approximately 120 million tonnes or more than fourteen tonnes of mineral aggregate per capita were used in Ontario* (approximately 167 million tonnes or 13 tonnes per capita were used in 2008)*.*
>
> *Although potential reserves exist in many parts of the Province, a reduction in the availability of mineral aggregates is occurring as a result of:*
>
> - *depletion of near market supplies;*
> - *effective elimination of some valuable mineral aggregate sources by other development, for example housing, occurring over or adjacent to the deposits; and*
> - *restrictive controls which make the establishment and operation of pits and quarries difficult.*
>
> *A scarcity of mineral aggregates is occurring within certain parts of Ontario. This results in increased mineral aggregate costs whether through hauling the material from distant sources; through using more expensive substitute materials; or through using more expensive processing techniques to upgrade lower quality materials. Such increased costs are ultimately transferred to the consumer. Therefore, it is important that sufficient mineral aggregate resources are available to meet the future needs of Ontario residents.*

This policy statement established mineral aggregates resources as a matter of Provincial interest and concern. It included specific policies to ensure that regard was paid to the importance of mineral aggregate and that the overall Provincial interest is taken into account in any related planning action.

In 1995, MARPS was rolled into the Comprehensive Set of Policy Statements (CSPS), which was issued under Section 3 of the *Planning Act*.

In 1996, the Provincial Policy Statement (PPS) came into effect and was revised February 1, 1997. The PPS was issued pursuant to Section 3 of the *Planning Act* and as such was a policy which all decision makers were required "*to have regard to*" in making decisions on applications to which the provisions of the PPS are relevant. The wording of the aggregate resource policies was similar to the original intent of MARPS but in an abbreviated form. The 1997 PPS was replaced by the 2005 PPS and the implementing *Planning Act* language "*to have regard to*" was changed to "*be consistent with*".

The *Aggregate Resources Act* (ARA) was enacted in 1990 and updated in 1997. It replaced the *Pits and Quarries Control Act* and established a more comprehensive licencing regime for pits and quarries, in terms of approvals, operations and rehabilitation as well as an annual licence fee per tonne for the Province and municipalities. The fee was increased from 6 cents to 11.5 cents per tonne in 2007. Seven and a half cents is distributed to the upper and lower tier municipality, 0.5 cents to the rehabilitation fund and 3.5 cents to the MNR program which includes funding for enforcement and other administrative matters.

A review of past reports suggests the historic issues regarding the public interest in supply continue today. Prior to 1971, aggregate supply, approval and regulation were primarily matters of local interest. The 1971 *Pits and Quarries Control Act* and subsequent policy positions elevated aggregate supply, approval and regulation to matters of Provincial interest.

These actions, in legislation and policy, were intended to ensure this basic resource continued to be available to meet a societal need for aggregate from CTM locations while minimizing the environmental, social and economic costs associated with its extraction and transportation.

Legislation and regulations under other environmental statutes were established to set standards for nuisance emissions such as dust and noise. Scientific analysis and conditions were required to minimize adverse impacts on the physical environment. Detailed plans were required to govern progressive rehabilitation such that the rural sites were returned either to an agricultural use (agricultural policies in the PPS) or to a natural heritage use (Greenbelt Plan and PPS).

The result of some 40 years of study and legislation is that mineral aggregate extraction in Ontario is highly regulated and is designed to minimize social and environmental impacts during and after the extraction.

2.0 CLOSE TO MARKET AGGREGATE: JURISDICTIONAL REVIEW

2.1 PROVINCE OF ONTARIO: CLOSE TO MARKET POLICY

Section 2.5.2.1 of the Provincial Policy Statement states that *"as much of the mineral aggregate resources as is realistically possible shall be made available as close to markets as possible"*. Protecting and maximizing the use and accessibility of close to market (CTM) resources can minimize the cost of transportation and the social and environmental impact of truck haulage.

Given the objective of minimizing haul distances, the Province has declared a Provincial interest in maintaining as much CTM supply as possible to minimize environmental, economic and social costs. The rationale is explained in the following MNR statements (Managing Aggregate Resources, Ministry of Natural Resources):

- "*Approximately 85% of total aggregate production takes place in southern Ontario where the demand for aggregates and aggregate-derived products is the highest."*
- *"Extracting aggregate resources close to where they are being utilized can also be considered the most environmentally sensitive alternative. Trucking resources long distances increases greenhouse gas emissions, which is one of the top environmental concerns in the world today."*
- *"The cost of transportation is estimated to be approximately 60% of the total cost of aggregate. Therefore, the economic value of an aggregate deposit is based not only on the quantity and quality of the deposit, but also how close the deposit is to its final destination."*
- *"Aggregates provide the critical resources for the $37 billion construction industry that employs 292,000 people in Ontario. The aggregate industry is estimated to directly employ 7,000 people. In addition, more than 34,000 people are indirectly employed in sectors such as transportation and equipment."*
- *"The value increases as the raw material is processed into the various construction materials and then utilized to build infrastructure such as hospitals and roads. For example, the commodities produced by the aggregate industry make a significant contribution to the $1.9 billion cement and concrete manufacturing industry, the $1.3 billion glass and glass products industry, and a $2.9 billion pharmaceutical and medicine manufacturing industry in Ontario."*
- *"Ontario has also benefited socially from accessible aggregate resources, thereby providing affordable infrastructure and housing costs."*
- *"The wise management of aggregate resources and balancing of resource interests will ensure a continued close to market supply."*[2]

[2] http://www.mnr.gov.on.ca/MNR/aggregates/resources.html

The concept of CTM has been studied for over 30 years. In 1976, the Mineral Aggregate Working Party stated that the long distance transportation of aggregates over 100 miles was a cause for concern as energy costs and fuel consumption would greatly increase.

In 1980, Peat Marwick & Partners and M.M. Dillon Ltd. completed a Mineral Aggregate Transportation Study for the Ministry of Natural Resources. The study concluded that long distance transportation of aggregates would increase the price of aggregates substantially. The study assessed transporting aggregate from the Saugeen area (counties of Grey, Bruce and Huron) and Manitoulin Island to the Greater Toronto Area (GTA). The study concluded that impacts of extraction on agricultural land and the natural environment would not be reduced significantly by moving production away from market areas.

In 1992, a study entitled “Aggregate Resources of Southern Ontario, A State of the Resource Study” discussed the applicability of CTM resources. The study stated that if distant sources were to be utilized, potential impacts would include increased transportation costs, increased capital and maintenance costs for roads, increased air pollution, increased social and environmental impacts in more remote resources areas and increased housing costs.

One of the key findings from the 1992 Study was that for the period of 1990 to 2010, Southern Ontario would move towards a critical economic, social and environmental situation in terms of protection of, and access to, aggregate resources required to meet the increasing demands of Ontario residents.

The Study referred to ‘new frontier aggregate areas’ that were being identified a greater distance from market areas as a result of increased urbanization in the GTA and more restrictive Provincial plans. The premature extraction of distant resources would sterilize ‘near-urban’ resources and cause increased costs and environmental impacts due to long distance transportation.

The study provided recommendations with respect to CTM resources:

1. Efforts should be made to make local aggregate resource areas more accessible and available so that there is less reliance on distant source areas; and

2. The ideal objective of any market area should be to utilize existing local resources that can meet the quantity and quality specifications of the various areas.

During the Niagara Escarpment Plan Review (1990-1994), Provincial Ministries studied the economic, environmental and social implications of discontinuing extraction from CTM resources in the Escarpment Rural Area of the Niagara Escarpment Plan[3]. The localized environmental effects of aggregate extraction would be transferred to communities outside the Plan area and communities along the longer haul routes would be subject to increased traffic, air pollution and noise.

[3] Extraction is prohibited in the Escarpment Natural and Escarpment Protection Area and only permitted by amendment in the Escarpment Rural Area

CTM aggregate operations also provide opportunities to rehabilitate depleted sites to urban, agricultural, natural heritage, recreational and public open spaces. The demand for opportunities and access to public open space, recreational and conservation areas in the GGH will significantly increase with the intensification goals of the Province. The GGH is expected to grow to approximately 11.5 million people by 2031. The Greenbelt Plan encourages operators to provide public access to former extraction sites upon final rehabilitation. The provision to rehabilitate former extraction sites to appropriate rural resources coupled with the Greenbelt Plan rehabilitation clause is a way to help meet demand for large public open spaces in the GGH. There are many examples; thousands of acres of existing and planned rehabilitated sites contribute to publicly accessible greenspace in and around the GGH (Figure 2.1 - Publicly Accessible Greenspace through Rehabilitation).

In summary, Ontario has maintained a CTM supply policy for the following economic, social and environmental reasons:

- Extracting the resource close to where it is being utilized is in keeping with the principles of sustainable development and avoids unnecessarily transferring impacts to other jurisdictions.
- The cost of transportation currently represents 60% of the total cost of aggregate and extraction further from market areas will increase the price. Ontario has benefited socially from CTM sources thereby providing affordable infrastructure and housing costs.
- Reducing the distance between the aggregate source and the job site reduces greenhouse gas emissions, which is one of the top environmental concerns today[4].
- Rehabilitated pits and quarries restore agricultural land, natural heritage features and provide essential public open spaces that are in high demand as the GGH continues to grow and intensify.

[4] This statement was confirmed in the 2009 Canadian Urban Institute study entitled ‘Between a Rock and a Hard Place’

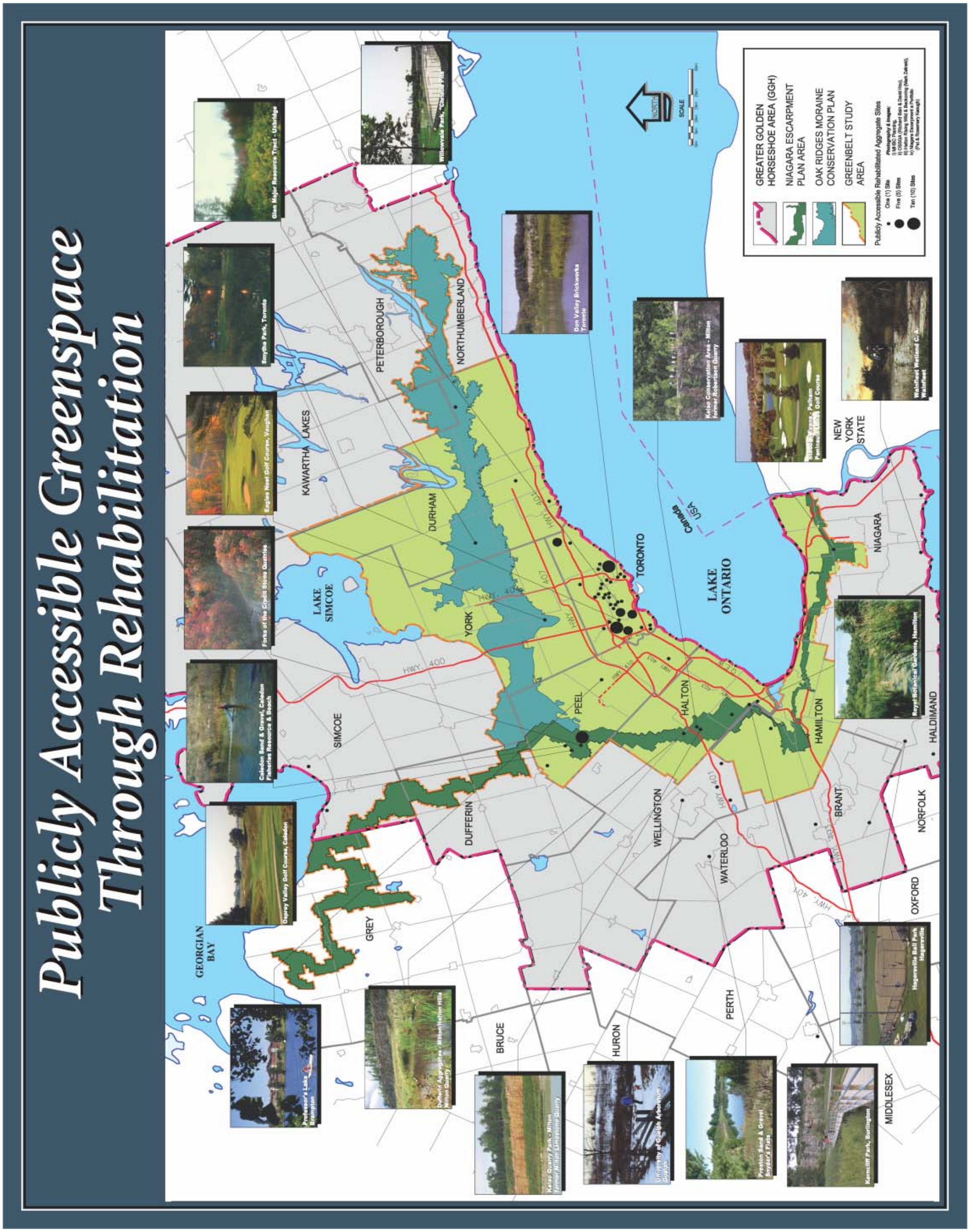


Figure 2.1 - Publicly Accessible Greenspace through Rehabilitation

2.2 OVERVIEW OF LITERATURE REVIEW

The purpose of the literature review was to evaluate policies for mineral aggregate planning in other jurisdictions and identify examples of jurisdictions that utilize a close to market (CTM) policy approach.

The initial review was focused on the documentation list as provided by the MNR in the State of the Aggregate Resource in Ontario Study (SAROS) Request for Proposals (RFP). This was supplemented by researching additional documents and jurisdictions in consultation with the Steering and Technical Committees. Thirty jurisdictions were included as part of the initial review process.

Upon completion of this preliminary step, 15 jurisdictions were identified for further review based on availability of information and studies (Section 2.3). The jurisdictions are:

- Australia
- Cayman Islands
- Czech Republic
- Denmark
- Italy
- Netherlands
- New Zealand
- Sweden
- United Kingdom
- California
- Illinois
- Maryland
- Pennsylvania
- Virginia
- West Virginia

Further, 5 jurisdictions were selected for an in-depth review of aggregate resource policies (Section 2.5) in consideration of the relative location of aggregate sources and market demand areas, aggregate production / consumption, market conditions, population and broad socio-economic factors of each jurisdiction. These jurisdictions are:

- United Kingdom
- Illinois
- Sweden
- Australia
- Cayman Islands

The jurisdictions evaluated in the initial and detailed review stages were selected based on available information to assist in the review. Several of the jurisdictions reviewed were European countries. These jurisdictions are notably all within the European Union (EU) and have an extensive amount of information available on planning for mineral aggregates.

Sources reviewed included academic papers, industry reports, media articles, legislation and government policies. These sources provided a general overview of each jurisdiction's aggregate industry and overall market conditions. Government, agency and industry contacts were established in the selected jurisdictions following the literature review.

2.3 PRELIMINARY JURISDICTIONAL REVIEW

Australia:

Planning and managing aggregate resources is undertaken at the state and local government level and is highly variable based on the availability of the resource. Identifying and protecting aggregate resources is generally not well integrated in the planning framework. Despite this factor, several states (Western Australia, Victoria, New South Wales and Queensland) aim to protect aggregate resources CTM in order to reduce transportation, land development and housing costs (Baker & Hendy, 2005).

Cayman Islands:

The government supports the importation of aggregates due primarily to preserving natural areas for their environmental features and tourism-related functions. The government is proposing to develop an aggregate importation docking facility to handle and distribute the imported aggregate. The key policy objective of this decision is to balance the need for development with the preservation of the natural environment (Central Planning Authority, 2004).

Czech Republic:

The Czech Republic experienced a transition from a centrally planned economy to a market-based economy in the 1990s, which resulted in a reduction in overall aggregate production in terms of overall output. The government provides direction for the extraction of aggregate through *The Raw Material Policy*. This document provides policies for the extraction of raw materials (fuels, mineral ores and aggregates). Neither CTM nor long distance extraction is supported as the policy contemplates both domestic extraction and the importing of aggregates where domestic demand supports the importation (European Environmental Agency, 2008).

Denmark:

Denmark is divided into five regions that provide a policy framework for aggregate extraction. Administration of the *Mining Law* is shared between regional and municipal councils. The Mining Plan in the Capital Region of Copenhagen aims to ensure a long-term supply (12 years) of aggregate is available while also ensuring these resources are used wisely relative to the natural environment. The regional council designates mining and quarrying areas where these uses are specifically permitted. The policies in the Mining Plan do not specifically address CTM extraction or long distance extraction (University of Leoben, 2004)

Italy:

In Italy, regional governments regulate mineral aggregate operations due to a decentralized national government. Italy is one of the leading aggregate producers in Europe (358 million tonnes in 2004). Planning policies vary across the country. Nationally, the approach has been to allow aggregate extraction to grow in response to demand if the impact on natural features is minimized. There were no clear examples of support for CTM or long distance extraction (European Environmental Agency, 2008).

Netherlands:

The Netherlands historically imported large amounts of aggregate from Germany to satisfy domestic demand. Annual demand is approximately 150 million tonnes or eight tonnes per capita. The government recently passed a *National Spatial Strategy* which is the government's framework for land use planning and development including aggregate resource policies. The government recognizes that CTM extraction in the Netherlands reduces transportation costs and energy consumption, which have occurred because of importation. The government is creating conditions that will allow the free market to function optimally in terms of aggregate extraction. This includes the efficient processing of aggregate licence applications (van der Meulen, 2005).

New Zealand:

Planning in New Zealand is conducted at a regional level. The *Auckland Region Policy Statement* provides land use policies for one of New Zealand's largest urban areas (almost one-third of New Zealand's population resides in Auckland Region). The policy states that an increased community importance for the natural environment has removed the availability of aggregate resources close to Auckland. The policy statement supports long distance extraction of aggregate. It is acknowledged that extracting resources from adjacent regions will increase the cost of aggregate (Auckland Regional Council, 1999).

Sweden:

The government established a maximum amount of natural gravel to be extracted by 2010 (12 million tonnes) in an effort to reduce demand. A recent report from the Swedish Environmental Council stated that this extraction limit would not be possible because of recent growth levels and construction in Sweden. An evaluation of government policy and legislation revealed no clear support for CTM or long distance extraction (Swedish Environmental Objectives Council, 2007).

United Kingdom:

The *Minerals Policy Statement 1* is the national aggregate resource policy statement for England. This statement sets out the government's national planning policies for minerals planning and complements other relevant statements of national planning policy. These policies support CTM extraction. The policy directs local authorities to recognize the benefits of resources CTM including the reduction in carbon emissions when compared to long distance truck transportation (Department for Communities and Local Government, 2006).

United States:

Aggregate resources are primarily managed at a local and county level in the United States. The U.S. system is guided by market forces and this causes aggregate producers to locate CTM if such deposits and demand exist. The lack of aggregate resource management policies from a state level can create an inconsistent approach to planning and managing aggregate resources from county to county.

In California, the governing legislation for aggregate extraction (*Surface Mining and Reclamation Act*) aims to ensure that the mineral resource potential of lands are recognized and considered in the planning process. A report from the State Mining and Geology Board (SMGB) stated that in order for aggregate resources to have value, they must be produced CTM. Shorter haul distances associated with CTM extraction results in less fuel consumption, air pollution, traffic congestion, road wear, tire and equipment wear. Local authorities must incorporate the information from the SMGB and California Geological Survey into their general land use plans and ensure there is a 50-year local supply of aggregate resources available (Department of Conservation, 2008).

2.4 JURISDICTIONAL REVIEW – SELECTED EXAMPLES

2.4.1 United Kingdom

The United Kingdom has a population of 60 million and is one of the leading aggregate producers in Europe (275 million tonnes in 2005). Approximately 80% of aggregate is used within 35 to 50 km of the source due to high transportation costs (European Environmental Agency, 2008).

The U.K. has several policy statements in effect that guide and regulates the development of pits and quarries. The *Minerals Policy Statement 1* is the lead planning document for minerals in England. It provides guidance for planning authorities and the industry and ensures that the need and economy for minerals is managed in an integrated way. The *Minerals Policy Statement 1* promotes the extraction of CTM resources:

> *"Take account of the benefit, including the reduction in carbon emissions, which local supplies of minerals would make in reducing the impact of transporting them over long distances by road"* (Minerals Policy Statement 1).

Scotland's government also contemplates and supports the extraction of CTM resources:

> *"Where feasible, new sites should be guided to locations close to markets thereby contributing to reducing energy consumption and pollution"* (Scottish Planning Policy 4: Planning for Minerals).

Primary resources in southeast England, an identified growth area, are diminishing placing an increased importance on resource extraction in areas to the north and marine dredging in the North Sea. The definition of CTM is expanding as those resources closest to areas of growth are depleted. Alternative sources such as marine dredging and mega-quarries are becoming more prevalent as a way to meet the demand of aggregate in southeast England.

2.4.2 Illinois

Illinois has a population of 12.9 million and one of the largest interstate networks in the United States. As a result, demand for aggregate is relatively high. Illinois has extensive deposits located in the northern part of the state where the majority of the population resides (Bhagwat, n.d.).

The extraction and management of aggregate resources is guided at a local level in Illinois. Counties can incorporate aggregate policies in their county plan and regulate the location of pits and quarries in local ordinances (zoning by-laws).

The expansion and development of pits and quarries in the Chicago area has resulted in increased local opposition as aggregate producers locate CTM. Illinois is faced with conflicting interests as other forms of development have encroached and developed on aggregate reserve areas. This has caused some producers to consider underground mining in existing quarries. As of 2008, there were seven underground mines located in the Chicago area (Korose, 2009).

While there is a lack of policy direction regarding CTM extraction, market forces are causing producers to locate CTM where deposits exist and demand is highest.

2.4.3 Sweden

Sweden has a population of 9 million and a similar climate to Ontario (temperate with cold winters). In 2005, 90 million tonnes of aggregate was produced in Sweden. The largest producers of aggregate are located in proximity to large urban areas in southwest and southeast Sweden.

The government imposed a natural gravel tax in 1996 due to environmental concerns and resource scarcity. Production of natural gravel has decreased since 1992. There is limited evidence to show that the gravel tax shifted demand away from natural gravel towards other resources. Instead, the combination of a change in road building material policies, a stricter aggregate permit system and consumer preferences have been cited as influencing the decreased production of natural gravel (European Environmental Agency, 2008).

By imposing a natural gravel tax and cap on total natural gravel production, the government’s aim was to increase the production of recycled materials. Recycled materials accounted for 9% (8 million tonnes) of Sweden’s total aggregate production in 2005.

The Ministry of the Environment discussed implementing a regional natural gravel tax which would be highest in southern Sweden. It was decided that the high economic and environmental costs of transporting aggregate from northern Sweden to the south would outweigh any benefits of imposing regional taxes.

2.4.4 Australia

Australia has a population of 21.2 million and the country produced approximately 110 million tonnes of aggregate in 2001. Australia is made up of six states and two territories. The state and territory governments are responsible for providing policies for aggregate resources while local governments regulate the location of aggregate operations.

Major deposits are located close to large urban market areas. In the states of Western Australia, Victoria, New South Wales and Queensland, one of the major policy objectives is the protection of mineral resources CTM. These states include the major Australian cities of Perth, Melbourne, Canberra, Sydney and Brisbane. In Western Australia, the CTM policy is in effect to help keep the cost of land development and housing low.

Specific CTM extraction policies from the Australian states include:

> *"The location of extractive resources is determined by geological conditions and is finite. They need to be accessed where they naturally occur and also be close to their markets"* (Queensland State Planning Policy 2/07);
>
> *"To identify and protect stone resources accessible to major markets and to provide a consistent planning approval process for extraction in accordance with acceptable environmental standards"* (Victoria State Policy Planning Framework, Clause 17/09); and
>
> *"This plan aims…to facilitate the development of extractive resources in proximity to the population of the Sydney Metropolitan Area by identifying land which contains extractive material of regional significance"* (New South Wales, Sydney Regional Environmental Plan, No. 9 – Extractive Industry No. 2-1995).

In Queensland, protection is also extended to the immediate section of haul road needed to get the aggregate resource from the deposit to a higher-level road.

2.4.5 Cayman Islands

The government policy in the Cayman Islands has been forced to look beyond local sources in favour of importation. The policy is based on a strategy to avoid environmental impacts of local supply, which does exist and can fulfill internal demand for many decades, in favour of preserving future resource areas in their natural condition (Central Planning Authority, 2004).

The decision by the Cayman Islands should be considered a specific action in a jurisdiction that is not comparable to larger landmasses, with more populated and industrialized economies. The Cayman Islands is mostly reliant on its tourism and business services industry and has a relatively low need for aggregates.

The long distance importation policy is from the Central Planning Authority's Aggregate Policy:

> *"Facilitate a long-term aggregate importation strategy.*
>
> *i) Compile a database of quantities and types of aggregate imported, aggregate sources, landed costs, and final disposition of aggregate if possible.*
>
> *ii) Plan for future establishment of aggregate importation docking facility of an appropriate design and location"*
>
> (Cayman Islands Central Planning Authority Aggregate Policy)

2.5 SUMMARY

Section 2 of this Paper examined Ontario and other jurisdictions on their approach to mineral aggregate areas. The purpose of this research was to determine if other developed countries have adopted comparable policy approaches as Ontario. The jurisdictions and policies describe the range of national/state positions on mineral aggregate supply. Policy examples are provided to further describe how the national/state position is implemented.

Several jurisdictions were identified that have CTM policies based on similar rationale as Ontario's approach (Australia, California, Netherlands and the United Kingdom). Historically, the most common factor for incorporating CTM policies was the need to ensure aggregate materials were available as economically as possible to the demand areas. This is because aggregates are a high bulk, low unit cost commodity which is sensitive to transportation costs.

Two jurisdictions, the Cayman Islands and New Zealand, supported long-distance importation of aggregate. It is noted that the Cayman Island's economy and population are not typical of the major aggregate demand jurisdictions. Its economy exists entirely on the business services and tourism sectors, and its policies are developed in this context.

In the remaining researched jurisdictions, general policies that guide the location of aggregate extraction were not evident. In these cases, market forces primarily prevailed. This occurs commonly in the United States, where there is a lack of federal and sometimes state involvement in the extraction of aggregate. Aggregate resources are primarily managed at a county or municipal level, some of which were found to have CTM type policies. Several states utilize long distance importation of aggregate including Texas and Louisiana. In these states, local supply is limited and long distance transportation is necessary (United States Geological Survey, 2009).

In Europe, both CTM and longer-distance multi-modal transportation are prevalent. In countries that do not have CTM policies, alternative sources are utilized including marine dredging (North Sea) or mega-quarries adjacent to water (Scotland, Norway). These sources are served by a dedicated transportation system of cargo ships (Crown Estate, U.K., 2008).

A 2004 study completed by researchers at the University of Leoben in Austria (on behalf of the European Commission) reviewed and evaluated the different approaches to mineral planning policies for countries in the EU. The study stated the importance of land use planning policies and finding a balance between the *"sustainable supply of society with minerals and the social and natural environment"*.[5] The extraction of aggregate is required in economically active and CTM areas. The study recommended to the European Commission that mineral resources be given more attention from a political and legislative view and that the benefit of accessing these resources in areas of high industrial activity needs to be understood (University of Leoben, 2004).

[5] *Minerals Planning Policies and Supply Practices in Europe* (November 2004), Department of Mining and Tunnelling, University of Leoben, Austria

In summary, jurisdictions either have policies requiring CTM aggregate or the jurisdictions do not state a preference and market forces result in operations locating close to urban centres. With the exception of only a few jurisdictions that promote importation of aggregate, jurisdictions only import aggregate when local availability/supply is limited or simply does not exist.

3.0 AGGREGATE AVAILABILITY IN SOUTHERN ONTARIO – PLANNING, ENVIRONMENTAL AND AGRICULTURAL CONSTRAINTS ANALYSIS

3.1 INTRODUCTION

Mineral aggregate deposits are fixed in location and must be extracted where they naturally occur in certain areas of the Province. While some areas have abundant geological deposits of aggregate resources, other areas do not have any. Geologically, the resource is plentiful but there are numerous factors that must be considered in licencing an area for extraction and it is becoming increasingly difficult to locate and acquire good quality aggregate deposits.

Mineral aggregate deposits are generally found in river valleys, outwash plains, limestone plains, eskers, kames and moraines. These landforms also contain other rural resources such as woodlands, wetlands, agriculture and water features.

To determine the extent of overlap of environmental, agricultural and social constraints in relation to selected bedrock resources areas, a Geographic Information System-based (GIS) mapping analysis was completed for all of Southern Ontario. Environmental, agricultural and social constraints were identified based on a review of the Provincial Policy Statement, Niagara Escarpment Plan and the Greenbelt Plan. In total, 20 constraints were identified and applied to the selected bedrock resource areas.

3.2 METHODOLOGY

Consistent with the SAROS terms of reference, a GIS-based mapping analysis was completed for the selected bedrock resources throughout the study area. There are other aggregate resources such as sand and gravel, and shale that were not included in the analysis in accordance with the Terms of Reference. The study area for this analysis includes Study Areas 1 to 6, comprising all of Southern Ontario. The purpose of this analysis was to determine the extent of overlap between environmental, agricultural and social constraints and the selected bedrock resource area.

The selected bedrock resource area mapping used in this analysis was obtained as a consolidated bedrock dataset from the Ministry of Northern Development, Mines and Forestry (MNDMF), which was compiled in 2006 from Aggregate Resource Inventory Paper (ARIP) data.

The bedrock resource base includes all bedrock formations in Areas 1 to 6 that contain appropriate limestone/dolostone bedrock formations suitable for extraction and have less than 8 m of overburden.

Based on a review of the Provincial Policy Statement, Niagara Escarpment Plan, Greenbelt Plan and other relevant factors, 20 constraints were identified[6]. These constraints were applied cumulatively to the selected resource area in the order listed Table 3.1. This order generally reflects a hierarchy starting with the more preclusive constraints based on policy considerations.

Constraint	Data Source
1. Existing Aggregate Licences (resource already extracted; includes all licences e.g. sand and gravel, shale, etc.)	MNR – NRVIS
2. Urban Areas	CANMAP/SOLRIS
3. NEC Natural Area	MMAH
4. NEC Protection Area	MMAH
5. Roadways	MNR – NRVIS
6. Railways	MNR – NRVIS
7. Provincially Significant Wetlands	MNR – NRVIS
8. ANSI Life Science	MNR – NRVIS
9. ANSI Earth Science	MNR – NRVIS
10. Potential Significant Woodlands (Areas 1, 2, 4: 1ha and Areas 3, 5, 6: 4ha)	SOLRIS (Forest, Coniferous, Mixed, Deciduous, Plantations)
11. Greenbelt Alvars	SOLRIS
12. Greenbelt Sand barrens, savannahs and tallgrass prairies	SOLRIS
13. Watercourses	MNR – NRVIS
14. Waterbodies	MNR – NRVIS
15. Wetlands (all wetlands other than PSW's)	SOLRIS (Marsh, Bog, Fen, Swamp)
16. Environmentally Significant Areas	MNR – NRVIS
17. Reserves and Wildlife Areas	MNR – NRVIS
18. Parks and Recreation Areas (e.g. Public Lands, Conservation Areas)	MNR - NRVIS / CANMAP
19. Prime Agricultural Land	Canadian Land Inventory - Land Capability For Agriculture (Class 1, 2 and 3)
20. Fragmented bedrock resource areas less than 60ha	Generated by GIS Constraint Layer Overlay

Table 3.1 - Listing of Planning, Environmental and Agricultural Constraints and Data Sources

The data/mapping was provided by the Province of Ontario and represents the best available mapping. The data sources for the mapping referenced above include:

- MNR-NRVIS (Natural Resources and Values Information System) - MNR's system for managing its corporate geographic databases.

[6] Oak Ridges Moraine Conservation Plan constraints were not identified since the GIS analysis focused on selected bedrock resource areas and the resource is located outside of the ORMCP.

- CANMAP – GIS database containing detailed attribution, digital street map data for display, analysis and location based applications.
- SOLRIS (Southern Ontario Land Resource Information System) is a regional, ecologically based, land cover / land use inventory.

This analysis is solely for the purpose of determining the extent of overlap between environmental, agricultural and social constraints and the bedrock resource area based on a desktop mapping analysis. Some of the constraints applied are not intended to represent constraints that would preclude access to the resource but instead are factors that have to be considered in assessing the availability of the resource. This analysis should also not be used to conclude that specific areas are available for extraction or as a basis for calculating potential aggregate reserves. Numerous other factors need to be considered to assess the availability of the resource. These factors are further discussed in Section 3.5.

3.2.1 Applicability to Sand & Gravel Resources

The GIS model built to analyze the selected bedrock resource area and overlapping constraints could be applied to the sand & gravel resource base if the Province required this in the future but was not part of the mandate of this Paper at this time.

3.3 OTHER FACTORS TO ASSESS AGGREGATE RESOURCE AVAILABILITY

In addition to the constraints identified in Section 3.2 there are numerous other factors listed below that need to be considered to assess the availability of the resource based on site-specific studies. These constraints have not been added to GIS mapping analysis since the mapping layers are not available and/or a site specific study is required to determine the extent of the constraint.

- *Other Environmental Features* – Numerous data layers were not available for use in this analysis, including: endangered and threatened species habitat, significant valleylands, significant wildlife habitat, significant cultural heritage resources, Greenbelt Area – Special Concern Species, Greenbelt Plan Area Seepage Areas and Springs. In addition, site-specific studies also typically identify additional environmental features that would not be captured by this study as they have not been previously mapped.
- *New Conservation Authority Mapping* – As part of Ontario Regulation 97/04, local conservation authorities are preparing updated wetland and watercourse mapping. This mapping has identified additional environmental features within the study area. This updated mapping was not available for use in this analysis.
- *Other Environmental Legislation* – Other pieces of environmental legislation must be also considered, such as the *Endangered Species Act*, *Migratory Birds Convention Act*, *Environmental Protection Act*, and *Fisheries Act*.
- *Water Resources Studies* – Site specific studies need to analyze potential impacts from groundwater drawdown, changes in baseflow, changes to surface water drainage patterns,

karst topography, proximity of water dependent environmental features, municipal wells (e.g. source water protection) and residential wells.

- *Protection of Adjacent Environmental Features* – The mapping analysis identifies that there are numerous environmental features overlapping the selected bedrock resource area and / or directly adjacent to the unconstrained areas. Environmental studies are required to identify which environmental features warrant protection and the setbacks required to protect these features. A single feature can have a significant impact on the availability of the resource area if the feature must be protected.

  Figure 3.1 illustrates an example of the potential impact that an environmental feature could have on the availability of an aggregate area. This figure represents a 60 ha agricultural site containing two small wetlands that total 1.0 ha and an adjacent Provincially Significant Wetland. In this scenario, site specific studies would need to be completed that consider the ecological features and functions of the wetlands, impacts based on groundwater drawdown, the loss of surface water catchment areas and the proximity/relationship to the Provincially Significant Wetland (e.g. complexing).

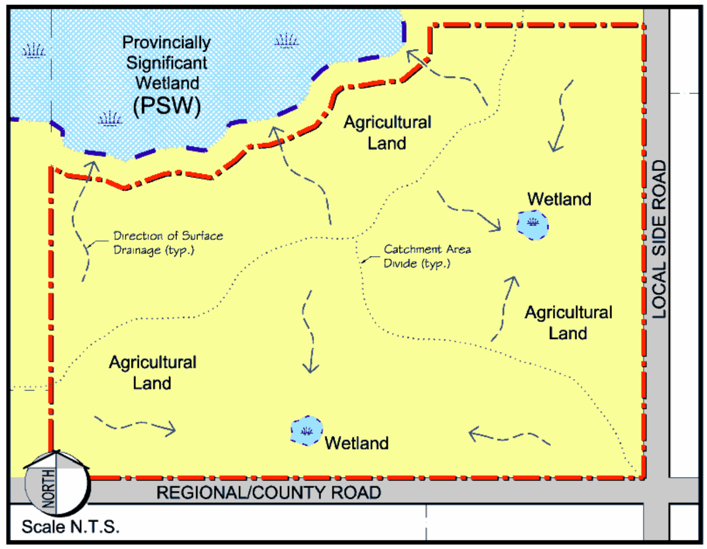


Figure 3.1 - Wetland Complexing on Agricultural Land

  All of these factors would need to be considered to determine if the two on-site wetlands contain significant ecological functions to warrant protection, and establish any necessary setbacks. A small environmental feature has the potential to sterilize access to a 60 ha resource area.

- *Previously Extracted Areas* – Areas that were previously extracted and no longer licenced under the *Aggregate Resources Act* were not identified in the mapping analysis.

- *Land Assembly and Proximity to Surrounding Residences* – Land assembly is a significant constraint affecting aggregate availability. Lot fragmentation and rural subdivisions have eliminated a number of potential resource areas. Typically, a number of parcels are required to assemble an economically viable extraction area with appropriate buffers to protect surrounding land uses;

- *Up-to-date Urban/Settlement Area Boundaries* – This analysis used CANMAP/SOLRIS data that was the most up-to-data layer made available. It is recognized that this data layer is outdated in some areas and does not include all urban areas and settlements.

- *Air, Noise and Blasting Guidelines* – As noted above, residential uses are commonly located within the area of influence of a quarry (500 m). A quarry must be operated in accordance with Ministry of the Environment guidelines for air quality, noise and blasting. These studies identify the required setbacks and operational controls to ensure these guidelines are met for adjacent receptors.

- *Residential Wells* - As noted above, residential uses are commonly located within the area of influence of a quarry (500 m). Studies are required to assess the ability of the operation to protect or restore an agricultural or residential water supply. These studies may identify the requirement for additional setbacks.

- *Cultural Heritage Resources* – Site-specific studies would need to be completed to identify archaeological, built heritage resources and cultural heritage landscapes. These studies may identify the requirement for additional setbacks.

- *Traffic Considerations* – Site-specific studies are required to assess the suitability of the road network to accommodate highway trucks to transport the product from the site to market.

- *Aggregate Resources Act Prescribed Setbacks* – The *Aggregate Resources Act* requires 15 m setbacks from property lines and 30 m setbacks from all roadways, residential properties and bodies of water.

- *Resource Quality/Quantity* – Site-specific study to assess the resource quality and quantity is required.

- *Other Potential Resources* – Site-specific studies assess the overburden and resource thickness of a particular area and base the economic viability of removing the resource in terms of extraction ratio. As such, areas with greater than 8m of overburden, outside that which has been highlighted by ARIP as primary resource deposits, may be considered.

Overall, there are numerous other factors that need to be considered when assembling and making available aggregate resource areas.

3.4 PLANNING, ENVIRONMENTAL AND AGRICULTURAL CONSTRAINTS ANALYSIS RESULTS

The planning, environmental and agricultural constraint analysis was completed for all of Southern Ontario, from Windsor to the southwest, Huntsville to the north and Ottawa to the east. The purpose of the analysis was to determine the extent of overlap of environmental, agricultural and social constraints in relation to selected bedrock resource areas.

The study area contains 786,825 ha of selected bedrock resource area throughout Southern Ontario (Areas 1 to 6). See Figure 3.2.

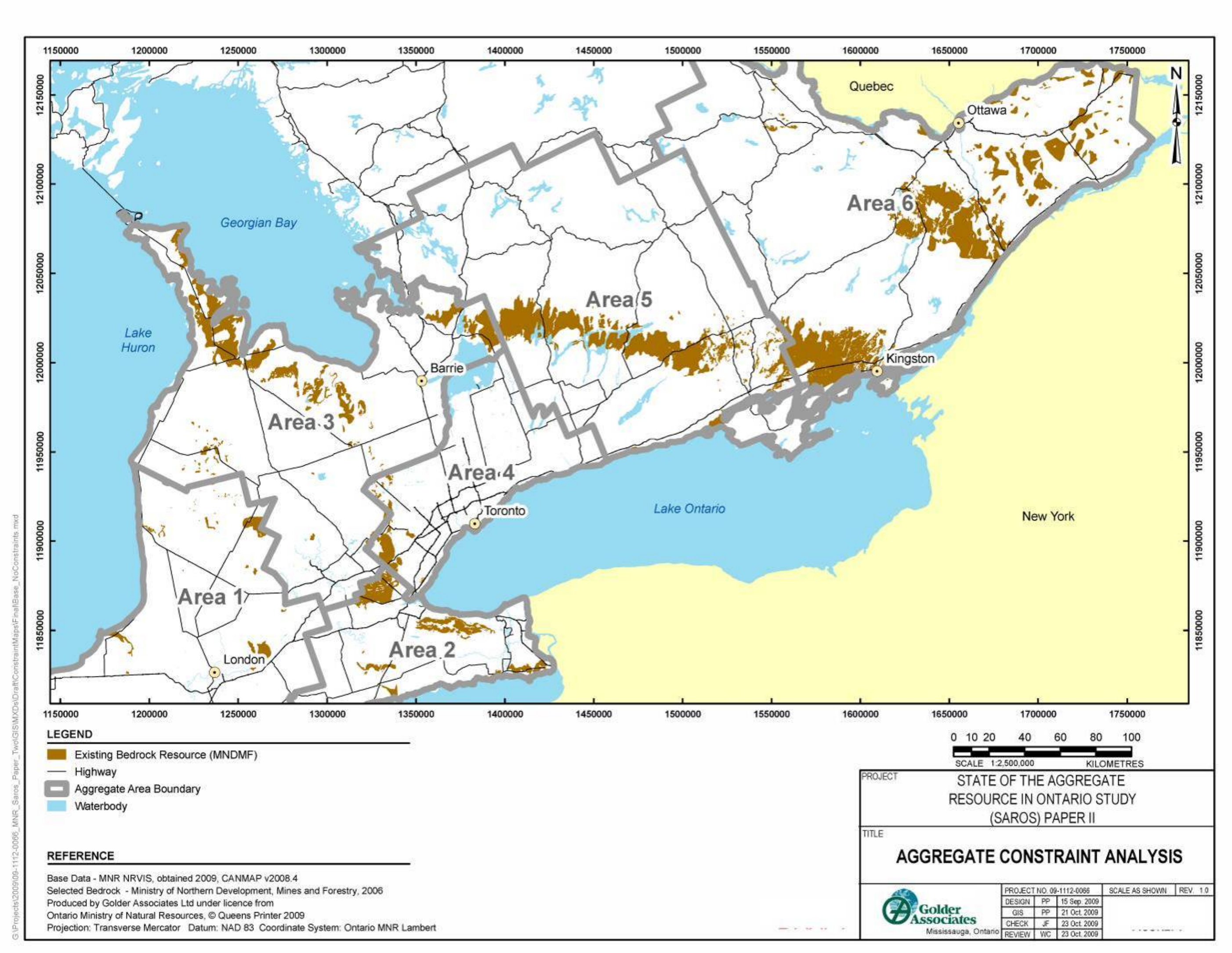


Figure 3.2 - Selected Bedrock Resource Areas in Southern Ontario

In total, 20 constraints were applied to the selected bedrock resource area mapping and 729,022 ha or 93% of the aggregate resource had overlapping constraints. See Table 3.2 and Figure 3.3.

Table 3.2 - Overall Selected Bedrock Deposits: Areas 1 to 6 – Southern Ontario

Constraint	Total Area (ha)	Area of constraint located within Remaining Bedrock Deposits (ha)*	Remaining Selected Bedrock Resource (ha)
Unconstrained Selected Bedrock Deposits	N/A	N/A	786,825
Existing Aggregate Licences (includes all licences e.g. sand and gravel, shale, etc.)	59,824	13,927	772,898
Urban Areas	426,113	14,090	758,808
NEC Natural Area	45,930	14,867	743,942
NEC Protection Area	67,436	15,557	728,385
Roadways	337,515	20,369	708,016
Railways	19,111	1,070	706,946
Provincially Significant Wetlands	434,150	53,883	653,063
ANSI Life Science	406,469	20,526	632,539
ANSI Earth Science	99,386	3,249	629,290
Potential Significant Woodlands (Areas 1, 2, 4: >1ha and Areas 3, 5, 6: >4ha)	1,461,725	131,017	498,273
Greenbelt Alvars	48	12	498,261
Greenbelt Sand Barrens, Savannahs and Tallgrass Prairies	179	0	498,261
Watercourses	8,718 (139,363 km)	1,078 (5,256 km)	497,183
Waterbodies	597,974	5,499	491,684
Wetlands (all wetlands other than PSW's)	1,714,807	106,791	384,893
Environmentally Significant Areas	155,977	1,074	383,819
Reserves and Wildlife Areas	120,494	3	383,816
Parks and Recreation Areas (e.g. Public Lands, Conservation Areas)	344,705	2,168	381,648
Prime Agricultural Land	5,292,806	214,183	167,465
Fragmented Resource Areas less than 60 ha	N/A	109,662	57,803
REMAINING BEDROCK RESOURCE AREA (HA)			**57,803**

*cumulative total taking into account combined constraints without double-counting

A copy of the individual constraints mapping is included in Appendix B.

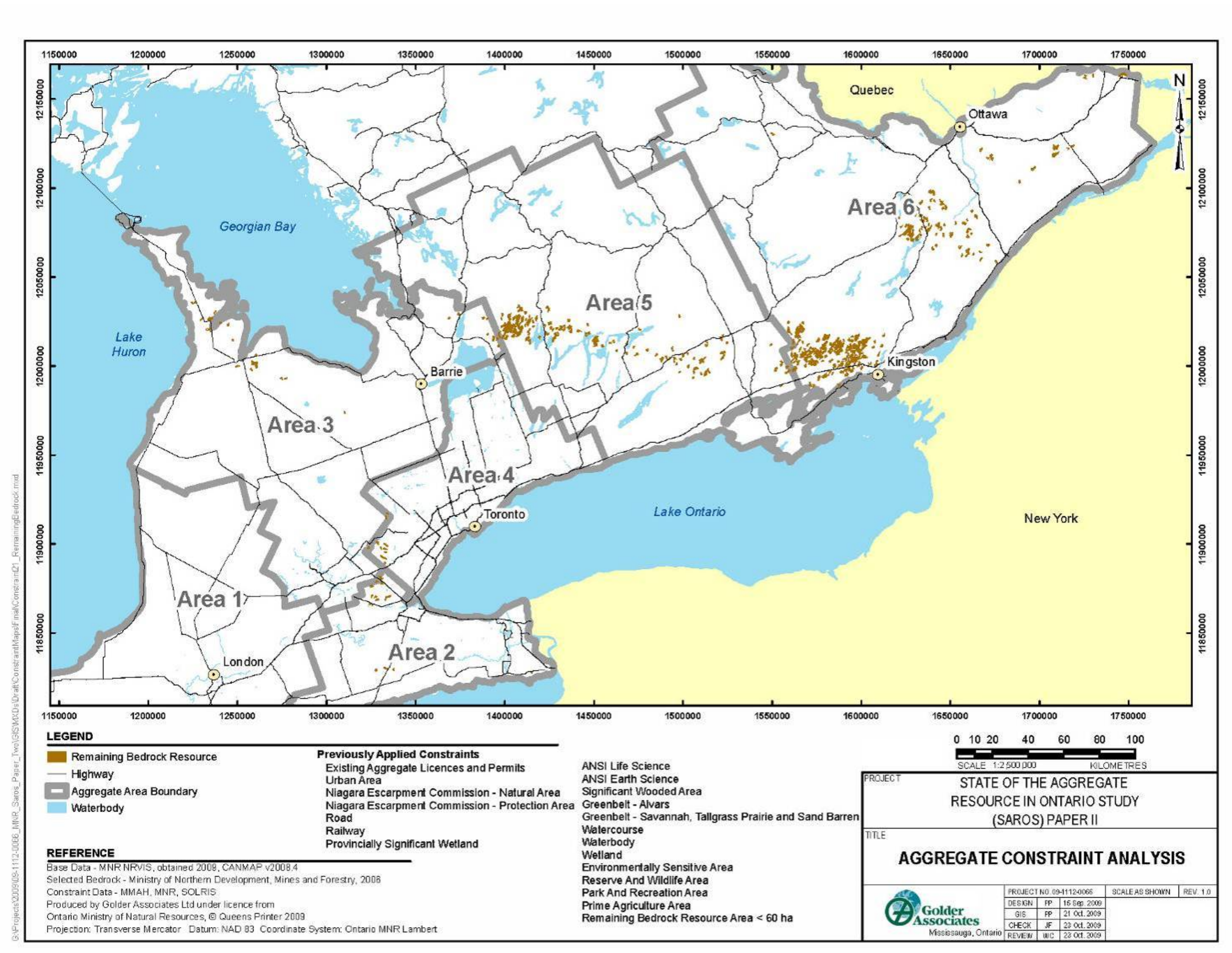


Figure 3.3 - Unconstrained Bedrock Resource Areas in Southern Ontario

The remaining unconstrained selected bedrock areas are not evenly distributed across Southern Ontario. Table 3.3 presents a breakdown of the distribution of the unconstrained bedrock resources by Study Area.

Area	Proportion of Unconstrained Bedrock Resources in Southern Ontario
Area 1, Southwest	0%
Area 2, Peninsula	2%
Area 3, West Central	6%
Area 4, Greater Toronto Area	1%
Area 5, East Central	30%
Area 6, East	61%

Table 3.3 - Proportion of Unconstrained Bedrock Resources by Area (does not add up to 100% due to rounding)

As noted above and illustrated on Figure 3.3, the majority of the unconstrained bedrock resources (91%) are generally located in Area 5 and 6. Area 5 extends from the eastern shore of Lake Simcoe east to Belleville, and Area 6 is generally located from Belleville east to Pembrooke, Ottawa and Cornwall.

This analysis is solely for the purpose of determining the extent of overlap between environmental, agricultural and social constraints and the bedrock resource area based on a desktop mapping analysis. Some of the constraints applied are not intended to represent constraints that would preclude access to the resource but instead are factors that have to be considered in assessing the availability of the resource. This analysis should also not be used to conclude that specific areas are available for extraction or as a basis for calculating potential aggregate reserves. There are numerous other factors that need to be considered to assess the availability of the resource based on site-specific studies (described in detail in Section 3.3):

- Other Environmental Features;
- Water Resources Studies;
- Protection of Adjacent Environmental Features;
- Land Assembly and Proximity to Surrounding Residences;
- Air, Noise and Blasting Guidelines;
- Protection of Residential Wells;
- Cultural Heritage Resources;
- Haul Route Availability and Traffic Considerations;
- *Aggregate Resources Act* Prescribed Setbacks; and
- Resource Quality/Quantity.

Based on this analysis it is evident that there is a high degree of overlap between environmental, agricultural and social considerations and the bedrock resource area (93% constrained) and there are numerous other factors that still need to be considered. These factors, combined with land fragmentation, are making it increasingly difficult and costly to licence new bedrock reserves.

The following sections summarize the results of the constraint analysis by geographic area.

3.4.1 Area 1 – Southwest

Area 1 includes Southwestern Ontario, generally from Windsor in the southwest, east to Woodstock and north to the northern boundary of Huron County. Area 1 contains approximately 23,780 ha of bedrock resource. After applying the 20 constraints, no resource remained. **This results in 100% of the bedrock resource base being constrained**.

Table 3.4 - Selected Bedrock Deposits: Area 1 – Southwest

Constraint	Total Area (ha)	Area of constraint located within Remaining Bedrock Deposits (ha)*	Remaining Selected Bedrock Resource (ha)
Unconstrained Selected Bedrock Deposits	N/A	N/A	23,780
Existing Aggregate Licences (includes all licences e.g. sand and gravel, shale, etc.)	14,138	1,442	22,338
Urban Areas	72,341	1,076	21,262
NEC Natural Area	0	0	21,262
NEC Protection Area	0	0	21,262
Roadways	62,152	672	20,590
Railways	4,490	66	20,524
Provincially Significant Wetlands	30,641	299	20,225
ANSI Life Science	24,040	2,076	18,149
ANSI Earth Science	19,002	64	18,085
Potential Significant Woodlands (>1 ha)	122,776	1,387	16,698
Greenbelt Alvars	0	0	16,698
Greenbelt Sand Barrens, Savannahs and Tallgrass Prairies	0	0	16,698
Watercourses	491 (24,178 km)	16 (173 km)	16,682
Waterbodies	21,108	175	16,507
Wetlands (all wetlands other than PSW's)	123,408	1,009	15,498
Environmentally Significant Areas	0	0	15,498
Reserves and Wildlife Areas	350	0	15,498
Parks and Recreation Areas (e.g. Public Lands, Conservation Areas)	10,442	44	15,454
Prime Agricultural Land	1,787,478	14,196	1,258
Fragmented Resource Areas less than 60 ha	N/A	1,258	0
REMAINING BEDROCK RESOURCE AREA (HA)			**0**

*cumulative total taking into account combined constraints without double-counting

3.4.2 Area 2 – Peninsula

Area 2 generally encompasses the Niagara Peninsula and Hamilton area, south to Lake Erie and west to Long Point. Area 2 contains approximately 59,732 ha of bedrock resource. After applying the 20 constraints, approximately 58,344 ha of the resource had overlapping constraints. **This results in approximately 98% of the bedrock resource base being constrained**.

Table 3.5 - Selected Bedrock Deposits: Area 2 – Peninsula

Constraint	Total Area (ha)	Area of constraint located within Remaining Bedrock Deposits (ha)*	Remaining Selected Bedrock Resource (ha)
Unconstrained Selected Bedrock Deposits	N/A	N/A	59,732
Existing Aggregate Licences (includes all licences e.g. sand and gravel, shale, etc.)	4,640	1,136	58,596
Urban Areas	57,120	2,010	56,586
NEC Natural Area	6,499	545	56,041
NEC Protection Area	9,738	1,270	54,771
Roadways	30,730	1,809	52,962
Railways	2,677	68	52,894
Provincially Significant Wetlands	42,483	6,557	46,337
ANSI Life Science	22,717	492	45,845
ANSI Earth Science	3,382	354	45,491
Potential Significant Woodlands (>1ha)	67,049	3,159	42,332
Greenbelt Alvars	0	0	42,332
Greenbelt Sand Barrens, Savannahs and Tallgrass Prairies	0	0	42,332
Watercourses	910 (10,333 km)	43 (500 km)	42,289
Waterbodies	21,688	153	42,136
Wetlands (all wetlands other than PSW's)	76,526	2,968	39,168
Environmentally Significant Areas	159	0	39,168
Reserves and Wildlife Areas	4,996	0	39,168
Parks and Recreation Areas (e.g. Public Lands, Conservation Areas)	6,813	318	38,850
Prime Agricultural Land	535,732	29,885	8,965
Fragmented Resource Areas less than 60 ha	N/A	7,577	1,388
REMAINING BEDROCK RESOURCE AREA (HA)			**1,388**

***cumulative total taking into account combined constraints without double-counting**

3.4.3 Area 3 – West Central

Area 3 includes the west-central area of Southern Ontario, generally from the Kitchener / Waterloo area, north to Georgian Bay, including the Bruce Peninsula, east to the eastern boundary of Simcoe County. Area 3 contains approximately 152,167 ha of bedrock resource. After applying the 20 constraints, approximately 148,959 ha of the resource had overlapping constraints. **This results in approximately 98% of the bedrock resource base being constrained**.

Table 3.6 - Selected Bedrock Deposits: Area 3 – West Central			
Constraint	**Total Area (ha)**	**Area of constraint located within Remaining Bedrock Deposits (ha)***	**Remaining Selected Bedrock Resource (ha)**
Unconstrained Selected Bedrock Deposits	N/A	N/A	152,167
Existing Aggregate Licences (includes all licences e.g. sand and gravel, shale, etc.)	13,734	2,908	149,259
Urban Areas	59,799	850	148,409
NEC Natural Area	29,761	10,673	137,736
NEC Protection Area	46,455	12,500	125,236
Roadways	54,610	2,940	122,296
Railways	2,926	179	122,117
Provincially Significant Wetlands	117,984	13,688	108,429
ANSI Life Science	115,866	4,050	104,379
ANSI Earth Science	41,993	544	103,835
Potential Significant Woodlands (>4ha)	320,058	29,074	74,761
Greenbelt Alvars	48	12	74,749
Greenbelt Sand Barrens, Savannahs and Tallgrass Prairies	0	0	74,749
Watercourses	2,024 (23,269 km)	65 (773 km)	74,684
Waterbodies	75,291	544	74,140
Wetlands (all wetlands other than PSW's)	280,897	11,313	62,827
Environmentally Significant Areas	1,700	34	62,793
Reserves and Wildlife Areas	82	0	62,793
Parks and Recreation Areas (e.g. Public Lands, Conservation Areas)	55,638	336	62,457
Prime Agricultural Land	1,191,229	45,445	17,012
Fragmented Resource Areas less than 60 ha	N/A	13,804	3,208
REMAINING BEDROCK RESOURCE AREA (HA)			**3,208**

***cumulative total taking into account combined constraints without double-counting**

3.4.4 Area 4 – Greater Toronto Area

Area 4 includes the Greater Toronto Area, generally extending from Burlington in the west, to Lake Simcoe to the north, and Durham Region to the east. Area 4 contains approximately 24,438 ha of bedrock resource. After applying the 20 constraints, approximately 23,643 ha of the resource had overlapping constraints. **This results in approximately 97% of the bedrock resource base being constrained**.

Table 3.7 - Selected Bedrock Deposits: Area 4 – Greater Toronto Area

Constraint	Total Area (ha)	Area of constraint located within Remaining Bedrock Deposits (ha)*	Remaining Selected Bedrock Resource (ha)
Unconstrained Selected Bedrock Deposits	N/A	N/A	24,438
Existing Aggregate Licences (includes all licences e.g. sand and gravel, shale, etc.)	10,634	1,189	23,249
Urban Areas	161,646	563	22,686
NEC Natural Area	9,669	3,649	19,037
NEC Protection Area	11,243	1,787	17,250
Roadways	60,273	580	16,670
Railways	2,702	45	16,625
Provincially Significant Wetlands	34,081	2,055	14,570
ANSI Life Science	48,312	621	13,949
ANSI Earth Science	12,852	164	13,785
Potential Significant Woodlands (>1ha)	99,064	3,178	10,607
Greenbelt Alvars	0	0	10,607
Greenbelt Sand Barrens, Savannahs and Tallgrass Prairies	71	0	10,607
Watercourses	845 (9,696 km)	9 (104 km)	10,598
Waterbodies	64,422	32	10,566
Wetlands (all wetlands other than PSW's)	70,548	1524	9,042
Environmentally Significant Areas	73,942	391	8,651
Reserves and Wildlife Areas	0	0	8,651
Parks and Recreation Areas (e.g. Public Lands, Conservation Areas)	41,710	160	8,491
Prime Agricultural Land	480,896	4,591	3,900
Fragmented Resource Areas less than 60 ha	N/A	3,105	795
REMAINING BEDROCK RESOURCE AREA (HA)			**795**

*****cumulative total taking into account combined constraints without double-counting

3.4.5 Area 5 – East Central

Area 5 includes east-central area of Southern Ontario, generally from Simcoe County and Georgian Bay in the west, north to Huntsville and east to Belleville. Area 5 contains approximately 190,710 ha of bedrock resource. After applying the 20 constraints, approximately 173,503 ha of the resource had overlapping constraints. **This results in approximately 91% of the bedrock resource base being constrained**.

Table 3.8 - Selected Bedrock Deposits: Area 5 – East Central

Constraint	Total Area (ha)	Area of constraint located within Remaining Bedrock Deposits (ha)*	Remaining Selected Bedrock Resource (ha)
Unconstrained Selected Bedrock Deposits	N/A	N/A	190,710
Existing Aggregate Licences (includes all licences e.g. sand and gravel, shale, etc.)	9,860	3,029	187,681
Urban Areas	22,226	1,507	186,174
NEC Natural Area	0	0	186,174
NEC Protection Area	0	0	186,174
Roadways	54,950	4,884	181,290
Railways	2,397	236	181,054
Provincially Significant Wetlands	82,526	11,804	169,250
ANSI Life Science	72,557	5,465	163,785
ANSI Earth Science	16,290	1,791	161,994
Potential Significant Woodlands (>4ha)	298,414	40,673	121,321
Greenbelt Alvars	0	0	121,321
Greenbelt Sand Barrens, Savannahs and Tallgrass Prairies	108	0	121,321
Watercourses	910 (30,779 km)	270 (1,061 km)	121,051
Waterbodies	238,091	3224	117,827
Wetlands (all wetlands other than PSW's)	858,804	44,600	73,227
Environmentally Significant Areas	80,176	649	72,578
Reserves and Wildlife Areas	75,877	0	72,578
Parks and Recreation Areas (e.g. Public Lands, Conservation Areas)	188,062	782	71,796
Prime Agricultural Land	442.215	23,235	48,561
Fragmented Resource Areas less than 60 ha	N/A	31,354	17,207
REMAINING BEDROCK RESOURCE AREA (HA)			**17,207**

*****cumulative total taking into account combined constraints without double-counting

3.4.6 Area 6 – East

Area 1 includes Eastern Ontario, generally from Belleville in the west, east to the Quebec border and north to Pembroke. Area 6 contains approximately 335,998 ha of bedrock resource. After applying the 20 constraints, approximately 300,793 ha of the resource had overlapping constraints. **This results in approximately 90% of the bedrock resource base being constrained**.

Table 3.9 - Selected Bedrock Deposits: Area 6 – East

Constraint	Total Area (ha)	Area of constraint located within Remaining Bedrock Deposits (ha)*	Remaining Selected Bedrock Resource (ha)
Unconstrained Selected Bedrock Deposits	N/A	N/A	335,998
Existing Aggregate Licences (includes all licences e.g. sand and gravel, shale, etc.)	6,818	4,223	331,775
Urban Areas	52,980	8,083	323,692
NEC Natural Area	0	0	323,692
NEC Protection Area	0	0	323,692
Roadways	74,799	9,484	314,208
Railways	3,920	476	313,732
Provincially Significant Wetlands	126,436	19,480	294,252
ANSI Life Science	122,978	7820	286,432
ANSI Earth Science	5869	332	286,100
Potential Significant Woodlands (>4ha)	554,364	53,546	232,554
Greenbelt Alvars	0	0	232,554
Greenbelt Sand Barrens, Savannahs and Tallgrass Prairies	0	0	232,554
Watercourses	3,539 (41,108 km)	675 (2,645 km)	231,879
Waterbodies	177,374	1370	230,509
Wetlands (all wetlands other than PSW's)	304,624	45,377	185,132
Environmentally Significant Areas	0	0	185,132
Reserves and Wildlife Areas	39,189	3	185,129
Parks and Recreation Areas (e.g. Public Lands, Conservation Areas)	42,041	529	184,600
Prime Agricultural Land	855,256	96,831	87,769
Fragmented Resource Areas less than 60 ha	N/A	52,564	35,205
REMAINING BEDROCK RESOURCE AREA (HA)			**35,205**

*****cumulative total taking into account combined constraints without double-counting

3.5 OVERVIEW OF SOUTHERN ONTARIO RURAL RESOURCES AND THE SELECTED BEDROCK RESOURCE AREAS

Table 3.10 includes a summary of all rural resources in Southern Ontario. The chart identifies the total size of the rural resource, the extent of the features overlap with the selected bedrock resource area and how much of the rural resource is located outside of the selected resource area. Figure 3.4 proportionally shows the size of the total selected bedrock area (white circle) and the cumulative layers of contraints that overlap the bedrock resource area. As a result there is only a limited area of unconstrained bedrock resources (gray circle) and numerous other factors still have to be considered.

Table 3.10 Overview of Southern Ontario Rural Resources

Overview of Southern Ontario Rural Resources and the Selected Bedrock Resource Area					
Rural Resources	Total Area of Feature (ha)	Overlap of Feature with Selected Bedrock Area (ha) / % of Total Area		Area of Feature Located Outside Selected Bedrock Area (ha) / % of Total Area	
Provincially Significant Wetlands (PSW)	434,150	53,883	**12%**	380,267	**88%**
Area of Natural and Scientific Interest (ANSI - Life/Earth)	505,855	23,774	**5%**	482,081	**95%**
Potential Significant Woodlands	1,461,725	132,017	**9%**	1,331,708	**91%**
Greenbelt Alvars, Sand Barrens, Savannahs and Tall Grass Prairies	227	12	**5%**	215	**95%**
Watercourses	8,718	1,080	**12%**	7,638	**88%**
Waterbodies	597,974	5,449	**1%**	592,475	**99%**
Wetlands	1,714,807	106,791	**6%**	1,608,036	**94%**
Environmentally Significant Areas	155,977	1,074	**1%**	154,903	**99%**
Parks/Wildlife Reserves	465,199	2,171	**1%**	463,028	**99%**
Prime Agricultural Land	5,292,803	214,183	**4%**	5,078,620	**96%**

*cumulative total taking into account combined constraints without double-counting

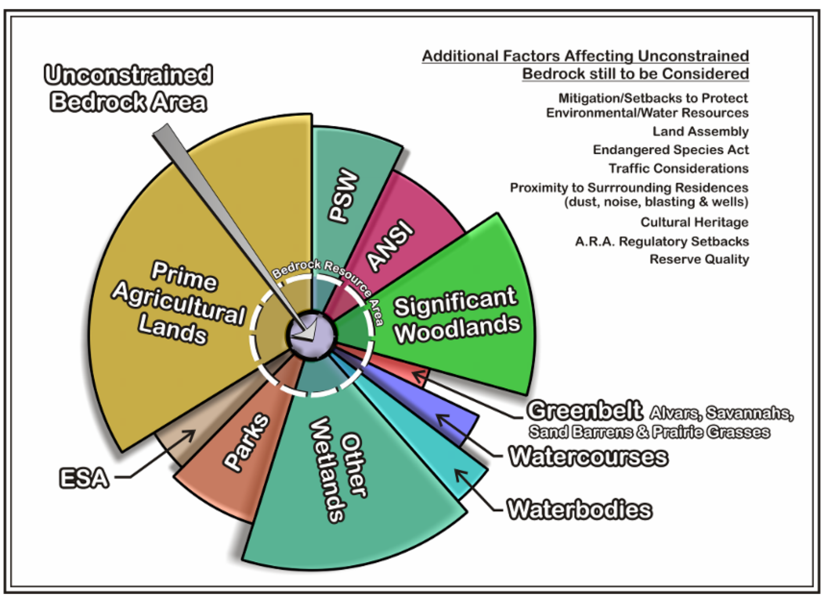


Figure 3.4 - Proportional Comparison of Total Rural Resource Areas and Bedrock Resource Areas

As illustrated in Table 3.10 and Figure 3.4, there is a high degree of overlap between planning, environmental and agricultural considerations. It is for this reason that the Province supports an integrated resource management approach:

The Provincial Policy Statement:

> *"The Provincial Policy Statement supports a comprehensive, integrated and long-term approach to planning, and recongizes linkages among policy areas"* (Part III).

The Growth Plan for the Greater Golden Horseshoe:

> *"A balanced approach to the wise use and management of all resources, including natural heritage, agriculture, and mineral aggregates, will be implemented"* (Part 4, Protecting What is Valuable).

The Ministry of Natural Resources Statement of Environment Values:

> *"An ecosystem approach to managing our natural resources enables a holistic perspective of social, economic and ecological aspects and provides the context for integrates resource management".*

Without an integrated and balanced approach it is unlikely that an aggregate deposit could be assembled and made available as there is a high probability of on-site and adjacent evironmental, agricultural and water resources to consider.

When considering policy approaches for mineral aggregates, key factors include:

- Mineral aggregates are an appropriate rural resource as stated in the Provincial Policy Statement.
- Mineral aggregate deposits are fixed in location and must be extracted where they naturally occur.
- Mineral aggregate deposits by their very nature, are found in geological features such as rivervalleys, outwash plains, limestone plains, eskers, kame and moraines. These landforms also contain wetlands, woodlands, agriculture and water features.
- Aggregate, similar to agriculture and forestry, is an essential commodity for our economic, social and environmental well-being.
- Aggregate operations are a space intensive use and due to their nature, remove surface features.
- Based on the constraint analysis, the majority of features are located outside of the selected bedrock resource area. For example: 95% of ANSI, 91% of significant woodlands, 93% of all wetlands and 96% of prime agricultural lands in Southern Ontario are located outside of selected bedrock resource areas.

- Aggregate extraction is distinct from other types of land uses. It is a temporary resource use; rehabilitation is a legislated requirement and rehabilitation can restore and/or enhance environmental and agricultural resources.

3.6 COMPARISON WITH "AGGREGATE RESOURCES OF SOUTHERN ONTARIO, A STATE OF THE RESOURCE STUDY" (1992)

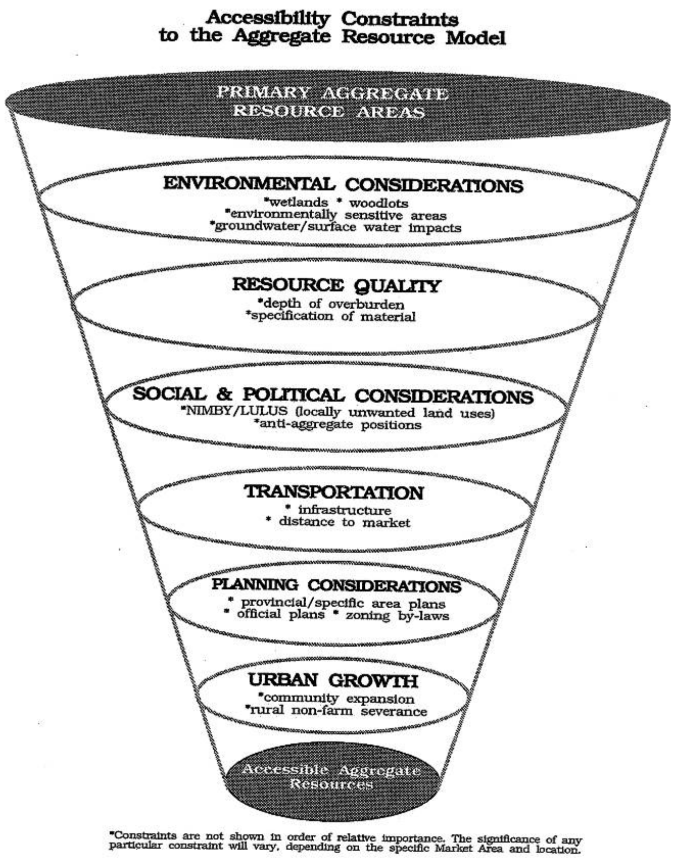


Figure 3.5 - Accessibility Constraints to the Aggregate Resource Model

The last Provincial aggregate study, entitled "Aggregate Resources of Southern Ontario, A State of the Resource Study" was completed in 1992. A portion of the study includes an examination of the environmental and planning issues related to aggregate resources.

Although the 1992 study did not include a detailed constraint analysis, a high-level overview of the environmental, social, and policy-based constraints was provided. The 1992 Study presented in concept some of the factors affecting aggregate availability and illustrated these constraints in a diagram (Figure 3.5).

The 1992 study identified the economic implications of a constrained resource, stating that because locating accessible resources is uncertain and costly due to the difficulties in obtaining approvals, the cost of licencing and increased transportation costs "*will make it more difficult for the industry to maintain an adequate supply at competitive prices for the consumers of Ontario*".

Although the 1992 and current analysis differ in their methodology, they both come to the same general conclusion that extractable resource areas are becoming increasingly challenging to locate and make available due to logistical, environmental, social and policy-based constraints.

3.7 SUMMARY

Section 3 of this Paper examined the planning, agricultural and environmental constraints that affect aggregate availability. Based on this analysis it was concluded that:

- Mineral aggregate deposits are fixed in location and must be extracted where they naturally occur.
- Mineral aggregate deposits by their very nature, are found in rivervalleys, outwash plains, limestone plains, eskers, kame and moraines. These landforms contain wetlands, woodlands, agriculture and water features.
- Based on a desk top mapping exercise, 20 constraints were applied and 93 % of the selected bedrock area has overlapping constraints. Of the remaining 7% that did not have overlapping constraints, 91% of this area is located within Study Areas 5 and 6 (Eastern Ontario).
- In addition to the 20 constraints that were applied there are numerous other factors that have to be considered in determining whether the deposit area can be assembled and made available to supply mineral aggregate needs.
- Aggregate operations are a space intensive use and due to the extent of overlap of competing uses the majority, if not all sites will have competing land uses on or adjacent to the aggregate deposit.
- Without an integrated and balanced approach it is unlikely that an aggregate deposit could be assembled and made available since there is a high probability of on-site and adjacent evironmental, agricultural and water resources to consider.
- Based on the constraint analysis, the majority of other features are located outside of the selected bedrock resource area. For example: 95% of ANSI, 91% of significant woodlands, 93% of all wetlands and 96% of prime agricultural lands are located outside of selected bedrock resource areas.

4.0 FEASIBILITY OF ALTERNATIVE SOURCES OF AGGREGATE

4.1 OVERVIEW

Paper 2 requires the consideration of alternative sources of aggregate, to meet Ontario's long-term availability and supply objectives.

The five alternative sources examined are:

- use of mine tailings;
- sand production from lake dredging;
- crushed stone supply from underground limestone mining;
- crushed stone supply from a mega-quarry; and
- use of manufactured sand.

Alternative sources of aggregate have been discussed for over 30 years in Ontario, and several reports have been commissioned by the Province to review this issue. It is also a common area of enquiry in aggregate resource management studies in other countries. Section 4.2 of this Paper reviews past studies which have assessed alternative sources of aggregate, and presents the conclusions of each. It also reports on historic and current practices, and operational considerations concerning the alternative option.

Section 4.3 of this Paper assesses the feasibility of each alternative source based on the literature review and information available. Underground mining and mega-quarries were found to have the strongest feasibility. Aggregates derived from these sources would be a viable solution and could provide for partial replacement of bedrock-derived aggregates (crushed stone) from traditional CTM quarry sources. The need for surface pit and quarry sites would still remain.

Section 4.4 of this Paper compares the current CTM quarry supply, with underground mining and mega-quarries. The comparison will evaluate the economic, environmental and social considerations of the existing and potential supply scenarios.

4.2 LITERATURE REVIEW, PRACTICES AND CONSIDERATIONS

Several government commissioned publications dealing with alternative supply options have been reviewed, relevant to both Ontario and other jurisdictions. The Ontario reports deal primarily with underground mining and dredging. Key excerpts taken from these reports and additional discussion are summarized in the following sections.

4.2.1 Underground Mining

Interest in underground mining of limestone aggregates is not a new idea in Ontario. In 1976, the Mineral Aggregates Working Party recommended that the Ontario government consider underground mining in Metro Toronto, Peel, York and the Niagara Escarpment. While additional investigations to assess the potential feasibility of underground mining have occurred since that time, no underground limestone mining operations have been developed in Ontario.

Underground mines have produced aggregates since the late 1890's in the United Sates, with the first underground mining recorded in Kansas City (Bernardos, A.G., Kaliampakos, D.C., et al, 2001). In 2007, there were 86 active underground mines in the US, and they produced 68.6 million tonnes of crushed stone. Active underground mines were located in 18 States. The five leading States were, in descending order of tonnage, Kentucky, Missouri, Illinois, Nebraska, and Iowa (United States Geological Survey, 2009). Their combined production was 49.6 million tonnes (72% of the total U.S. crushed stone produced underground). With a total crushed stone production of approximately 1.6 billion tonnes per annum in the U.S., underground production accounts for 15%. Underground mining is also practiced in Europe.

Several studies have been completed assessing underground mining in Ontario. These are summarized as follows:

Mineral Aggregate Study of the Central Ontario Planning Region (Proctor & Redfern, 1974)

- *It does not appear that there will be any immediate changes in current surface mining extraction methods that would affect available supply with the possible exception of underground mining.*
- *Costs for underground mining are currently prohibitive but may fall into line in the future because of ever increasing road transport costs.*
- *Underground mining for limestone appears to be a realistic alternative in the future.*
- *Tunnel mining could be considered in the Niagara Escarpment if the difference in cost is the trade-off for preserving the Escarpment in its natural state.*
- *Currently, the difference in cost of extracting crushed limestone by vertical shaft mining over quarrying is too great (approximately 3 times).*
- *If transportation costs for hauling aggregate become too high, underground mining could be feasible especially east of Toronto which is furthest from conventional sources.*
- *Tunnel mining is not feasible in Central Ontario except for a few locations along the Escarpment where overlying rocks are thick enough to prevent a collapse.*
- *In most cases, limestone produced from underground mines is too costly to incur added transport charges.*
- *Vertical shaft mining is possible in Lake Ontario – envisioned east of Toronto with a room and pillar operation up to 1,000 feet below the surface (estimated that the max. workable capacity for one shaft would be 1 million tons annually).*

Advantages of underground mining:

- *Can be operated on a year-round uninterrupted basis;*
- *Does not require overburden removal;*
- *Requires small surface area;*
- *Little or no environmental disturbance;*
- *Minimum surface rehabilitation of mined out areas;*
- *Eminently suited for those areas whose surface is expensive or preempted by other uses such as near cities; and*
- *Mined areas may serve as storage sites.*

Disadvantages of underground mining:

- *Requires large initial investment;*
- *Up to 40% of reserves are left in the ground;*
- *Equipment must be small and is more difficult to move;*
- *Water, gas and possibly petroleum may cause problems;*
- *Safety requirements are much more strict and regulations are much more comprehensive; and*
- *The cost generally runs 50% more than open cast mining.*

Mineral Aggregate Study & Geological Inventory, Part of the Eastern Ontario Region (Proctor & Redfern, 1975)

- *The underground mining of crushed stone appears to have some merit for the future especially in the urban areas of Eastern Ontario.*
- *Bedrock resources are evident for some 20 miles east of the City of Ottawa.*
- *Underground mining for the future should be considered but Eastern Ontario does not appear to be deficient of surface materials.*

Mineral Aggregate Study & Geological Inventory – Southwestern Ontario (Proctor & Redfern, 1977)

- *Potential for underground mining of limestone in certain areas of Windsor/Amherstburg area, but costs are likely substantially higher than costs for imported aggregate.*

- *Aggregate produced in an underground mining operation would be more expensive than aggregate shipped from the U.S. or northern parts of Southwestern Ontario.*

Mineral Aggregate Transportation Study Final Report (Peat Marwick and M.M. Dillon, 1980)

- *Underground mines would be excellent candidates for producing aggregates in combination with open pit extraction.*
- *The costs for underground mining were found to be higher than those of open pit excavation but lower than the combined costs of open pit extraction and long distance transportation.*
- *Underground mining plants could be located adjacent to the Toronto freeway system to minimize the distance of haul routes.*
- *Underground mining could only be a partial solution to the aggregate supply problem because only stone can be mined underground and there is a demand for fine aggregates.*
- *It would be difficult to obtain mineral rights for underground extraction especially in urban areas.*
- *With respect to the flexibility and reliability of service there would be little difference between local underground mining and the long distance rail transportation option.*
- *Underground mining would have significant environmental advantages with respect to impacts on communities, on agricultural land and on the natural environment.*
- *Subsurface limestone mining has potential and should be considered further as an aggregate resource area.*

Aggregate Resources of Southern Ontario – A State of the Resource Study (Planning Initiatives, 1992)

- *Subsurface mining has proved to be technically feasible in many parts of the world and provides many environmental benefits.*
- *There are many potential locations for subsurface mines in the Greater Toronto Area, including the area beneath Lake Ontario, and in the Niagara Escarpment under an already existing quarry or in a large tract of Crown land.*
- *A subsurface mine serving the GTA would aim to produce between 3 and 5 million tonnes per year to be viable.*
- *The positive features of a subsurface mine located close to the market are reduced transportation costs, reduced pollution and reduced energy consumption.*
- *It has been indicated that subsurface operating costs are two to four times open pit costs.*

- *It is imperative to plan the after use of the mined space early in the process so the mine can be designed to produce the kind of space required for the after use.*

- *Although subsurface limestone mining would only provide a limited supply of stone, it would be an important contribution to the overall GTA demand for aggregate.*

Other reports specifically prepared with respect to underground mining include:

- In 1976, a report by Acres Consulting Services assessed the feasibility of developing both a shallow underground operation and accessing the resource via a 300 m shaft (Acres Consulting Services Ltd., 1976). The conclusions were that a shallow mine in the escarpment alternative was marginally uneconomic and a deep mine below Toronto was marginally economic, for sale of product in Metro Toronto. A recommendation however, was to consider the secondary use of the mined out space for industrial applications and to make this type of operation economically viable was to make development of a joint underground aggregate operation contingent on an industrial after-use.

- In March 1982, a report published by L. Thompson of the Central Region, MNR, assessed the potential for underground mining of aggregate in urban centres like Metro Toronto (Thompson, L.G.D., 1982). The report looked at the difference in costs between developing an underground versus a surface mining operation and discussed options to reduce cost differentials. The paper used examples of sources approximately 50 km and 150 km from Metro Toronto to assess the feasibility of developing an underground mining operation from a currently operating quarry. The author concluded there are four main factors which should be taken into account when considering the feasibility of underground mining of aggregates: the increasing cost of fuel; mining of the highest quality product possible to maximize profit; simultaneously extracting different industrial minerals; and high volume production.

- In 1986, Ontario Hydro completed a report on underground mining of limestone within the Province. Commissioned by the Industrial Minerals Section of the MNR and the Ontario Geological Survey of the Ministry of Northern Development and Mines (MNDM), these ministries requested a geotechnical feasibility study of sub-surface mining of aggregate materials. This report has been cited in subsequent reports which state that detailed information on engineering properties of various rock units; potential characteristics of the mine; mine layout; rock support requirements; technical feasibility; potential for ground subsidence and feasibility of the mined out space-use were laid out in the report. Unfortunately, a copy of this report is not currently available (Aughenbaugh, N.B., Christiansen, C.R., Scott, J.J. [ed.], 1974).

Current Practices

United States underground aggregate mines are located in limestone bedrock and are frequently initiated from an existing surface quarry operation, which may or may not be active. The advantages of selecting an existing quarry site for underground mine development are:

- the quarry land use (and that of associated facilities) is established;

- surface facilities and equipment for processing are in place to cater to underground operations;
- access to transportation networks is in place, with established traffic patterns;
- for quarries that are operated above the water table, rehabilitation of the surface excavation can continue concurrently with underground operations;
- markets are well developed locally; and
- there is a potential market available for secondary use of underground space for storage and other industrial uses.

Underground mine development that is not associated with an existing surface quarry operation would occur at a ‘greenfield’ site. These types of underground mines do exist in the U.S. but they are not the typical approach for mine development. Additional factors to consider for greenfield underground mines would include:

- higher development, operational and production costs due to lack of surface quarry for resource access and stockpiling/processing;
- development of surface workings for aggregate processing, stockpiling and loading; and, loading/space requirements for truck haulage; and
- land use/planning challenges of introducing a new use and haul route.

Extraction Operations

In situations where underground mining is initiated as a new phase of a suitably deep existing surface mining operation, it usually occurs by developing a decline (sloped access) at the bottom of a high outer quarry face. Extraction occurs in a manner similar to underground coal mines, using the “room and pillar” method. The site-specific physical and geotechnical nature of the bedrock and the design of the mining engineer determine the process and geometry of underground excavation.

Once the initial extraction area has been opened, the extraction process becomes fairly routine. Bedrock is first drilled and blasted. Blasting occurs more frequently than at surface quarries as drill/blast holes are smaller and a lower volume of rock blasted in each individual blast. Some mines report that blasts occur up to several times a day. As underground mining progresses through the “room and pillar approach”, measures are taken to prevent mine collapse. This occurs by “roof bolting”, whereby holes are drilled into the mine roof and bolts inserted to clamp the roof beds together. In addition, “scaling” is carried out on the side-walls, to remove loose or hanging rock from the exposed faces.

With the room and pillar extraction method, the underground mine resembles a series of large caverns, separated by limestone walls and with pillars of limestone bedrock interspersed at pre-determined and engineered points within the caverns (“rooms”) to provide support to the ceiling or roof. This is a necessary part of the underground mine but results in a high degree of waste of the resource. Typically, in the order of 30 to 40 percent by volume of an extraction area is rendered unavailable for extraction. Accordingly, by virtue of the room and pillar extraction method, a greater amount of area is required in an underground mine than at a typical surface quarry, to produce the same amount of aggregate.

Blast rock is removed from the rock face and conveyed or hauled for primary crushing which is usually at the surface, in the open quarry area. However, in some mines, primary processing has been located underground. In the latter case, these would be mines which have sufficiently mined-out areas to accommodate the processing plant and related activity areas. Using a conveyor system to move aggregate on a declined ramp, rather than haulage trucks or trams, is preferred to reduce costs in the case of ramp access from a surface quarry to the underground mine.

At the point the bedrock material, whether it is blast rock or primary processed crushed stone, exits from an underground mine, which would generally be the floor of an existing surface quarry, the aggregate supply process is the same to that for surface quarries. Bedrock material is processed through one or more crushing plants with the crushed stone conveyed or hauled to stockpiles of various stone size and gradation. From the stockpiles, loaders are used to load stone into highway trucks for delivery to market locations. Some U.S. mines have access to bulk-transport facilities.

By virtue of being underground, mines are not affected by climate and hence operations can occur year-round. While this has benefits in areas where there is a constant year-round demand for aggregate, it is not as much of a factor that would have great significance in Ontario as the construction season, particularly for roadwork, closely matches the climatic seasons. However, for the amount/types of product that is demanded in the winter, underground mining could limit the need for large volumes of inventory being stockpiled, which typically occurs in Ontario surface quarries in order to meet the winter demand.

Environmental Factors

The underground mine's most defining characteristic is that it occurs below the earth's surface. The immediate benefit of this mining technique is reduced surface footprint of the mine itself, although the mine will be associated with an existing surface quarry from which it was initiated, or, it will require dedicated surface workings for processing, stockpiling and distribution. A reduced surface footprint allows for retention of the natural landscape above the mine operation, particularly if the mine is deep enough to avoid negative interactions with ground and surface water features. Environmental impacts can occur if the mine operates at a shallow depth, i.e. with insufficient separation from the ground surface, and water-related features are present.

Should an underground mine require dewatering, it has the potential to lower groundwater levels in a shallow aquifer above the mine and potentially affect sensitive aquatic features and private water wells.

Limestone units typically form significant aquifers and are widely developed as a source of municipal or domestic water supplies. In Southern Ontario, the Guelph-Amabel Formations comprise a regionally extensive aquifer system from which a number of urban centres (e.g. Cambridge and Guelph) obtain municipal water supplies. Furthermore, groundwater discharge from this aquifer system supports stream base flow and cold water fish habitat in many watersheds.

Dewatering to support underground mining in the Guelph-Amabel Formations where not overlain by a regionally extensive aquitard (low permeable rock units) would result in widespread lowering of the water table and the potential impact to stream baseflow and aquatic habitat should they be located in close proximity to the mine and be hydraulically connected.

Depending on hyrdogeological conditions, dewatering may be required throughout the life of an underground mine, in both its active phase and its closure/after-use phase, if there is to be some specific use of the depleted mine excavations (e.g. for storage). If no end use were contemplated then continuous pumping may not be required, as the mine could be flooded under final closure conditions. There has been some discussion in the literature of the use of flooded underground mines as groundwater reservoirs.

Studies to support the permitting of an underground mine would likely require extensive assessment of groundwater flow and the potential to impact existing groundwater users and sensitive environmental features. Groundwater flow patterns may not return to pre-mining conditions following flooding at closure as the presence of an extensive underground opening will affect localized groundwater levels and gradients.

Geotechnical monitoring activities related to rock dynamics at an underground mine are conducted prior to and throughout the life of the mine and sometimes post closure. During development and subsequent operation, there will be continuous monitoring of noise, vibration and dust levels, along with regular environmental monitoring and rock mass stability monitoring. Post closure, the primary area of monitoring will switch to rock mass conditions, aimed at high factors of safety for long-term stability.

Economic Factors

Production costs are higher at underground mines than for surface quarries due to higher labour costs, and because the depth of the aggregate deposit and access to the reserves result in higher development, operating, decommissioning and depreciation costs. Wastage is also a factor resulting in poorer economics.

Machinery is generally smaller, particularly at the time of start-up and until such time as the mine is fully developed, thereby resulting in poorer economics. Blasting is carried out with smaller volumes of rock produced, and handling of blasted bedrock material prior to reaching the processing plant can be more extensive, even with primary processing occurring underground. In addition, mine safety related activities such as monitoring, scaling and roof bolting must be carried out on a continuous basis.

A 1981 study undertook a comparative analysis of the overall production costs for both surface and underground mining, including the capital investment costs (Hedberg, H., 1981). It concluded that the costs were more than three times higher for underground production as compared to surface production. However, in the Thompson study for MNR, it was suggested that these costs might be reduced to no more than two times, by utilizing current surface operations where a large amount of the capital investment has been made, and by developing large-scale operations.

Social Factors

Social acceptance may be improved with respect to the smaller surface environmental impact of the underground mine. However, concerns related to visual and nuisance impacts, associated with processing, stockpiling, loading and trucking (which would remain at surface), rock stability and impacts to aquifer and wells, in the case of a shallow mine, would still be expected. The 1992 Aggregate Resources of Southern Ontario - A State of the Resource Study stated that truck traffic was the most dominant social issue with respect to aggregate operations and this would remain unchanged compared to an underground mine. In most cases, there will be some visible signs of activities associated with underground mining operation, such as ventilation shafts, access-ways, and utility structures, but these would only take up a limited area.

Underground mining would also lead to social implications for the labour force. In Ontario, the safety of workers in either a surface mine or an underground mine is covered under the *Occupational Health and Safety Act*. Employees in soft rock (e.g. limestone) underground mines must complete the Common Core for Basic Underground Soft Rock Mining Skills (Program # P770130 Basic Common Core Program), administered by the Ministry of Training, Colleges and Universities.

Underground mining would be a completely new experience for workers in today's construction aggregates industry, presenting new challenges in the working environment. For example, ventilation is not an issue at surface quarries but is a very important concern at underground mines. Workers would be operating in an environment where a more stringent safety culture has to be implemented. Underground operations tend to be more labour intensive and the workforce will require a higher degree of both operational and health and safety training.

In southern Ontario, the size of population and its mining history means that there is a pool of available labour with the necessary degree of training and experience required. Training programs to develop specific skill sets necessary for operating an underground mine have already been developed including equipment operation and specialist techniques for drilling and blasting. Such programs already in effect in Ontario and include those run by Northern Centre for Advanced Technology (NORCAT) in Sudbury.

Regulatory Regime

In Ontario, the extraction of aggregates solely by underground mining will fall under the regulation of the *Mining Act*, administered by the Ministry of Northern Development, Mines and Forestry (MNDMF).

The purpose of the *Mining Act* is to encourage prospecting, staking and exploration for the development of mineral resources and to minimize the impact of these activities on public health and safety and the environment through rehabilitation of mining lands in Ontario. The Act allows licenced prospectors to obtain the exclusive right to explore for specific minerals where the mining rights are open for staking (i.e. unpatented mining rights).

On privately owned land, common in Southern Ontario, the mining rights are not open for staking as they rest with the landowner. The process of staking a claim will require negotiation with the landowner for access to the land. Under the terms of the new *Mining Act* (currently going through Provincial Legislature), the Mineral Rights owner then will have to cede all rights to the minerals on the property owned and have the sub-surface Mining Rights released back to the Crown so that a claim may be staked. To bring a claim to lease requires the submission of an Application for Lease to the Provincial Recording Office, stating whether the application is for *Mining Rights Only* or *Mining and Surface Rights*.

Several aspects of the *Mining Act* and *Aggregate Resources Act* will overlap when considering a greenfield site for the development of either a surface and underground aggregate operation; or, an underground operation only (Ministry of Natural Resources, 2006). Reports required to be submitted in order to be granted an aggregate Licence or Permit will form the basis of the Closure Plan that is necessary for permission to extract aggregates from underground operations. When considering the development of an underground operation from within an existing surface operation, it will be necessary to stake a claim and convert that to a Lease for the Mining Rights prior to submitting a Closure Plan for the underground portion of the operation.

Closure Requirements

In order to convert a Claim into a Lease for the Mining Rights, it will be necessary to submit a Closure Plan for the underground mine. This Closure Plan describes measures, including protective measures, which must be undertaken during the entire life of the mine to rehabilitate the mine site. These rehabilitation measures aim to restore the site to its former use or condition or to make the site suitable for a use that the Director of Mine Rehabilitation, Ministry of Northern Development, Mines and Forestry (MNDMF) determines (Queens Printer for Ontario, 2007).

In planning for closure, four main objectives need to be considered (Canary Research Institute for Mining, Environment and Health, 2006). These are:

- protect public health and safety;
- mitigate or eliminate environmental damage;
- achieve a productive use of land, or return to its original condition or an acceptable alternative; and
- to the extent achievable, provide for sustainability of social and economic benefits resulting from mine development and operations.

After-Use

The development of underground mines offers the potential for an after-use for the underground space. Characteristics of the worked-out mine such as constant temperature and climate conditions throughout the year, and the high degree of protection and security, make it attractive to the storage industry. Under some conditions, reuse of an underground mine for storage purposes may also improve the economics of an underground mine (Haycocks, S.G., Karmis, M., Haycocks, C., 1992). To accommodate secondary usage, a mine should be designed to have the maximum usable space and the minimum conversion cost to industrial space (Aughenbaugh, N.B., Christiansen, C.R., Scott, J.J. [ed.], 1974).

Examples of end uses for limestone mines are mostly storage related, such as warehousing or wine and food storage, and products that require darkness and consistent temperature/humidity. In Kansas City, the Hunt Midwest SubTropolis is the world's largest underground business complex, covering 3,670 ha (9,068 acres) and with 10 km (6.5 miles) of road and 3 km (2.1 miles) of rail corridor (Buzbee, J.). Two emerging fields for after-use include energy storage (compressed air from wind turbines) and geothermal energy.

Considerations for Siting an Underground Mine

In the United States, many underground mines have started from deep existing surface quarry operations, by excavating a horizontal decline from the quarry wall into the target bedrock formation. While this would be a desirable mode of underground mining in Ontario, there are some challenges to this approach as most Southern Ontario quarries are relatively shallow and lateral underground mining would pose issues regarding thickness of cap rock above the excavation.

An Ontario underground mine is more likely to develop:

- at the site of an existing surface quarry by constructing a ramp or shaft down to units of limestone that are stratigraphically lower than the bedrock of the quarry floor, allowing for utilization of existing infrastructure for processing, stockpiling, loading and shipping; or
- at a greenfield location by construction of a ramp or vertical shaft from the surface to the desired bedrock formation at depth. This type of development will require dedicated surface facilities for processing, stockpiling, loading and shipping.

The following matters would form the main considerations for mines at existing quarries, where access to surface workings (processing/stockpiling and trucking) is assumed as being in place:

- depth to resource, thickness of resource, and resource quality (bedrock formation);
- low permeability bedrock unlikely to create widespread dewatering of the local aquifer; and
- need to ensure sufficient thickness of roof cover to allow for the development of a room and pillar mine.

Considerations for greenfield developments would include the above matters, but with the introduction of associated activities of processing, stockpiling, loading and shipping, that are not pre-existing uses at the site. Achieving the necessary thickness of cap rock is more assured for the greenfield mine, as it would develop by a ramp or vertical shaft to access suitable bedrock such as the Lindsay Formation, with a lower member thickness of approximately 60m. This scenario would limit disturbance to the surface environment from physical mine excavation due to depth of overlying rock, although surface disturbance would result from the ramp or mine shaft development and the requirement for surface processing, stockpiling and shipping operations.

Recommendations for Further Study

To further investigate the feasibility of developing underground sources of aggregate supply in Southern Ontario, the following work is suggested:

- Develop a more detailed geological model of areas of potential interest, using all available geological information and supplementing this with additional drilling to better define key geological and geotechnical parameters;
- Develop a detailed hydrogeological model to assess the characteristics and the potential impacts on aquifers. This would entail comprehensive characterization of the overlying rock units and assessment of potential mitigation measures;
- Detailed costing for the development of both underground mines close to the market and for surface mining of resources further afield;
- Assess the potential for using adjacent stratigraphic units for purposes other than aggregate, with specific interest in value added products like chemical lime, cement and building stone;
- Assess the feasibility of combining an operation developed to extract both limestone and gypsum (which is an industrial mineral already mined underground);
- Compilation of all available rock engineering and regional stress information pertaining to the various Southern Ontario limestone units;
- Analysis of the available geological and drilling records to assess where there is true underground potential given such variables as thickness of units; geotechnical suitability for underground mining and natural variation in the quality of the resource; and
- Analyze the actual potential for secondary use of the space taking in to account the type of end use, the local market, redevelopment costs and economic potential for such space.

4.2.2 Dredging

Dredging of aggregates has a long history, particularly in Europe, and in the United Kingdom (U.K.) especially. The seabed, as an alternate source to land-based pits and quarries, is an important resource in several parts of the world. However, the practice is generally not as prevalent in North America, due to the availability of land-based sources and the need for specialized high-volume dredging equipment.

An assessment of the historical practice of dredging in Ontario and the potential for implementing this practice in the future in this Province has been carried out; as well as a review of other jurisdictions across Canada and around the world where dredging is more common practice. To provide some background to this assessment of the potential for dredging of aggregate materials in Ontario, a review of this practice in other jurisdictions in Canada, California and the United Kingdom was conducted.

The conclusions from Ontario studies that have addressed dredging are summarized as follows:

Mineral Aggregate Study of the Central Ontario Planning Region (Proctor & Redfern, 1974)

- *Large quantities of natural mineral aggregate are known to exist on the northern shores of Lake Huron but transportation costs may mitigate against the development of these reserves.*

Mineral Aggregate Study & Geological Inventory, Part of the Eastern Ontario Region (Proctor & Redfern, 1975)

- *Dredging from lake beds may be possible to produce limited quantities of sand and gravel but this would have no appreciable effect on normal practices or supply.*

Mineral Aggregate Transportation Study Final Report (Peat Marwick and M.M. Dillon, 1980)

- *The opportunities for increasing lake dredging are uncertain – usually only sand is produced and its graduation cannot be adequately controlled to fully compete with the product of a good land-based plant.*
- *The fact that the Ontario fleet of sand-sucker vessels has been reduced to one is indicative of the judgment of experienced operators as to the prospects for economical operations.*
- *Increased information on the location and quality of the sand and gravel resources in the Great Lakes would aid in any evaluation of the potential for dredging in these areas.*

Aggregate Resources of Southern Ontario – A State of the Resource Study (Planning Initiatives, 1992)

- *Sand and gravel dredging can be operated in a manner that is compatible with environmental and other concerns, if there is adequate legislation, careful planning and close coordination between all concerned parties.*
- *With all the issues confronting this industry, it is difficult to envision dredging supplying significant volumes of sand and gravel in Ontario in the near future*
- *One of the problems with dredging is the lack of information on the location and the quality of the sand and gravel resources in the Great Lakes*

Dredging in Ontario

In Ontario, dredging of aggregate materials from lake bottoms or river mouths is currently limited to one permitted operation, a Permit that was issued under another statute, and transferred to the provisions of the *Aggregate Resources Act*. However, no extraction under this Permit (in the vicinity of the mouth of the Niagara River) has taken place for at least ten years (personal communications – MNR, 2009). A detailed description of this operation, at the time it was active, is provided in a 1985 report by Mirza Engineering commissioned by the Region of Niagara which explored alternative sources of sand and gravel for the Niagara region (Mirza Engineering Inc., 1985).

The report found that deleterious materials were a common feature of sand and gravel deposits of the Lake Ontario Basin. Other constraints included:

- The high cost of royalties, which in 1984 was $0.25 per tonne[7];
- The fact that the dredged sand obtained directly from the boat cannot be used without further processing; and
- New docking facilities would be needed at suitably located sites proximal to the major markets, of which none exist or have the capacity to cater to the industry. A docking, storage and mixing facility would require a minimum 20 acres (8 ha) and it would need to be equipped with suitable blending equipment.

On the environmental side, the Mirza report found that the effect of dredging coarse material on the lake is considered minimal. The amount of sediment material put in suspension by dredging may be locally concentrated, but would be quantitatively insignificant with respect to the amount placed in suspension during a natural storm. Fish habitat concerns in particular were looked at. The report found that the dredging and resultant local turbidity would result in sealing of surface porosity of granular material and that may be harmful to the fish. However, the report authors stated that dredging could be regulated such that it is not concentrated on areas best suited for fauna development, or timed not to interfere with migration and spawning periods.

While somewhat more common in the past, environmental concerns (Grattan-Bellew et al, 1978) and questions of quality have limited production to a small percentage of total aggregates production in the Province. In particular, aggregates dredging in the Ottawa and St. Marys Rivers ceased due to fisheries concerns (personal communications – MNR, 2009). Several documents have been released by the Ministry of the Environment (MOE) regarding dredging, but they are not specifically related to off-shore dredging of aggregates (MOE, 1994, 1995, etc.). In at least one instance, aggregates dredging in the U.S. has been prevented due to the presence of the salamander mussel (Hayes, L., 2008). This species has been identified as the mudpuppy mussel by COSEWIC, and it is considered an endangered species in Ontario. However, it has only been located in the Sydenham River.

A critical issue with dredging is the location and quality of the resource. Detailed bathymetric surveys of the lower Great Lakes have been completed by the U.S. National Oceanic and Atmospheric Administration (NOAA). The bathymetry of Lake Huron includes Georgian Bay and the North Channel (NOAA, various). While these surveys provide detailed topography of the lakebeds, no information was released on the characteristics of lakebed sediments.

Three sedimentary units have been recognized in the surficial sediments of Lake Ontario based on sampling and echo-sounding (Thomas, 1972). These units include glacial till and bedrock, glaciolacustrine clay and postglacial mud. Only minor units of sand and silt were identified in the surficial sediments of Lake Ontario. It appears that coarser sediments suitable for aggregates may only be very localized (for example, near or within river estuaries) and / or overlain by significant

[7] Some municipalities included a $0.08 per tonne fee for a rehabilitation fund in addition to the $0.25 cent per tonne Provincial royalty.

thicknesses of the finer sediments.

With regard to issues of quality, it has been noted that gravels in Lake Ontario near the mouth of the Niagara River contain concentrations of chert, a deleterious material causing alkali expansion if used in concrete. It has also been suggested that other gravel deposits in Lake Ontario, such as those found in the Kingston area, would also be alkali-expansive due to the presence of reactive carbonate rocks. Any aggregate sourced from Lake Ontario would need to be tested for alkali expansivity prior to use as concrete aggregate (Grattan-Bellew et al, 1978).

A dredging operation in Ontario would require issuance of an Aggregate Permit under the *Aggregate Resources Act*. Dredging is classified as extraction of 'land under water'. The application process includes plans and a series of studies designed to address extraction in marine conditions. The application would be in accordance with Category 13 of the Provincial Standards and require a site plan and reports in the fields of aggregate geology, natural environment, stakeholder impact, marine archaeology, contaminated sediments, and natural lake processes. Dedicated impact assessment on marine habitat, fisheries resources as well as the natural environment as a whole would be required. Issues of remediation and compensation would have to be addressed. Issuance of Federal Government authorizations would automatically trigger the *Canadian Environmental Assessment Act* process.

British Columbia

In Canada, British Columbia (BC) has relied to a more considerable extent, at least in the past, on dredged construction aggregates than other Provinces. The primary source of the dredged materials has historically been the Fraser River, rather than coastal seabed deposits. It should be noted that this act of dredging in the Fraser was considered primarily to maintain the navigability of the river channel.

From 1980 to 1995, dredging supplied from 1.6 million tonnes to 7.8 million tonnes per annum. This comprised 9% to 33% of the total construction aggregates production for the Lower Mainland, which, in turn, was an average of 50% of sand and gravel production in the province. However, due to environmental and quality concerns, and the development of other land-based sources, the proportion of dredged aggregate materials production has recently declined and now comprises 2% to 4% of BC's total aggregate production (Golder Associates Ltd., 2006; personal communications – Golder Associates Ltd., 2009; British Columbia, 2009). Dredged material in the Fraser River has historically consisted of poorly sorted sands of uniform gradation, suitable only for sub-base or backfill uses, and thus of limited demand (Golder, 2006).

Maritime Provinces

In the Maritime Provinces, the Geological Survey of Canada has mapped and sampled seabed aggregate deposits on the Atlantic coastal shelf (Pickrill & Piper, 2003). Particularly promising are several deposits in the Bay of Fundy that have been generated as a result of the actions of tidal currents (Fundy Issues, 1996). However, concerns have been raised about the potential impact on habitat, particularly with regard to possible degradation of fisheries resources. As such, the practice of dredging for aggregate has not occurred in the Maritime Provinces to date.

Dredging Practices in California

California uses marine aggregates to a limited extent (Kohler, 2006). For example, one international building materials company is the largest marine dredged aggregates producer in the San Francisco area, and dredges high quality sand from long-term leases in the San Francisco Bay. Production by this company alone has exceeded two million tonnes / annum (PR Newswire, 2009). However, it appears dredging accounts for only about 1% to 2% of the total production of aggregates in the State.

Dredging Practices in the United Kingdom

Approximately 21% of the sand and gravel used in England and Wales is supplied by the marine aggregate industry. In the south east of England, 33% of sand and gravel for construction comes from the seabed (Crown Estate web site). There was approximately 11.9 million tonnes of dredged aggregates in 2005, and of this total, 6.5 million tonnes were exported to continental Europe, thus reducing availability for domestic use (British Geological Survey, 2008).

One of the main benefits of using marine sources identified in the U.K. is that ships can deliver aggregates directly to existing wharves in urban areas, thus reducing transport by road and reducing traffic congestion and pollution. In 2004, it was estimated that dredging practices saved 340,000 truck trips in London alone (Crown Estate web site). Local truck transport from the wharf to the City job-site would still be required.

Marine aggregate dredging is closely regulated by the Marine and Fisheries Agency and the Department of the Environment, Food and Rural Affairs. Each dredging ship carries a sophisticated electronic monitoring system (EMS) to track and record its movements within its allocated licenced area.

A considerable amount of research has been undertaken in the U.K. on impacts of marine aggregates dredging, including recovery rates, restoration / remediation, and habitat creation / enhancement. It has been shown that small scale aggregate dredging of some 150,000 tonnes per annum, even with intensive extraction rates per km^2, has a limited impact on the environment (Hitchcock & Bell, 2004). However, it was also noted that, where on-board screening occurs, the resultant sediment plume would provide a mechanism for potential extension of the impact well beyond the zone of extraction. The rates at which benthic communities recover from marine dredging vary with dredging intensity and duration, and the pre-existing characteristics of the sediments. Rapid recovery, from months to 2 to 4 years have been noted in deposits of shallow water mobile sands, while in deep water stable gravels, recovery may take more than 15 years (Emu Ltd., 2004). A comprehensive four-year field study (CEFAS, 2004) concluded that recovery rates might be longer than otherwise reported. The study also concluded that re-establishment of benthic communities after dredging can only be attained if the topography and original sediment composition has been restored, and the natural ebb and flow regime has not changed.

4.2.3 Mine Tailings

Mine tailings located in Northern Ontario comprise one of the largest sources of solid waste. This source of material consists of broken rock from open pit and underground mines (mine waste rock) and coarse mine rejects from screening and separation processes.

Mine tailings tend to be located in remote areas well outside the practical distance for them to be economically transported to areas of high construction aggregate demand (GTA and southern-central Ontario). At underground mining operations, most of the mine tailings that is potentially suitable for use as construction aggregate is being used to backfill the mine.

There are typically other significant technical and environmental constraints on their use that must be assessed on a site/source-specific basis such as:

- fineness (mine tailings);
- chemical/environmental concerns (acid generation potential of mine waste rock, radioactivity, leachates; alkali-aggregate reactivity potential); and
- variability (due to co-mingling of different rock types in stockpiles).

Some examples of where mined rock, excavated incidental to a non-aggregate project, has been used as aggregate include:

- the use of byproduct trap-rock overburden from historic iron ore extraction at Aecon's Marmora plant which is processed for use as premium surface course aggregates used in asphalt surface for '400 series' freeways;
- use of excavated shale from water treatment facility construction in Holcim Canada's cement plant at Clarkson (Mississauga); and
- stockpiling of shale from the Niagara Tunnel Project as feed material for future brick manufacturing (also processing of dolostone from the intake channel for granular base and sub-base for on site roads construction).

There can be issues of contamination of the by-product rock that render it unacceptable in aggregate applications.

While there have been some mine tailings success stories, it is unlikely that significant use of mine tailing will be made in Ontario until favourable transportation costs to Southern Ontario are available. Due to the significant environmental constraints, there is probably little potential for use of mine tailings.

4.2.4 Mega-Quarries

The criteria established for a mega-quarry in the Study Terms of Reference (as amended) are reserves of at least 150 million tonnes and an annual production capacity of at least 10 million tonnes. The reserves criterion is consistent with a review of the literature associated with the mega-quarry concept but the annual production capacity figure cited in some of the literature was 5 million tonnes.

A mega-quarry operation meeting these criteria for the supply of construction aggregates to the Ontario market would be characterized by the combination of an expansive geographic area, abundant aggregate reserves, and a high production capacity. In addition, given the premise that one (or more) mega-quarry sites would need to replace, to some degree, supply from more numerous but smaller traditional quarries, this implies it would be an inland site, with capacity to produce a range of finished products for direct delivery to the market location. Accordingly, ready access to roads of an appropriate standard/capacity would be required. Given the surface area needs of a mega-quarry, it is likely that the mega-quarry would be located in areas somewhat removed from closer to market locations.

While the concept of a mega-quarry approach is relatively new to Ontario, there are existing Ontario quarry operations of a substantial licenced/extraction area, and hence reserves; and, with a high volume production capacity. However, these factors are based on their historic approval, operation and response to market conditions, and not from a dedicated intent to fulfill the role and expectations implied by a mega-quarry, as this is a relatively new concept for Ontario.

Data from the United States Geological Survey indicates that in 2005, there were 17 crushed stone operations in the U.S. that produced more than 5 million tonnes, although no information was available as to their extractable reserves. In Europe, dedicated mega-quarries are located in coastal areas, and are sub-classified as coastal super-quarries, where shipments are made exclusively by ship.

The concept approach of a mega-quarry was first made publicly as a recommendation in the report of the Verney Committee (1976) in the United Kingdom (U.K.), and was the earliest documented source using this term that was reviewed as part of this Paper. The Committee identified three key actions, to respond to regional scarcity, one of which was the creation of coastal super-quarries. It was envisaged that stone would be shipped from a remote location by sea to high-demand areas in southeast England. Sites were identified in Scotland and other European countries. The report listed four general criteria to evaluate suitability:

- substantial suitable rock resources;
- proximity to deep water;
- environmental acceptability; and
- remoteness from population.

Since the time of the Verney report, only one super-quarry has been developed in the UK at Glensanda in western Scotland. It is accessible, and ships only by water; is about 2,400 ha in area with 800 million tonnes of reserves, and produced 10 million tonnes per year initially which has now dropped to about seven million tonnes per year (National Stone Centre, 2008). A second mega-quarry was proposed in Scotland (Isle of Harris) and after an extensive and protracted application process, it was denied for environmental reasons.

In Ontario, the process to establish a dedicated operation in accordance with the mega-quarry concept would follow the same process as currently exists for a traditional quarry site. It can be anticipated that a licence under the *Aggregate Resources Act* (ARA) and Official Plan and Zoning By-law amendments under the *Planning Act* would be required. Approvals under other Federal and Provincial legislation would be required, as necessary. The ARA and Official Plan (OP) amendment procedures lay-out the study and other information requirements in order to establish a quarry operation. Both processes are public, and require a planning rationale and scientific studies focused on natural environment/ecology, archaeology, hydrogeology and hydrology, traffic, blasting and noise. The need for additional studies would be determined on an individual basis.

One of the primary challenges to establishing a mega-quarry for Southern Ontario supply would be the significant land acquisition required to provide the aggregate tonnage and enough buffer land to mitigate noise, dust, blasting and well impacts on surrounding land uses. Given the criterion of a minimum 150 million tonnes of reserves, it would require an extraction area of approximately 280 ha (690 acres) at a 20 metre extraction depth. Total land requirements that account for excavation setbacks and buffers from environmental features would increase the land requirement even further. Results from Paper 5 of the SAROS project indicate that for large quarries, over 60 ha in licenced area, extraction is permitted only on 77% of the licenced area (on average). Given the degree of parcel fragmentation in Southern Ontario, most of which is private property, the feasibility of securing such a land assembly is challenging.

In addition, and related to the land area required, it would be likely in most situations that a number of overlapping rural resource interests (water, environmental, agriculture), some of which would be significant, would also exist on or adjacent to the quarry property and would require consideration through the approvals process. As such, the following criteria need to be considered in order to locate a mega-quarry:

- Secure a large land area, comprising large land parcels for land assembly;
- Recognition that large areas will have multiple overlapping constraints such as environmental, agricultural and social factors that need to be considered and balanced;
- Sufficient volumes of stone, with acceptable quality characteristics (i.e., able to meet product specifications) to support a high level of production of a variety of aggregate products;
- Proximity to market or access to efficient road networks of sufficient capacity to carry the necessary tonnages; and
- Sufficient capital resources to assemble the land and develop a mega-quarry.

It should be noted that the traditional cut-off for economically accessible bedrock aggregate has been in the order of less than 8m of overburden as mapped in ARIP publications. However, other potential resource areas may be economical taking into account the ratio of overburden thickness versus resource thickness and the economies of scale.

4.2.5 Manufactured Sand

The Ontario Provincial Standard Specification (OPSS) defines “manufactured sand” as sand produced by the crushing and further processing, i.e., washing, grading, classifying, of quarried rock, boulders, cobbles, or gravel from which the natural fine aggregate has been removed.

Manufactured sand can be considered as a possible alternative source of aggregate in that it would serve to partially replace natural fine sand aggregates in certain applications, and in certain geographic areas. Historically, manufactured sand has been produced from limestone quarries and quarry processing operations in areas where there is a relative abundance of limestone bedrock, and a lack of locally available natural sand material. Quarries where manufactured sand is produced have to possess a highly developed suite of processing equipment. Two high demand geographic areas where such geology exists, and manufactured sand has historically been produced, are the Ottawa area and the Niagara area.

However, the production method for manufactured sand is highly energy intensive and the product, while generally suitable for use in concrete and asphalt, is unsuitable for other uses due to its harsh angular shape and reduced workability. A significant difficulty is due to the large amount of extreme fine material sizes that are generated from the crushing process (Derry Michener Booth and Wahl, Ontario Geological Survey, 1989).

The production of manufactured sand at a typical limestone quarry processing operation would not result in any additional social or environmental impacts beyond what would already be occurring at the quarry site, although disposing of the very fine waste materials can be challenging. Its feasibility as an alternative source is largely constrained due to economic factors (e.g. production costs and limited applications). This results in issues of competitive disadvantage, particularly if there are natural sand deposits in the local market area.

4.3 ASSESSMENT OF FEASIBILITY OF ALTERNATIVE SOURCES

Five possible sources of alternative aggregate supply have been considered. These are: mine tailings, dredging, underground mines, mega-quarries and manufactured sand. Of these, underground mining and mega-quarries have been found to have a stronger feasibility than mine tailings, dredging and manufactured sand when considered in terms of economic, social and environmental implications.

Mine Tailings

The use of mine tailings presents challenges primarily due to its economic and environmental consequences. These materials are located in Northern Ontario and hence would require long distance transportation for them to be brought to market (issues regarding the use of rail and ship as methods for delivery from Northern Ontario have been assessed elsewhere in this Paper).

With increased transportation will come increased costs and resultant environmental implications of greenhouse gas emissions (see Section 5.5.2). The cost implications of these materials are also elevated if they require treatment to remove the residues of the mining or production process from which they have emanated.

In addition, feasibility of this material suffers due to suitability for aggregate use, as tailings material covers a broad range of materials, size and gradations. Aggregate requirements are very specific in terms of these factors and given their end-use and durability criteria for natural aggregates, a significant portion of Ontario mine tailings may not be suitable for aggregate applications.

Dredging

While a considerable body of work exists on marine aggregates dredging, the vast majority of information applies to the European experience, particularly the U.K., and to seabeds associated with the continental shelf. There is little information available on the location and extent of suitable potential sources within Canadian boundaries of the lower Great Lakes, however the potential is likely very limited and localized. Of the deposits that are known and have been extracted in the past, there are quality issues.

The feasibility of using dredged aggregates is limited due to economic and environmental concerns and limited knowledge on the location of the resource. With the relative abundance and availability of land-based aggregates in Ontario, and the fact that high quality marine deposits have not been identified in any significance, development of large-scale aggregate dredging operations is unlikely to be viable in the short or medium-term, particularly without sufficient docking facilities in close proximity to major markets.

On the economic side, the process to extract is more expensive and Ontario does not have the required infrastructure to stockpile, process and ship aggregate dredged from Ontario waterways. On the environmental side, current federal legislation that protects fish habitat would be a significant hurdle to overcome and would be a significant impediment to development of riverbed and lakebed sources of aggregate materials. Time and cost factors associated with the necessary approvals, both at the Provincial and Federal level and possibly with the United States (International Joint Commission) would add to the complexity of the approval process.

Manufactured Sand

There is relatively little discussion of manufactured sand in Provincial scale publications. Its routine production has largely occurred in geographic areas where the abundance of bedrock, lack of natural sand and the presence of extensive processing infrastructure (crushers, wash plants) have combined to cause it to be an economically viable product. However, such conditions do not exist across the Province. The feasibility of manufactured sand as an alternative source to natural sand should be viewed as a regional consideration, with significant economic limitations in the broader context.

Underground Mining and Mega-Quarries

Based on the research to date, underground mining and mega-quarries emerge as the more feasible options for alternative/additional supply sources. A comparative assessment of these potential sources of bedrock-derived aggregates (crushed stone) follows in the next section.

4.4 COMPARATIVE ASSESSMENT OF CURRENT SUPPLY, UNDERGROUND MINING AND MEGA-QUARRIES

This section examines the most feasible forms of alternative aggregate supply scenarios, underground mining and mega-quarries, in comparison to the existing situation which is supply from surface quarries. The comparison assesses the economic, environmental and social considerations of the existing and potential supply scenarios.

Social

In assessing the current supply of aggregate with underground mining and mega-quarries, the following social considerations were evaluated:

- Noise;
- Blasting;
- Truck Traffic;
- Dust/Air Quality; and
- Visual.

<u>Noise</u>

Noise produced at any extraction operation must be mitigated to meet MOE guidelines. Underground mining will result in noise generated at the surface similar to a surface quarry with respect to stockpiling, loading and trucking activity. Primary processing at some underground mines in the U.S. does occur below surface, resulting in an elimination of some processing-related noise at the surface; however, the operations that occur at surface will still be audible for the surrounding community.

At a mega-quarry, it is likely that greater setbacks or additional noise mitigation would be required as a result of larger, more intensive operations. Noise produced at this type of operation would be generated from the same facilities as current surface quarry operations.

<u>Blasting</u>

Blasting activity at underground sites would occur more frequently but at a lesser explosive force than at surface quarries. Blast vibration is reduced at underground sites and air percussion and noise from blasting are essentially eliminated at surrounding receptors.

Conversely, blasting at a mega-quarry site may occur with a higher level of frequency than at existing quarries, and at higher explosive forces given the larger volumes of rock to be blasted, and may require greater mitigation. MOE guidelines limit noise and vibration levels to values that are amongst the most stringent in North America. These guidelines must be met for all quarries and can be accomplished with controlled blasting techniques and use of modern-day blasting technologies.

Truck Traffic

Trucking activity is widely accepted as the most objectionable activity related to aggregate production (Planning Initiatives, 1992). Trucking activity is common to all three types of crushed stone operations with increased/concentrated trucking being a likely event for the mega-quarry operation.

Depending on the operation's location, a rail option could potentially exist for transport from a mega-quarry and this has to be assessed relative to the number of homes affected by the rail routes. If truck traffic were the only mode of transport from a mega-quarry source, then traffic levels would exceed what is generally produced at existing surface quarries and underground mines. Accordingly, access to a road infrastructure of sufficient capacity is a key criterion for any type of operation.

Inherent to concerns about traffic are concerns over the visual impact of intense truck activity, site entrance/exit points and possible traffic management concerns on the approaches to and from extraction sites. These concerns would be considered as being similar for surface quarries and underground mining and greater for a mega-quarry.

Dust/Air Quality

Limits on dust levels, which factor into air quality issues, are prescribed under MOE guidelines. For surface quarries, the mega-quarry and underground mining, dust levels are expected to be similar, other than dust generated from blasting will be contained for an underground mining operation. Surface operations at all of the sites will result in dust being generated from stockpiling, loading and haulage and would require common and well-established dust control techniques of road paving/sweeping, use of water and other dust suppressants serve as effective dust mitigation. Control of dust is a prescribed condition for licence issuance under the ARA.

Processing operations can also contribute to dust accumulation. At an underground mine, the dust source is eliminated for the primary processing component if it occurs underground. However, at surface quarries or the mega-quarry, spraying water on processing equipment is an effective and commonly used dust control method. Given the higher aggregate production at the mega-quarry site, correspondingly higher levels of mitigation may be required.

Visual

Underground mines have an advantage in terms of visual impact in that they are sub-surface, however due to the visibility of truck traffic and processing, stockpiling and shipping at surface, this advantage is limited. The surface workings and its processing equipment would be screened from public view by mitigation including earthen berms, tree screens and other landscaping practices.

For the mega-quarry, similar visual screening techniques would likely be used to reduce public exposure to the site. Therefore, the physical excavation at a surface quarry is not likely to be readily open to public view, although it would be essentially eliminated for underground mines.

Economic

Underground mining is an established source of bedrock-derived aggregates in the United States and in Europe. Studies have shown that the cost of aggregates produced from this type of source can be between two and three times the cost of surface quarry materials. This results primarily from higher production costs (both mechanical and labour). Wastage of resource due to room and pillar mining method is also an added factor. The higher cost is significant enough that some studies report that making economic use of the depleted mine site is a necessary consideration when assessing mine feasibility.

Many underground mines in the U.S. are associated with existing surface quarry sites. This reduces the economic constraints posed by underground mines as these sources can make use of pre-existing surface works for processing and shipping. In the case where there is no existing surface quarry, i.e. a greenfield underground mine, the economic disadvantage of underground mines would be even more pronounced. In the U.S., several factors have combined to make underground mining economically feasible. The lack of suitable close to market resources at the surface, or difficulty in accessing and obtaining approvals for existing surface resources, are some of the factors. In the case of Ontario, resources still exist at the surface and planning policy and legislation such as the *Aggregate Resources Act* provide for a regulated mechanism by which those resources can be extracted and social and environment impacts minimized.

In line with the basic economic principle of 'economies of scale', it would be expected that a mega-quarry would result in an advantageous economic position with consideration to the production cycle. Efficiencies would derive from having secure and reliable access to a large reserve area of sufficient quality, and high capacity systems for the provision, handling, processing and shipping of a wide range of crushed stone aggregates.

The very existence of land-based mega-quarry sites in the United States implies they are economical to operate and generate sufficient returns for the owner/operator. Overall competitiveness in the market could be reduced if production was from only a few mega-quarry sites which were controlled by fewer corporate interests. Other negative factors economically for a mega-quarry would be the likely event of an increased haul distance. Economies of scale efficiencies of a mega-quarry may be substantive only to the processing and in-quarry activities; and may not extend to the trucking component, as a significant portion of the trucking industry is by private contractor.

Environmental

The following environmental considerations are evaluated for the alternative sources and current supply of aggregate:

- Wildlife/Habitat Disturbance;
- Agricultural Impacts;
- Groundwater/Surface Water; and
- After Use/Rehabilitation.

Wildlife/Habitat Disturbance

The most significant benefit of underground mining is its reduced surface footprint. Natural features that exist at the surface are excluded from disturbance, thereby maintaining their use as habitat for wildlife, and for recreational use, provided dewatering impacts are appropriately mitigated or avoided by extraction at a depth where there is no hydraulic connection to surface features.

Surface quarrying results in a loss of the surface features during extraction subject to a requirement to progressively rehabilitate. Progressive rehabilitation can restore or enhance natural heritage features to ensure long-term environmental protection.

The reduced surface footprint of an underground mine is an obvious attribute when compared with surface quarries. However, an underground mine will have an existing surface quarry in place; or, require the use of surface land for stockpiling, processing, loading and shipping activities. The net result is that the underground mine provides for a source of aggregate materials that can be extracted with a reduced surface footprint, either because:

1. It would not add to the existing surface feature impacts of a traditional quarry; or
2. The surface working area required by a greenfield mine is reduced.

The comparison of surface impacts between a mega-quarry and a traditional surface quarry essentially relate to one of concentrated versus dispersed impacts, the former being the case for a mega-quarry, and the latter being the case for the traditional supply scenario. However, in both approaches, policies require environmental impacts to be mitigated and minimized. Similarly, both types of quarry would be required to undertake site rehabilitation resulting in temporary impacts and providing opportunity for improved environmental attributes and benefits upon rehabilitation.

Agricultural Impacts

The preservation of surface land as result of underground mining allows for ongoing farming practices to occur uninterrupted and without any substantial loss in area.

Surface quarries are required to rehabilitate back to agricultural conditions if located in an area of agricultural significance, unless that is not possible by virtue of their depth or water table location. In practice, many quarries are operated below the water table or will experience water influx, thereby resulting in a permanent loss of agricultural lands. However, the overall impact on the agricultural land base would be considered minimal as the Province’s agricultural land supply in southern Ontario is over 5 million hectares.

Groundwater/Surface Water

Existing legislation requires that groundwater wells be protected from quarrying impacts, with a site operation designed such that there are no adverse effects to groundwater resources. Impacts from surface quarries would be expected to be lesser than that of a mega-quarry as in general, the size of the influence zone is proportional to the size of the excavation. Monitoring, control and mitigation is more manageable on a smaller site, although this is site specific and relates to the proximity to surrounding water receptors or natural environment features.

An issue for shallow underground mining is that it could potentially affect shallow groundwater aquifers. This could also affect surface features that are reliant on hydrogeological factors. Surface water features would be protected from dewatering occurring at an underground mine, provided there remains a thick enough sequence of stable, natural rock between the roof of the mine and the surface feature (i.e., the mine is located in deeper strata). Underground mines that are located in deeper strata will have little to no impact on surface features other than the potential need to discharge poorer quality water that is typically found in deeper formations. This water would require treatment prior to discharge. Mitigation and protection measures would be implemented based on site-specific studies.

After Use/Rehabilitation

The *Aggregate Resources Act* (ARA) requires that sites be rehabilitated on a progressive basis so they are restored to their former use or a condition that is compatible with surrounding land uses. Specific policies apply for rehabilitation of sites in areas of prime agricultural lands. Surface quarries have been rehabilitated to a wide variety of after-uses, including recreational uses, agricultural uses, natural heritage areas, industrial development and residential uses. Quarries that extract aggregates from below the water table result in lakes that can be used for active or passive recreational uses or conservation uses. Mega-quarry surface rehabilitation would also be bound by the same ARA provisions.

Under the existing legislative regime, rehabilitation requirements for underground mines would be subject to the *Mining Act*. The Act requires that the mine be restored to its former use or condition or to a use determined by the Director of Mine Rehabilitation. Given the likely strategic location of underground mines in close to market locations and the inherent physical and environmental characteristics of subsurface caverns, it is likely that underground mines would be used for some secondary purpose. In the United States, this has included warehousing/storage, wine cellars, and offices.

4.5 SUMMARY

The following table summarizes the comparative assessment of the relative social, economic and environmental factors associated with the current supply scenario and the underground mining and mega-quarry scenarios. Social factors have been broken down into individual parameters.

Social, Environmental or Economic Consideration	Current Standard	Comparative Net Assessment to Current Standard	
	Surface Quarry	Underground Mining	Mega-Quarry
Noise	▪ Must be mitigated to meet MOE guidelines	▪ Similar – due to surface activities	▪ Similar – may require greater mitigation
Blasting	▪ Must be mitigated to meet MOE guidelines	▪ Improved – reduced noise and vibration	▪ Similar– may require greater mitigation
Truck Traffic	▪ Dispersed/multiple sources	▪ Similar	▪ Increased – greater shipping volume
Dust / Air Quality	▪ Must be mitigated to meet MOE guidelines	▪ Similar – due to surface activities	▪ Similar– may require greater mitigation
Visual	▪ Screening to reduce visual exposure	▪ Improved (for extraction only). Screening to reduce visual exposure of surface activities.	▪ Similar
Wildlife and Habitat Disturbance	▪ Need to minimize and mitigate impacts ▪ Rehabilitation required	▪ Improved – reduced surface footprint	▪ Similar
Agricultural Impacts	▪ Most quarries located below water and rehabilitated back to natural/recreation	▪ Improved	▪ Similar
Groundwater	▪ Need to minimize and mitigate impacts	▪ Similar for shallow mines ▪ Improved for deeper mines	▪ Similar
Surface water	▪ Need to minimize and mitigate impacts	▪ Similar for shallow mines ▪ Improved for deeper mines	▪ Similar
After Use / Rehabilitation	▪ Rehabilitation primarily to natural heritage, or recreation end-use	▪ Different types of end-use, primarily economic	▪ Similar
Price of Aggregate	▪ Status Quo	▪ Increased	▪ Increased – fewer sites, longer distance to market, reduced competition

Table 4.1, Comparative Assessment of the Current Supply Scenario with Underground Mining and Mega-Quarries

Section 4 of this Paper provided for consideration of alternative sources of aggregate to meet Ontario's long-term availability and supply objectives. The five alternative sources considered were:

- use of mine tailings;
- sand production from lake dredging;
- crushed stone supply from underground limestone mining;
- crushed stone supply from a mega-quarry; and
- use of manufactured sand.

The purpose of this research and review of past feasibility studies was to determine the feasibility of the alternative sources with respect to economic, social and environmental implications, in comparison to the current CTM based approach.

Dredging, mine tailings and manufactured sand were considered to have a poor feasibility, with higher production/delivery costs being a common factor.

Mine tailings are located at distant locations, and provide challenges due to their potential for environmental contamination and their physical properties which can make certain wastes unsuitable for aggregate use.

Sand dredging, from the Great Lakes, has occurred in the past but there has been no activity in recent years. The need for significant land-based infrastructure, quality concerns and environmental issues resulting from the marine extraction environment are all significant constraints to the development of this alternative source, particularly in areas where sufficient land-based sand deposits are still available.

Manufactured sand was considered to be of applicability in regional areas based on specific geological criteria and access to highly-developed processing facilities.

Of the five options considered, mega-quarries and underground mining were found to have the strongest feasibility. These sources would only supplement the supply of crushed stone aggregates and not completely replace supply from traditional quarries.

Underground mining and mega-quarries are feasible alternative sources of aggregate supply. There are advantages and disadvantages to both alternatives, as compared to the existing CTM approach. Issues related to proximity to market and impacts of surface activities, primarily processing and trucking, that cause social concerns today under the present system would still remain. Further, even with the potential utilization of the alternative sources, the need for traditional supply from quarries (and pits) in close to market locations will still play a critical role for high demand market areas such as those in Southern Ontario.

5.0 FEASIBILITY OF ALTERNATIVE MODES OF TRANSPORTATION

5.1 OVERVIEW

The transportation component of Paper 2 examines the feasibility of alternative transportation systems to supply aggregates to the Greater Toronto Area (GTA) which is the major Ontario market representing approximately one-third of Ontario's aggregate demand. The purpose of this assessment is to compare the status quo strategy of maximizing close to market (CTM) supply to alternative approaches that would replace at least part of this CTM supply with importation from distant sources. The three alternative transportation modes considered in this analysis are marine, rail and long distance trucking. The evaluation considers economic, social and environmental factors and provides both qualitative and quantitative measures to compare the merits of the alternatives to continuing the status quo policy approach.

Table 5.1 - Evaluation Scenarios	
A	Long Haul Trucking from North Bay
B	Rail from North Bay
C	Marine from Manitoulin
D	Close to Market (CTM)

The Provincial Policy that supports maximizing CTM supply has been in place (in various forms) for four decades and is subject to regular review and update. The information provided in this section of the SAROS report has been developed in order to inform future policy reviews and evaluation of the CTM model in comparison to alternative strategies.

5.2 LITERATURE REVIEW

Consideration of further from market locations for aggregate extraction and alternative transportation systems have been reviewed in several Ontario background reports and policy discussions over the years. Examples include:

- Mineral Aggregate Study (Central Ontario, Eastern Ontario and Southwestern Ontario – 1974-1977), Proctor & Redfern Ltd.;
- A Policy for Mineral Aggregate Resource Management in Ontario (1976), Ontario Mineral Aggregate Working Party;
- Mineral Aggregate Transportation Study (1980), Peat Marwick & Partners and M.M. Dillon Ltd.; and
- Aggregate Resources of Southern Ontario, A State of the Resource Study (1992), Planning Initiatives Ltd.

The 1992 "Aggregate Resources of Southern Ontario, A State of the Resource Study" reviewed transportation issues and alternative modes. With respect to long distance trucking, the 1992 Study concluded that the hauling of aggregate products from distant resource areas would dramatically increase the cost of the aggregate product to the consumer. Reliance on distant sources would compound social and environmental pressures emerging along major haul routes contributing to further additional costs. Longer movements would inflict more damage to the highway system, burn more fossil fuel, generate additional pollution and raise construction costs. Some of the key 1992 findings related to the transportation modes were:

Road:

- Trucking handles 97% of aggregate movements and the average haul distance is 34 km.
- High volume trucks carrying 42 tonnes of aggregate only represent between 3% and 15% of total loads.
- A review of the capacity of existing haul routes to handle future long distance haulage from distance source areas should be conducted, particularly in the GTA market area.

Marine:

- Additional imports by water to the GTA could be accommodated within the existing docking infrastructure, but rezoning difficulties may be encountered to allow additional storage areas for aggregates. Night-time running may have to be sanctioned if downtown travel from dock areas was to be economic and travel time practical.
- The main reasons why marine transportation is not utilized are the lack of navigable waterways contiguous to present supply sites and the 3-month winter closure.
- The use of the Toronto Harbour for importing/exporting aggregates should be examined. Direct access to a transportation system is available at the foot of the harbour.
- Service from Manitoulin Island to Toronto would cost up to $12.60/tonne. Even at half that price, aggregate transported from Manitoulin Island would have difficulty penetrating the Toronto market. Possible traffic from Manitoulin Island to Owen Sound, Collingwood or Midland for further passage by rail to GTA would not appear to be economically feasible.
- Future prospects are discouraging, although possible barging, or imports from New York State are possible, particularly if Niagara Escarpment or Oak Ridges Moraine sources are reduced.

Rail:

- Rail transport of aggregates has declined over the past 20 years and CN and CP are convinced that the prospects for moving aggregate by rail are not favourable.

- Removed sidings, lack of rail connections, closed branch lines, and lack of distribution depots impinge against further unsubsidized rail use.
- Utilizing rail from distant source areas is dependent on the physical and economic availability of suitable sites for truck transfer depots and the support of rail management. Existing truck depots are limited in number, size and economic viability.
- The rail system in Southern Ontario is operating at far less than capacity and could handle new aggregate traffic.
- The advantages of rail transportation include lower accident risk, better energy use and lower labour costs per shipment.
- If long-haul aggregate traffic is diverted to the rail network, it could delay expenditures on road repair, renewal and upgrading but some cost savings could be diverted to the rejuvenation of the rail network.

The 1992 Study reviewed and relied, in part, on the 1980 "Mineral Aggregate Transportation Study" by Peat Marwick & Partners and M.M. Dillon Limited. The purpose of that study was to find the most effective means of transportation from selected source areas in the Saugeen area (Grey, Bruce and Huron Counties) and Manitoulin Island to selected markets and determine their costs and impacts. Long distance transportation options were compared to other possible solutions. The 1980 study included forecasting future demand, reconciliation with projected supplies, estimate of materials to be supplied by long distance transport, evaluation of options for transportation, indication of cost effective alternatives and determining relative transportation costs. The major conclusions of the 1980 study include:

- Long distance transportation of mineral aggregates would increase the price of delivered products substantially. The predicted increase rate was at least 50% for aggregate delivered by rail from the Saugeen area and would be even higher if aggregates were transported from greater distances or by other methods of transportation such as trucks or ships.
- The rail transportation system would require significant capital investments and would consume almost twice as much fuel as the local supply system.
- The impacts of aggregate production sites on agricultural lands and on the natural environment would not be reduced significantly by moving production further away from population centres.
- The number of local residents affected by extraction in associated transportation of aggregates near production sites would be smaller in remote source areas. However, impacts on communities may not be less because of the concentrated nature of the operations. In addition, many people will be affected by long distance transportation including rail line relocation and heavy traffic.
- The only significant reduction of impacts that could be achieved through long distance transportation of mineral aggregates would be a reduction in the harmful effects of trucking in

the Toronto area. The major advantage would be achieved where rail-receiving terminals could be located adjacent to Toronto's freeway network to allow distribution without disturbing people along local roads.

- The study included alternative suggestions for reducing the impacts of local trucking such as construction of new access roads, financial subsidies for road improvements, dedicated haul roads, and better enforcement of trucking regulations.

In summary, previous studies have highlighted the social, economic and environmental benefits of the CTM supply strategy and significant barriers and negative implications of shifting supply to more distant sources. Ontario has pursued a CTM strategy and developed its policy and legislative framework accordingly over the past 40 years.

The current 2009 SAROS update work represents the first comprehensive re-evaluation of transportation alternatives since the 1980 "Mineral Aggregate Transportation Study". In addition, several of the matters identified for further study in the 1992 "Aggregate Resources of Southern Ontario, A State of the Resource Study" have been considered in the current work.

5.3 METHODOLOGY AND KEY CONSIDERATIONS

Delivery of material to the GTA market area was the basis for this analysis. The quantity of material required for the GTA was assumed to be 60 million tonnes annually[8] over a 30-year study period. In the past, it has been estimated that approximately 60% of GTA's aggregate requirements have been produced locally[9] (i.e. from pits or quarries located within the GTA) and 40% has been imported from adjacent municipalities such as Wellington and Simcoe Counties. The portion of locally produced material has decreased in recent years indicating a shift away from close to market supply.

The quantity of material to be provided by alternative delivery systems is significant. Sixty million tonnes annually represents 1.8 to 2.4 million truckloads (depending on truck size) and even small increases in haul distance have a relevant cumulative effect in terms of cost, environmental and social considerations.

The purpose of this discussion is to consider the implication of a wholesale shift away from CTM supply for the GTA.[10] The analysis considers practical limitations on the quantities and material that could be handled by alternative systems. For the purposes of describing delivery requirements it was assumed that 35 million tonnes would be delivered by alternative systems representing replacement of the material that GTA has historically produced from pits and quarries located within its jurisdictional boundaries.

[8] The 60 Mt per year aggregate demand is based upon "The Implications of Restricting Aggregate Supply in the GTA" completed by Clayton Research and MHBC Planning in April 2004.
[9] Three-quarters of this is derived from pits and quarries in the Niagara Escarpment and Oak Ridges Moraine Conservation Plan Areas.
[10] The Ontario Greenbelt Alliance has called for a ban of new aggregate extraction in the Greenbelt, Niagara Escarpment, Oak Ridges Moraine and prime agriculture land. See "Green Gravel: Priorities for Aggregate Reform in Ontario" and "Greenbelt Report: Second Anniversary Edition, February 2007"

A 2020-2050 (30-year) study period was selected to capture short and medium term costs and spread the cost of capital expenditures over a reasonable period. The first year of analysis is 2020 to allow for time that would be required to implement the new system.

In order to evaluate and compare transportation alternatives it was first necessary to establish base assumptions and describe facilities and material flow paths that would be required to achieve delivery of aggregate by the alternative systems. The starting points were provided in the study terms of reference and these were elaborated on and refined in order to develop a realistic representative option for each mode.

Each scenario was developed by breaking down the entire material flow path into discrete components of handling and transportation. In order to compare the scenarios fairly, the flow path from source pit or quarry to the final destination job site must be accounted for. For example, it is not sufficient to compare per tonne / kilometre shipping or rail costs to trucking costs without accounting for additional stages of the delivery system that would be required to complete delivery to the job site. Accordingly, the full system including required redistribution facilities and final stages of delivery to job sites by truck are built into the comparison.

The various assumptions used to develop the representative options for each mode are further detailed in technical data provided to the MNR. The calculations were developed into an Excel spreadsheet file featuring:

- A tab for input of the desired total aggregate to be transported, and how it should be split among the available modes of road, rail and marine;
- Individual tabs by transport modes for the detailed year-by-year calculations of distances, vehicle numbers and costs, etc.; and
- A summary tab that collects all the individual mode costs, inflates them to the appropriate future years, and discounts them to current (2009) dollars to produce a cost per unit for the transportation mode.

By adjusting the values in the spreadsheet for aggregate transport demand and how it is to be shared among the modes, different scenarios for demand levels and transport strategies can be evaluated. Similarly, different values for fuel cost, labour rates, vehicle costs, etc. can be tested.

A description of the represented options selected for the purposes of the comparisons are provided in Section 5.4. The comparisons are based on an annual delivered quantity of 35 million tonnes (representing the GTA demand of 60 million tonnes per year less assumed continued shorter-haul imports to the GTA of 25 million tonnes per year from municipalities adjacent to the GTA).

The final stage of analysis included a detailed cost comparison and quantification of greenhouse gas emissions associated with each scenario. In addition to these quantifications, a comparative discussion of environmental and social impacts associated with each scenario is provided.

5.4 DESCRIPTION OF TRANSPORTATION SCENARIOS

Requirements for Redistribution Terminals

The final delivery of aggregate to user sites, whatever the origin of the material, must be done by truck. Most often, this means a smaller 3-4 axle dump truck capable of manoeuvring on rough ground and restrictive geometry of urban streets and construction sites. Therefore, it is assumed that a set of redistribution terminals located across the GTA would be required to complete the delivery of material to the job site. This is equally true for rail, marine and long distance truck transportation.

The key issue in defining the scenarios was to determine appropriate size and capacity for these redistribution terminals. Taking into account truck movement requirements, a 2 million tonne per year (average) facility was chosen for the long-haul trucking scenario. A number of these facilities would be required in order to deliver significant quantities of material to GTA job sites and reduce reliance on CTM sources in any meaningful way.

In the rail scenario, a redistribution terminal could support an average of 3 million tonnes per year because of the elimination of arriving larger, long-haul trucks. The difference in traffic generation (fewer trucks entering and exiting the redistribution terminal) creates more space to handle the delivered aggregate in the rail scenario.

For the delivery of 35 million tonnes per year (60% of GTA requirements), multiple (11-18) redistribution terminals would be required across the GTA. It is envisioned that such facilities would be located in industrial areas with good rail or highway access as appropriate, and some existing GTA-area aggregate production sites might also be converted to such a use. The capacity of individual sites would need to be determined on a case-by-case basis considering site area and the findings of a transportation study.

The redistribution terminals would be required to accommodate high volumes of incoming traffic to deliver the materials from distant sources, large areas to stockpile the variety of products required and shipping facilities to load, weigh and ship high volumes of materials to the GTA job sites.

The unit cost for terminal handling was assumed to be $2/tonne.

Annual Demand: 35,000,000 tonnes			Terminal Requirements for Varying Aggregate Production Levels — 35 t per truck, Delivered from north		23.5 t per truck, Sent out to local users					
Tonnes per Year through Terminal	Operating Days per Year	Operating Hours per Day	Tonnes per Day Arriving	Loaded Trucks[1] Arriving Per Day	Tonnes per Day Leaving	Loaded Trucks[2] Leaving Per Day	Total Trucks per Day (Loaded + Empty; Inbound + Outbound)	Total Inbound + Outbound Trucks per Hour	Headway between Trucks Entering / Exiting Terminal [s]	Number of Terminals Required
35,000,000	252	10	138,889	3,968	138,889	5,910	19,757	1,976	1.8	1
20,000,000	252	10	79,365	2,268	79,365	3,377	11,290	1,129	3.2	2
10,000,000	252	10	39,683	1,134	39,683	1,689	5,645	564	6.4	4
5,000,000	252	10	19,841	567	19,841	844	2,822	282	12.8	7
2,000,000	252	10	7,937	227	7,937	338	1,129	113	31.9	18
1,770,000	252	10	7,024	201	7,024	299	999	100	36.0	20
1,000,000	252	10	3,968	113	3,968	169	564	56	63.8	35
500,000	252	10	1,984	57	1,984	84	282	28	127.6	70

[1] Loaded Trucks Arriving Per Day: Assuming use of 6-Axle Triaxle Semi-Trailer with Payload = 35 t

[2] Loaded Trucks Arriving Per Day: Assuming use of 4-Axle Triaxle Truck with Payload = 23.5 t

Table 5.2 - Terminal Requirements for Varying Aggregate Production Levels

Note the fundamental difference between a redistribution terminal and an operating extraction site is that all material in a redistribution site generates two trips as it must arrive before it is sent out. If the terminal has aggregates delivered by ship or train, then trucking activity is limited to removing the aggregates from the site, but the marine and long haul trucking scenarios also include long-haul trucks arriving, either from the northern source, or from an intermediate port. For this reason, for a given level of truck traffic, a truck-only distribution site would handle less material than a producing extraction site.

For the purposes of this analysis as specified in the terms of reference, the Vaughan Corporate Centre (VCC) was selected as a representative location for the redistribution terminals in order to provide a common point of reference (see Figure 5.1). In reality, the redistribution terminals would be dispersed around the GTA to provide a more efficient distribution system and spread the volume of traffic.

Source Assumptions

The source of material for the long distance rail and truck scenarios was designated in the terms of reference as North Bay, to represent the potential for northern Ontario aggregate sources. No further detailing of where in the north the materials are to be extracted, or how they are moved to North Bay for shipment south was necessary in this scope as those elements would be common to all alternative scenarios.

For the marine shipping alternative, the designated origin source is Manitoulin Island. As is the case for the long haul and rail alternatives, the analysis starts at the loading facility which is the dock in the marine shipping alternative. The dock could be located at the pit or quarry location but as the volumes to be delivered increase there would be increasing amounts of material that would have to be delivered from inland pits and quarries to the dock location. This is not accounted for in the analysis.

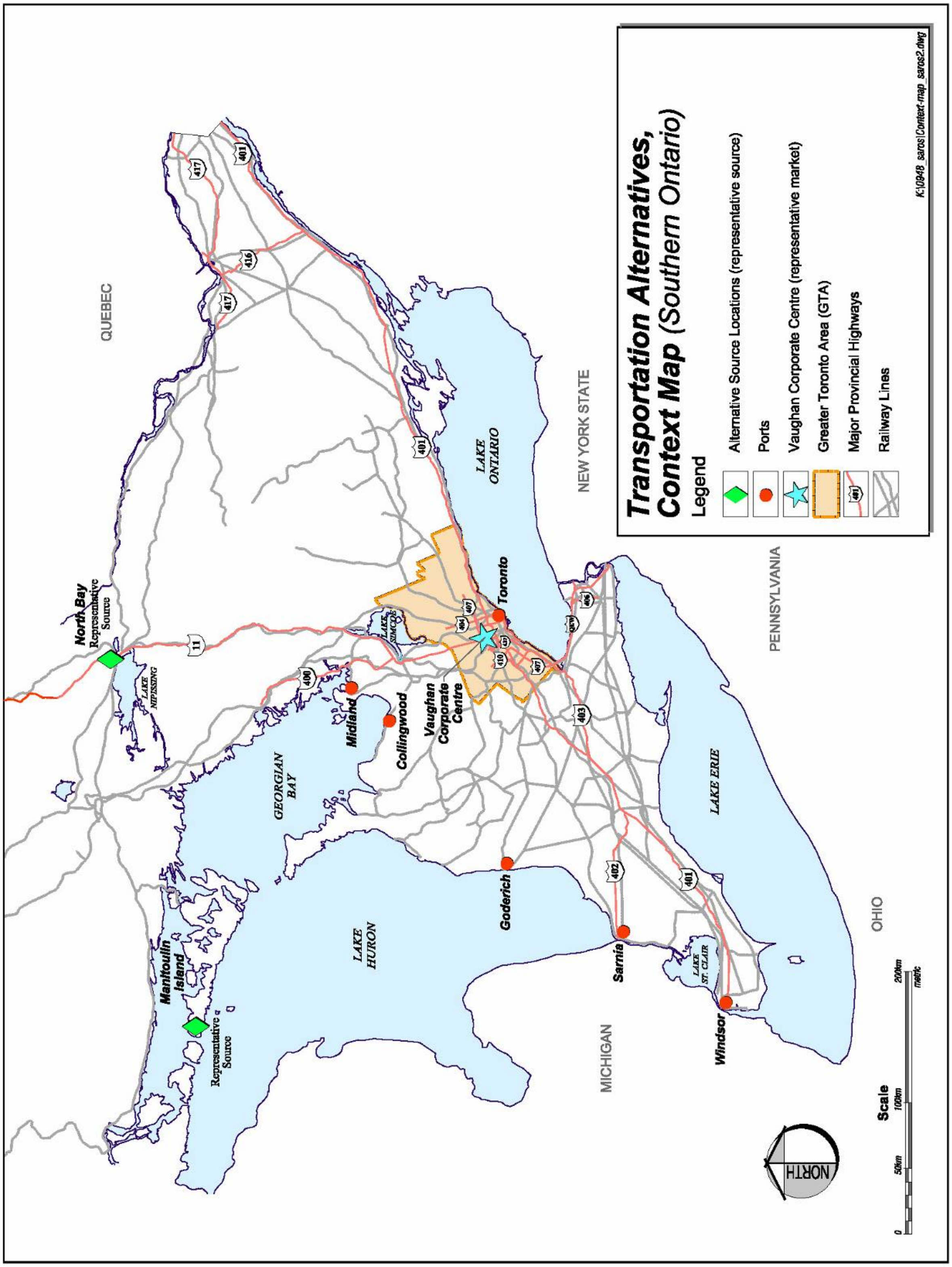


Figure 5.1 – Transportation Alternatives, Context Map

Long-Haul Trucking

The long-haul trucking option involves three nodes: the loading of material at a pit and quarry or redistribution terminal at the loading point in North Bay as specified in the terms of reference; the trucking transportation between North Bay and the GTA; and the redistribution terminal in the GTA.

Development of the long distance truck transport option included considerations such as:

- Common truck types used for long distance hauling of aggregate products;
- Capital costs associated with the trucking equipment, including tractors and trailers;
- Life cycle replacement of truck tractors and trailers;
- Vehicle operating costs, including drivers wages, licensing, insurance, maintenance (tires, repairs, cleaning and other) and fuel;
- Time and labour, including number of annual shipping days, travel distance, trip times, and loading/unloading times;
- Road infrastructure costs, including increased road maintenance, and capacity improvements where necessary; and
- Capital and operating costs for long haul to local delivery truck redistribution terminals at the southern end.

The first node is the quarry/stockpile in North Bay. The exact location of this source is undetermined, and indeed may be composed of several different sites in the general vicinity of North Bay, or even produced further north and shipped to North Bay. It is assumed that all truck trips originate at the Highway 11 / 17 intersection to provide a representative distance for this analysis. The end destination is assumed to be the Highway 400 / Highway 7 interchange which is intended to be representative of a GTA redistribution terminal.

The second node is the truck transportation from the remote source to the GTA redistribution terminal. There are several common truck configurations used for the long-haul transportation of aggregates in Ontario. For the comparison of long haul trucking with the other transportation modes, a tractor – triaxle semi-trailer combination with 6 total axles was selected as the common truck type. Each truck has a payload of 35 tonnes and is expected to cost approximately $265,000 in 2009 dollars for tractor and trailer. A cyclic pattern for fleet renewal would be required with tractors requiring replacement every 5 years and trailers requiring replacement every 8 years.

North Bay and the representative redistribution terminal are separated by approximately 320 km. The assumed travel route involves 245 km along Highway 11 (posted speed limit = 90 km/h) and 75 km along Highway 400 (posted speed limit = 100 km/h). Assuming that the trucks will operate at an average travel speed of 80% of the posted speed limit over the duration of the trip, it is estimated that each one-way trip between North Bay and the GTA redistribution terminal will take approximately 4.6 hours (including one 15-minute break).

Delivery of 35 million tonnes per year represents one million 35 tonne deliveries to the GTA each year. Taking into account seasonal distribution of deliveries and available shipping days, up to 5,000 truck trips per day per direction would be generated or 500 per hour travelling south on Highway 11 / 400 to the redistribution terminals.

Operating costs for the truck transportation include such elements as wages, maintenance, fuel, insurance, and overhead costs. Long-haul trucking would be anticipated to occur on 252 days each year (weekdays less holidays, year-round). The route and load/unload times are such that a single driver and truck can make the round trip in one day.

An important consideration is that there are some sections of the Highway 11 / 400 haul route for which this increase in truck traffic in combination with reasonable background traffic growth would mean highway widening will be necessary before 2020. Costs for this have been included in the calculations, on the assumption that the truck traffic will be constant over the 30-year horizon and that any additional widening which will be warranted due to traffic growth will therefore not be attributable to the aggregate haul route.

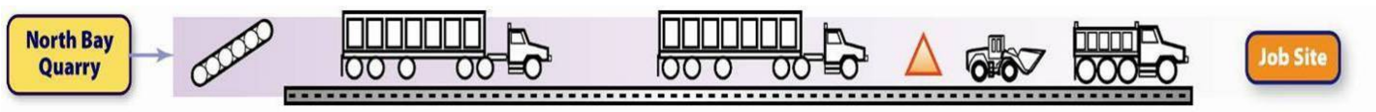
In recent years, there has been consideration of the potential operational and safety benefits of truck-only lanes or even truck-only highways. In combination with the existing truck demands, it may be advantageous to designate some lanes as truck-only. However, the additional cost for such a change has not been included in this analysis.

Road maintenance costs are expected to increase with the additional heavy truck traffic. The incremental cost of heavy trucks on road maintenance has been included based on a factor of $0.0204 per truck-km, in turn based on marginal cost estimates from the MTO.

The third node is the redistribution terminal or series of terminals that are required for storage and distribution of the aggregate to the local job sites. At the GTA redistribution terminal, aggregate would be unloaded from the long haul trucks, stockpiled for a limited time, and subsequently loaded into smaller trucks for transportation to local job sites. The terminal(s) would carry an expected capital cost of $3.5 million per million tonnes of redistributed aggregate.

The average delivery trip from the redistribution terminal to the job site is assumed to be 35 km and this is held constant (no increase) over the 30 year study period.

Long Haul Trucking – Summary Statistics



- Haul route consists of Highway 11/400
- Hwy 400 widening required at a cost of approximately $800 million
- Up to 5,000 truck trips per day per direction over a 10 hour day, roughly 500 per hour
- 9.6 hour round trip to and from GTA redistribution terminal including loading/unloading
- 5,000 new tractor trailer units required with replacement every 5 to 8 years
- 400% increase in truck traffic on Highway 11 in Huntsville
- 95% increase in truck traffic on Highway 11 at Simcoe Road 20
- 50% increase in truck traffic on Highway 400 at Highway 9
- Deliver to 18 GTA redistribution terminals with each terminal requiring roughly 6 ha (15 acres) of land with extended hours for operation and trucking activity
- Assume 35 km trip from redistribution terminal to job site
- Cost: $44.31 per tonne (2009 dollars)
- 12.73 billion litres of fuel
- 22.3 billion km driven
- 44.4 million tonnes of greenhouse gases

Rail:

The rail transportation option involves three nodes: the rail yard in North Bay; the rail transportation between North Bay and the GTA; and the GTA rail yard/redistribution terminal.

Development of the long distance rail transport option included the following considerations:

- Expansion and operation of the North Bay rail terminal including capital costs associated with expansion (additional land for stockpiles and new tracks) and operational costs associated with the daily operations of the terminal. Expansion requirements will include the construction of three new loop tracks for assembly of unit trains;
- Fleet considerations including rolling stock specifications, number of rail cars required, and capital costs;
- Time and labour, including number of annual shipping days, travel distance, trip times etc.;
- Availability of mainline rail capacity and competitive railcar transport rates;
- Capital costs required for the construction of rail-to-truck terminals at the destination end;
- Operating costs for the rail yard, rail transport, and redistribution terminal include such elements as wages, maintenance, fuel, insurance, and overhead costs.

Currently, there is a Canadian National Railway operated rail yard in North Bay. Railyard improvements would be required in order for the yard to handle the increased demand for aggregate, including the addition of loop tracks for railcar loading access.

At the North Bay origin site:

- Aggregate would be delivered to the terminal. Should one or more large aggregate extraction sites be located within a suitable distance (i.e. to make the installation economically viable) of the North Bay rail terminal, a rail spur between the quarry location(s) and the North Bay rail yard might be constructed if it were to minimize transport costs at the origin end, however that analysis is beyond the scope of this report and not included in the analysis.
- Terminal equipment would stockpile the aggregate.
- Terminal conveyors would load the railcars. All rail transport would be via unit trains consisting of 80 railcars each. The railcars would each have a capacity of 90 tonnes and would be bottom-unloading hopper cars with open tops. Capital costs for each railcar are estimated at $90,000, and they would be expected to have a service life of at least 30 years. Rail transport would also be expected to occur on 252 days each year (year-round).

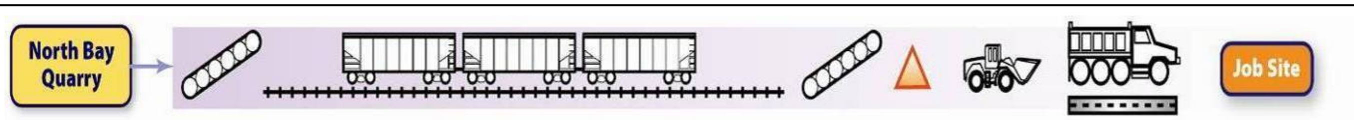
There were no assumed infrastructure improvements on the rail lines as the rail line provides a direct route. An 80-car train is more likely to fit on existing passing sidings than longer trains. A passing siding is akin to a passing lane on a one-lane road. A significant portion of the route between North Bay and the GTA redistribution terminal is single track with passing sidings.

At the destination site, trains would arrive at the terminal where aggregate would be unloaded from the bottom of each railcar into collection areas under the tracks. Aggregate would be transferred to stockpiles via terminal conveyors and front-end loaders. The trains would depart empty to return to the origin site.

A series of rail yards/redistribution terminals (number to depend on the traffic capacities of available sites) would be required in the GTA for storage and distribution of the aggregate to the local job sites. The terminal(s) would carry an expected capital cost of $3.5 million per million tonnes of redistributed aggregate.

The redistribution terminal expansions would consist of additional trackage, laydown/stockpiling area, and associated aggregate handling equipment (conveyors, front-end loaders, etc. Such improvements would be expected to require a footprint of approximately 40 hectares (100 acres).

Rail – Summary Statistics



- Expand CNR rail yard in North Bay with 40 ha (100 ac) footprint required for additional trackage, stockpiling, and aggregate handling
- Transport via 80 car unit trains
- 7,880 new rail cars required (bottom-dumping hoppers)
- 20 trains / day in each direction
- 12 GTA redistribution terminals required handling 3 Mt/y
- Redistribution terminals would require 10 ha (25 acres) of land for stockpiling and trackwork
- Cost: $17.66/tonne (2009 dollars)
- 5.5 billion litres of fuel
- 26.5 million tonnes of greenhouse gases

Marine:

The marine transportation option involves five nodes: the marine terminal at Manitoulin Island; the marine transportation between Manitoulin Island and the receiving ports; the marine ports for transferring aggregate from marine vessel to rail and/or truck; the trucking/rail transport between the ports and the GTA; and the redistribution terminal in the GTA.

Development of the long distance marine transport option included the following considerations:

- Expansion and operation of the Manitoulin Island marine terminal including capital costs associated with expansion, and operational costs associated with the daily operations of the terminal;
- Fleet considerations including vessel specifications, number of vessels required, and capital costs;
- Time and labour, including number of annual shipping days, travel distance, trip times, loading and unloading, etc.;
- Availability of suitable port facilities in southern Ontario, existing and potential future aggregate handling capacities with improvements;
- Costs associated with the expansion and operation of the receiving ports that have existing aggregate capacity and expansion potential (Goderich, Sarnia, Windsor, and Toronto) including considerations for over-winter stockpiling capacity;
- Costs and system requirements for overland transportation of aggregates from various ports to destination sites in the GTA (via truck and/or rail). Since most available ports are still quite far from the GTA destinations, it is assumed that an intermediate transport stage would be required to move material from the ports to local GTA redistribution terminals for loading on local delivery trucks. Only the Port of Toronto is sufficiently close to the GTA to realistically eliminate this stage, but due to its location in the middle of downtown Toronto, it was judged to have the least potential capacity for aggregate handling (based on land use and haul routes).

The 1992 “Aggregate Resources of Southern Ontario, A State of the Resource Study” identified issues related to the availability of Toronto Harbour port facilities and suggested that this be examined further. The current update took a closer look at port facilities and concludes that this is a significant limitation and real barrier to the delivery of any significant volume of aggregate to the GTA by ship.

The selection of destination port facilities to handle the material arriving from Manitoulin Island was identified as a critical element of the marine alternative. Through consideration of factors such as distance to Manitoulin Island, likely route, vessel size and speed, existing port facilities and depth, rail and road access, and expansion potential, four major ports were selected for use in the marine transportation scenario: Goderich, Sarnia, Windsor and Toronto. All four of these ports have existing aggregate handling facilities. However, it is anticipated that facility upgrades such as increased footprint for stockpiling, mode transfer equipment upgrades, and increased berthing capacity would be required at each port to handle the increase in delivered aggregate. Even with the foreseeable improvements, it is not expected that a combined receiving capacity of greater than 10 million tonnes per year could be achieved with existing ports.

It was concluded that only one million tonnes per year can be shipped through an expanded facility at the Port of Toronto. The port presently has maximum annual capacity of approximately 250,000 tonnes per year. Expansion opportunities are limited due to land availability for stockpiling and aggregate handling as well as limitations on the number of trucks that can logistically serve the port because of traffic congestion in the Toronto area. Other disincentives for the Port of Toronto are requirements for additional ships due to increased cycle time due to the long distance and potential for Welland Canal delays.

A detailed discussion of these and other port facilities was completed in support of this analysis and is included in Appendix C.

Since most of the ports available are not near GTA job sites (with the notable exception of Toronto, which is expected to be able to handle only up to one million tonnes per year with expansion), an additional transport stage would be required to move the aggregate to more centrally located redistribution terminals (as described in the other scenarios). It is possible that to some extent, direct trucking could occur from ports to job sites; this is expected to be limited due to the port locations. Instead, the aggregate would require transportation via some combination of trucking (medium-haul trucking) and/or rail (medium-haul rail) to the redistribution terminal in the GTA. In any case, the medium-haul transportation component will require similar system nodes to those outlined in the aforementioned long-haul trucking and rail transportation systems.

The determination that even expanded Toronto Harbour port facilities are unlikely to accommodate any significant volumes of aggregate and the need to consider further from market ports with additional rail or truck transportation to market significantly disadvantages the marine shipping alternatives and is reflected in significantly higher costs and GHG emissions.

The marine terminal at Manitoulin Island is currently equipped to handle 5 million tonnes of aggregate on an annual basis. Terminal capacity could be doubled with some infrastructure expansion. In particular, terminal footprint would need to be expanded to allow for greater stockpiling; two additional conveyors and four additional front-end loaders would be required for daily use; and equipment related to stockpiling would require purchasing (e.g. concrete barriers, roadways, scales, etc.). Shipping more than 10 million tonnes into the GTA market would require construction of entirely new ports and new quarries on Manitoulin Island or elsewhere around the shorelines of the Great Lakes or other locations.

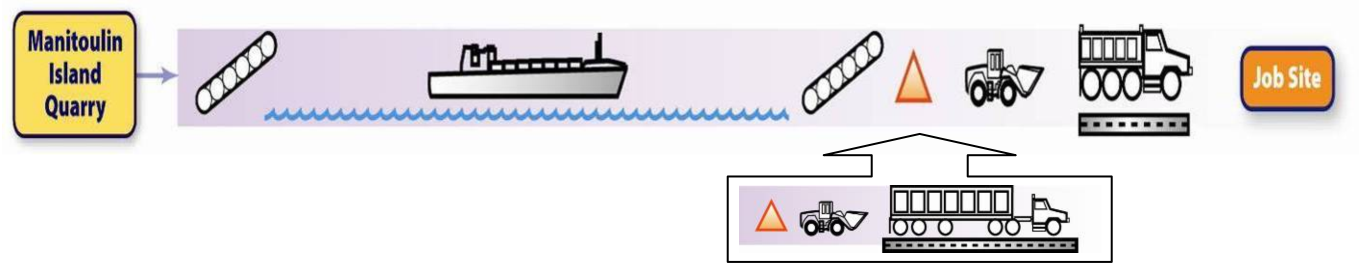
Marine transportation of the aggregate would occur on vessels with capacity of 25,000 tonnes each. Each vessel would cost $65 million in 2009 dollars. Operating costs of the vessels, including all fuel, wages, maintenance, etc., is expected to total $25,000 per shipping day for each vessel.

An additional complication of the marine mode that does not affect rail or trucking is the winter shut-down required due to conditions on the Great Lakes. Despite the decline in aggregate demand over the winter months, a considerable stockpile of aggregates will need to be accumulated in the destination ports over the shipping season to provide supply to users over the approximately 100 days in the winter months during which there will be no ships arriving. Storage space is often limited at job sites and for the purposes of this scenario, it has been assumed that the stockpiles would be maintained at the receiving ports, and the truck or rail leg of transport from the port to the urban area redistribution terminals would continue over the winter.

Accounting for reduced aggregate demand over the winter months, for 35 million tonnes per year to be handled by the marine mode, it is estimated that the receiving ports would need to have a stockpile of 3.7 million tonnes in place at the end of the shipping season to serve through the winter months. Using an estimate of 45,000 tonnes per hectare, over 82 hectares (203 acres) of additional area would be needed to store the aggregate necessary.

At the destination port, the ships arrive and dock 10 hours after departing the origin port on Manitoulin Island. The ship-based conveyor system would unload the ship into port stockpiles (note the need for over-winter stockpiles which is described below). Trucks or trains (as appropriate) would be loaded by 4-wheel loaders (approximately 5 hours to load an 80-car train). The loaded railcars are stored in the port's railyard and trains are assembled for pick-up by the serving railroad.

Marine – Summary Statistics



- 27 new vessels for 35Mt/y at $65 million each
- Significant expansion of the existing dock is required at Manitoulin and establishing at least 2-3 additional sources and large dock facilities on the Island or alternative shore
- Destination ports are assumed to be expandable to 10Mt/y, again new ports would be needed to go beyond this level
- Limited port capacities means several distant from market ports would be utilized and materials would be transported from ports to GTA redistribution terminals by truck or rail
- Approximately 82 ha (203 ac) of land at the destination ports will be required for over-winter stockpiling
- Multiple redistribution terminals required in and around GTA similar to long distance rail and truck scenarios as previously described
- Costs: $29.29 per tonne for marine-rail, $52.14 per tonne for marine-truck (2009 dollars)
- 7.7 billion litres of fuel for marine-rail, 13.7 billion litres for marine-truck
- 28.4 million tonnes of greenhouse gases for marine-rail, 47.3 million tonnes of greenhouse gases for marine-truck

Close to Market – Status Quo:

CTM trucking refers to the short-haul transportation of aggregates by trucking directly from local pits and quarries to the job sites. CTM trucking would be carried out using 4-axle dump trucks with 23.5 tonne payload capacities. The capital costs per truck would be approximately $140,000 (2009 dollars). Operational costs for short-haul trucking reflect those of long haul trucking with modified inputs (e.g. lower wages, etc.).

The current average haul distance for GTA CTM pits and quarries is estimated at 35 km. Even with strong implementation to achieve CTM supply this distance will increase over the long-term as the closest sites are depleted. To account for this, the CTM haul distance is increased to 45 km by the 2020 start of the analysis period, and thereafter by 0.5 km every year over the 30-year study period to 60 km by 2050.

No redistribution terminals are accounted for as the material can usually be delivered directly from the pit or quarry to the GTA job site.

- Distance from local quarry to job site starts at average 45 km in 2020 and increases to 60 km by the end of the 30-year study period
- Cost: $9.46 per tonne
- 2.7 billion litres of fuel
- 7,450 local delivery loads per day
- 14,900 new local delivery dump trucks purchased over 30 years
- 12,1 million tonnes of greenhouse gases

5.5 COMPARISON OF SELECTED SCENARIOS

5.5.1 Costs

Table 5.3 summarizes the costs per tonne (2009 dollars) for aggregate transport by each scenario described in Section 5.4. The cost calculation is not sensitive to varying the volume to be imported. Economies of scale are achieved at relatively low volumes of 2-3 million tonnes which represents a reasonably sized redistribution terminal. Increasing the tonnages to be supplied means additional terminals are required but the unit (per tonne) cost remains constant. Unit costs for the 10 million tonnes per year and 35 million tonnes per year scenarios were compared and are not significantly different.

Table 5.3 - Transportation Cost Comparison – Delivery to GTA

Scenario	2009 $ / tonne (transportation only)	Ratio to CTM
A Long Haul Trucking from North Bay	$44.31	4.7
B Rail from North Bay	$17.66	1.9
C Marine from Manitoulin (with supplemental rail from dock to GTA)	$29.29	3.1
D CTM pits and quarries	$9.46	1

It is important to note that in all cases, a good part of the expected GTA annual demand of 60 million tonnes per year is still produced at CTM sources, and this will likely be the case as long as local supply is available since transportation is such a large component of the total cost of aggregates.

Table 5.4 - Incremental Transportation Costs Over 30 Years

Scenario	@/10 MT/Year (300 MT delivered)	@ 35 MT/Year (1050 MT delivered)
A Long Haul Trucking	$10.5 billion	$36.6 billion
B Rail	$2.5 billion	$8.6 billion
C Marine	$6.0 billion	$20.8 billion
D CTM	Nil	Nil

Some additional observations and comments:

- Scenario A: which uses long-haul trucks results in nearly five times the transport cost of CTM.
- Scenario B: long-haul rail can be seen to be much cheaper than long haul trucking for this route at less than half the price per tonne, but still nearly double the cost of CTM.
- Scenario C: while marine is cheaper per unit distance over water, as soon as the cargo is landed it still needs to get closer to market, so the cost increases quickly as most ports are not convenient to market (with the exception of Toronto). Not only does this entail an additional unloading and reloading step at the port, but compounding the problem, when the additional transport is provided by rail, it can be at higher rail rates than those available for the North Bay to GTA route, due to the distances involved. When the additional transport from the port is undertaken by truck, the cost increases still further, resulting in the most expensive scenario of those examined. However, it is only marginally more expensive than the long-haul trucking from North Bay, so the marine option is not far beyond all others in price.
- Scenario D: CTM trucking is the most cost-efficient scenario as the distances involved are much shorter than those for other modes and no redistribution terminals or deliveries are required.

The magnitude of the additional costs and impacts are greater than in previous studies. This is attributable to the large distance between the remote source origin (assumed to be North Bay) and the GTA in the case of the rail and trucking alternative. In the case of the shipping option, the large magnitude of impact is attributable to the lack of available dock capacity in or close to the GTA and the need to incorporate a second stage of long distance haul from the dock to the GTA redistribution terminal.

In the unlikely event that the Port of Toronto capacity issues could be overcome, the costs associated with the additional land base transportation from destination ports into the GTA that is accounted for in the reported scenarios would be eliminated. However, offsetting increases would be incurred for additional ships due to increased cycle time associated with the longer travel distance and potential for Welland Canal delays. This scenario was not calculated but is estimated to still be above $20 per tonne delivery cost and more than double the cost of delivery from close to market.

For significantly larger aggregate quantities (i.e. complete replacement of GTA 60 million tonnes per year demand from remote sources), costs would increase:

- Most costs would increase more-or-less linearly with aggregate demand, such as number of trucks, fuel cost, etc.
- Some costs increase in a more stepwise manner as thresholds of capacity are crossed. For example, a new redistribution terminal would be needed for every one million tonnes per year

or so – it would not be economical to build smaller terminals to cope with minor increases in demand over the available terminal capacity.

- Highway capacity represents a larger threshold of capacity, in that one additional lane can support considerable additional traffic, but comes at a large price. As demand increases, widening of the highway would likely be warranted for more segments of the haul route, possibly even beyond the current ultimate planned cross-section for some locations. This would need to be examined in more detail to determine the impacts and whether or not additional routes would be needed to split the truck traffic demand

5.5.2 Greenhouse Gases

This Section presents the analysis of greenhouse gases (GHG) emission intensity (i.e., tonne of $CO_{2\ equivalent}$ per 1000 tonnes of aggregate) associated with each aggregate transport scenario. The analysis of GHG emissions efficiency was based on a simplified Life Cycle Analysis (LCA) of the transport scenarios, including a Life Cycle Inventory (LCI) of the main components with relevant carbon footprint in each scenario, followed by quantification of the GHG emissions. The entire quantification process is referred in this analysis as the GHG inventory (the Inventory).

For purpose of the Inventory, it was assumed that the production (i.e., extraction and processing) and final use of aggregate would have similar GHG intensity for all four transport scenarios. Therefore, the Inventory includes GHG emissions associated with aggregate transport from the sources to the job sites, as well as GHG emissions associated with material handling operations required for these transport operations.

Considering a life cycle perspective, the GHG inventory included emissions associated with the following components:

- Production and distribution of fuels consumed in vehicles and equipment used for transport and material handling operations;
- Production, disposal and recycling of vehicles and equipment used for transport and material handling operations;
- Production / re-treading of tires for trucks used in the transport operations; and
- Energy use during transport and material handling operations:
  - Direct GHG emissions resulting from fuel combustion in vehicles and equipment used for transport and handling operations; and
  - Indirect GHG emissions associated with generation of electricity consumed by equipment used for handling operations.

Emissions associated with electricity use and the first three items listed above comprise indirect GHG emissions. These emissions included in the Inventory are a consequence of the transport / material handling operations, but occur at sources not directly used for these operations.

Other potential indirect GHG emission sources associated with the life cycle of the transport scenarios have been identified but have not been quantified in the Inventory. These potential emissions sources include vehicle use for commuting of drivers and other technical personnel required for the transport operations, as well as vehicles, equipment use and production of materials used for road maintenance and to increase capacity of roads and redistribution terminals. It was considered that emissions from these sources would not have significant impacts on the relative emissions associated with each transport scenario.

The methodology used for quantification of the life cycle GHG emissions associated with the transport scenarios was based on:

- Guidelines for National Greenhouse Gas Inventories (2006) prepared by the Intergovernmental Panel on Climate Change (IPCC); and
- Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model, prepared by the Argonne National Laboratory, a division of the U.S. Department of Energy.

The quantification of life cycle GHG emissions associated with each transport scenario was carried out multiplying total fuel and energy use and vehicle and equipment requirements by the corresponding emission factors.

All scenarios were evaluated considering an annual demand of 35 million tonnes. It must be noted that the existing ports included in Scenarios C-1 and C-2 (Goderich, Sarnia, Windsor and Toronto) can only be expanded to a combined maximum total capacity of 10 million tonnes per year. Additional marine transport of aggregate would require construction of new ports, which are assumed to be equidistance from origin to destination. Therefore, for the purpose of the calculation, the additional capacity of new ports was distributed proportionately between the existing port locations. The construction of new port facilities would likely generate more GGH emissions per tonne as compared to expanding existing ports and this is not accounted for in the per tonne GHG intensity results. This simplification would not significantly affect the comparisons and conclusions.

Technical data provided to the MNR further explains the steps carried out in the quantification of the life cycle GHG intensities and provides detached calculation spreadsheets.

Table 5.5 - Summary of GHG emissions and intensities associated with the transport scenarios

Scenarios	GHG Intensity – Transport Total (t CO2e/1000 t agg.)	Ratio to CTM (Status Quo)
A: from North Bay via truck transport	44.4	3.67
B: from North Bay via rail transport	26.5	2.19
C-1: from Manitoulin Island via marine/rail transport	28.4	2.35
C-2: from Manitoulin Island via marine/road transport	47.3	3.91
D: from closest-to-market source (status quo)	12.1	1.00

Table 5.6 - Composition of the GHG emissions intensities - Transport and material handling operations

Scenarios	GHG Intensity - Transport	GHG Intensity - Material Handling	GHG Intensity - Transport Total
	(t CO2e/1000 t agg.)	(t CO2e/1000 t agg.)	(t CO2e/1000 t agg.)
A: from North Bay via truck transport	41.5 (93.4%)	2.9 (6.6%)	44.4 (100%)
B: from North Bay via rail transport	23.0 (86.8%)	3.5 (13.2%)	26.5 (100%)
C-1: from Manitoulin Island via marine/rail transport	26.2 (92.4%)	2.2 (7.6%)	28.4 (100%)
C-2: from Manitoulin Island via marine/road transport	44.8 (94.7%)	2.5 (5.3%)	47.3 (100%)
D: from closest-to-market source (status quo)	10.9 (90.2%)	1.2 (9.8%)	12.1 (100%)

Table 5.7 - Composition of the GHG emissions intensities - Life cycle

Scenarios	GHG Intensity - Fuel / Energy Consumption	GHG Intensity - Fuel Production	GHG Intensity - Equipment/ Materials Life Cycle	GHG Intensity - Transport
	(t CO2e/1000 t agg.)	(t CO2e/1000 t agg.)	(t CO2e/1000 t agg.)	(t CO2e/1000 t agg.)
A: from North Bay via truck transport	35.0 (79.0%)	7.4 (16.7%)	1.9 (4.3%)	44.4 (100%)
B: from North Bay via rail transport	21.2 (80.0%)	4.2 (16.0%)	1.1 (4.0%)	26.5 (100%)
C-1: from Manitoulin Island via marine/ rail transport	22.0 (77.5%)	4.5 (15.7%)	1.9 (6.8%)	28.4 (100%)
C-2: from Manitoulin Island via marine/road transport	36.8 (77.7%)	7.8 (16.6%)	2.7 (5.7%)	47.3 (100%)
D: from closest-to-market source (status quo)	9.5 (78.2%)	2.0 (16.6%)	0.6 (5.2%)	12.1 (100%)

Figure 5.2 - Composition of GHG emissions intensities – Transport and Material Handling

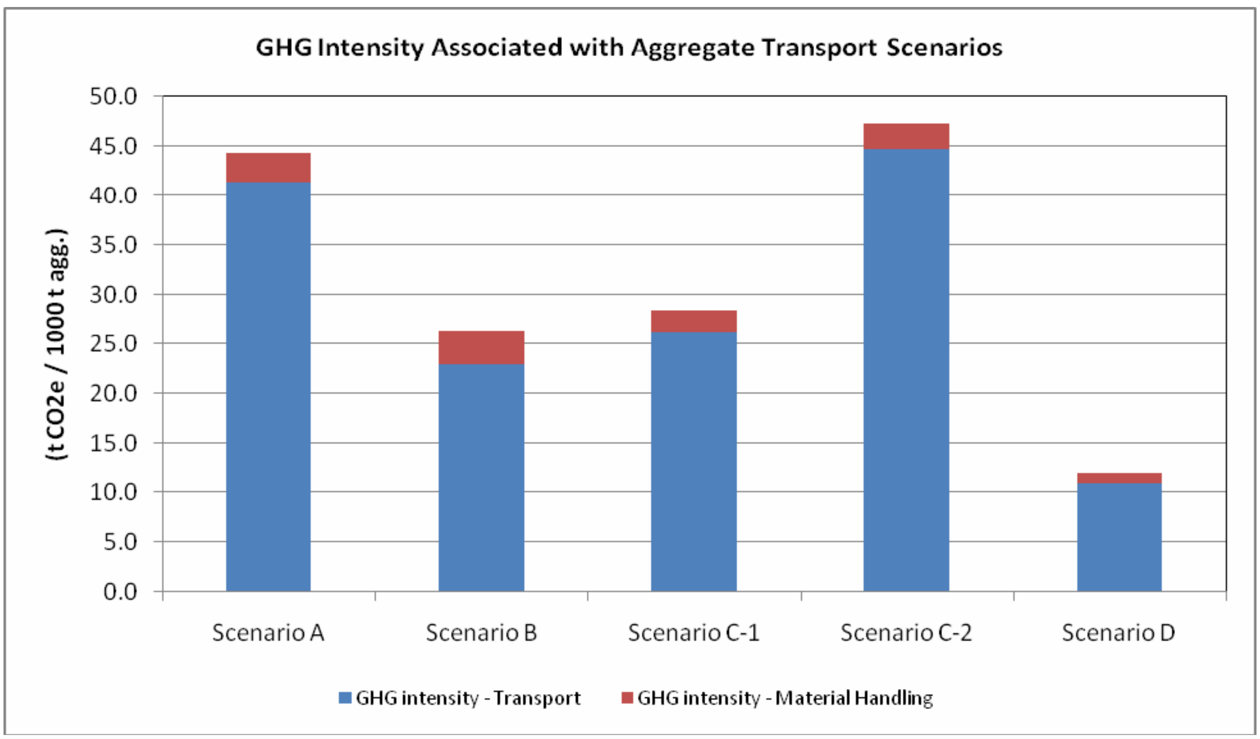


Figure 5.3 - Composition of the GHG emissions intensities - Life Cycle

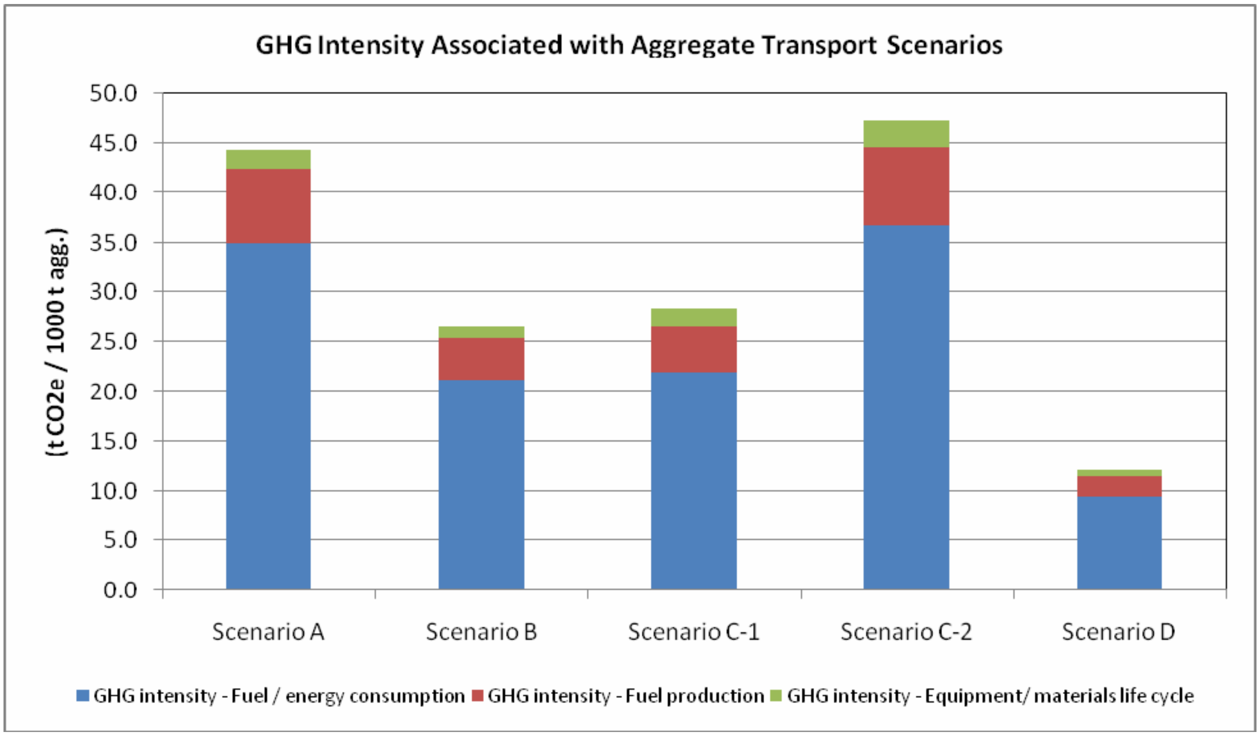


Table 5.8 - Incremental Greenhouse Gases Over 30 Years	
Scenario	**@ 35 MT/Year (1050 MT delivered) (t CO2e)**
A Long Haul Trucking	33.9 million tonnes
B Rail	15.1 million tonnes
C1 Marine via Rail	17.1 million tonnes
C2 Marine via Truck	37.0 million tonnes
D CTM	Nil

Results

The results indicate that all alternative scenarios assessed would lead to significant higher life cycle GHG emissions when compared to the CTM status quo scenario (Scenario D). The main reason is the significant increase in the transport distances in the alternative scenarios, since the sources of aggregate would be more distant from the job sites. Although railcars and vessels present lower GHG intensities per km than trucks, the overall efficiencies of scenarios using these transport modes are decreased due to the necessity of additional truck transport.

GHG emissions not quantified in the inventory, including that associated with additional construction and maintenance of structures (e.g., roads, redistribution terminals), would be higher for the alternative scenarios than for the status quo, increasing the difference between GHG intensities associated with the CTM Scenario D and the alternative scenarios.

Material handling emissions in the alternative scenarios would be significantly higher than in the status quo scenario due to the additional handling operations resulting from additional transport segments/modes and an additional intermediate storage area at the redistribution terminal. The material handling, however, comprise a small portion of the total GHG emissions intensities.

Considering a life cycle perspective, the main contribution to the GHG emissions intensities would be the fuel consumption, which is expected considering the large amounts of fuels (i.e., energy) required to transport the aggregate material from the sources to the job sites. Due to the large amount of fuel required, the contribution of fuel production and distribution for the life cycle GHG emissions is also significant. The contribution of life cycle emissions associated with production of vehicles and equipments is relatively small, mainly because their long use before replacement is required.

It must be noted that the calculation of GHG emissions intensities associated with the transport scenarios was based on current fuel / energy efficiencies and emission factors. It is expected that fuel and energy efficiencies will improve with time, resulting in lower emission intensities for the transport scenarios examined. Eventual future use of hybrid and/or electric vehicles and equipment could also lead to lower emissions intensities. Increasing participation of low GHG intensity power generation sources would result in lower grid emission factors, reducing the GHG intensities related to direct electricity use (e.g., conveyors) and indirect use (e.g., production of vehicles and equipments). Quantification of future improvements in fuel efficiencies and changes in emission factors were not included in this analysis due to the level of complexity and uncertainty involved in this type of long-term projections (from 2020 to 2050).

5.5.3 Other Environmental Considerations

The popularization of reducing societies' environmental footprint by reducing consumptive habits and sustaining ourselves on locally produced goods and services[11] provides a relevant context for consideration of other environmental factors associated with long distance transportation of

[11] See for example the "100 Mile Diet: A Year of Local Eating" Endorsed by Dr. David Suzuki as "maybe one of the most important ways we save ourselves and the planet". Note than an average person in Ontario consumes approximately one tonne of food per year and 14 tonnes of aggregate.

aggregate to market. In addition to the emission of greenhouse gases discussed in Section 5.5.3, there would be additional environmental consequences associated with the consumption of resources and manufacturing processes necessary to produce and maintain the vessels, facilities and infrastructure that are required to implement the alternative far from market systems considered in this analysis. For example, the long distance trucking scenario would require an additional 854,682 tires over the study period.

The other main environmental difference between the assessed alternatives would be environmental implications associated with the construction of additional infrastructure to accommodate the handling and movement of aggregate from distant sources. The impacts of new or expanded origin and destination docks, additional lanes of highway, new rail lines, new redistribution terminals, etc. are all incremental environmental impacts that are over and above what is required to deliver from CTM job sites to the GTA market.

At the local level in Southern Ontario, there would be no environmental benefit to an extraction site further from market over a CTM extraction site. Significant environmental features and functions are protected in either case. In areas north of the Canadian Shield (as shown on Figure 1 in the Provincial Policy Statement), there are more permissive policies for development and site alteration in natural heritage features.

Shifting to long distance sources would phase out pits and quarries, which are an interim land use with associated after-use opportunities and replace them with redistribution terminals which would be a more permanent land use. Rehabilitated CTM pits and quarries can provide agricultural, environmental and recreational benefits for a growing population in the GGH. Thousands of acres of publicly accessible greenspace in and around the GTA are derived from former extraction sites. Examples include the Royal Botanical Gardens in Hamilton, Burlington's Kerncliff Quarry, Kelso Quarry Park in Milton, Don Valley Brickworks in Toronto and numerous other conservation areas and recreational facilities such as golf courses and city parks.

5.5.4 Social Considerations

Each of the evaluated transportation alternatives will have effects on people who live, work and recreate in the vicinity of the associated extraction site, transportation routes and redistribution terminals. These effects are controlled and mitigated in Ontario by various environmental and land use legislation, policy and regulations, guidelines and best management practices.

On a macro-scale comparative basis, the differences in social effects between the options can be evaluated based on the nature, length, duration and location of the transportation stage and the need for additional redistribution terminals as well as secondary transportation stages required for each scenario.

Comparison of social impacts should consider size, volume and number of operations and associated transportation facilities. The current CTM system would tend to disperse impacts among somewhat smaller facilities as compared to the long distance alternatives assessed in this study which would tend to have larger facilities with concentrated haul route effects. Generally the distribution terminals considered in this analysis would handle an average of 2-3 million tonnes per year whereas an average pit or quarry operation in the GTA maybe smaller. Despite the smaller size, the impacts on adjacent uses at the site level are probably similar because both facilities would strive to meet Provincial guidelines and regulatory limits.

The CTM pits and quarries are often grouped together due to the geological distribution of the resource. As a result, there is potential for cumulative effects that could offset the benefit of the smaller operations on a comparative basis. At the transportation stage, there is also a dispersed vs. concentrated consideration to apply. The CTM model disperses traffic to a greater extent than the long distance alternative which would tend to focus traffic volume on fewer routes. There are offsetting considerations and the pros and cons of dispersed vs. concentrated are debatable. Actual social impact will be determined by good planning and operational practices. For the purposes of the following discussion, it is assumed that the two key variables to compare at a macro scale are distance travelled (longer routes affect more people – both travelling public and adjacent residents) and, the need for additional facilities (such as docks or redistribution terminals).

In order to compare social impacts, four areas of potential impact are realized and discussed for each mode. These are:

- Impacts that occur at the extraction site;
- Impacts that occur along the primary transportation route from the extraction site to the job site or redistribution terminal (as applicable);
- Impacts associated with activities at the redistribution terminals (not applicable for CTM); and
- Impacts of secondary transportation from redistribution terminals to the job site (where applicable).

At the extraction site, it is reasonable to expect lower social impacts because there is a good possibility that fewer people are affected at remote extraction locations. These sites would typically (but not necessarily) be located in areas with lower rural population densities where larger properties are available for assembly and buffer functions. This is not to say that more remote extraction sites are not without their own controversies. Recent experience with such applications suggests that they can also be vigorously opposed by local populations and outdoor enthusiasts.[12]

The social impacts along the primary transportation routes would be especially low for the marine shipping options where very few people or communities would be affected on route. On the other hand, social impacts along primary transportation routes would be higher for long distance truck and rail options as compared to the CTM status quo. This simply reflects the fact that more residents and communities would be affected by the longer distances traveled. These effects include noise and dust associated with vehicular traffic and potential for traffic congestion due to additional truck kilometres and / or at grade railway crossings. The effects of the CTM status quo are dispersed / diluted across wider areas whereas the impacts along rail lines or key highway links for long distance sources would be more concentrated.

There is a direct correlation between social impacts affecting the travelling public and total

[12] See Superior Aggregates (Wawa) OMB Decision (July 15, 2009 – PL040025)

kilometres travelled. Accident rates and traffic delays are significant social considerations that are directly related to numbers of vehicles on the road and total kilometres travelled. The most effective means of reducing highway accidents and traffic congestion is to reduce the kilometres travelled and there are very significant differences in the alternatives considered.

At a collision rate of 165 per million vehicle kilometres[13], the incremental effect of delivering just 10 million tonnes per year by long haul truck as compared to delivery from CTM sources would be approximately 9,950 additional collisions including nearly 32 fatalities over the 30-year study period.

These types of incremental impacts do not apply to shipping and rail alternatives which would have similar order of magnitude effects as compared to CTM pits and quarries taking into account the need for redistribution terminals and delivery to the job site.

For the long haul trucking scenarios (and also applicable in principle to the medium-haul trucking from ports to redistribution terminals), there would be social impacts in the form of increased noise from trucking. However, for the main haul route from North Bay to the GTA, with the requirement to upgrade the entire route to a minimum of a 4-lane divided highway, likely with grade separations at most or all intersections, the exposure of residents would be somewhat limited.

There would be new social impacts at the redistribution terminals associated with the long distance trucking, rail or marine shipping alternatives. These impacts include truck traffic and on site noise, dust and visual impacts related to storage, handling and the potential processing / blending of aggregate materials. The marine shipping alternative has an additional social impact where industrial docks could conflict with residential and recreational uses along the waterfront. These docks and redistribution terminals are not required for the CTM status quo. The degree of impact would be dependent on the location, design and operating practices.

The impacts of transportation from the redistribution terminals to the job site also have to be accounted for and would be higher for the long distance truck, marine shipping and rail scenarios because this stage generally does not apply to CTM status quo. In a comparative sense, these impacts would be generally equivalent to the initial effects of the primary transportation route from the CTM pit or quarry to the job site.

Accordingly, the social impacts of alternative delivery systems from long distance sources would be greater than continued delivery from status quo CTM. The potentially higher social impacts of extraction at the CTM extraction site would be partially offset by the impacts associated with redistribution terminals located in urban or near urban rural settings. The social impacts associated with haulage from CTM extraction sites generally equates to the impacts of the secondary transportation stage from redistribution terminals to the job site. On a net basis, the incremental social impacts associated with the alternative long distance scenarios are mostly attributable to the impacts that occur along the transportation routes. These would be significantly greater for the truck and rail system as compared to marine shipping. In terms of ranking based on social impacts, the preferred option overall is dispersed CTM followed by marine, rail and long distance trucking.

[13] This is a crude estimate of the impact based on the most recent MTO Provincial collision rates (Ontario Road Safety Annual Report, 2006) and average rates for all roads in the Province whereas the haul route would be on the highest order of roadway which typically have considerably lower collision rates than this average.

5.6 HOW WOULD THIS BE ACHIEVED?

While the preceding analysis has demonstrated significant economic, social and environmental benefits of maintaining and implementing a CTM supply policy, the following discussion is provided in order to illustrate some of the implementation barriers that would exist should government decide to pursue long distance alternatives.

It should be recognized that significant government intervention in the market place would be required in order to achieve any meaningful shift away from the CTM sources. As indicated in the cost comparison, there are strong market forces encouraging CTM supply points given the significant implications on the delivered price of transporting materials from further away. As noted, there are also significant environmental and social benefits associated with this policy.

Simply changing the policy direction would not be sufficient to achieve any significant shift as market forces would ensure that a competitive industry would continue to seek out and licence the closest to market sources in order to gain competitive market advantage.

In order to achieve “far from market” supply, price modification (subsidies or penalties) would be required or applications for new or expanded CTM operations to supply aggregate to the GTA would presumably be prohibited. CTM pits and quarries now supplying the GTA would be allowed to deplete. Current applications and investments that have been made in order to implement the current CTM policy direction would either be allowed to continue under the current policy regime or discontinued with compensation in order to speed up the transition to the more expensive alternatives.

Pits and quarries on the periphery of the GTA would still operate to supply local markets (or, in the scenarios presented above, supplement the long distance importation). There would have to be strict enforcement of market areas and sales so that these closer to market sources were not allowed to compete with the long distance alternatives.

The Provincial government may also have to be prepared to facilitate and accelerate the approval of new far from market sources, transportation infrastructure and redistribution terminals. Such measures could include use of expropriation to secure necessary land, accelerating infrastructure approvals and eliminating the need for municipal land use control.

5.7 SUMMARY

Previous transportation studies and reviews have highlighted the social, economic and environmental benefits of Ontario’s CTM supply strategy. Significant barriers and negative implications of shifting supply to more distant sources have been previously identified. Ontario has pursued a CTM strategy and developed its policy and legislative framework accordingly over the past 40 years.

The results of the transportation component of Paper 2 confirm that there would be significant economic, environmental and social implications of shifting away from the CTM policy in favour of importation from long distance sources for the GTA market.

- The delivery cost would more than double. Delivery from CTM pits and quarries is by far the most economical scenario given the much smaller distances traveled and the opportunity for direct delivery from source to job site.

- Replacing CTM supply with imports from sources further from market would significantly increase greenhouse gas emissions.

- As noted in previous studies there is no identifiable environmental benefit of extracting aggregate at a pit or quarry located further from market. Significant natural features and functions are protected and further from market. In areas north of the Canadian Shield, there are more permissive policies for development and site alteration in natural heritage features. There are however, additional negative environmental impacts associated with long distance haul alternatives. In addition to greenhouse gases, there are environmental consequences associated with consumption of resources and manufacturing processes necessary to produce and maintain transportation vessels, facilities and infrastructure.

- Social impacts of alternative delivery systems from long distance sources would be greater than continued delivery of status quo CTM.

- Significant government intervention would be required in order to shift away from CTM sources. This would include market interventions and compensation, expropriation and overriding municipal land use controls.

- Implementing an alternative far from market supply strategy would require significant capital investment and construction for new infrastructure, vehicles and facilities. This would take years to achieve and close to market sources would continue to be required in the interim and phase-in periods.

The analysis has identified real barriers to replacing CTM supply with long distance sources. This is particularly true in the case of shipping where port capacities are restricted and expansion opportunities limited. In the case of long distance trucking, the existing road infrastructure (Highway 11 / 400) would be over capacity with the increase in truck traffic. In the case of rail, there is the need for multiple redistribution terminals in the GTA along rail lines.

The results of the assessment should not be taken as a conclusion that some long distance importation by rail or ship is not feasible, appropriate, cost-effective or environmentally inappropriate. Smaller quantities and/or rail from closer sources, may well prove to be viable and in fact are currently occurring or under consideration. However, it is reasonable to conclude that there are strong economic, environmental and social reasons why the alternative scenarios will not take the place of CTM sources and short haul delivery.

The results of this review confirm that extracting aggregates close to where they are utilized is the most environmentally sensitive alternative and also has significant social and economic benefits.

6.0 CONCLUSIONS

This component of the MNR SAROS update has reviewed the basis for and evolution of Ontario's close to market aggregate supply strategy. The literature review identified similar policy approaches and rationale in other parts of the world. The constraints analysis demonstrates that many Ontario aggregate deposits occur in close proximity with environmental features, agricultural and other constraints.

Large-scale extraction of aggregate resources from any source or location and the associated processing and transportation of products to market necessarily involve the use of heavy machines and large vessels to transport a heavy, high bulk material to the job site. None of the alternative sources, mining methods or transportation modes that have been reviewed can resolve the need for such activity in some form or another. As recently observed in a research paper reviewing Ontario aggregate issues, those who suggest alternatives as a solution to land use conflicts are destined to be disappointed[14].

<u>Aggregate Resource Management and Supply:</u>

Ontario has elected to pursue a CTM supply policy. This approach is representative of sound economic, social and environmental policy for the following reasons:

- Extracting the resource close to where it is being utilized is in keeping with the principle of sustainable development and avoids unnecessarily transferring impacts to other jurisdictions.
- The cost of transportation currently represents 60% of the total cost of aggregate and extraction further from market will increase the price. Ontario has benefited socially from CTM sources thereby providing affordable infrastructure and housing costs.
- Reducing the distance between the aggregate source and the job site reduces greenhouse gas emissions which is one of the top environmental concerns today.
- Rehabilitated pits and quarries restore agricultural use, natural heritage features and are providing essential public open spaces that are in high demand as the GGH continues to grow and intensify.
- Existing planning policy already protects some of the most significant environmental areas in Southern Ontario. For example, 70 % of the Niagara Escarpment Plan Area and over 50 % of the high potential aggregate areas in the Oak Ridges Moraine Conservation Plan Area cannot be considered for new or expanded mineral aggregate operations.

<u>Close to Market Research:</u>

Section 2 of this Paper examined other jurisdictions and their approach to mineral aggregate resource policies, specifically close to market considerations. The purpose of this research was to identify other developed countries that have adopted a policy approach comparable to Ontario.

[14] CUI (2009), "Between Rock and a Hard Place", p. 29

- Historically, the most common factor for incorporating CTM policies was the need to ensure aggregate materials were available as economically as possible to the demand areas.

- Where jurisdictions did not have general policies that guide the location of aggregate extraction, market forces primarily prevailed. Despite the lack of a consistent policy framework, traditional industry practices and market forces cause operators to locate CTM where such deposits exist.

- Some jurisdictions support long distance transportation when local availability/supply is limited or does not exist or based on other factors (e.g. tourism, preservation of natural features).

Several examples of jurisdictions that adopt a CTM policy approach with similar environmental and economic rationale have been identified. Only a few jurisdictions promote importation of aggregate, most jurisdictions only import aggregate when local availability/supply is limited or simply does not exist.

Planning, Environmental and Agricultural Constraints Analysis

Section 3 of this Paper examined the planning, environmental and agricultural constraints that affect aggregate availability. Based on this analysis it was concluded that:

- Mineral aggregate deposits are fixed in location and must be extracted where they naturally occur.

- Mineral aggregate deposits by their very nature, are found in rivervalleys, outwash plains, limestone plains, eskers, kame and moraines. These landforms contain wetlands, woodlands, agriculture and water features.

- Based on a desk top mapping exercise, 20 constraints were applied and 93 % of the selected bedrock area has overlapping constraints. Of the remaining 7% that did not have overlapping constraints, 91% of this area is located within Study Area 5 and 6 (Eastern Ontario).

- In addition to the 20 constraints that were applied there are numerous other factors that have to be considered in determining whether the deposit area can be assembled and made available to supply mineral aggregate needs.

- Aggregate operations are a space intensive use and due to the extent of overlap of competing uses the majority, if not all sites will have competing land uses on or adjacent to the aggregate deposit.

- Without an integrated and balanced approach it is unlikely that an aggregate deposit could be assembled and made available since there is a high probability of on-site and adjacent evironmental, agricultural and water resources to consider.

- Based on the constraint analysis, the majority of other features are located outside of the selected bedrock resource area. For example: 95% of ANSI, 91% of significant woodlands, 93% of all wetlands and 96% of prime agricultural lands are located outside of selected bedrock resource areas.

Feasibility of Alternative Sources of Aggregate:

Section 4 of this Paper provided for consideration of alternative sources of aggregate, other than close to market (CTM) supply, to meet Ontario's long-term availability and supply objectives. The five alternative sources considered were:

- use of mine tailings;
- sand production from lake dredging;
- crushed stone supply from underground limestone mining;
- crushed stone supply from a mega-quarry; and
- use of manufactured sand.

The purpose of this research and review of past feasibility studies was to determine the feasibility of the alternative sources with respect to economic, social and environmental implications.

Dredging, mine tailings and manufactured sand were considered to have a poor feasibility, with higher production/delivery costs being a common factor. Mine tailings are located at distant locations, and provide challenges due to their potential for environmental contamination and their physical properties which can make certain wastes unsuitable for aggregate use.

Sand dredging, from the Great Lakes, has occurred in the past but there has been no activity in recent years. The need for significant land-based infrastructure, quality concerns and environmental issues resulting from the marine extraction environment are all significant constraints to the development of this alternative source, particularly in areas where sufficient land-based sand deposits are still available.

Manufactured sand was considered to be of applicability in regional areas based on specific geological criteria and access to highly-developed processing facilities.

Of the five options considered, mega-quarries and underground mining were found to have the strongest feasibility. These sources would only supplement the supply of crushed stone aggregates and not completely replace supply from traditional quarries.

There are advantages and disadvantages to both alternatives, as compared to the existing surface quarry approach. Issues related to proximity to market and impacts of surface activities, primarily processing and trucking, that cause social concerns today under the present system would still remain. Further, even with the potential utilization of the alternative sources, the need for traditional supply from quarries (and pits) in close to market locations will still play a critical role for high demand market areas such as those in Southern Ontario.

Feasibility of Alternative Modes of Transportation:

The transportation analysis concludes that there would be significant economic, environmental and social implications of shifting away from the CTM policy in favour of importation from long distance sources for the GTA market.

- Alternative transportation systems supplying aggregate to the Greater Toronto Area were examined including marine, rail and long distance trucking. To transport 35 million tonnes per year by long distance trucking from North Bay to the Vaughan Corporate Centre (VCC), approximately 5,000 tractor-trailer units (capacity of 35 tonnes) will be required. To transport the same amount by rail from North Bay to the VCC, approximately 7,880 new railcars (capacity of 90 tonnes) will be required. To transport aggregate by ship from Manitoulin Island to the VCC will require 27 vessels handling 25,000 tonnes each. Marine transportation will require a diversion to rail or truck once the vessel has landed in Southern Ontario.

- CTM truck transport is the most cost-efficient scenario for aggregate transport ($9.46/tonne) followed by rail ($17.66/tonne), marine to rail ($29.29/tonne), long distance trucking ($44.31/tonne) and marine to trucking ($52.14/tonne).

- The social impacts of alternative transportation systems from long distance sources would be greater than the continued delivery from CTM sources. The potentially higher social impacts of extraction at the CTM extraction site would be offset by the impacts associated with long distance haul and redistribution terminals located in urban or near urban settings.

- The greenhouse gases (GHG) emission intensity analysis for each alternative transportation system indicated that all alternative systems would lead to significantly higher life cycle GHG emissions when compared to the existing CTM scenario.

- The increase in transport distances significantly affects the GHG emissions for each alternative system. Although rail and marine transportation present lower GHG intensities per kilometer than trucks, the overall efficiencies of using rail and marine are decreased due to the necessity of additional truck transport to the end user.

The analysis has identified real barriers to replacing CTM supply with long distance sources. This is particularly true in the case of shipping where port capacities are restricted and expansion opportunities limited. In the case of long distance trucking, the existing road infrastructure (Highway 11 / 400) would be over capacity with the increase in truck traffic. In the case of rail, there is the need for multiple redistribution terminals in the GTA along rail lines.

The results of the assessment should not be taken as a conclusion that some long distance importation by rail or ship is not feasible, appropriate, cost-effective or environmentally inappropriate. Smaller quantities and/or rail from closer sources, may well prove to be viable and in fact are currently occurring or under consideration. However, it is reasonable to conclude that there are strong economic, environmental and social reasons why the alternative scenarios will not take the place of CTM sources and short haul delivery.

The results of this review confirm that extracting aggregates close to where they are utilized is the most environmentally sensitive alternative and also has significant social and economic benefits.

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8.0 APPENDICES

A Project Team Members

B Planning, Environmental and Agricultural Constraints Mapping

C Port Facilities Review

APPENDIX A – Project Team Members:

MHBC Planning

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Neal DeRuyter
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Adrian Cammaert

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Don Cleghorn – Project Manager, analysis & documentation
Darryl Spencer – trucking research, analysis & documentation
Tom Young – rail and marine analysis & documentation
Mark Hemphill – rail research & assessment
Jeff Monroe – ports research & assessment
Fred Kramer – economist

Golder Associates (Section 4)

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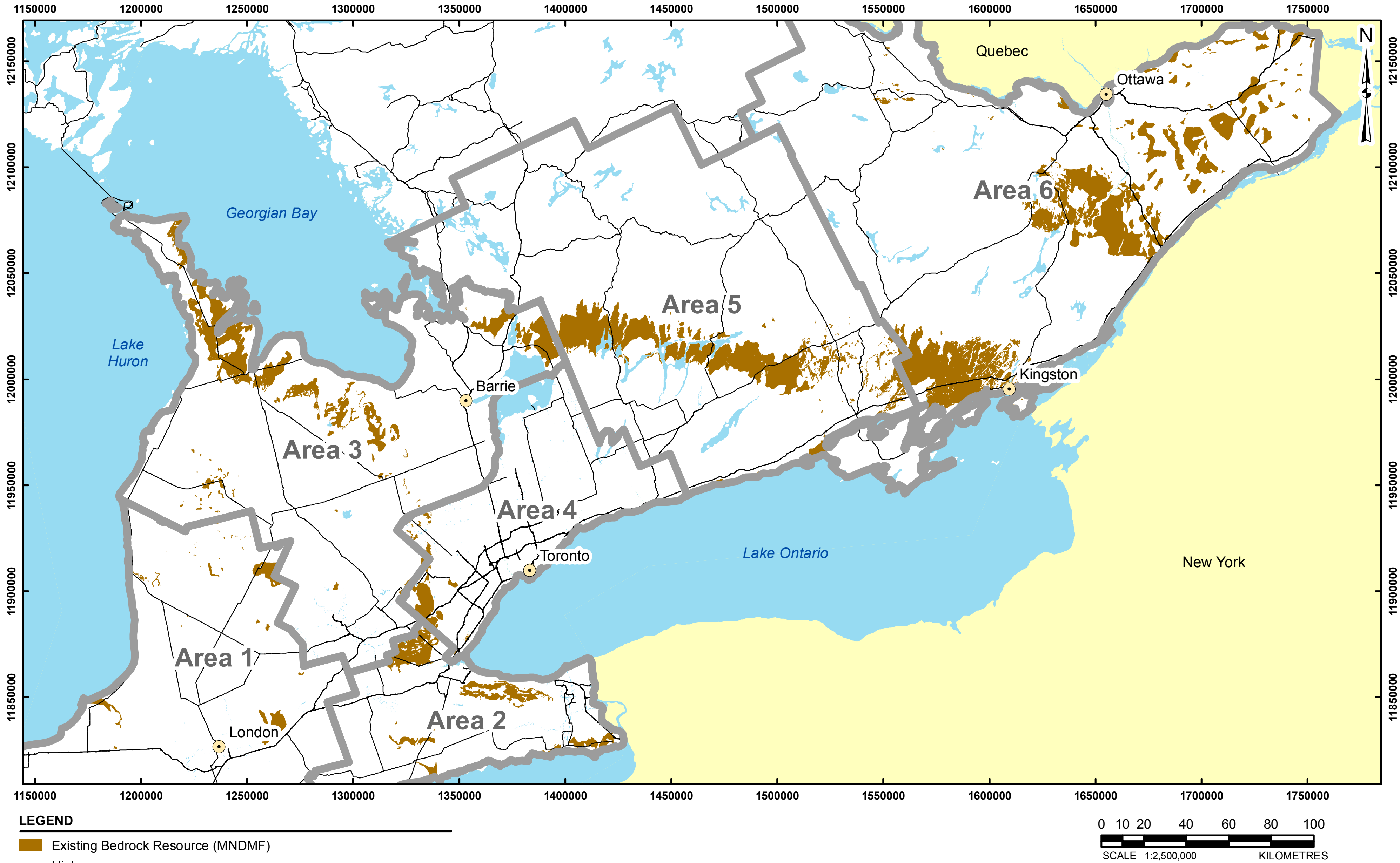
David Hanratty – reviewer
John Petrie – senior reviewer
Cathy & Will Pitman – underground ground mining section author
Antonio Freitas – GHG emissions section author

LVM-JEGEL (Section 4)

Alain Duclos
Michael MacKay



LEGEND

- Existing Bedrock Resource (MNDMF)
- Highway
- Aggregate Area Boundary
- Waterbody

REFERENCE

Base Data - MNR NRVIS, obtained 2009, CANMAP v2008.4
Selected Bedrock - Ministry of Northern Development, Mines and Forestry, 2006
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2009
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: Ontario MNR Lambert

PROJECT

STATE OF THE AGGREGATE RESOURCE IN ONTARIO STUDY (SAROS) PAPER II

TITLE

AGGREGATE CONSTRAINT ANALYSIS

Golder Associates
Mississauga, Ontario

PROJECT NO. 09-1112-0066			SCALE AS SHOWN	REV. 1.0
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GIS	PP	21 Oct. 2009	FIGURE: B -	
CHECK	JF	23 Oct. 2009	FIGURE: 1	
REVIEW	WC	23 Oct. 2009		

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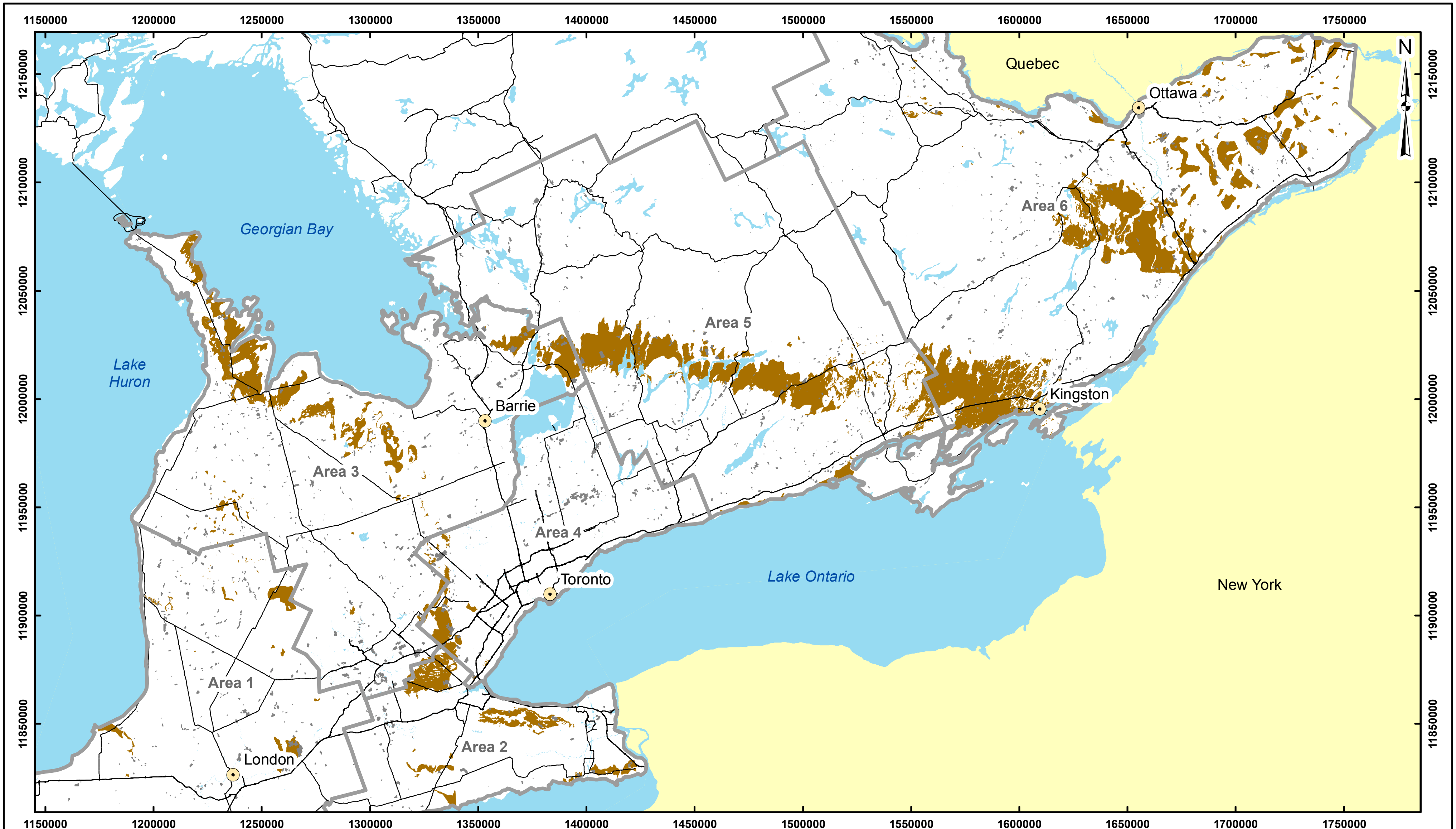

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- **Existing Aggregate Licences and Permits (ALPS)**
- Remaining Bedrock Resource
- Highway
- Aggregate Area Boundary
- Waterbody

REFERENCE

Base Data - MNR NRVIS, obtained 2009, CANMAP v2008.4
Selected Bedrock - Ministry of Northern Development, Mines and Forestry, 2006
Constraint Data - MMAH, MNR, SOLRIS
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Projection: Transverse Mercator Datum: NAD 83 Coordinate System: Ontario MNR Lambert

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PROJECT
STATE OF THE AGGREGATE RESOURCE IN ONTARIO STUDY (SAROS) PAPER II

TITLE
AGGREGATE CONSTRAINT ANALYSIS

Golder Associates
Mississauga, Ontario

PROJECT NO. 09-1112-0066			SCALE AS SHOWN	REV. 1.0
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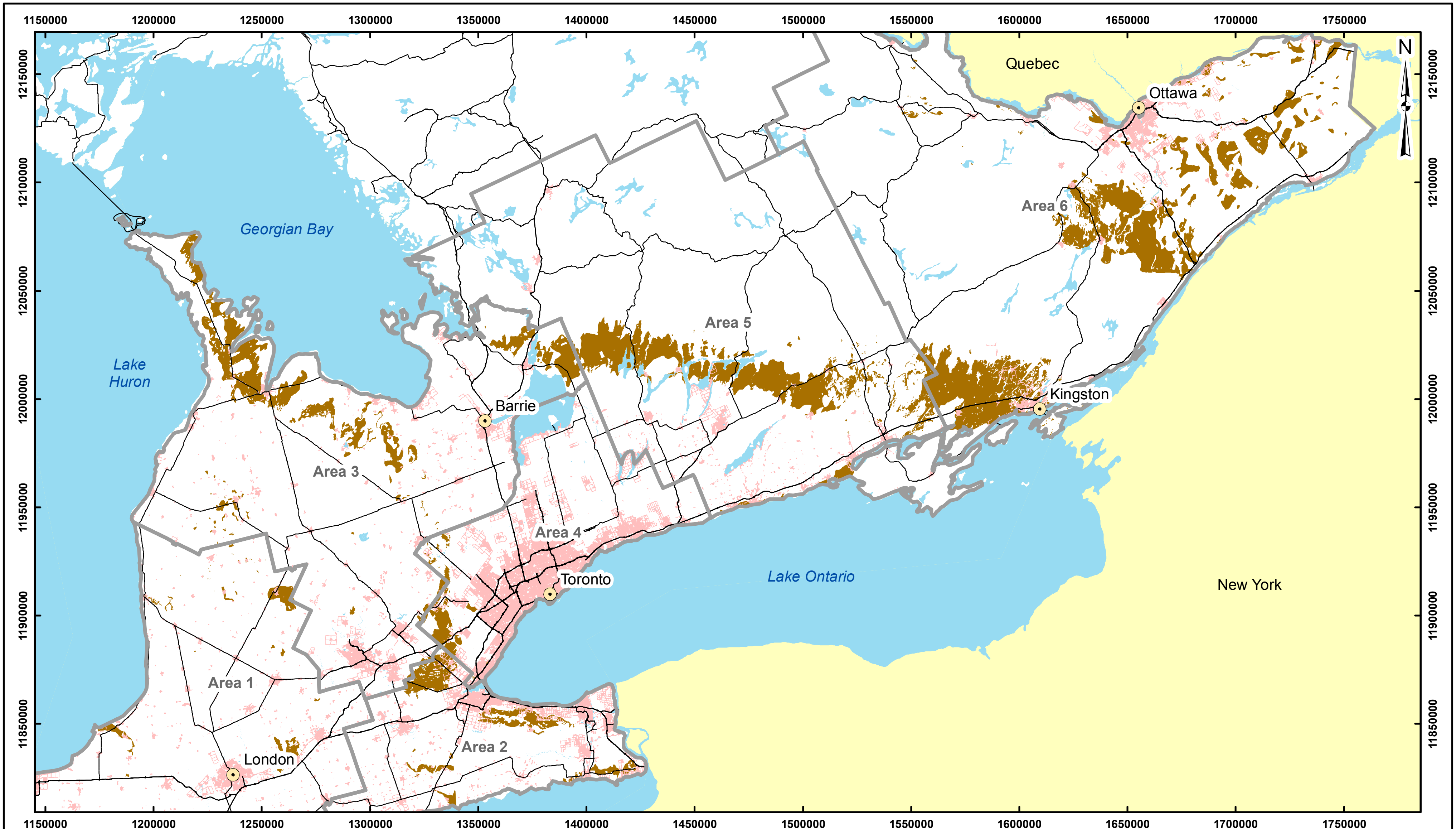

LEGEND

- **Urban Area**
- Remaining Bedrock Resource
- Highway
- Aggregate Area Boundary
- Waterbody

Previously Applied Constraints

Existing Aggregate Licences and Permits

REFERENCE

Base Data - MNR NRVIS, obtained 2009, CANMAP v2008.4
Selected Bedrock - Ministry of Northern Development, Mines and Forestry, 2006
Constraint Data - MMAH, MNR, SOLRIS
Produced by Golder Associates Ltd under licence from
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Projection: Transverse Mercator Datum: NAD 83 Coordinate System: Ontario MNR Lambert

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PROJECT
STATE OF THE AGGREGATE
RESOURCE IN ONTARIO STUDY
(SAROS) PAPER II

TITLE
AGGREGATE CONSTRAINT ANALYSIS

Golder Associates
Mississauga, Ontario

PROJECT NO. 09-1112-0066			SCALE AS SHOWN	REV. 1.0
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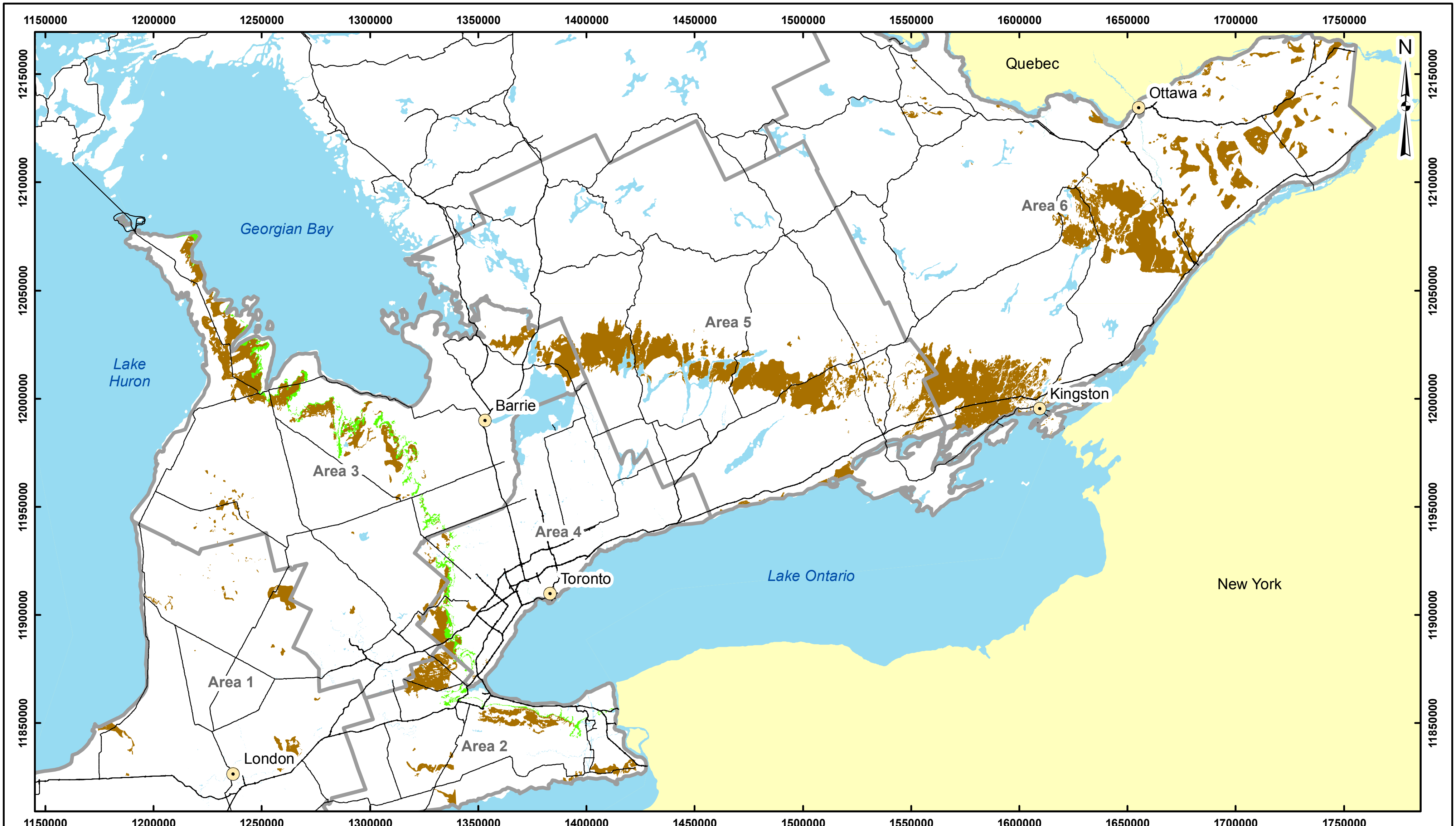

LEGEND

- Niagara Escarpment Plan – Escarpment Natural Area
- Remaining Bedrock Resource
- Highway
- Aggregate Area Boundary
- Waterbody

Previously Applied Constraints

Existing Aggregate Licences and Permits
Urban Area

REFERENCE

Base Data - MNR NRVIS, obtained 2009, CANMAP v2008.4
Selected Bedrock - Ministry of Northern Development, Mines and Forestry, 2006
Constraint Data - MMAH, MNR, SOLRIS
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Projection: Transverse Mercator Datum: NAD 83 Coordinate System: Ontario MNR Lambert

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SCALE 1:2,500,000 KILOMETRES

PROJECT
STATE OF THE AGGREGATE RESOURCE IN ONTARIO STUDY (SAROS) PAPER II

TITLE
AGGREGATE CONSTRAINT ANALYSIS

Golder Associates
Mississauga, Ontario

PROJECT NO. 09-1112-0066			SCALE AS SHOWN	REV. 1.0
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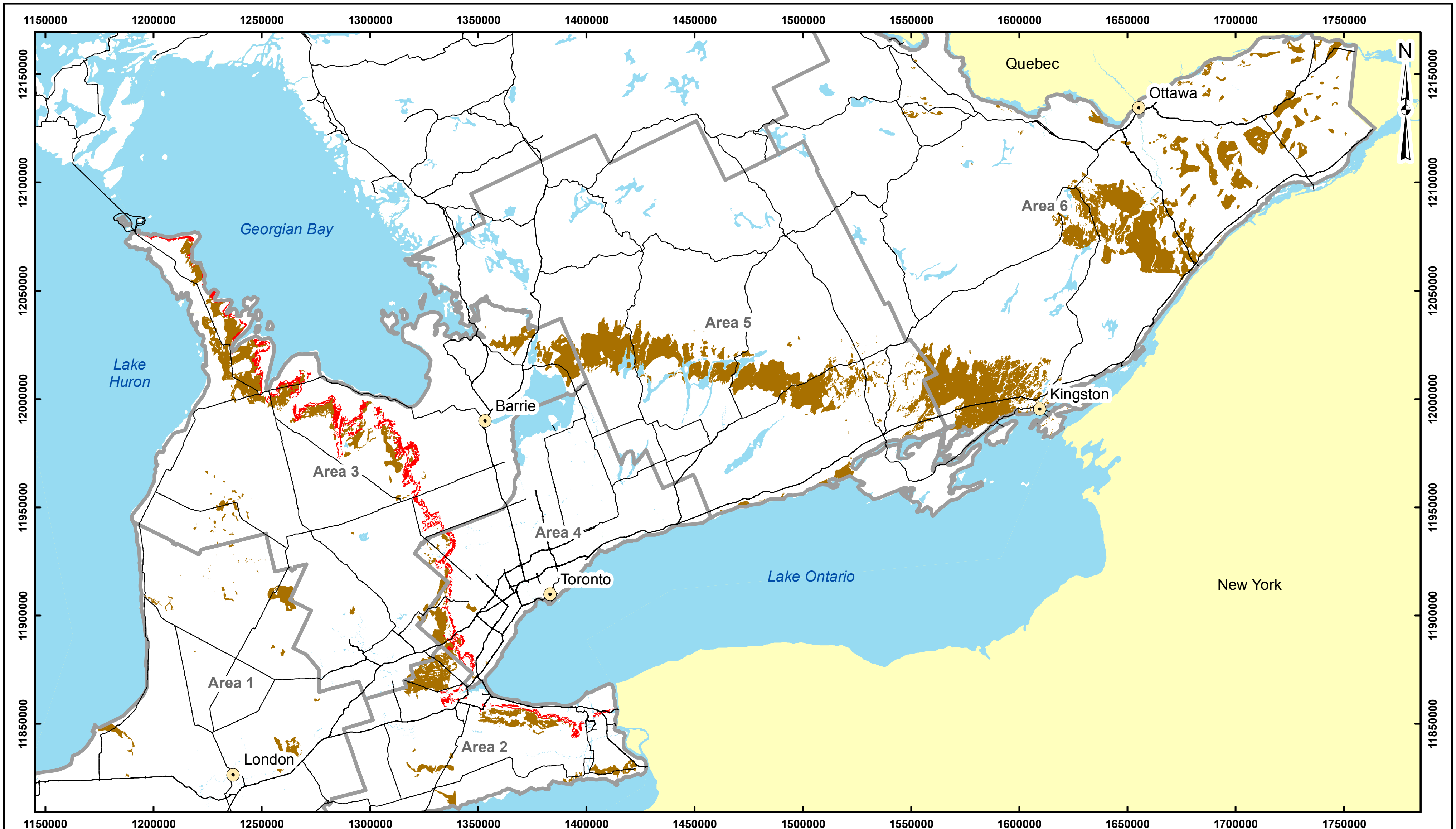

LEGEND

- Niagara Escarpment Plan – Escarpment Protection Area
- Remaining Bedrock Resource
- Highway
- Aggregate Area Boundary
- Waterbody

Previously Applied Constraints

Existing Aggregate Licences and Permits
Urban Area
Niagara Escarpment Plan - Natural Area

REFERENCE

Base Data - MNR NRVIS, obtained 2009, CANMAP v2008.4
Selected Bedrock - Ministry of Northern Development, Mines and Forestry, 2006
Constraint Data - MMAH, MNR, SOLRIS
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Projection: Transverse Mercator Datum: NAD 83 Coordinate System: Ontario MNR Lambert

0 10 20 40 60 80 100
SCALE 1:2,500,000 KILOMETRES

PROJECT
STATE OF THE AGGREGATE RESOURCE IN ONTARIO STUDY (SAROS) PAPER II

TITLE
AGGREGATE CONSTRAINT ANALYSIS

Golder Associates
Mississauga, Ontario

PROJECT NO. 09-1112-0066			SCALE AS SHOWN	REV. 1.0
DESIGN	PP	15 Sep. 2009	FIGURE: B -	
GIS	PP	21 Oct. 2009		
CHECK	JF	23 Oct. 2009	FIGURE: 5	
REVIEW	WC	23 Oct. 2009		

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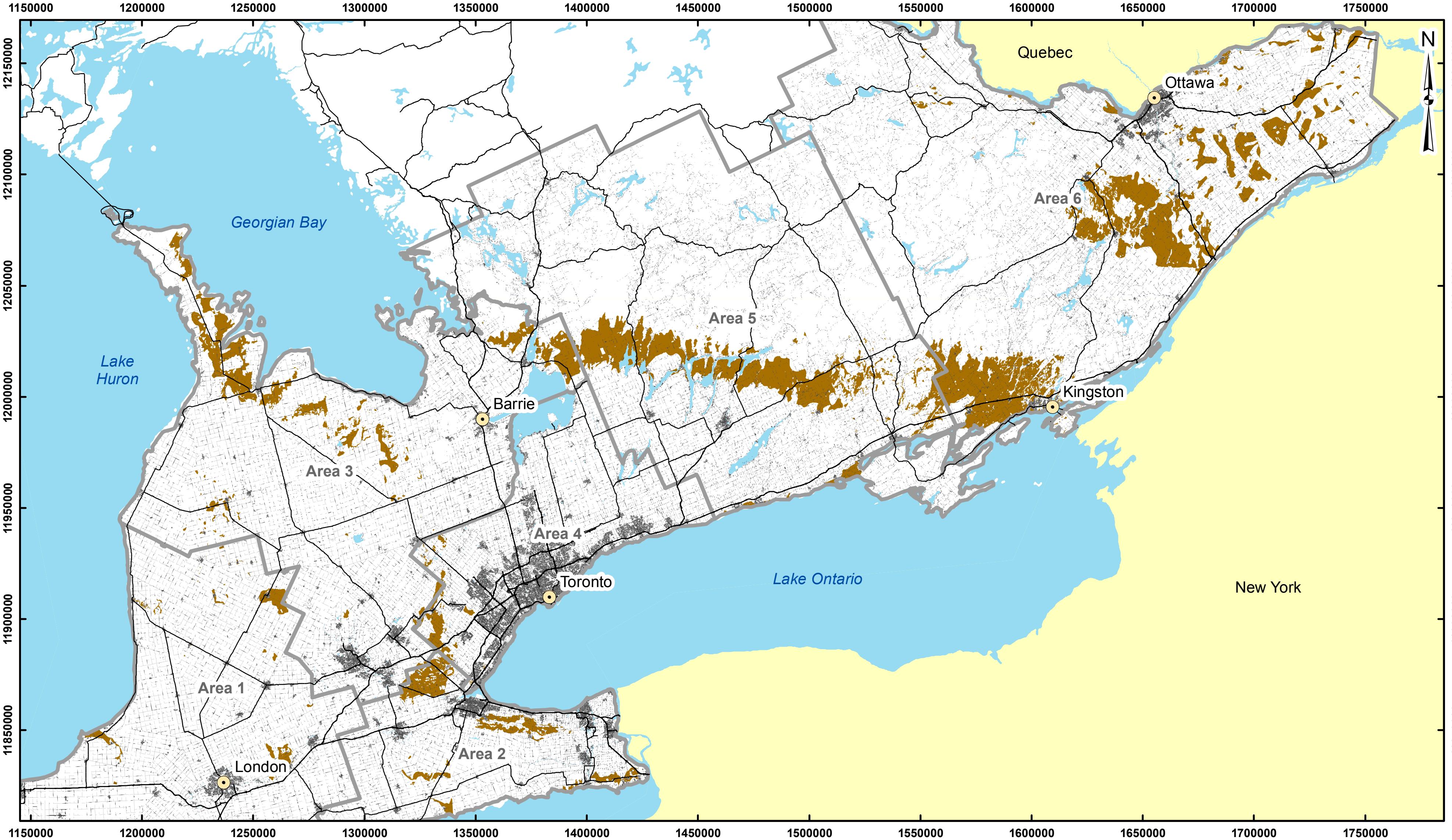

LEGEND

- Road
- Remaining Bedrock Resource
- Highway
- Aggregate Area Boundary
- Waterbody

Previously Applied Constraints

- Existing Aggregate Licences and Permits
- Urban Area
- Niagara Escarpment Plan - Natural Area
- Niagara Escarpment Plan - Protection Area

0 10 20 40 60 80 100

SCALE 1:2,500,000 KILOMETRES

REFERENCE

Base Data - MNR NRVIS, obtained 2009, CANMAP v2008.4
Selected Bedrock - Ministry of Northern Development, Mines and Forestry, 2006
Constraint Data - MMAH, MNR, SOLRIS
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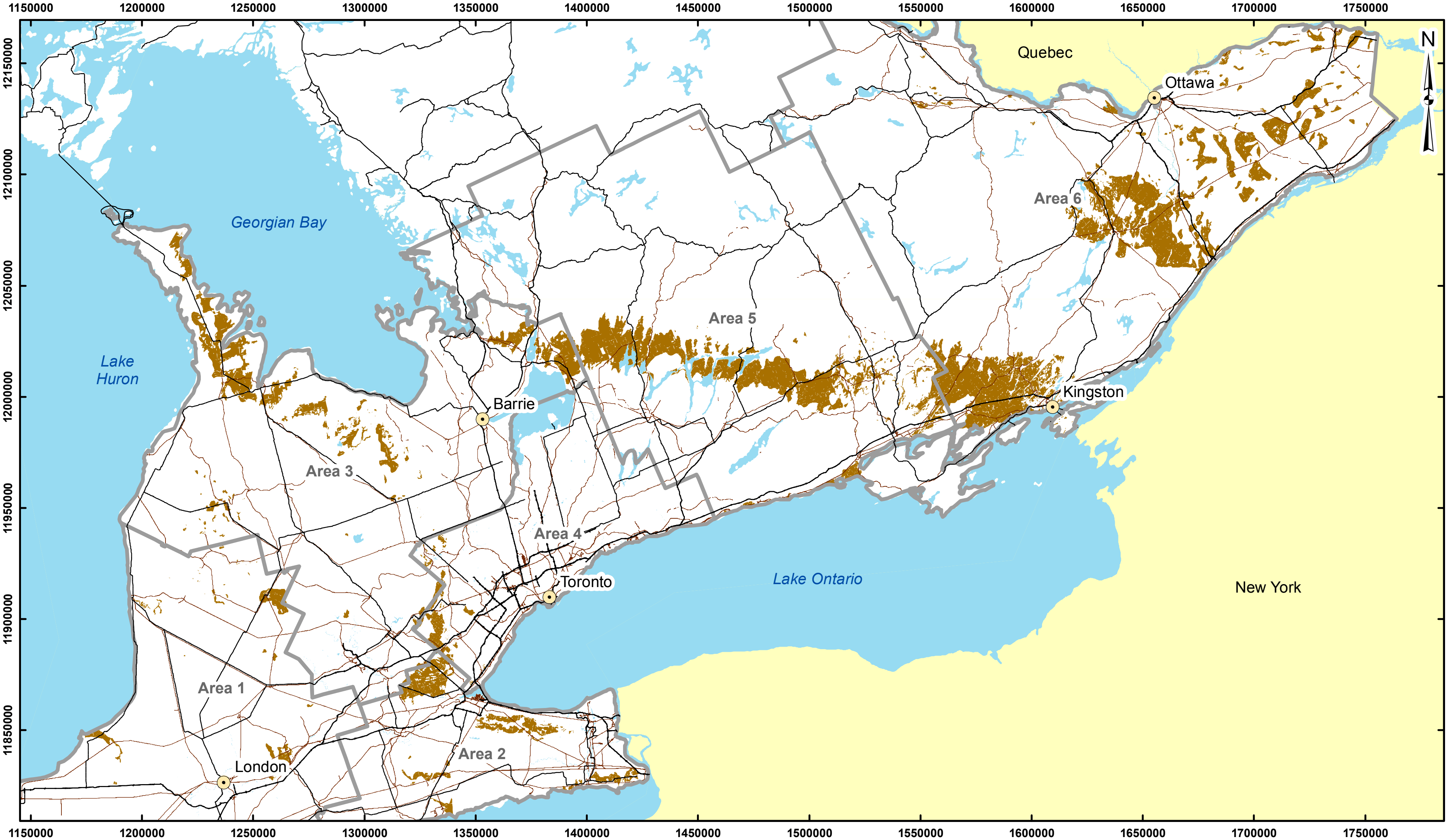
PROJECT
STATE OF THE AGGREGATE RESOURCE IN ONTARIO STUDY (SAROS) PAPER II

TITLE
AGGREGATE CONSTRAINT ANALYSIS

Golder Associates
Mississauga, Ontario

PROJECT NO. 09-1112-0066			SCALE AS SHOWN	REV. 1.0
DESIGN	PP	15 Sep. 2009	FIGURE: B -	
GIS	PP	21 Oct. 2009		
CHECK	JF	23 Oct. 2009	FIGURE: 6	
REVIEW	WC	23 Oct. 2009		

G:\Projects\2009\09-1112-0066_MNR_Saros_Paper_Two\GIS\MXDs\Draft\ConstraintMaps\Final\Constraint5_Roads.mxd



LEGEND

- Railway
- Remaining Bedrock Resource
- Highway
- Aggregate Area Boundary
- Waterbody

Previously Applied Constraints

Existing Aggregate Licences and Permits
Urban Area
Niagara Escarpment Plan - Natural Area
Niagara Escarpment Plan - Protection Area
Road

REFERENCE

Base Data - MNR NRVIS, obtained 2009, CANMAP v2008.4
Selected Bedrock - Ministry of Northern Development, Mines and Forestry, 2006
Constraint Data - MMAH, MNR, SOLRIS
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Projection: Transverse Mercator Datum: NAD 83 Coordinate System: Ontario MNR Lambert

0 10 20 40 60 80 100
SCALE 1:2,500,000 KILOMETRES

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STATE OF THE AGGREGATE RESOURCE IN ONTARIO STUDY (SAROS) PAPER II

TITLE
AGGREGATE CONSTRAINT ANALYSIS

Golder Associates
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PROJECT NO. 09-1112-0066			SCALE AS SHOWN	REV. 1.0
DESIGN	PP	15 Sep. 2009	FIGURE: B -	
GIS	PP	22 Oct. 2009	FIGURE: 7	
CHECK	JF	23 Oct. 2009		
REVIEW	WC	23 Oct. 2009		

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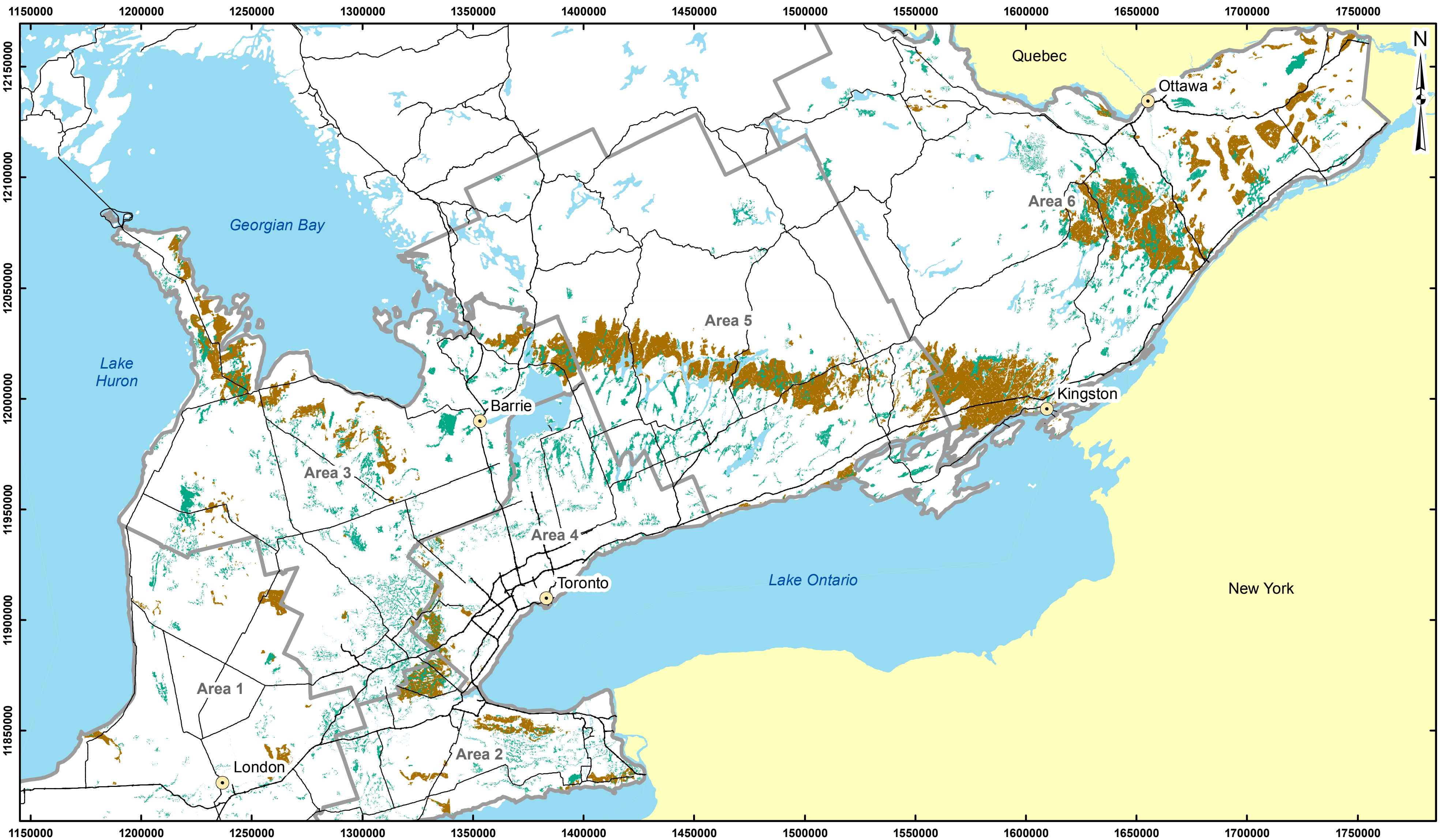

0 10 20 40 60 80 100

SCALE 1:2,500,000 KILOMETRES

LEGEND

- **Provincially Significant Wetland**
- Remaining Bedrock Resource
- Highway
- Aggregate Area Boundary
- Waterbody

Previously Applied Constraints

- Existing Aggregate Licences and Permits
- Urban Area
- Niagara Escarpment Plan - Natural Area
- Niagara Escarpment Plan - Protection Area
- Road
- Railway

REFERENCE

Base Data - MNR NRVIS, obtained 2009, CANMAP v2008.4
Selected Bedrock - Ministry of Northern Development, Mines and Forestry, 2006
Constraint Data - MMAH, MNR, SOLRIS
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AGGREGATE CONSTRAINT ANALYSIS

Golder Associates
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PROJECT NO. 09-1112-0066			SCALE AS SHOWN	REV. 1.0
DESIGN	PP	15 Sep. 2009	FIGURE: B - FIGURE: 8	
GIS	PP	22 Oct. 2009		
CHECK	JF	23 Oct. 2009		
REVIEW	WC	23 Oct. 2009		

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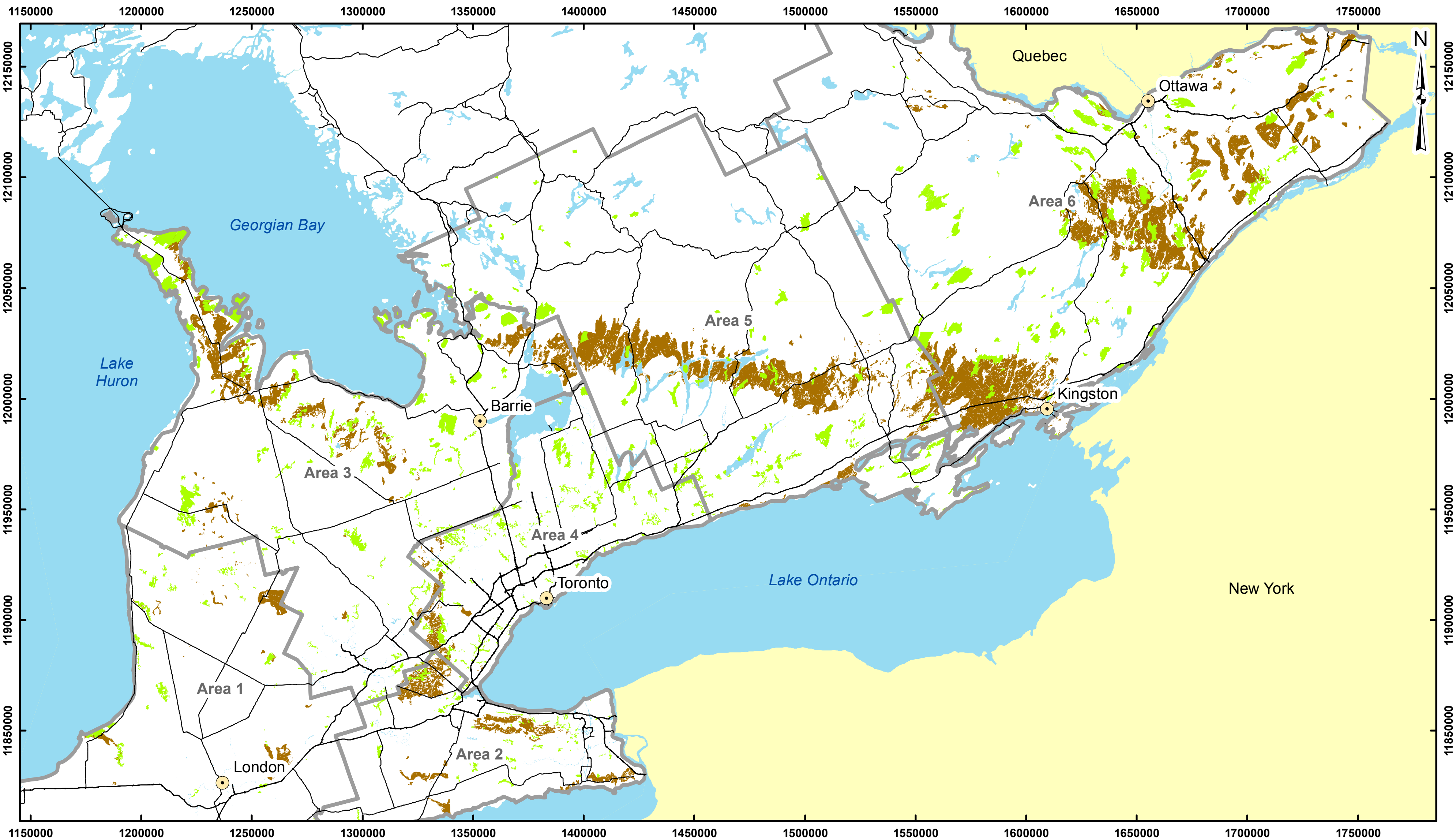

LEGEND

- ANSI Life Science
- Remaining Bedrock Resource
- Highway
- Aggregate Area Boundary
- Waterbody

Previously Applied Constraints

Existing Aggregate Licences and Permits
Urban Area
Niagara Escarpment Plan - Natural Area
Niagara Escarpment Plan - Protection Area
Road
Railway
Provincially Significant Wetland

REFERENCE

Base Data - MNR NRVIS, obtained 2009, CANMAP v2008.4
Selected Bedrock - Ministry of Northern Development, Mines and Forestry, 2006
Constraint Data - MMAH, MNR, SOLRIS
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0 10 20 40 60 80 100
SCALE 1:2,500,000 KILOMETRES

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STATE OF THE AGGREGATE RESOURCE IN ONTARIO STUDY (SAROS) PAPER II

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AGGREGATE CONSTRAINT ANALYSIS

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PROJECT NO. 09-1112-0066			SCALE AS SHOWN	REV. 1.0
DESIGN	PP	15 Sep. 2009	FIGURE: B -	
GIS	PP	22 Oct. 2009	FIGURE: 9	
CHECK	JF	23 Oct. 2009		
REVIEW	WC	23 Oct. 2009		

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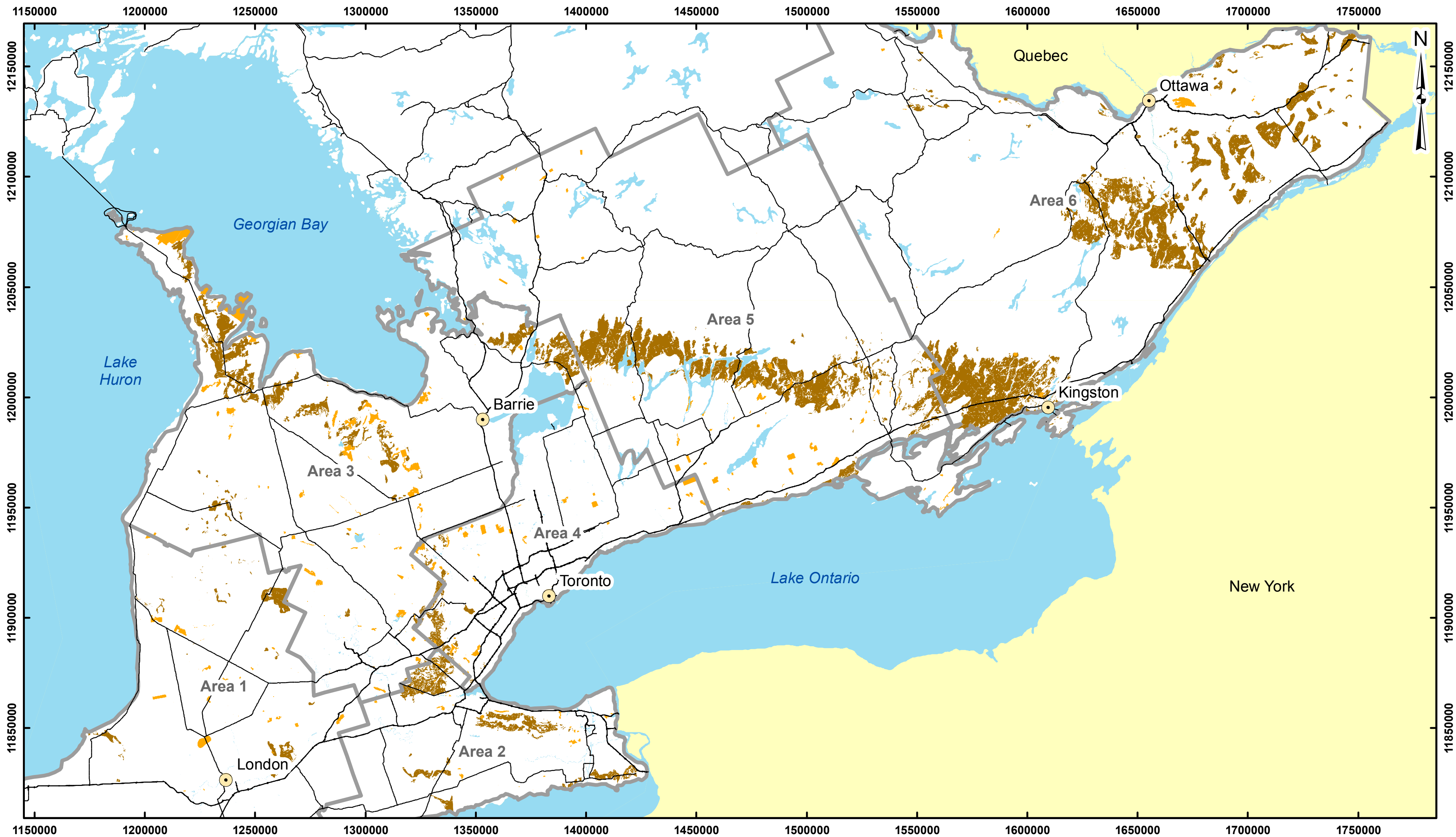

LEGEND

- ANSI Earth Science
- Remaining Bedrock Resource
- Highway
- Aggregate Area Boundary
- Waterbody

Previously Applied Constraints

- Existing Aggregate Licences and Permits
- Urban Area
- Niagara Escarpment Plan - Natural Area
- Niagara Escarpment Plan - Protection Area
- Road
- Railway
- Provincially Significant Wetland

ANSI Life Science

0 10 20 40 60 80 100

SCALE 1:2,500,000 KILOMETRES

REFERENCE

Base Data - MNR NRVIS, obtained 2009, CANMAP v2008.4
Selected Bedrock - Ministry of Northern Development, Mines and Forestry, 2006
Constraint Data - MMAH, MNR, SOLRIS
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Projection: Transverse Mercator Datum: NAD 83 Coordinate System: Ontario MNR Lambert

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AGGREGATE CONSTRAINT ANALYSIS

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PROJECT NO. 09-1112-0066			SCALE AS SHOWN	REV. 1.0
DESIGN	PP	15 Sep. 2009	FIGURE: B -	
GIS	PP	21 Oct. 2009	FIGURE: 10	
CHECK	JF	23 Oct. 2009		
REVIEW	WC	23 Oct. 2009		

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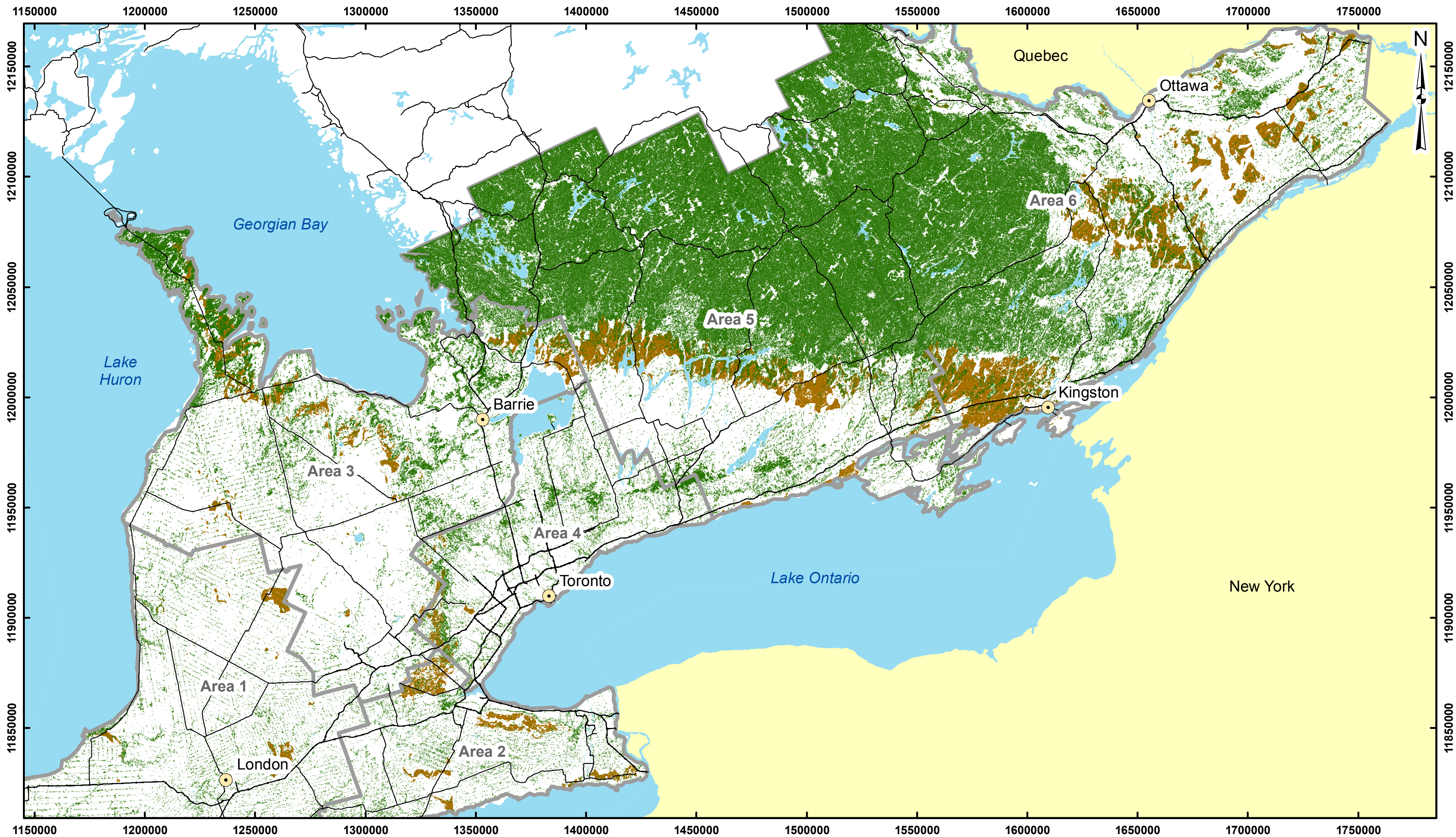

LEGEND

Significant Wooded Area
Remaining Bedrock Resource
Highway
Aggregate Area Boundary
Waterbody

Previously Applied Constraints
Existing Aggregate Licences and Permits
Urban Area
Niagara Escarpment Plan - Natural Area
Niagara Escarpment Plan - Protection Area
Road
Railway
Provincially Significant Wetland
ANSI Life Science
ANSI Earth Science

0 10 20 40 60 80 100
SCALE 1:2,500,000 KILOMETRES

REFERENCE

Base Data - MNR NRVIS, obtained 2009, CANMAP v2008.4
Selected Bedrock - Ministry of Northern Development, Mines and Forestry, 2006
Constraint Data - MMAH, MNR, SOLRIS
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PROJECT NO. 09-1112-0066			SCALE AS SHOWN	REV. 1.0
DESIGN	PP	15 Sep. 2009	FIGURE: B -	
GIS	PP	22 Oct. 2009	FIGURE: 11	
CHECK	JF	23 Oct. 2009		
REVIEW	WC	23 Oct. 2009		

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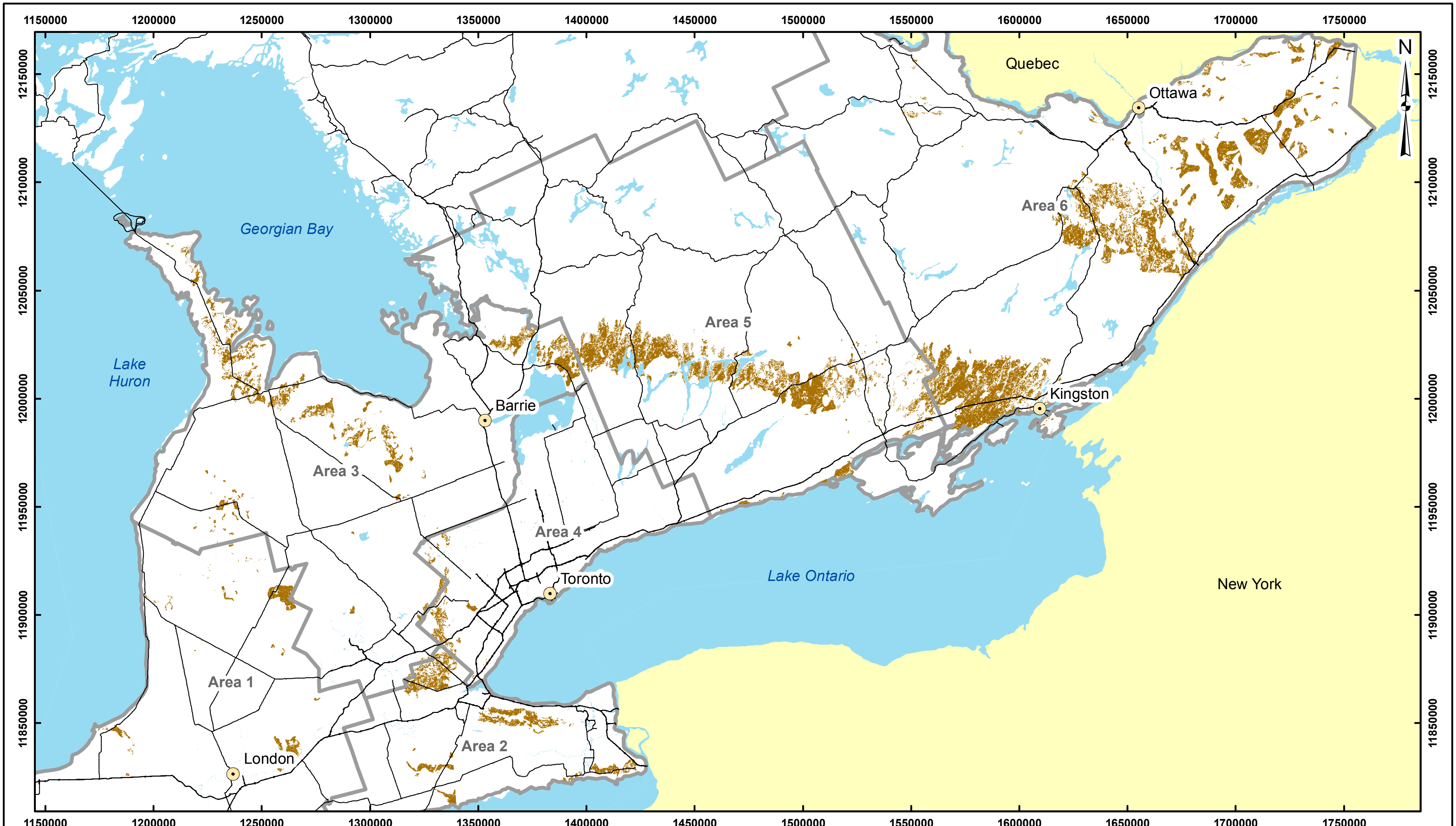

LEGEND

- **Greenbelt - Alvars**
- Remaining Bedrock Resource
- Highway
- Aggregate Area Boundary
- Waterbody

Previously Applied Constraints

- Existing Aggregate Licences and Permits
- Urban Area
- Niagara Escarpment Plan - Natural Area
- Niagara Escarpment Plan - Protection Area
- Road
- Railway
- Provincially Significant Wetland
- ANSI Life Science
- ANSI Earth Science
- Significant Wooded Area

0 10 20 40 60 80 100

SCALE 1:2,500,000 KILOMETRES

REFERENCE

Base Data - MNR NRVIS, obtained 2009, CANMAP v2008.4
Selected Bedrock - Ministry of Northern Development, Mines and Forestry, 2006
Constraint Data - MMAH, MNR, SOLRIS
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AGGREGATE CONSTRAINT ANALYSIS

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PROJECT NO. 09-1112-0066			SCALE AS SHOWN	REV. 1.0
DESIGN	PP	15 Sep. 2009	FIGURE: B -	
GIS	PP	21 Oct. 2009		
CHECK	JF	23 Oct. 2009	FIGURE: 12	
REVIEW	WC	23 Oct. 2009		

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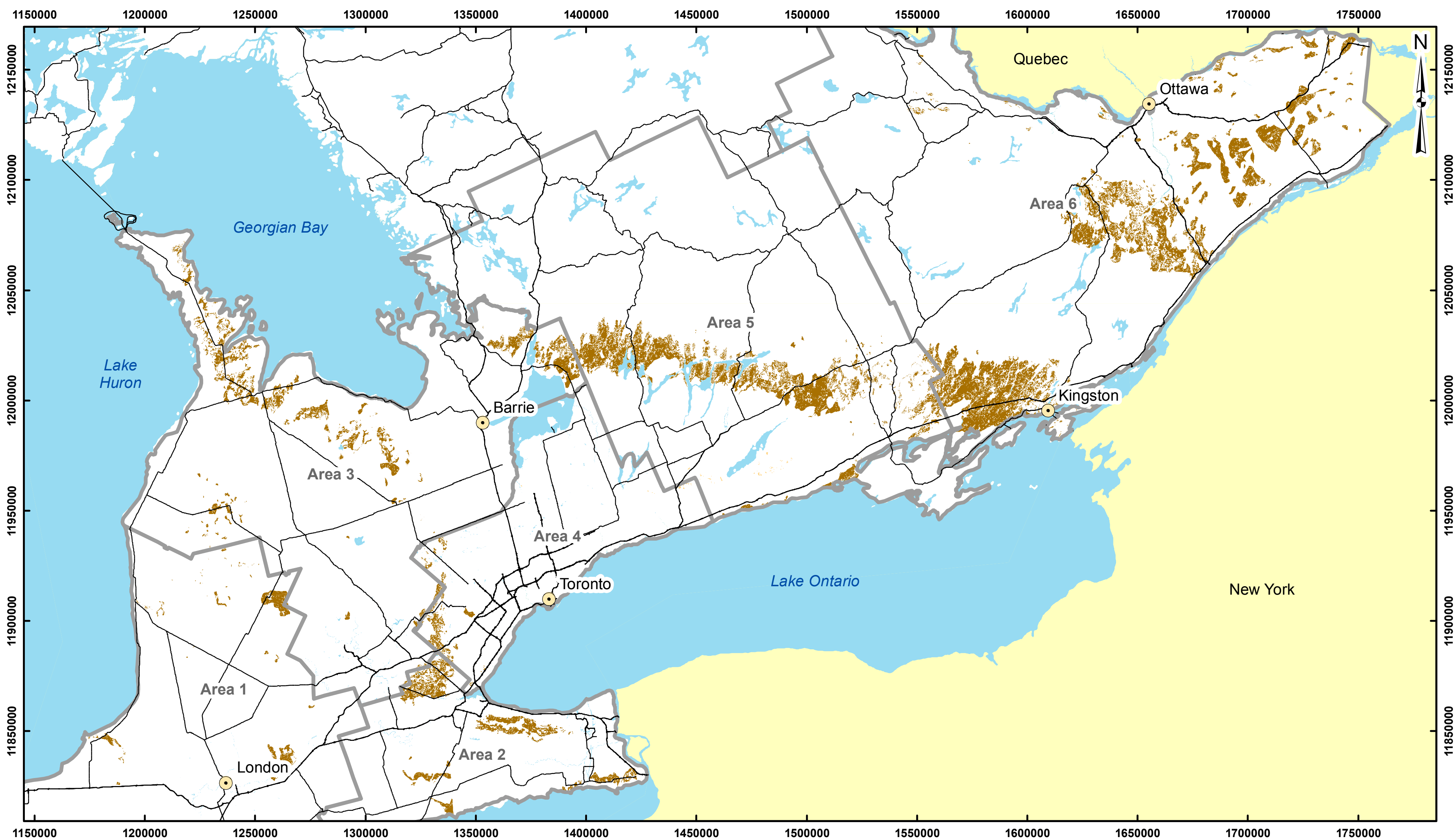

LEGEND

- Greenbelt - Savannah, Tallgrass Prairies and Sand barrens
- Remaining Bedrock Resource
- Highway
- Aggregate Area Boundary
- Waterbody

Previously Applied Constraints

- Existing Aggregate Licences and Permits
- Urban Area
- Niagara Escarpment Plan - Natural Area
- Niagara Escarpment Plan - Protection Area
- Road
- Railway
- Provincially Significant Wetland
- ANSI Life Science
- ANSI Earth Science
- Significant Wooded Area
- Greenbelt - Alvars

REFERENCE

Base Data - MNR NRVIS, obtained 2009, CANMAP v2008.4
Selected Bedrock - Ministry of Northern Development, Mines and Forestry, 2006
Constraint Data - MMAH, MNR, SOLRIS
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Projection: Transverse Mercator Datum: NAD 83 Coordinate System: Ontario MNR Lambert

0 10 20 40 60 80 100

SCALE 1:2,500,000 KILOMETRES

PROJECT
STATE OF THE AGGREGATE RESOURCE IN ONTARIO STUDY (SAROS) PAPER II

TITLE
AGGREGATE CONSTRAINT ANALYSIS

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PROJECT NO. 09-1112-0066			SCALE AS SHOWN	REV. 1.0
DESIGN	PP	15 Sep. 2009	FIGURE: B -	
GIS	PP	21 Oct. 2009		
CHECK	JF	23 Oct. 2009	FIGURE: 13	
REVIEW	WC	23 Oct. 2009		

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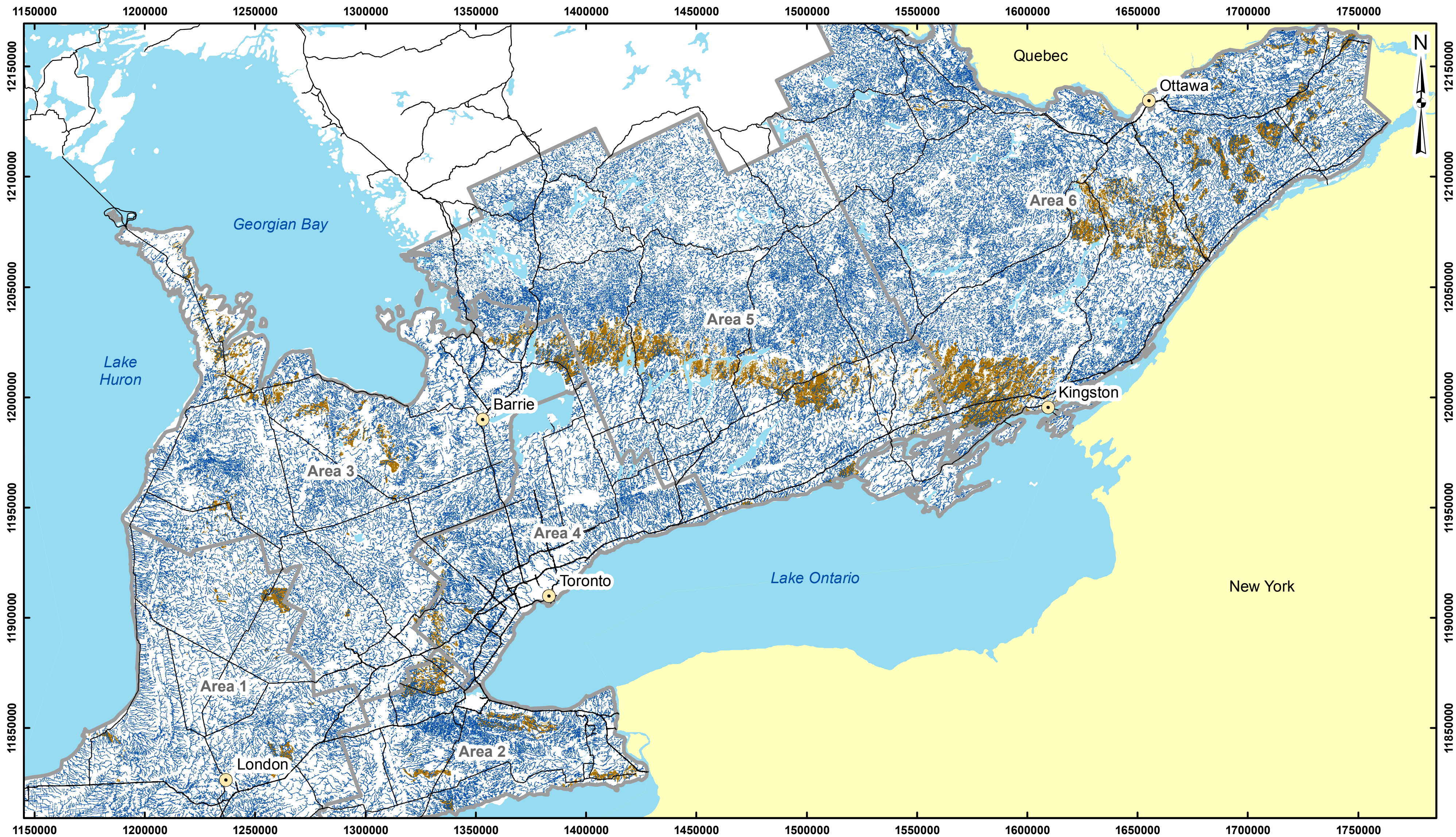

LEGEND

- Highway
- Aggregate Area Boundary
- Watercourse
- Remaining Bedrock Resource
- Waterbody

Previously Applied Constraints

Existing Aggregate Licences and Permits
Urban Area
Niagara Escarpment Plan - Natural Area
Niagara Escarpment Plan - Protection Area
Road
Railway
Provincially Significant Wetland

ANSI Life Science
ANSI Earth Science
Significant Wooded Area
Greenbelt - Alvars
Greenbelt - Savannah, Tallgrass Prairie and Sand Barren

0 10 20 40 60 80 100
SCALE 1:2,500,000 KILOMETRES

REFERENCE

Base Data - MNR NRVIS, obtained 2009, CANMAP v2008.4
Selected Bedrock - Ministry of Northern Development, Mines and Forestry, 2006
Constraint Data - MMAH, MNR, SOLRIS
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PROJECT NO. 09-1112-0066			SCALE AS SHOWN	REV. 1.0
DESIGN	PP	15 Sep. 2009	FIGURE: B -	
GIS	PP	21 Oct. 2009	FIGURE: 14	
CHECK	JF	23 Oct. 2009		
REVIEW	WC			

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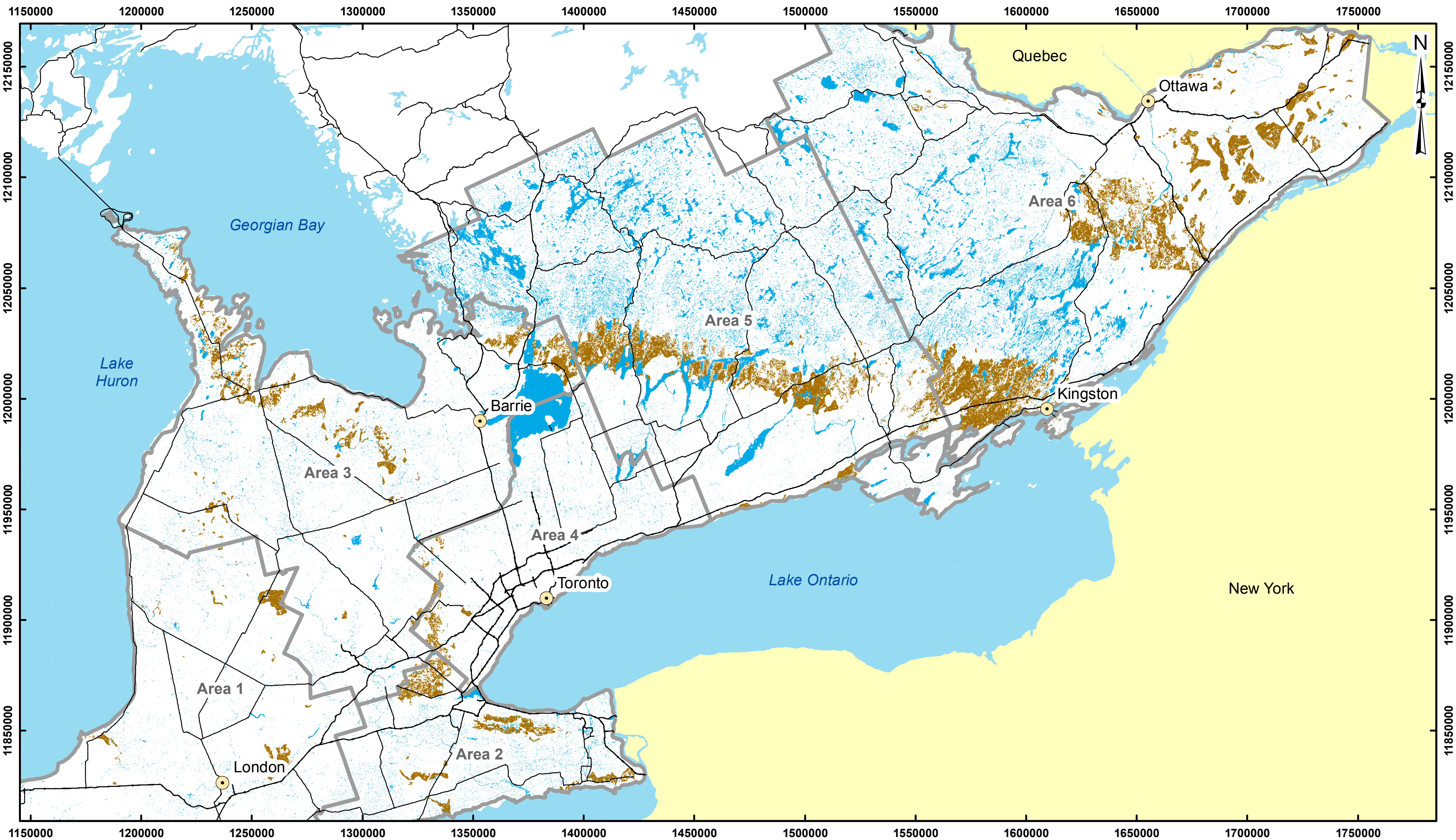

0 10 20 40 60 80 100

SCALE 1:2,500,000 KILOMETRES

LEGEND

- Waterbody
- Remaining Bedrock Resource
- Highway
- Aggregate Area Boundary
- Waterbody

Previously Applied Constraints

Existing Aggregate Licences and Permits
Urban Area
Niagara Escarpment Plan - Natural Area
Niagara Escarpment Plan - Protection Area
Road
Railway
Provincially Significant Wetland
ANSI Life Science
ANSI Earth Science
Significant Wooded Area
Greenbelt - Alvars
Greenbelt - Savannah, Tallgrass Prairie and Sand Barren
Watercourse

REFERENCE

Base Data - MNR NRVIS, obtained 2009, CANMAP v2008.4
Selected Bedrock - Ministry of Northern Development, Mines and Forestry, 2006
Constraint Data - MMAH, MNR, SOLRIS
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PROJECT NO. 09-1112-0066			SCALE AS SHOWN	REV. 1.0
DESIGN	PP	15 Sep. 2009	FIGURE: B - FIGURE: 15	
GIS	PP	21 Oct. 2009		
CHECK	JF	23 Oct. 2009		
REVIEW	WC	23 Oct. 2009		

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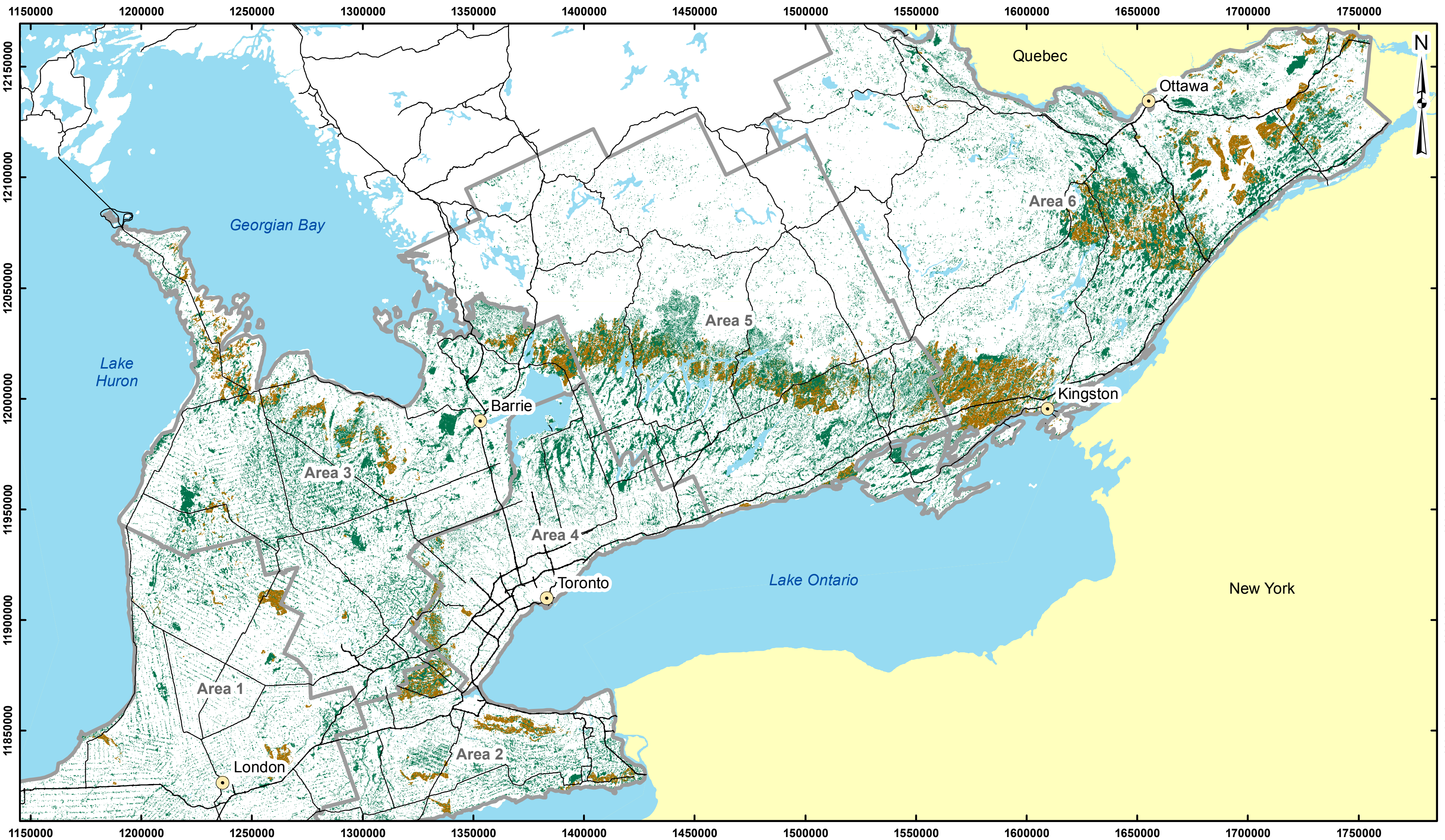

LEGEND

- Wetland
- Remaining Bedrock Resource
- Highway
- Aggregate Area Boundary
- Waterbody

Previously Applied Constraints

Existing Aggregate Licences and Permits
Urban Area
Niagara Escarpment Plan - Natural Area
Niagara Escarpment Plan - Protection Area
Road
Railway
Provincially Significant Wetland
ANSI Life Science
ANSI Earth Science
Significant Wooded Area
Greenbelt - Alvars
Greenbelt - Savannah, Tallgrass Prairie and Sand Barren
Watercourse
Waterbody

0 10 20 40 60 80 100
SCALE 1:2,500,000 KILOMETRES

REFERENCE

Base Data - MNR NRVIS, obtained 2009, CANMAP v2008.4
Selected Bedrock - Ministry of Northern Development, Mines and Forestry, 2006
Constraint Data - MMAH, MNR, SOLRIS
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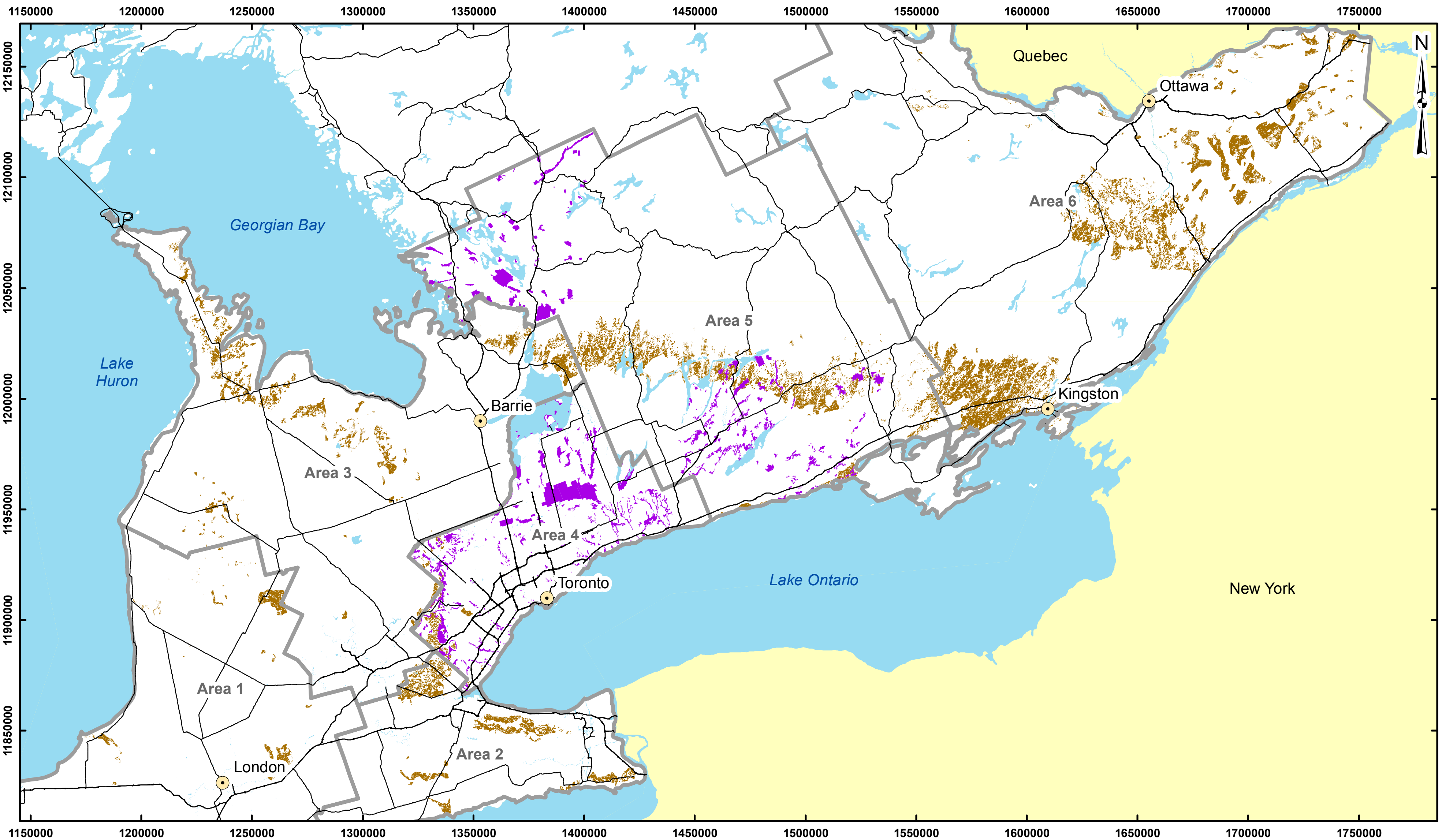
PROJECT NO. 09-1112-0066			SCALE AS SHOWN	REV. 1.0
DESIGN	PP	15 Sep. 2009		
GIS	PP	21 Oct. 2009		
CHECK	JF	23 Oct. 2009		
REVIEW	WC	23 Oct. 2009		

FIGURE: B -
FIGURE: 16

G:\Projects\2009\09-1112-0066_MNR_Saros_Paper_Two\GIS\MXDs\Draft\ConstraintMaps\Final\Constraint15_Wetland.mxd



LEGEND

- Environmentally Sensitive Area
- Remaining Bedrock Resource
- Highway
- Aggregate Area Boundary
- Waterbody

Previously Applied Constraints

Existing Aggregate Licences and Permits
Urban Area
Niagara Escarpment Plan - Natural Area
Niagara Escarpment Plan - Protection Area
Road
Railway
Provincially Significant Wetland
ANSI Life Science
ANSI Earth Science
Significant Wooded Area
Greenbelt - Alvars
Greenbelt - Savannah, Tallgrass Prairie and Sand Barren
Watercourse
Waterbody
Wetland

REFERENCE

Base Data - MNR NRVIS, obtained 2009, CANMAP v2008.4
Selected Bedrock - Ministry of Northern Development, Mines and Forestry, 2006
Constraint Data - MMAH, MNR, SOLRIS
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0 10 20 40 60 80 100
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PROJECT NO. 09-1112-0066			SCALE AS SHOWN	REV. 1.0
DESIGN	PP	15 Sep. 2009	FIGURE: B -	
GIS	PP	21 Oct. 2009	FIGURE: 17	
CHECK	JF	23 Oct. 2009		
REVIEW	WC	23 Oct. 2009		

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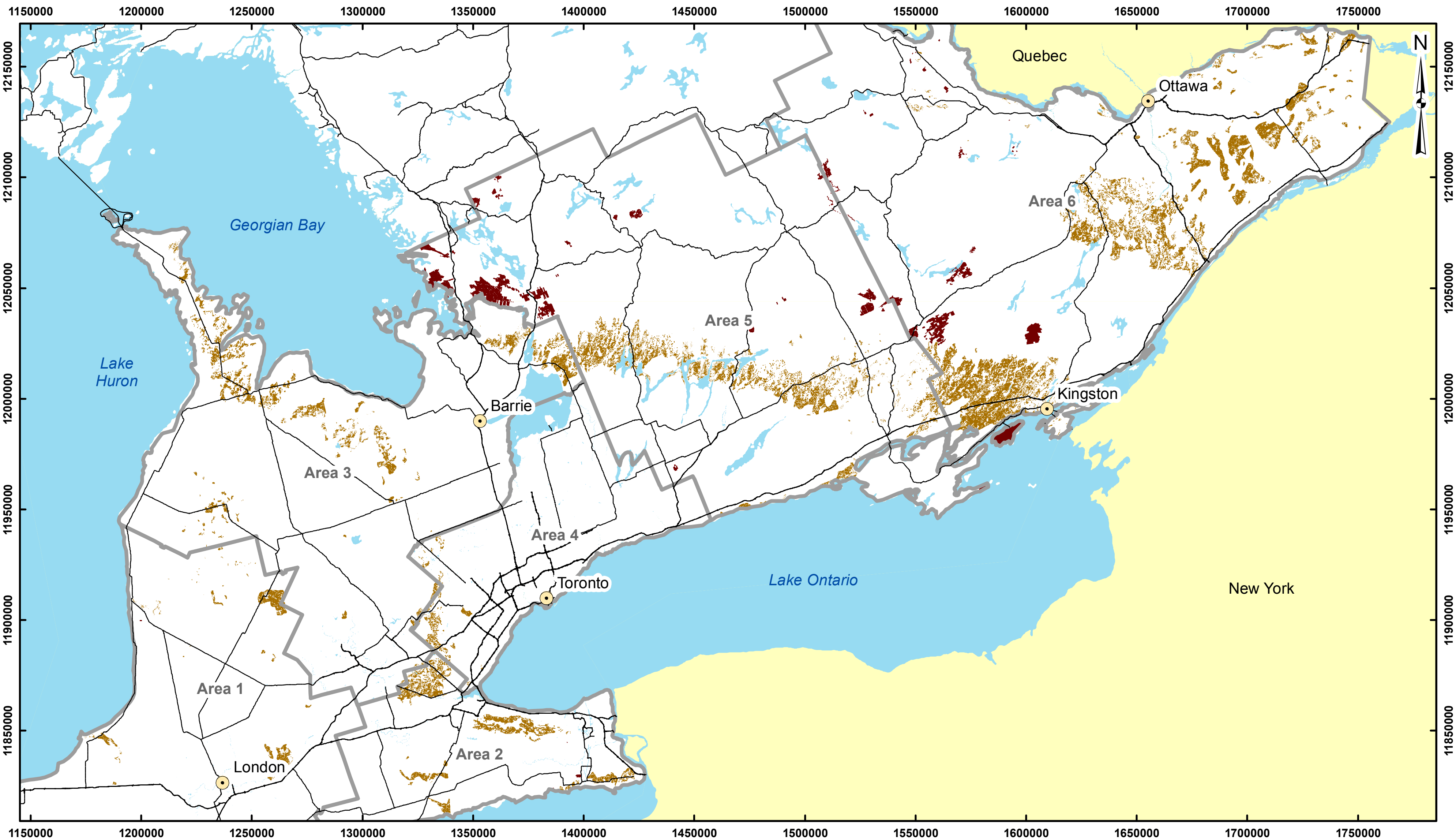

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LEGEND

- Reserve and Wildlife Area
- Remaining Bedrock Resource
- Highway
- Aggregate Area Boundary
- Waterbody

Previously Applied Constraints

Existing Aggregate Licences and Permits
Urban Area
Niagara Escarpment Plan - Natural Area
Niagara Escarpment Plan - Protection Area
Road
Railway
Provincially Significant Wetland
ANSI Life Science
ANSI Earth Science
Significant Wooded Area
Greenbelt - Alvars
Greenbelt - Savannah, Tallgrass Prairie and Sand Barren
Watercourse
Waterbody
Wetland
Environmentally Sensitive Area

REFERENCE

Base Data - MNR NRVIS, obtained 2009, CANMAP v2008.4
Selected Bedrock - Ministry of Northern Development, Mines and Forestry, 2006
Constraint Data - MMAH, MNR, SOLRIS
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0 10 20 40 60 80 100
SCALE 1:2,500,000 KILOMETRES

PROJECT
STATE OF THE AGGREGATE RESOURCE IN ONTARIO STUDY (SAROS) PAPER II

TITLE
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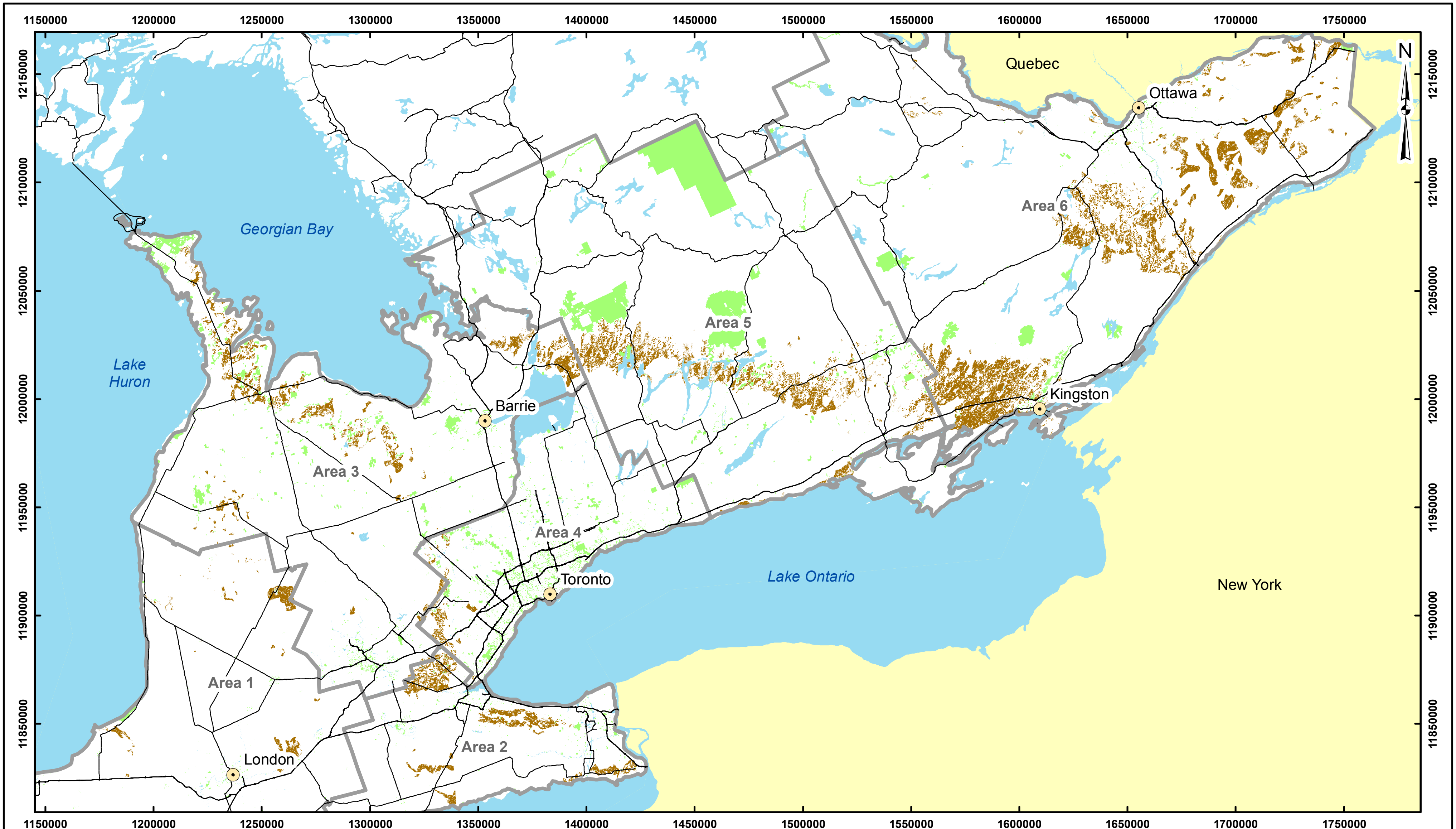
Golder Associates
Mississauga, Ontario

PROJECT NO. 09-1112-0066			SCALE AS SHOWN	REV. 1.0
DESIGN	PP	15 Sep. 2009	**FIGURE: B -**	
GIS	PP	21 Oct. 2009		
CHECK	JF	23 Oct. 2009	**FIGURE: 18**	
REVIEW	WC	23 Oct. 2009		



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LEGEND

- **Park and Recreation Area**
- Remaining Bedrock Resource
- Highway
- Aggregate Area Boundary
- Waterbody

Previously Applied Constraints

Existing Aggregate Licences and Permits
Urban Area
Niagara Escarpment Plan - Natural Area
Niagara Escarpment Plan - Protection Area
Road
Railway
Provincially Significant Wetland
ANSI Life Science
ANSI Earth Science
Significant Wooded Area
Greenbelt - Alvars
Greenbelt - Savannah, Tallgrass Prairie and Sand Barren
Watercourse
Waterbody
Wetland
Environmentally Sensitive Area
Reserve And Wildlife Area

REFERENCE

Base Data - MNR NRVIS, obtained 2009, CANMAP v2008.4
Selected Bedrock - Ministry of Northern Development, Mines and Forestry, 2006
Constraint Data - MMAH, MNR, SOLRIS
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0 10 20 40 60 80 100
SCALE 1:2,500,000 KILOMETRES

PROJECT
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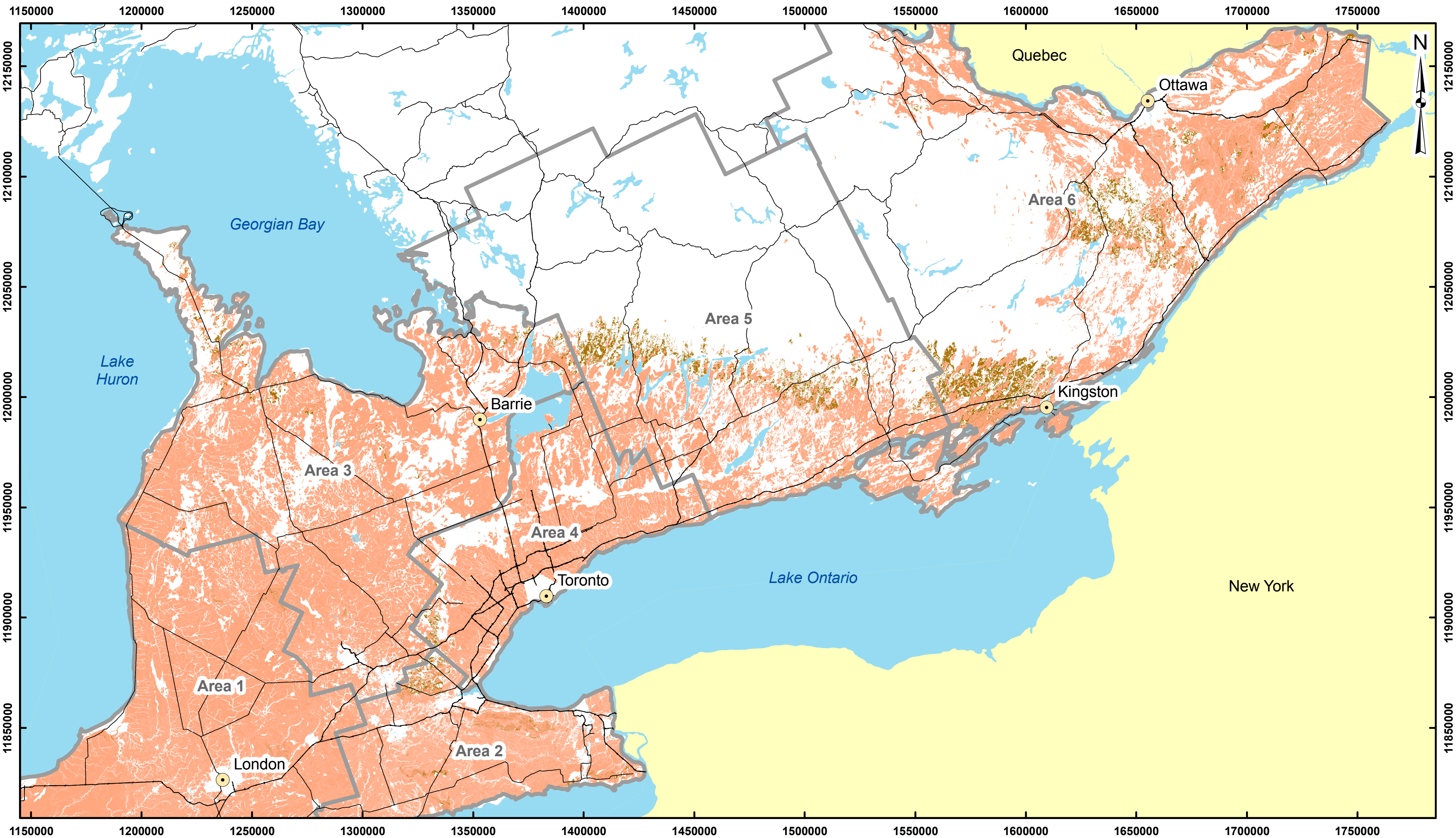
PROJECT NO. 09-1112-0066			SCALE AS SHOWN	REV. 1.0
DESIGN	PP	15 Sep. 2009	**FIGURE: B -**	
GIS	PP	21 Oct. 2009		
CHECK	JF	23 Oct. 2009	**FIGURE: 19**	
REVIEW	WC	23 Oct. 2009		



LEGEND

- Prime Agricultural Lands (Classes 1, 2 and 3)
- Remaining Bedrock Resource
- Highway
- Aggregate Area Boundary
- Waterbody

Previously Applied Constraints

Existing Aggregate Licences and Permits
Urban Area
Niagara Escarpment Plan - Natural Area
Niagara Escarpment Plan - Protection Area
Road
Railway
Provincially Significant Wetland
ANSI Life Science
ANSI Earth Science
Significant Wooded Area
Greenbelt - Alvars
Greenbelt - Savannah, Tallgrass Prairie and Sand Barren
Watercourse
Waterbody
Wetland
Environmentally Sensitive Area
Reserve And Wildlife Area
Park And Recreation Area

REFERENCE

Base Data - MNR NRVIS, obtained 2009, CANMAP v2008.4
Selected Bedrock - Ministry of Northern Development, Mines and Forestry, 2006
Constraint Data - MMAH, MNR, SOLRIS
Produced by Golder Associates Ltd under licence from
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Projection: Transverse Mercator Datum: NAD 83 Coordinate System: Ontario MNR Lambert

0 10 20 40 60 80 100
SCALE 1:2,500,000 KILOMETRES

PROJECT
STATE OF THE AGGREGATE RESOURCE IN ONTARIO STUDY (SAROS) PAPER II

TITLE
AGGREGATE CONSTRAINT ANALYSIS

Golder Associates
Mississauga, Ontario

PROJECT NO. 09-1112-0066			SCALE AS SHOWN	REV. 1.0
DESIGN	PP	15 Sep. 2009	FIGURE: B - FIGURE: 20	
GIS	PP	21 Oct. 2009		
CHECK	JF	23 Oct. 2009		
REVIEW	WC	23 Oct. 2009		

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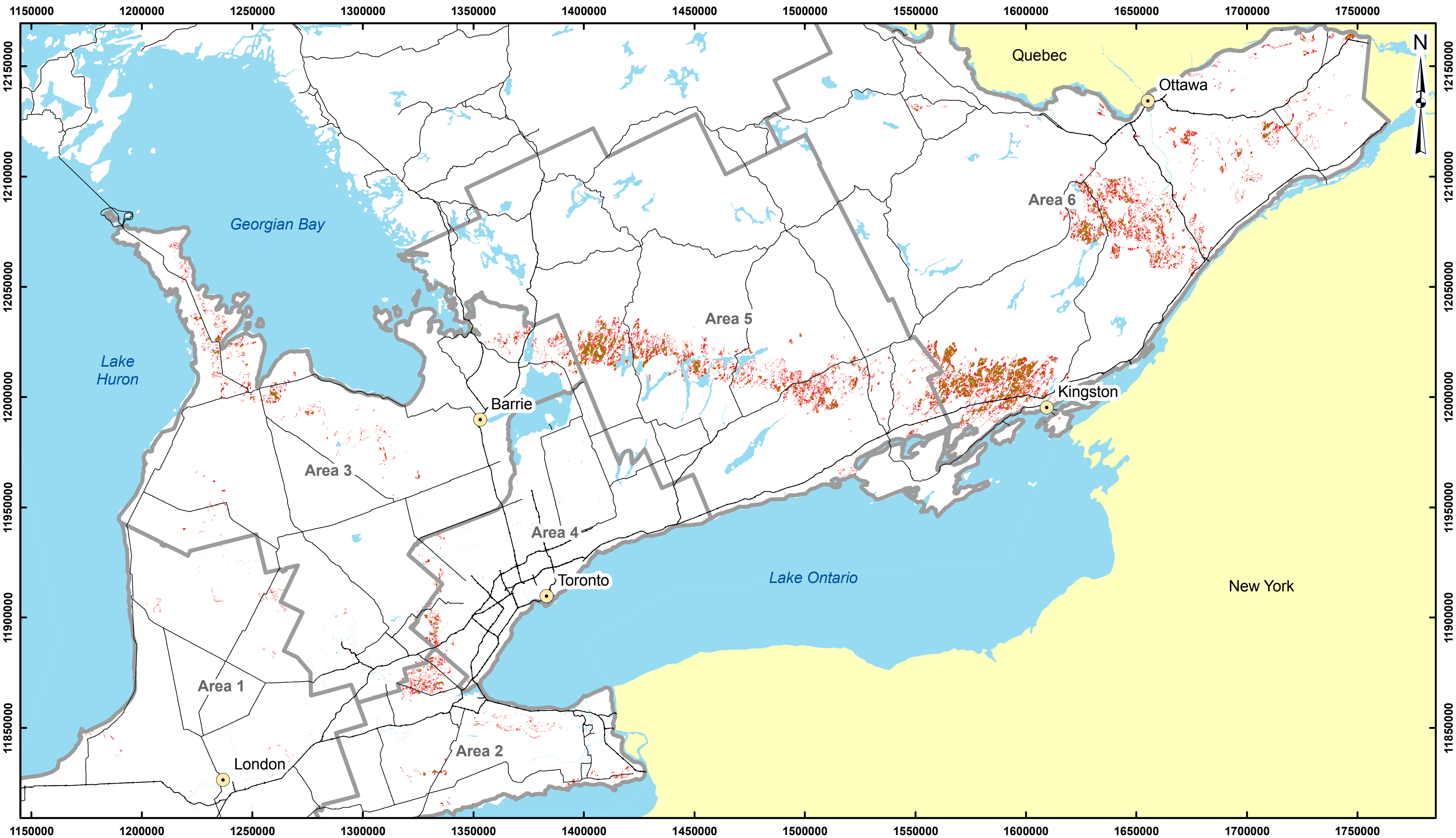

LEGEND

- **Remaining Bedrock Resource Area < 60 ha**
- Remaining Bedrock Resource
- Highway
- Aggregate Area Boundary
- Waterbody

Previously Applied Constraints

Existing Aggregate Licences and Permits
Urban Area
Niagara Escarpment Plan - Natural Area
Niagara Escarpment Plan - Protection Area
Road
Railway
Provincially Significant Wetland
ANSI Life Science
ANSI Earth Science
Significant Wooded Area
Greenbelt - Alvars
Greenbelt - Savannah, Tallgrass Prairie and Sand Barren
Watercourse
Waterbody
Wetland
Environmentally Sensitive Area
Reserve And Wildlife Area
Park And Recreation Area
Prime Agricultural Lands

REFERENCE

Base Data - MNR NRVIS, obtained 2009, CANMAP v2008.4
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SCALE 1:2,500,000 KILOMETRES

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DESIGN	PP	15 Sep. 2009	FIGURE: B -	
GIS	PP	21 Oct. 2009		
CHECK	JF	23 Oct. 2009	FIGURE: 21	
REVIEW	WC	23 Oct. 2009		

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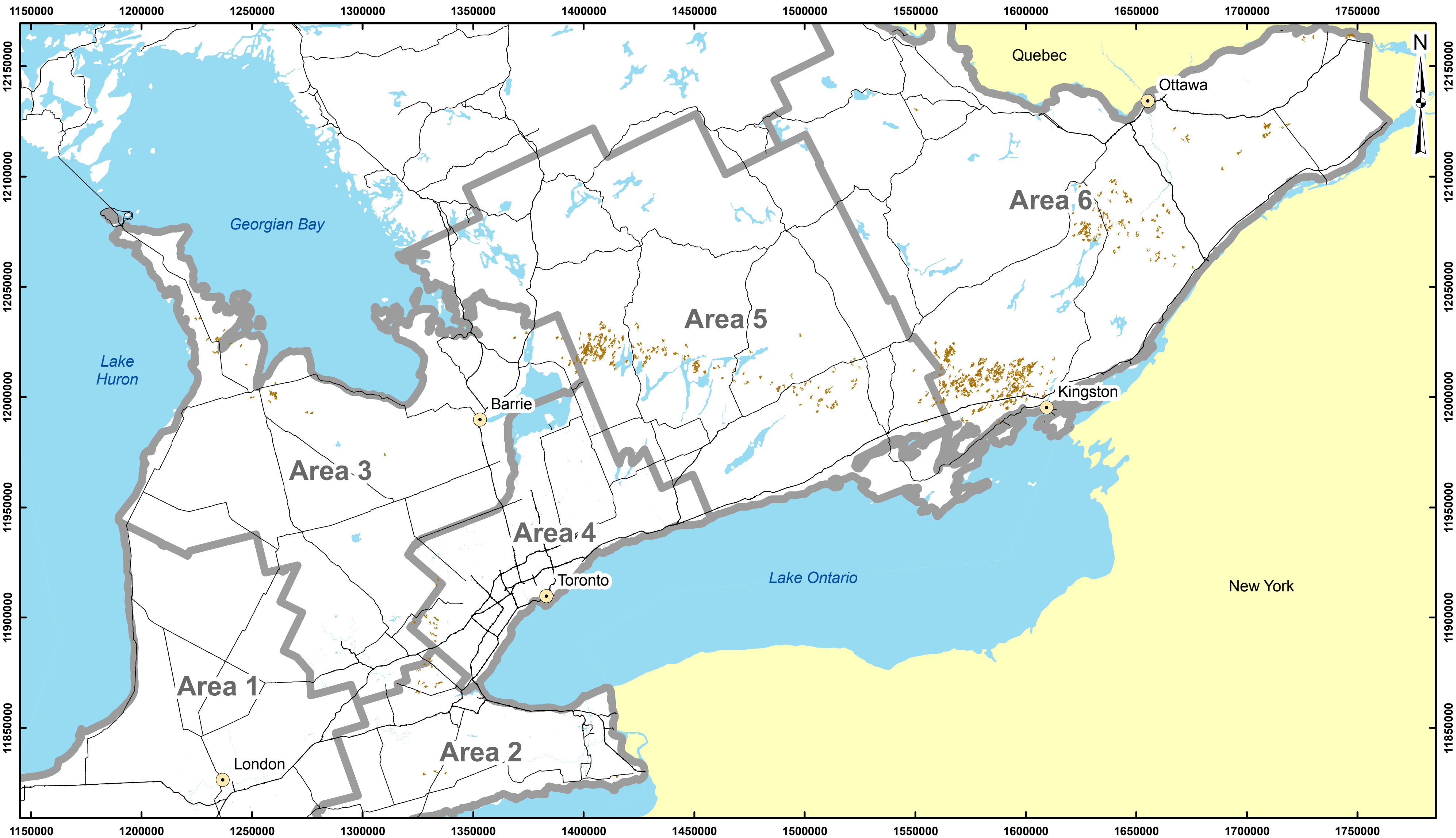

LEGEND

- Remaining Bedrock Resource
- Highway
- Aggregate Area Boundary
- Waterbody

Previously Applied Constraints

Existing Aggregate Licences and Permits
Urban Area
Niagara Escarpment Commission - Natural Area
Niagara Escarpment Commission - Protection Area
Road
Railway
Provincially Significant Wetland
ANSI Life Science
ANSI Earth Science
Significant Wooded Area
Greenbelt - Alvars
Greenbelt - Savannah, Tallgrass Prairie and Sand Barren
Watercourse
Waterbody
Wetland
Environmentally Sensitive Area
Reserve And Wildlife Area
Park And Recreation Area
Prime Agricultural Lands
Remaining Bedrock Resource Area < 60 ha

REFERENCE

Base Data - MNR NRVIS, obtained 2009, CANMAP v2008.4
Selected Bedrock - Ministry of Northern Development, Mines and Forestry, 2006
Constraint Data - MMAH, MNR, SOLRIS
Produced by Golder Associates Ltd under licence from
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0 10 20 40 60 80 100
SCALE 1:2,500,000 KILOMETRES

PROJECT
STATE OF THE AGGREGATE RESOURCE IN ONTARIO STUDY (SAROS) PAPER II

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DESIGN	PP	15 Sep. 2009	FIGURE: B -	
GIS	PP	21 Oct. 2009	FIGURE: 22	
CHECK	JF	23 Oct. 2009		
REVIEW	WC	23 Oct. 2009		

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APPENDIX C – PORT FACILITIES REVIEW

Node 3: Destination Marine Terminals

There is a point in the analysis of shipping modes where transitional points weigh heavy to one mode or another. In looking at the scope of the transportation requirements several key factors were considered which included volume, origin-destination (O/D) distance, availability of other modes and shipment cycles.

It is apparent that the large volume requirement lends itself heavily to the use of vessels for transportation by water either directly to the destination point or to a transitional point where good intermodal connections and the capacity for storage exists. Storage is critical because the shipping system is only open roughly 255 days annually and to maintain a continual flow, stockpiling will be required.

Several main considerations were looked at:

1. Short voyage distances to an intermediate point was cost effective because a smaller number of vessels were required to complete the marine segment cycles.
2. Longer voyage segments were more cost effective but could be offset by the need to provide a larger number of vessels to do a direct O/D cycle.
3. The Welland Canal was a limitation due to transit time and tolls which added to the total per ton shipment cost. In addition, an anticipated maintenance cycle for the canal which would affect operational periods could adversely impact cycle times, deliveries and cost.
4. Intermediate ports near the Welland Canal would not prove cost effective because of the need for addition vessels to meet marginal cycle periods.

The conclusion was that short marine cycles to ports with adequate transload capability and storage or direct shipment between the O/D points would be the most cost effective for high volume, low value bulk cargo. Based on that, three ports with the best short term cycles were selected for review as well as the possibility for direct shipment to the final destination, taking into consideration the possible operational disruptions of the Welland Canal. Intermediate ports were viewed as a third but least desirable alternative.

Finally, the SAROS terms of reference specified that Vaughan City Centre (VCC) was to be the representative destination for aggregate transport, as some fixed O/D pair is required to make comparisons. The Welland Canal area is 150 km from VCC, thereby requiring a long marine segment as well as a relatively long road or rail segment to complete the journey. While local facilities along the Canal may well be useful for delivery of materials for use within Niagara Region, ports along the Canal are not seen as practical for the case study at hand.

Aggregates being transported by water from Manitoulin Island could be transported to one of several commercial ports on Lake Huron and Lake Ontario. Port selection was based on some key criteria. The ports themselves were reviewed with the following criteria as significant:

1. Distance from the origination port (Manitoulin Island)

2. Likely route
3. Vessel size and speed
4. Port infrastructure
5. Port depth and access
6. Port cycle time
7. Upland storage availability
8. Rail and road access
9. Existing facility volume
10. Available capacity above current throughput
11. Port management
12. Logistic flexibility
13. Voyage cycles
14. Number of O/D handling components
15. Economies of high volume long distance marine transport vs. availability of vessel capacity
16. Cost factors
17. Seasonality

Each of these evaluation parameters are discussed in more detail below:

1. Distance from the origination port

Potential route distances have an impact on several key factors including how long the vessel will be engaged, daily charter rates, how many vessels will need to be engaged, how the vessels can be paired so that there is a continuous cycle of transportation, cost of fuel and operation, and the impact on port capacity.

2. Likely route

The Great Lakes for the most part are wide and deep and do not limit vessel size. The limiting factors are the connecting rivers or canals, and the ports themselves. Overall, Great Lakes routes have deep water. However, once the vessels need to transit between lakes, they are limited in size to river depth, channel width or locks size in canals.

3. Vessel size and speed

Vessels traveling on the Great Lakes west of Toronto are generally limited to a maximum length of 735 feet (224 m), an average width of around 80-90 feet (24-27 m) and a depth of 26 feet (8 m). This limits the amount of cargo that a ship can carry between 25 and 30 thousand dead weight tonnes. If the vessel has to transit between several lakes, it will not be able to exceed this general carriage capacity. Large bulk ships are limited to 10 to 15 knots (18 to 28 km/h); depending upon their age and propulsion systems. These slow speeds add considerable time when vessels are transiting longer distances. Great Lakes weather conditions are also a factor. The Great Lakes are fresh water which has a lower specific gravity than salt water, winds from adverse weather systems can increase wave height considerably in a short period of time thus requiring the vessel to slow down, increasing the cycle time. For the purposes of this discussion, cycle time includes when the vessel is at the load port and ready to accept cargo, cargo loading time, vessel departure and transit, port arrival, docking, harbour transit, unloading, departure, return transit, arrival to the point where the vessel is ready to accept cargo again. Most vessels transit one way on a load voyage (which means fully loaded with cargo) and then return in a ballast voyage; carrying no cargo.

4. Port infrastructure
   Because of vessel size limitations, most ports have piers and pier aprons specifically designed to accommodate the largest Great Lakes vessel. Average pier length is generally around 1,000 feet (300 m) which allows for flexible loading and discharge of different types of vessels. Many port facilities, however, are built for one specific type of cargo handling and may comprise a small pier with mooring dolphins to keep the vessel along side. The berths themselves, which includes the watershed area alongside the pier, is measured by length, width and depth.

5. Port depth and access
   There are a number of smaller ports throughout the Great Lakes that can easily accommodate most lake bulkers. They were designed and built when the average vessel size was smaller and some cannot accommodate the largest lakes carriers. As a result of this, there are narrow channels, tight turns, limited turning basins and harbour depth which limits the economy's gained by using the largest vessels. Some ports which may have good access and facilities in the outer harbours, have limited access in inner harbours where bulk facilities are often located.

6. Port cycle time
   Most lake ships are now self unloaders and an average vessel can discharge its cargo between 6 and 10 hours. Delays can be caused by the inability of a port to affectively move cargo from the shoreside discharge point to upland storage. This can delay vessel discharge rates and increase shoreside port time.

7. Upland storage availability
   Since most aggregate cargo is not time sensitive for delivery, the cargo normally experiences extensive dwell times at marine facilities. Storage areas of between 10 and 25 acres are generally adequate for most types of standardized marine operations based on throughput, dwell time requirements and out-the-door delivery.

8. Rail and road access
   A critical component of cargo delivery to the destination point is rail and highway connections. Our port selection evaluation took into account availability of active short line or main line service as well as highway connections, and ability to accommodate significant truck traffic.

9. Existing facility volume
   Ports can have adequate facilities but if they are heavily used, this will limit the amount of volume or potential volume that can be moved through these facilities. While several of the ports had high volume throughput tonnages, there are currently no congestion issues identified that would limit an increase in some cargo movements.

10. Available capacity above current throughput
    Due to the nature of the study's anticipation of higher volume throughput, the ports were reviewed to determine if they had adequate existing excess capacity or where capable of having new capacity added. The ports currently handing large volumes of aggregate all appear to have existing access capacity. It should be noted that if anticipated volumes are realistic, no single port would accommodate the entire increase in volume.

11. Port management

We reviewed the management structure of the identified ports to determine if they had professional commercial management in place or were public entities. Commercial operators are much more efficient than public operators and all of the terminal operators were commercial.

12. Flexibility of Logistics

The ports are one link in the logistic chain. A careful review was made to see if the ports had the capability of handling scheduled vessels in variable cycles, caused by weather or congestion delays. They were also looked at to see if they could stockpile cargo and if they had any limitations on out-the-door transloading or delivery.

13. Voyage cycles

Shorter voyages which include ports that have close geographical distances generally require lesser amount of dedicated tonnage. The longer the voyage, the longer the vessel is engaged in transit and the larger number of vessels will be needed to equal shorter voyage cycles with smaller number of vessels.

14. Number of O/D handling components

The most effective means of transportation involves limited modal transfers. The more effectively you can utilize a single mode of transportation from origin to destination, the more efficient the delivery will be. Transportation, for example, that goes directly from ship to truck is more effective than having a rail component in most cases.

15. Economies of high volume long distance marine transport vs. availability of vessel capacity

The larger the vessel and the higher the volume of cargo that can be carried in a single voyage is much more cost effective the longer distance it is carried. This however becomes problematic when larger volumes are involved. As volume demand increases, more ships have to be engaged. Currently, there is a limit on available tonnage and new vessels would have to be built to meet substantial demand.

16. Cost factors

The cost factor is the most complicated element of the logistics approach. Assuming the specified origin and destination points, fewer vessels can be used on short marine transits but then they require one or two additional modes of transportation to the destination point. When compared with other modes of transportation for example, moving an equal amount of cargo 1000 miles (1600 km) by ship is about half the cost of moving the same amount by rail assuming a full vessel load.

Longer transits by water require additional vessels but will eliminate several intermodal exchanges. However, due to the nature of the Great Lakes and the waterway connections among them, the additional factor of the cost of using the Welland Canal must also be included in the equation.

A smaller number of vessels on a short marine transport can deliver product in short cycle times where it can then be stockpiled and transferred to rail or truck for movement to the final destination. While it is often cheaper to move the commodity the longest distance possible by water, anticipated volume dictates the need to build a number of vessels whose capital costs could not be recovered on low value cargoes in a reasonable time period.

Most of the ports have similar cost structures and fees for handling cargo so the major variation is vessel operating and capital costs.

17. Seasonality
A key limiting factor of the Great Lakes is the operating season outside of those times when lakes, rivers and other areas are frozen. Marine operations can occur on average only 250 to 260 days per year. This applies equally to all marine operations.

Based on the above criteria, we looked at the available ports to determined which were capable, ready, equipped and willing to handle the specified criteria. The following is a list of the ports that were evaluated and a more detailed discussion of each port follows this list:

Ports on Lake Huron / Georgian Bay

- Port of Collingwood
- Port of Midland
- Port of Goderich
- Port of Sarnia / Port Huron

Port on Detroit River (Between Lake Erie and Lake St. Clair)

- Port of Windsor

Ports on Lake Ontario

- Port of Toronto

A profile of each of these ports follows:

A. Port of Collingwood

Collingwood is a former deep water port on the southern shore of Georgian Bay, in the area known as the Georgian Triangle. It is 104 km (65 miles) north of Toronto via Highway 400 and Highway 26. The community is developing a new waterfront and harbour plan mostly focused on recreational boating.

Collingwood is served by Highway 26, which runs along the shore of Nottawasaga Bay, and County Road 124. The town has a rail trail along a former Canadian National Rail line. There is a former spur heading north through the town's central business district, to the large grain elevators at the downtown wharf, where trains were formerly loaded and unloaded dock-side. The town of Collingwood started a public transportation initiative in 2007 and has recently developed a *new waterfront master plan that does not support industrial activities*. *There are no existing facilities for transportation of aggregate*.

B. Port of Midland

The town and port of Midland is located in Simcoe County, Ontario, which lies on the south shore of Georgian Bay and is 128 km (80 miles) north of Toronto. Midland was incorporated as a village in 1878 and as a town in 1890. The population is around 16,000. Midland had an active port at one time and was featured in several studies regarding the shipment of aggregates. The port has diminished in importance and numerous recreational boating industries and park areas have replaced the once active industrial waterfront. *The area no longer appears to support marine or rail industrial activity.*

C. Port of Goderich

Located on the eastern shore of Lake Huron, the Port of Goderich handles bulk commodities and has good highway and rail connections. The Port of Goderich is located approximately 233 km (140 miles) from Toronto. Goderich Harbour is owned by the town and is operated under contract by Goderich Port Management Corporation. It is an industrial harbour, used primarily to load salt from the Sifto salt mines onto lake and ocean freighters. The pier can accommodate self-unloading vessels up to 730 ft (222.6 m). Approximately 100 large lake and ocean freighters call on the port annually to load salt from the mine and to deliver and load other commodities such as grains and calcium chloride. The port consists of approximately 22.7 acres which are town-owned and fully serviced with full hydrant system for fire protection plus an additional 75.9 acres readily serviceable. Approximately 10 acres of privately owned, unserviced industrial land is also on the market.

There is good access for truck transportation via Highways 8 and 21, which intersect in town. There is also an industrial rail connection at Goderich, provided by a short-line railroad, the Goderich and Exeter Railway (GEXR). GEXR is a RailAmerica owned company. The Goderich and Exeter connects with the Canadian National Railway at both Exeter and Toronto. The connection at Toronto is at CN's MacMillan Yard, and is via trackage rights, which may be restrictive in terms of volumes or operating characteristics.

Sifto Canada, Inc operates a salt mine underneath Goderich's harbour. The mine extends 5 km under Lake Huron and is the largest salt mine in the world. The mine produces approximately 3.5 million tonnes annually and is owned by Domtar Chemicals Company.

The picture below shows a bulk ship in the Port of Goderich.

D. Port of Windsor

The Port of Windsor is a large full-service port that extends about 21.2 km (13.2 miles) along the Canadian shore of the Detroit River between Lake Erie and Lake St. Clair opposite Detroit, Michigan. All terminals within the Port are either leased to or owned by private operators. There are 14 terminals in the Port actively moving goods by water and an additional five have a handling capability for various commodities. There is more than 4,880 m (16,000 ft) of berthing space, more than 89 ha (220 acres) of open storage space and over 40,876 m^2 (449,000 ft^2) of covered storage space.

There is one unsheltered anchorage in the Port with a second one available in the Port of Detroit. Harbour depths vary between depths of 30.8' to 36.1' (9.4 m to 11.0 m). Vessels can be accommodated in most of but not all of the berths in the port up to a maximum "length, overall" (LOA) of 1,004' (306.2 m), maximum beam 105' (32 m), maximum draft 29.5' (9 m). There are four terminals in the port that regularly handle sand, stone and aggregate.

The port is managed by the Windsor Port Authority which has 65 acres (26.3 ha) of land available in the Port of Windsor for development. Ojibway Shores, adjoining the Morterm facility, has over 426.7 m (1,400 ft) of frontage on the Detroit River and up to 32 acres (12.9 ha) of land. The remaining acreage is in five parcels on Russell Street, one parcel having the potential for barge access on the Detroit River. Land is available for lease for long term use.

The table below summarizes the volume of aggregate handled at the Port of Windsor over the last 10 years (numbers are in thousands of tonnes):

Table 1: Port of Windsor aggregate volumes

Commodity	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Aggregates	2,516	2,609	2,216	2,118	1,864	2,102	2,774	2,330	2,042	1,929

Lafarge Canada Inc. Windsor Terminal

There is an existing aggregate-handling terminal in Windsor, operated by Lafarge. The terminal is located at 3450 Russell Street in Windsor. This terminal receives the majority of its aggregates from Lafarge's Manitoulin Quarry. The Lafarge Windsor dock handles different sizes of aggregates for use in manufacture of asphalt and concrete and clear stones. The Lafarge aggregate terminal consists of approximately 244 m (800 ft) of dock frontage and nearly 15 acres (6.07 ha) of land. The terminal can store approximately 225,000 tonnes at any given time.

Lafarge Windsor can accommodate self-unloading vessels up to 730 ft (222.6 m) and is equipped to move the material on shore to stockpiles and load onto trucks. While there is rail to the port of Windsor, LaFarge does not currently utilize rail to move product from this facility. The Lafarge Terminal is estimated to be able to handle an additional 20% more tonnage without major infrastructure improvements.

E. Port of Sarnia

Sarnia is the largest city on Lake Huron and is a centre for lake freighters and ocean ships moving grain, ore, aggregate, cement and petroleum products. Large pipelines bring Alberta oil to Sarnia, where oil refining and petrochemical production remain significant to the local economy. Large salt beds located under the city are a source of chlorine used in chemical processing. The port has numerous petrochemical terminals located along the St. Clair River, which connects Lake Huron to Lake Erie. The port shares the waterway with Port Huron, Michigan located on the west side of the river. Both Canadian National Railway (CN) and CSX have rail connections into the port.

The picture below shows the Ports of Sarnia and Port Huron:

Facilities in the port include the Sunoco Oil Terminal, Imperial Oil Terminal, Polysar Export Terminal, Shell Oil Terminal, Cargill-AgHorizons Ltd, Lafarge North America, Lanxess Terminal, Sarnia Concrete, Southwester, and Suncor. Sarnia has a large CN freight yard and several railroads with various operating rights. The terminal has approximately 600,000 tonnes of storage capacity for aggregate.

Lafarge operates a large facility in the port with rail and highway access. The terminal has access to several deepwater berths capable of handling cement, petroleum and aggregate along with large storage areas. The terminal is located parallel to the main ship channel on the St. Clair River.

The St. Clair River is 64 km (39 miles) long and drops 1.5 m (5 ft) in elevation from Lake Huron to Lake St. Clair. The shipping channel on Lake St. Clair itself is 56 km (35 miles) long from the end of the St. Clair River to the beginning of the Detroit River. The Detroit River is 51 km (32 miles) long and drops 1 m (3 ft) in elevation from Lake St. Clair to its mouth at Lake Erie. The marine terminals in Sarnia are located parallel to the river and can accommodate the largest of lake ships. Berth depths average between 26 and 30 ft (8 to 9 m). The channel through St. Clair River has been improved in places by dredging and the U.S. federal project depth in the river is 27 ft (8.2 m).

The central part of Lake Huron is mainly an open water area, but drifting patches of thin ice may be present from early February until mid-March. These patches drift south toward the St. Clair River. An ice bridge forms across the head of the river. Ice accumulates to a depth 12 to 18 inches above the ice bridge; the bridge itself achieves a much greater thickness. Ice normally begins to form in harbours and shallow-water areas in early December with ice fields and concentrated brash forming in early January.

F. Port of Toronto

Toronto Harbour is both a commercial port and a recreational port with all of the port's commercial activities confined to the harbour's eastern side. The Port of Toronto has in excess of 50 acres of paved marshalling area, long/short-term storage, Canada customs-bonded heated warehousing and a full range of cargo handling equipment. The Port of Toronto provides immediate access to marine routes, major highways and rail facilities. Bulk cargo is a primary commodity and includes sugar, salt, cement, aggregates, asphalt and liquids. There is adequate port space to handle additional tonnage according to the primary terminal operator, Logistec.

Toronto also has a second harbour, called the Outer Harbour, which has never developed into a commercially viable seaport. The Outer Harbour was created in the 1950s by the Toronto Harbour Commission through the construction of a new breakwater called the Outer Harbour East Headland. It was expected that there would be a significant increase in the number of ships calling at Toronto once the Saint Lawrence Seaway opened but the need for an extra harbour never materialized, and there is limited traffic there at this point. The area is partially industrial and partially abandoned known as the Port Lands.

The port includes the following facilities:

- Port area of 50 acres (20.234 ha).
- Seven marine berths, all to St. Lawrence Seaway depth.
- Intermodal connections to road and rail service.
- Marine terminal building with 150,000 ft^2 (13,935 m^2) of storage, located close to the berths.
- Container distribution centre with 100,000 ft^2 (9,290 m^2) of heated storage, inside rail loading dock, inside truck docks, and many container.
- Cargo yard that is paved, fenced, customs bonded and has 24 hour security.
- Rail service by both of Canada's railroads, Canadian National Railway and Canadian Pacific Railway.
- Several sidings providing access throughout the port area, including direct dock and warehouse access.
- Container yard includes container handling equipment and electrical plugs for reefers.
- A maintenance centre for maintaining/repairing the equipment

The Port has significant industrial land. A number of port users have located in the port and connect to marine services, rail and major highways. The port lands are also used extensively for effective distribution services for Toronto, the Greater Toronto Area (GTA) and beyond. A number of waterfront sites are available for expansion.

The port is accessed from Lake Ontario from the Western Great Lakes through the Welland Canal. The Welland Canal is a ship canal in Canada, that runs 42 km (27.0 miles) from Port Colborne, Ontario on Lake Erie to Port Weller, Ontario on Lake Ontario. As part of the St. Lawrence Seaway, the canal allows ships to avoid Niagara Falls by traversing the Niagara Escarpment.

Approximately 40,000,000 tonnes of cargo is carried through the Welland Canal annually by over 3,000 ocean and lake vessels. It was a major factor in the growth of the city of Montreal. The canal's Lake Erie (southern) terminus, at Port Colborne, is 99.5 m (326.5 ft) higher in elevation than the Lake Ontario (northern) terminus at Port Weller. The canal comprises eight lift locks, each 24.4 m (80 ft) wide by 233.5 m (766 ft) long. Due to the Garden City Skyway (QEW) bridge, the maximum ship height allowed is 35.5 m (116.5 ft). All other roadway crossings of the canal are movable bridges (lift or Bascule) or tunnels. The maximum permissible vessel length is 225.5 m (740 ft). It takes ships an average of 11 hours to traverse the canal's length.

Assumptions

It was assumed that of the ports assessed above, the only ports located north of Lake Erie that are capable of handling significant volumes of aggregates are Goderich, Sarnia and Windsor. Of the three, Goderich provides the fastest turnaround time for smaller vessels. Windsor is the most diversified and has the best capability including storage. All three ports have rail connections although Windsor will require a short truck dray for material to the railhead. Given the distance of each of these ports from the GTA, it was assumed that aggregates would be transported by rail.

In addition to these three ports, there would also be the potential for ships to transport aggregates to one or several of the ports on Lake Ontario. While there are opportunities at the Ports of Maitland and Nanticoke, this assessment will focus on the potential for shipment directly to the Port of Toronto, with aggregate being transferred to truck for delivery to the GTA. Toronto was chosen because of its close proximity to the GTA, though the same analysis would be applicable to any of the ports on Lake Ontario.

Based on discussions with terminal operators and material handlers, as well ass our collective experience in transportation logistics, we have made the following assumptions for the cost estimates of each of the ports:

- The current maximum annual capacity for transporting aggregate through the Port of Windsor is approximately 3 million tonnes (The Port of Windsor handled 2.7 million tonnes of aggregate in 2005). We assume that the Port of Windsor could handle approximately 5 million tonnes annually with capital improvements and increasing the footprint of the terminal to allow for increased stockpiling of materials.
- The current maximum annual capacity at the Port of Sarnia is approximately 500,000 tonnes. We would assume that Sarnia could handle approximately 2 million tonnes of aggregate with significant expansion of the terminal footprint (for stockpiling / handling) as well as improvements to the railyard to allow for increased loading via rail
- While a significant portion of the Port of Goderich is dedicated to handling salt, the Port has the additional potential capacity to handle approximately 500,000 tonnes of aggregate. With significant expansion of the berthing capacity and terminal footprint, the Port could handle up to approximately 2 million tonnes per year.
- The current maximum annual capacity at the Port of Toronto is approximately 250,000 tonnes per year. With expansion, the Port of Toronto could handle approximately 1 million tonnes per year. The Port of Toronto expansion is limited due to availability of land for stockpiling / aggregate handling as well as a limitation on the number of trucks that can logistically serve the port, due to the congestion in the Toronto area
- For expansions of port terminals, the following per-unit cost estimates will be used:
    - Pier construction (inclusive of engineering, permitting, design and construction): $2-3 million for expansion to handle an additional vessel per day
    - $50,000 per acre (0.4 ha) for stockpiling / aggregate handling

Marine Sub-scenarios

Since in most cases the ports available are not near any major aggregate demand sites, clearly significant additional transportation links will be needed to implement a marine-based aggregate transportation network. To account for this we will assemble two alternative time series cost scenarios for marine: one for ports near to the final destination (e.g. Toronto), and one for more remote ports (e.g. Goderich). While Toronto will require considerably more marine distance and travel time, it is close to ultimate destinations, while Goderich is much closer to Manitoulin Island, but will require longer highway trips to serve the GTA.

Social Issues to Consider

For the scenarios that involve marine transport of aggregate through port facilities, the most significant social impacts are typically realized at the terminal ends of the routes. The marine transport of aggregate via ships has a relatively small impact to surrounding communities. At the terminal ends of each marine route, where there is a transfer of aggregate from either ship-to-truck, ship-to-rail or truck-to-ship, there are the following considerations from a social impact perspective:

- Noise: The transfer of aggregate will require heavy machinery that will generate noise during operations
- Truck traffic: The trucks entering / exiting these terminals would have an impact on the roadways of the local community
- Fugitive dust: The handling of aggregates would generate dust that has the potential to impact the air quality of the surrounding community
- Ambient lighting: If the terminal(s) were to operate outside of daylight hours, the terminals would require lighting that has the potential to impact the local community.

While the issues above must be considered, several of the ports that were evaluated have expressed a significant interest in the potential to increase the industrial activity at their ports. Many of these ports have seen a decline in freight handled over the last 12 to 18 months, and have suffered job losses with this decrease. The potential to add construction, operating and management jobs to participate in the handling of increased aggregate via marine transport would be very attractive to several ports, as discussed above.